CENTRIC 2014

The Seventh International Conference on Advances in Human-oriented and Personalized Mechanisms, Technologies, and Services

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CENTRIC 2014 Editors

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CENTRIC 2014

Forward

The Seventh International Conference on Advances in Human-oriented and Personalized Mechanisms, Technologies, and Services (CENTRIC 2014), held between October 12 - 16, 2014 in Nice, France, continued a series of events focusing on human-oriented and personalized mechanisms, technologies, and services, commonly known as I-centric.

There is a cohort of technologies that favor the so called “user-centric” services and applications. While some of them reached some maturity, others are to prove their economics (WiMax, IPTV, RFID, etc.). The human-oriented and personalized technologies and services rely on a key set of features, some to be deployed, others getting more mature (personal profiles, preferences, identity, proximity, personal devices, etc.). Advanced applications covering human related activities benefit from personalized and human-oriented networks and services, especially preventive and personalized medicine, body networks and devices, or anticipative systems.

The conference had the following tracks:

- User research and usage behavior
- Personalization
- User-centric supporting mechanisms and personalized service technologies
- User-centric applications and centric views
- User experience and usability

Similar to the previous edition, this event attracted excellent contributions and active participation from all over the world. We were very pleased to receive top quality contributions.

We take here the opportunity to warmly thank all the members of the CENTRIC 2014 technical program committee, as well as the numerous reviewers. The creation of such a high quality conference program would not have been possible without their involvement. We also kindly thank all the authors that dedicated much of their time and effort to contribute to CENTRIC 2014. We truly believe that, thanks to all these efforts, the final conference program consisted of top quality contributions.

Also, this event could not have been a reality without the support of many individuals, organizations and sponsors. We also gratefully thank the members of the CENTRIC 2014 organizing committee for their help in handling the logistics and for their work that made this professional meeting a success.

We hope CENTRIC 2014 was a successful international forum for the exchange of ideas and results between academia and industry and to promote further progress in the area of human-oriented and personalized mechanisms, technologies and services. We also hope that Nice, France provided a pleasant environment during the conference and everyone saved some time to enjoy the charm of the city.

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Table of Contents

Making the Most of Customer Product Reviews 1
Florian Volk, Janette Pitzschel, and Max Muhlhauser

Mobile App Marketing: A Conjoint-based Analysis on the Importance of App Store Elements 7
Stephan Bohm and Stefan Schreiber

Gender Differences in Gesture-based Interaction 15
Manolya Kavakli and Yan Ling Chen

Assessment of Expectations and Needs of a Sensor Network to Promote Elderly's Sense of Safety and Security 22
Annica Kristoffersson, Ella Kolkowska, and Amy Loutfi

Towards Universally Usable Smart Homes – How Can MyUI, URC and openHAB Contribute to an Adaptive User Interface Platform? 29
Lukas Smirek, Gottfried Zimmermann, and Daniel Ziegler

User Models and Domain Ontologies for Generating Personalized Questions and Answers 39
Marta Gatius

Design and Personalisation: For a Person of by a Person? 44
Tom Fisher and Iryna Kuksa

EMMA: A Context-Aware Middleware for Energy Management on Mobile Devices 48
Andre Ebert, Florian Dorfmeister, Marco Maier, and Claudia Linnhoff-Popien

Human-Centric and Privacy-Protecting Trust Establishment over the Internet 54
Holger Kinkelin, Heiko Niedermayer, Simon Mittelberger, and Georg Carle

Security and Safety Composition Methodology 60
Seraj Fayyad and Josef Noll

User-centric Recommendation Model for AAC based on Multi-criteria Planning 66
Sebastian Sastoque Hernandez, Daniela Mancilla Valdes, Jesus Mendoza Medina, and Marcela Iregui Guerrero

Towards an Integration of Process Modeling and GDSS for Crisis Management 73
Heiko Thimm and Robert Katura

Interaction-based Ontology Modeling for User-Centric Social Networks Environments 77
Luigi Di Caro, Alice Ruggeri, and Guido Boella

Centricity in Project Risk Management: Towards a Conceptual Framework for Improved Practice 83
Jose Irizar and Martin Wynn

A Surveillance System to Counter Vandalism of Transmission Line Equipment 89
JohnPaul Asiimwe, Adella Kyohairwe, Cosmas Mwikirize, and Richard Okou

Communication Behavior Modification -Application for Promoting Wi-Fi Network Usage by Visualizing Usage History- 95
Sumaru Niida, Hidetoshi Yokota, and Shigehiro Ano

Making the Most of Customer Product Reviews

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***Abstract*—Online product reviews are a twofold user-centric instrument: reviews are written by users and, furthermore, aid other users with their purchase decisions. Moreover, detailed product reviews that rate product parts help retailers in improving products by identifying reasons for defects. In this paper, we report, analyse, and discuss the results and findings of two user studies (160 and 229 participants respectively). We contribute findings on customer reviewing behaviour and on improving reviews to include ratings for product parts. Furthermore, we analyse reviewing incentives and evaluate an alternative review system that presents its users with a list of known problems that they can select from.**

Keywords–Online Product Reviews; Product Rating; Rating Decomposition; Customer-centric; Review Systems.

I. INTRODUCTION

Online product reviews are a remarkable user-centric component of e-business. The duality of reviews involves customers at two times during their online shopping experience: at first, potential customers of a product read reviews to evaluate product suitability and therefore, base their purchase decision on reviews. After a purchase, the second aspect of reviews becomes relevant when customers may write their own product reviews in an altruistic action to help others with their purchase decisions. In general, product reviews report the experience with the product alongside with an indication of the product's merits (called *rating* from now on).

Even though customer product reviews suffer from conceptual problems, for example, authors lying about their experience with a product or reviews written by paid authors who never bought the product, reviews are considered such important for online business that they are implemented in almost every online shopping platform. Besides aiding potential customers, reviews also provide benefits for online retailers. Highly-rated products reach higher prices compared with low-rated products [1][2]. Moreover, potential customers will usually choose the highest-rated product from a set of functionally identical ones.

The impact of product reviews on customers is in the focus of research since some time. Our interest in customer reviews differs. In order to improve the benefit for both customers and retailers, we are interested in splitting a review into sub-ratings for individual parts of a product. Most products sold today are composed of parts contributed by different, potentially independent suppliers. However, customers receive assembled products and thus, reviews address products as a whole. While this is helpful for customers, having ratings for product parts would enable retailers to improve the assembled product by identifying weak parts and consequently replacing their suppliers with other suppliers that deliver higher quality. Eventually, this will have impact on the overall product quality and thus, on customer satisfaction, as well as on the reviews written for the product. Beyond the scope of this paper, such knowledge on individual ratings would also have impact on pricing strategies of retailers and similar.

Therefore, we are interested in ways to *decompose* product reviews into detailed reviews for sub-components. It would be a strong assumption to expect the general customer to be able to write individual reviews for product parts or even to identify such ones. In order explore reviewer capabilities, as well as to understand how and why reviews are written, we conducted a preliminary survey (160 participants) on the attitudes of customers towards reviewing followed by a second study (229 participants) that further investigates the results of the preliminary study. By the term *customer capabilities*, we summarize both the ability and the willingness to produce detailed reviews. For the second study, the following assumption was made: customers are generally unable to identify and rate parts of products individually. Thus, we focused on the capabilities to identify defects and the reasons for the defects. Defect identification is close to (negative) ratings for individual parts, because it delivers the information needed to identify and replace suppliers of weak product parts. This aids both retailers in improving product quality and customers in buying better products.

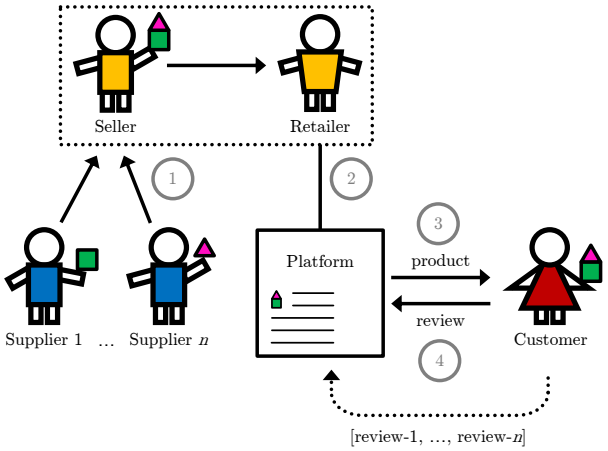

Figure 1. The e-business reviews scenario: the retailer sells a product made from components of different suppliers to customers. Each customer may write a review about the product as whole. Nevertheless, our interest is to obtain reviews for individual parts of the product.

Our studies assume the scenario depicted in Figure 1. A *seller* assembles a product from parts contributed by several *suppliers*. The finally assembled product is given to the *re-*

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tailer, which uses an *e-business platform* to offer the product to potential *customers*. The seller and retailer may as well be the same entity without influence on the results of our studies. Products that are offered on the platform consist of a description and a set of product reviews written by customers. When a customer makes a purchase decision, the product is given to the customer, who may write a *product review*, which will be available on the platform to other potential customers. Our intention is to determine the possibility of obtaining decomposed reviews from customers.

A. Structure

This paper is organised as follows: we survey work related to customer product reviews in Section II. Afterwards, in Section III, we present the setup and demographics of the two studies we conducted. In Section IV, we report our findings on customer review behaviour, while Section V focuses on the results on how customers can be incentivised to write more useful reviews. Based on the results of the first study, we presented the participants of the second study with an alternative review system. The reactions to the proposed review system are analysed in Section VI. We conclude in Section VII.

II. Related Work

Online customer product reviews are of interest in several fields of research, especially in psychology, economics, and computer science. In the latter field, most research targets the extraction of features and ratings from textual reviews by text mining. This section reviews a selection of the scientific work most relevant to our approach of decomposing customer product reviews.

A. General Aspects of Customer Product Reviews

In 2004, Resnick et al. conducted an experiment to research the effects of positive and negative reputation in eBay [1]. Thereby, eBay users can rate a transaction, that means, a purchase, as either *positive*, *negative* or *neutral*. Based on these ratings, a reputation is built up for every eBay user. Resnick et al. found that sellers with good ratings—and thus, good reputation—were able to achieve significantly higher prices for the same products compared to sellers with less good ratings. According to the authors, eBay's reputation system is flawed but works anyway because buyers pay insufficient attention to bad reviews.

In [3], Li, Zhang, and Martin present an alternative review system for e-marketplaces. To overcome the flaws of current systems (e.g., no information is available on new market entities; delayed effects of negative reviews), they propose a system in which reviews are kept private between the buyers and the marketplace operator, which needs to be a trusted third party. The operator then applies punishments to misbehaving retailers. Related approaches to improve review systems have been made, for example, by Miller, Resnick, and Zeckhauser in [4]. Such improved systems usually apply financial measures to prevent misbehaviour; either by punishing misbehaving entities [3] or by rewarding good behaviour [4].

Our research is targeted towards making better use of reviews, not towards replacing the review systems themselves.

B. Effects and Motivations behind Customer Product Reviews

With the example of online movie reviews, Dellarocas and Narayan investigated the motivations of customers to write product reviews [5]. They found that exceptionally good or bad movies, high marketing effort, public disagreement on quality, and the number of already available reviews lead to an increased number of reviews. Dellarocas and Narayan could reject their hypothesis that customers write reviews out of altruism. Their results fit with ours from Section IV-B where applicable.

Research on the impact of reviews on the number of sales has been made by Chevalier and Mayzlin [2]. The authors investigated the effects of customer reviews for books on two large online shops. Besides a general tendency towards positive reviews, they found that better reviews correlate with higher sales numbers. Moreover, the impact of bad reviews is higher than that of good ones. The most interesting finding for our work, especially regarding consequences drawn from tests with our alternative review system, is that customers prefer written reviews over ratings only.

C. Text Mining Customer Product Reviews

There are many approaches in computer science that apply text mining on written customer product reviews. All these approaches use text mining to identify product features and the sentiments of customers towards these features. Thereby, features are detected in different ways and assigned with a rating.

Aciar et al. apply text mining with a product-specific ontology [6]. The authors define the ontology upfront and match the results of their text mining afterwards. Moreover, they calculate an overall product rating from all identified features. We believe that the customers should have the option to rate a product independently from their written review as it is possible that relevant influence factors are missing from the set of identified features.

Striving towards assisting manufacturers in increasing product quality, Archak, Ghose, and Ipeirotis apply text mining to customer product reviews [7]. In contrast to Aciar et al. [6], their approach includes learning the features from the reviews without the use of a predefined ontology.

The text mining approach by Yu et al. distinguishes between reviews that contain so-called *Pros&Cons lists* and pure textual reviews [8]. Besides this differentiation, the authors also identify product features (which they call "aspects") and sentiments towards these features.

In terms of decomposed ratings, product features are similar to product parts. While our approach in this paper aims at receiving reviews that are already decomposed from customers, applying text mining to reviews seems promising to aid review decomposition for situations in which the customers are unable to write decomposed ratings by themselves.

III. Study Setup

To explore customer reviewing behaviour and their capabilities to write detailed reviews, we conducted two studies.

 ISBN: 978-1-61208-369-8

The results of the first *preliminary study* helped in designing the second *full study*.

Both studies were conducted by means of structured online questionnaires. Invitations were sent to our extended network of family and international friends with the plea to redistribute to their friends and family. Both questionnaires were available in English and German language. For each question, the participants could choose from a list of predefined answers that ranged from specific answer like *yes* or *no* to an indication of tendency, e.g., *totally agree*, *agree*, *do not agree*, *do not agree at all*. When applicable, participants could concurrently select multiple answers.

The preliminary study was designed to gather data on the general attitude of customers towards online reviews. The full study was focused on the participants' capabilities in writing detailed ratings that may reveal faulty parts of a product. Additionally, the study was intended to reveal incentives that increase the probability of customers to write reviews. At the end, we presented the participants with a fictitious alternative review system designed on the results from the preliminary study. Details on the alternative system are explained in Section VI.

During both studies, all participants were asked for their gender, their employment status, and if they consider their job being in the field of technology or not. The participants were not asked for their age. Of course, all data was collected anonymously.

Overall, 160 people participated in the preliminary study. For the full study, we were able to recruit 229 people. Figure 2 shows the distribution of genders and of participants that see their job in the technological field. In both studies, almost 30% of the participants are female. The amount of participants with a technological job and those without increased from 60% to about 66%.

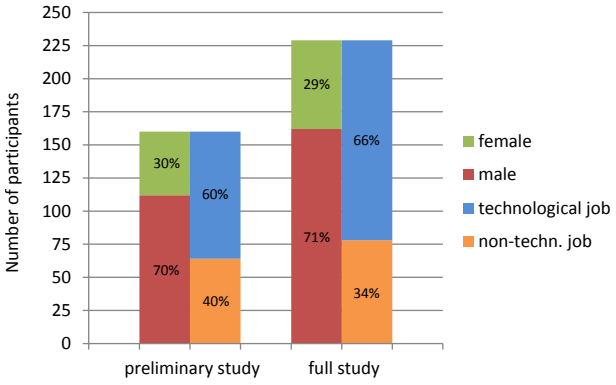

Figure 2. The distribution of genders and participants who consider their job being in a technological field for both studies.

The distribution among the different states of employment was similar in both studies. As Figure 3 shows, the vast majority of participants consisted of (university) students and employees. Due to the high percentage of German-speaking participants (around 80% of the participants chose to answer the questionnaire in German), it is to assume that undergrad students mostly chose "student", while Ph.D. students chose "employed" as a Ph.D. position usually is a full time position at a German university.

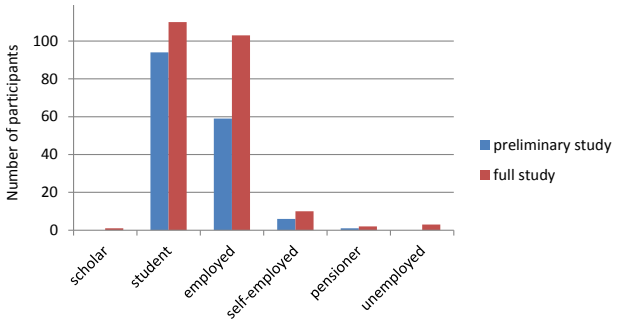

Figure 3. The distribution of participants among distinct types of employment for both studies.

In the preliminary questionnaire, all 160 participants answered the question if they ever bought products online with *yes*. Therefore, this demographic question was removed from the full study. However, we received an e-mail from one person stating she didn't complete our questionnaire because she never used online shopping before.

IV. Customer Reviewing Behaviour

The preliminary study targeted general customer reviewing behaviour. This sections discusses the main findings.

As expected, a high percentage of potential customers base their purchase decisions on product reviews from other customers. When asked if they are influenced by product reviews, 50% of the participants answered with *agree* and further 26.25% answered with *totally agree*. Therein, we see a reason to believe that customer reviews have an important effect on e-business in general. However, there appears to be a contradiction as only 75% of the participants ever wrote a review (in text form, on a point scale or in a mixed setting). Moreover, 79.2% of those who write reviews, only write reviews rarely.

A. Why Customers don't write Reviews

In order to investigate why customers don't write reviews, those 25% participants who claimed not to write reviews were asked for their reasons. Multiple answers were possible. The two most chosen answers were *missing motivation to do so* (75%) and *unwillingness to perform a registration which is required to write reviews* (67.5%). The same answers were given by the participants who write reviews only rarely. An overview on all answers is given in Table I.

TABLE I. Reasons not to write reviews as given by those who write reviews only rarely. Multiple answers allowed.

Reason	Participants	Fraction
I lack motivation	71	74.74%
I don't want to register	65	68.42%
I forget to write reviews	42	44.21%
I don't mind writing reviews	36	37.89%
Other customers already write reviews	30	31.58%
I'm aware that it's bad not to write reviews	21	22.11%
I consider reviews dispensable	12	12.63%
Reviews don't represent the reality	11	11.58%
I regret to write reviews rarely	7	7.37%
I don't know how to write a review	5	5.26%
other	8	8.42%

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B. Why Customers write Reviews

All participants that claimed to write reviews were asked for their reasons to do so. For every potential reason, the participants could state their consent on a five point Likert scale ranging from *totally agree*, *agree*, *neutral*, *do not agree*, *do not agree at all*. In Table II, the first two options are summarized under *positive tendency*, the last two ones under *negative tendency*. A sixth option *no opinion* could be selected in case none of the above applied. We asked for the eight reasons to write reviews as given in Table II.

TABLE II. REASONS TO WRITE PRODUCT REVIEWS. PARTICIPANTS WHO CHOSE *no opinion* ARE NOT LISTED.

I write reviews…	Positive Tendency	Neutral Tendency	Negative Tendency
to share my firm conviction for the product	80.83%	9.17%	8.33%
to warn other potential customers	76.67%	10.83%	9.17%
to share my experience with others	73.34%	11.67%	11.66%
because I want others to follow suit	38.33%	28.83%	35.00%
to express my frustrations	36.66%	12.50%	47.50&
without deeper reason	30.84%	25.83%	32.50%
to receive discounts or other benefits	22.50%	15.00%	58.33%
to receive assistance	20.00%	15.83%	55.83%

Participants could list additional reasons for writing reviews in a text field. Most notable reasons were *boredom* and *doing the retailer a favour*.

Many customers implicitly assume that the majority of reviews is written by unsatisfied customers. The assumption herein is that customers invest more time when they are dissatisfied with a product, for example, to "let off steam". Our findings do not back this assumption. In contrast, we found that there is no general correlation between writing a review and the tendency of the review.

In order to identify a general tendency towards positive or negative reviews, the participants had to indicate their level of agreement to the following two statements: *if I write a review, the review is always negative* and *if I write a review, the review is always positive*.

As can be seen in Figure 4, there is no tendency towards writing only negative reviews. However, a slight trend towards writing positive reviews is visible.

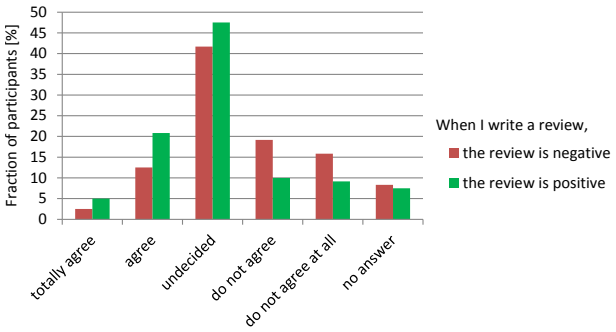

Figure 4. Tendencies towards generally writing positive or negative reviews respectively.

In conclusion, the best way for retailers to gather product reviews is to have convinced customers. Reviews are as often written to warn about potential defects as to share product experiences. This finding reconfirms that there is no tendency towards writing negative reviews.

C. The Influence of Warranty

The reaction of customers to a defect depends mostly on the state of warranty. If delivered with a defect, customers will send the product back to the retailer, regardless of the price. Moreover, searching the reason for the defect only plays a minor role. Nevertheless, 51.53% of the participants stated that they are usually capable of identifying the reason for a defect. Additionally, only 13.97% of the participants write reviews a long time after a purchase.

We conclude that it is especially difficult to obtain decomposed product reviews during the warranty period as customers are more prone to sending the product back than to find the defect. Getting information on product wearing is also difficult.

V. REVIEWING INCENTIVES

One part of the full study investigated how customers can be motivated to write more product reviews. We explored three potential incentives: receiving an explanation how a review helps the retailer to improve the product, receiving feedback to a review from the retailer, and rewards for writing a review. Figure 5 lists the participants' answers when asked for their level of consent towards each of the potential incentives.

Figure 5. Potential incentives for customers to write more product reviews.

Interestingly, there is no significant difference between the participants that claim to have a technological job and those who don't (Fisher-Freeman-Halton test [9]).

In summary, only rewarding the customers would increase the amount of reviews. However, rewards may distort the balance between positive and negative reviews. On one hand, customers might write more positive reviews as a form of positive reciprocity towards the retailer. On the other hand, those customers that are not satisfied with a product might not be interested in the reward. Consider the following example: when buying a video game, the retailer offers free access to a bonus level as reward for customers that write a review. Especially customers who dislike the video game profit less from a bonus level than satisfied customers. Therefore, a tendency towards positive reviews is created by the reward. That is, rewards need to be designed carefully not to influence the reviews. In fact, most retailers would be interested in manipulating customers towards writing positive reviews; but, this is not the intention of our research.

 ISBN: 978-1-61208-369-8

VI. Alternative Review System

The next part of the full study explored which features customers like most in review systems. Additionally to classifying the importance of specific features, the participants were presented with an alternative review system. The given task was to compare the proposed system with one that has the features of common review systems: rating a product from five stars (best) to one star (worst) and writing a textual review. This section first discusses the features of review systems, then presents the alternative review system and closes with the evaluation of the proposed system.

A. Features of Review Systems

For several features of review systems, the participants of the full study could state their level of agreement. Table III presents an overview of features that we could identify to be relevant.

TABLE III. Relevance of the features of a review system.

Feature	Agreement
Overview over all products	94.32%
Detailed reviews from other customers	85.15%
Short reviews from other customers	80.79%
Ability to write reviews instead of ratings	61.57%

Interestingly, 68.5% of the participants who want access to detailed reviews anyhow prefer short and compact reviews over detailed ones. We believe that this type of potential customer uses short reviews to get an overview over available products and their features, but exploits detailed reviews for the final purchase decision.

Other features we tested are of minor relevance, for example, the possibility to leave reviews fast or allowing only reviews from authors who previously purchased the product. 4.5% of all participants are not interested in reading reviews (or ratings) from other customers at all.

Based on the results of this part of the full study, we deduce that a customer-centric review system should assist potential customers with a good overview over the ratings for all available products with the option to get detailed information for specific products. Moreover, after a purchase, a relevant set of customers expects a review system to accept textual reviews instead of just a product rating.

B. The Alternative Review System

In common review systems, customers who bought a product can leave a rating (e.g., one to five stars) for the product and additionally, they can write an arbitrarily long textual review. As motivated in the introductory section of this paper, reviews left using such systems are focused on the product as a whole. It would be an improvement for both customers and retailers when product reviews included ratings for product parts. The participants of the full study were presented with an alternative review system that leads to such a type of product reviews.

As shown in Figure 6(a), a customer is asked to leave a star rating (part 1) and to select all problems with the product the customer had (part 2). Therefore, the customer is given a list of all known problems with the product. The alternative review system does not include the option to write textual reviews.

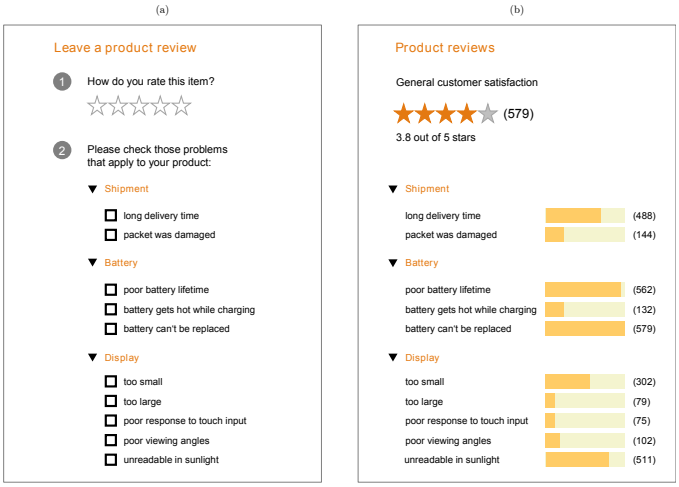

Figure 6. A mockup of the alternative review system with a smartphone as example product: (a) interface for authors of product reviews, (b) interface for potential customers. (The figure was edited for print.)

When a potential customer accesses reviews for a product, a form similar to Figure 6(b) is shown. On top, the average rating of all reviewers is shown. Below the average rating, all known problems are listed with a numeric indicator how many reviewers reported to have this problem.

C. Evaluation of the Proposed System

When asked if they perceived the alternative review system to be more intuitive than the common ones, 68.12% of the participants agreed (either *totally agree* or *agree*). 46.67% of the participants would like to see the alternative system to replace the common ones. However, the largest fraction of participants prefers not to replace the common systems. When asked if they want to see the alternative system as an addition to common ones, 89.52% agreed. In total, 93.91% of the participants said that they would like the alternative system to be used (either as a replacement or as an addition to common ones). Details can be found in Figure 7.

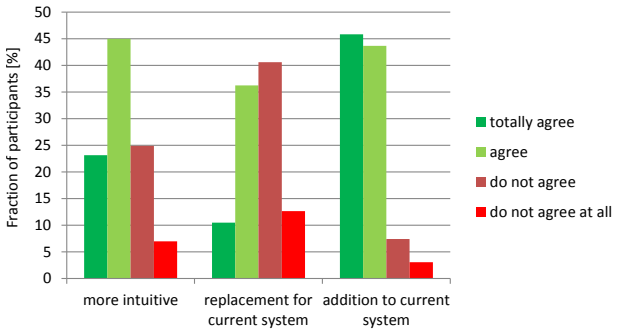

Figure 7. Reactions to the proposed alternative review system.

Afterwards, the participants could agree or disagree with reasons for using the proposed system. 59.72% of those who would like the alternative system to be used (replacement or addition) stated that the newer system would be faster and easier to use. However, 69.86% of all participants assume that a predefined list of problems is not representative enough for individual reviews. This is backed by the fact that 89.52%

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of all participants would want to leave additional textual reviews when using the proposed system. Even in the group of those who wanted to replace the common systems with the alternative review system, 41.48% would want to leave additional textual reviews.

We therefore conclude that our proposed system needs further refinement to be accepted by a majority of customers. However, when customers are provided with an option to additionally leave text reviews, the alternative review system is able to assist customers in writing better product reviews. Such better reviews help other customers to identify potential problems with a product faster and more reliable because the overview over problems is accompanied with a numeric indicator how often the problem occured. For the same reasons, the reviews help retailers to improve product quality, which, eventually, also helps customers. Moreover, retailers can extract previously unknown problems with a product from the written reviews and add those to the list of known problems in the review form.

While we do not encourage forcing customers to write reviews in any way, 89.08% of all participants stated that they would fill a mandatory questionnaire when returning products. A questionnaire like this could be designed similar to our proposed review system, but should include a free text field.

VII. Conclusions and Future Work

Online product reviews assist users in two ways: first, customers can base their purchase decisions on reviews to identify the best product to buy. Second, retailers can use product reviews to identify problems with a product and thus, improve the product quality.

In this paper, we report the results of two studies on online customer product reviewing behaviour. Furthermore, we analyse and discuss the results and findings. We identify reasons for customers not to write product reviews (top reason: lack of motivation), as well as reasons why customers write product reviews (top reason: firm conviction for the product). Subsequently, we explore potential incentives for customers to write more or better reviews.

When using product reviews, retailers should be especially aware of three aspects:

- Only few customers write reviews a long time after the purchase. Thus, reviews mention only problems that occur early in the product lifetime or already exist when delivered, but not those that are caused by wearout.
- Customers will return products during the warranty period without trying to identify or fix problems. Thus, it is difficult to obtain decomposed product reviews during this period.
- When incentivising customers with rewards to write reviews, the design of the reward might distort the representativeness of the reviews.

We also evaluate a mockup of an alternative review system that strives towards producing detailed ratings for parts of products instead of reviews that target a product as a whole. Ratings for parts of a product enable directed improvements to products from the retailers, e.g., by replacing the suppliers of those product parts that cause defects. A major finding is that a list of known problems from which customers can select those problems that apply to them is insufficient. Customers prefer to have the option to leave textual reviews.

For future research, a prototypical implementation of the alternative review system with textual reviews is needed for in-depth evaluation of the system. Thus, a comparison of reviews created with the new system and reviews created with current review systems should reveal if the new system leads to improved reviews.

A second future research direction is the use of mandatory feedback forms when returning products. Our study reveals a high customer acceptance for such feedback forms. Open questions are how useful the information from such feedback forms is and how to transform the results back into reviews that can be used by other customers.

Acknowledgment

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References

[1] P. Resnick, R. Zeckhauser, J. Swanson, and K. Lockwood, “The value of reputation on eBay: a controlled experiment,” *Experimental Economics*, vol. 9, no. 2, pp. 79–101, 2006.

[2] J. A. Chevalier and D. Mayzlin, “The effect of word of mouth on sales: Online book reviews,” *Journal of Marketing Research*, vol. 43, no. 3, pp. 345–354, 2006.

[3] Q. Li, J. Zhang, and K. M. Martin, “Feedback as ”shadow of the present”: An alternative to reputation systems for e-marketplaces.” in *TrustCom*, G. Min, Y. Wu, L. C. Liu, X. Jin, S. A. Jarvis, and A. Y. Al-Dubai, Eds. IEEE Computer Society, 2012, pp. 334–341.

[4] N. Miller, P. Resnick, and R. Zeckhauser, “Eliciting informative feedback: The peer-prediction method.” *Management Science*, vol. 51, no. 9, pp. 1359–1373, 2005.

[5] C. Dellarocas, R. Narayan, and C. Park, “What motivates people to review a product online? A study of the product-specific antecedents of online movie ratings,” *Workshop on Information Systems and Economics (WISE)*, 2006.

[6] S. Aciar, D. Zhang, S. J. Simoff, and J. K. Debenham, “Informed recommender: Basing recommendations on consumer product reviews,” *IEEE Intelligent Systems*, vol. 22, no. 3, pp. 39–47, 2007.

[7] N. Archak, A. Ghose, and P. Ipeirotis, “Show me the money! Deriving the pricing power of product features by mining consumer reviews,” in *Proceedings of the ACM SIGKDD Conference on Knowledge Discovery and Data Mining (KDD)*, 2007, pp. 56–65.

[8] J. Yu, Z.-J. Zha, M. Wang, and T.-S. Chua, “Aspect ranking: Identifying important product aspects from online consumer reviews,” in *ACL*, D. Lin, Y. Matsumoto, and R. Mihalcea, Eds. The Association for Computer Linguistics, 2011, pp. 1496–1505.

[9] G. H. Freeman and T. R. Halton, “Note on an exact treatment of contingency, goodness of fit and other problems of significance,” *Biometrika*, vol. 38, pp. 141–149, 1951.

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Mobile App Marketing:
A Conjoint-based Analysis on the Importance of App Store Elements

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***Abstract*—Today, little is known about how the various elements involved in the presentation of mobile applications (apps) in app stores influence the download or purchase decision. Current publications primairly focus on the possibilities and technical tools of app store marketing based on best practices or experience. However, research on customer preferences with regards to the presentation of apps in app stores as well as the impact of single app store elements on purchase or usage decisions has yet to be addressed. In this context, the key research objective of this paper is to analyse the impact of individual app store elements on customer choice. Accordingly, this study will identify the relative importance of individual app store elements to derive recommendations on how to successfully present mobile applications in app stores. With this objective in mind, a conjoint analysis was carried out in this study for a fictitious mobile messaging app to be presented in the Apple App Store.**

Keywords-Mobile App Marketing; App Store Elements; App Marketing; Consumer Preference; Conjoint Analysis.

I. INTRODUCTION

The number of available mobile applications is steadily growing. More than a million applications are now available for Android and iOS in the respective app stores (i.e., GooglePlay and Apple App Store). Accordingly, the competition among individual app providers has also risen continuously [1]. The competitive pressure is constantly rising along with the number of available offers and the growing number of possible alternatives for the user. It has long since ceased to be enough to simply turn a good idea into an app. More and more, the question has become which factors trigger the user's purchase decision. Numerous managers in the mobile phone business are now forced to deal with this situation and to define mobile app marketing strategies on how to achieve and defend a competitive position for their apps in the market.

The specification of marketing plans and strategies is usually made using the concept of the marketing mix, which also plays a key role in mobile app marketing [2]. As we know, the marketing mix should be an optimal combination of marketing tools from the areas of Product (product policy), Price (pricing policy), Promotion (communication policy) and Place (distribution policy) [3]. These "4Ps" are also the components of the app store marketing toolkit. Product policy starts at a very early stage and deals with the app idea and with the subsequent design of the application [2].

With regards to pricing policy both before and after the launch of the mobile app, a wide range of decisions have to be made. These decisions range from adequate price level to dynamic pricing strategies designed to systematically alter prices over time in order to react to changes in actual demand and current market conditions. However, pricing policy is limited by the possibilites and restrictions of the app stores. For example, the app stores may specify certain price points to be selected or not permit providers to offer trial versions for a limited period of time [4].

Distribution policy generally deals with all the marketing decisions and activities concerned with the delivery channel from the producer to the customer and therefore from production to consumption [3]. As early on as the development stage of an app, the distribution channel is determined, or at least influenced, by the technical implementation. So-called web applications, for example, can simply be made available for download per link or published via any webserver. The distribution channel for so-called hybrid und native applications, on the other hand, is the app store. Before use, they must be completely downloaded and installed on the mobile device. While native applications are created using the platform-specific development environment and programming language, web technology is usually used with hybrid applications. Additional development frameworks and tools, however, allow for further processing and compilation of this source code in a way that enables its distribution via an app store in a similar way to a native application.

Within the communication policy we have to differentiate between activities inside and outside the app store. These include advertising and other activities which provide and spread information intended to familiarise the potential customer with the app and its features. App stores are usually the only official channel for the smartphone user to buy and install new apps on their mobile devices. Thus, the communication policy within the app stores and the corresponding design of the various app store elements are of particular importance [5]. Here, it must be noted that each store has its specific regulations and guidelines on how to publish an app for distribution via the store and on the elements that can be used for the presentation of the app in the store. However, although the regulations vary in detail, the core concepts and the core elements for the app presentation are quite similar.

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In this context, the objective of this study is to develop appropriate recommendations for the setup and design of important app store elements and to empirically validate common app store marketing best practices. For this reason, a conjoint-based approach was choosen to analyse user preferences and characterize the relative importance of different app store elements.

With this in mind, Section II presents a short discussion on related work and current best practices in app store marketing. Section III describes important elements of the presentation for mobile applications in app stores. The explanations refer to the example of the Apple App Store; can, however, to a great extent be generalised to include other app stores. In Section IV, the methodological approach of this study is then described. Significant results of this conjoint analysis are presented in Section V, before we finally discuss the central findings and recommendations for practical implementation in the concluding section.

II. Related Work

Mobile app marketing is still a relatively new marketing topic. It wasn't until the first app stores emerged that the necessity for a market-oriented way of thinking when developing and marketing mobile apps started to become aparent [4]. In principle, we can say that many well established concepts from general marketing practices are transferable to mobile app marketing. In this understanding, mobile app store marketing adopts standard marketing principles and tools and adapts them to the needs of the app specific market.

Current literature on mobile app marketing predominatly focuses on guidelines and recommendations for the successful monetarisation of app concepts. For example, the topic of app marketing can be found as part of the technical literature on app development in which the monetarisation of the app in the app store is seen as being the final step in the app development process [4][6][7].

Additionally, more specialised publications focusing on mobile app marketing are available as well [1][5][8][9]. However, most of these publications comprise structured guidelines and extended checklists on how to successfully monetise mobile applications based on the authors' experience or the discussion of successful case studies. In contrast, scientific research on app stores and app (store) marketing is rather rare today.

Only few publications have so far dealt with individual aspects of app stores, mainly focusing on app ranking mechanisms and fraud [10][11][12], pricing strategies [13] or recommendations and user reviews [14][15].

Against this background, a significant research gap can be observed with regard to the availability of empirically based recommendations on the market-oriented configuration of app store elements. The suggested research approach, a study measuring customer preferences based on a conjoint analysis, has been applied to software selection processes and even to mobile application development [16][17], but is rather new to the specific area of app store marketing.

III. App Store Elements

As stated above, the design of the various app store elements is one of the key instruments of mobile app marketing. Potential users search for suitable mobile applications in the app store and obtain information about their features and properties [2]. In order to acquire a common frame of reference for this study, we focussed solely on the Apple App Store. There are various app stores for different mobile operating systems which are characterised by different appearances, but which are fundamentally very similar in terms of the possibilities to present mobile applications.

A fictitious messenger app was chosen to concentrate on the importance of the app store elements and prevent participants from being biased by ealier purchase decisions, knowledge of real-world app presentations or brand preferences. The Apple App Store can be accessed via several mobile devices. It is possible, for example, to open the app store via smartphones (iPhone) and tablets (iPad) to download applications. However, the number of elements is the same for all devices and always identical in each case.

In total, based of an analysis of the Apple App Store and the best practices derived from the mobile app marketing literature in Section II, eight key app store elements were examined for this study which will be described in more detail below. Moreover, the study also deals with variations of each of the attributes which were compared and examined with regard to their influence on customer preference in terms of a purchase or usage decision. The fictitious messenger app was presented to the participants of the study based on the attributes and its selected attribute levels only. There was no prototype or trial-version in an app store available in this study.

A. App Icon

The app icon is seen as being one of the most crucial elements, as it is generally the first visual element that a potential user sees. The purely aesthetic design of the app icon can already have an effect on the development of user preference, for example in the way that the impression the icon makes is taken to be an indication of the quality of the app. The app icon and the app name are central design elements in many app stores, not least because a search request in the store appears directly on the search result page [4][18].

In Figure 1, three icon versions are shown that were developed for a fictitious messenger app in the study.

(1) „High quality" version | (2) „Medium quality" version | (3) „Low quality" version

Figure 1. App Icons Variations

In the form of these icons, the intention is to refer to a particular messaging app which is characterised by an especially high level of security. Best practice guidelines have been used to develop the design variations [19]. For example, the clarity of the graphic elements to visualise the messaging and security features of the app, the colouring and the legibility of the writing were varied in order to portray the spectrum from a representative "high" to a "low" quality of the icon design. While icon (1) has easy to understand graphical representations of messanging, icon (3) uses a confusing illustration and illegible writing. The consideration of the icon design as an attribute will allow an empirical verification of the aforementioned existing best practices in the study.

B. App Name

As mentioned above, the name of the app is also a central element with respect to the presentation of mobile applications in app stores, as it is shown in the app store's search and ranking lists and may therefore influence the user's purchase decision [4]. The app name should fulfil certain criteria in order to be easy to remember on the one hand, and easy to find via the app store's search algorithms on the other. Ideally, solutions to internationalise the name should also be available [2]. For the test app in the conjoint analysis, the same name was used for all three, but a claim was added for extra clarification – varying from a simple allusion to security to a technical description which is difficult for the average user to understand (high to low comprehensibility):

- „high": SafeTalk – Your Safe Messenger
- „medium": SafeTalk Secure Messenger
- „low": Safetalk with AES-256 Encryption

C. Reviews („stars") and the number of reviews

The reviews in the app store are assigned according to the star principle (1–5 stars) and are – together with the number of total reviews – an initial indicator for the user of how satisfied other users were with the app after downloading. A high number of stars is perceived as being a positive purchase recommendation [5]. App providers should note that star reviews are not immediately displayed for new apps but are only published once a meaningful average value can be calculated. In the Apple App Store, this means a minimum of 5 reviews. Apple also differentiates according to countries. At present, it is not possible for the user who is giving the review to interact directly with the app provider [2]. The following analysis includes the review alternatives none, three and five stars.

D. Price

Pricing is another element which is immediately displayed on the search result page and in all the app store's lists (for example in the „top charts") and can therefore influence the user's purchase decision during the app selection process. For the analysis in this study, a cost-free version and three price points were chosen which represented a low, a medium and a high price segment, respectively, in comparison to actual mobile messaging applications (0.89 EUR, 1.79 EUR, 2.69 EUR).

E. Screenshots

Screenshots are usually only visible in the detail view of an app. An exception is the result page of the search feature. Here, the first of a total of five possible screenshots is already shown in the preview. Screenshots have several tasks: On the one hand, they should display the features of the mobile application and, on the other, communicate the app's design [2]. Screenshots offer crucial support to the descriptive text as many users do not read this or only read it in part and therefore rely heavily on the screenshots for their purchase decision [18]. App store users draw conclusions from the screenshots as to the aesthetics and user friendliness of the mobile application as a whole [5]. In this study, three different qualities of screenshots were created (high, medium, low), which vary with regard to recognisability and clarity of the functional elements of the mobile messaging app. The bad screenshot, for example, displays rather random content, whereas the good one highlights important core functions with accompanying explanations.

F. App Description

The descriptive text is the only element presented here which appears solely in the detail view of an app once it is opened. The Apple App Store allows a descriptive text with a maximal number of 4000 characters [5]. The descriptive text is important for two reasons: Firstly, potential customers are presented with a list of sales arguments and secondly, the search algorithms of most app stores use the text to carry out corresponding search requests. As the optimisation for search purposes was not the main focus here, the quality of the descriptive text was varied mostly in terms of comprehensibility. Here again, three levels of quality were created (high, medium, low). Whereas the good description used simple language and easily comprehensible wording, the bad descriptive text was characterised by technical terms which the average user would find difficult to understand. In addition, the text was automatically translated as is often the case in app stores which reduced the comprehensibility yet further.

G. Server Location (as an additional attribute)

As a messenger with special focus on secure communication had been chosen as a fictional product for analysis, an additional attribute entitled "server location" was included in the study for evaluation. This is not an element of an app store in a narrow sense, but an important company-related attribute of the app provider that can be emphasized within the app description. While the aforementioned attribute is used to measure how the quality of language influences user preferences, the server location is an example of how various app characteristic, even if just mentioned in the description, could have an impact on customer choice. Due to current discussions about data security in Germany [19], heightened customer awareness was assumed to be a significant influencer on customer preference. By including this attribute, we wanted to test whether and to what extent such attributes contribute to the user's purchase decision in comparison to the other marketing-related app store elements. Server locations in the US, in Germany and an unknown server location were included in the study.

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IV. METHODOLOGY

The conjoint analysis is considered to be the standard method when investigating customer preferences and buying decisions. Traditional Conjoint Analysis (TCA) goes back to the year 1964 and was developed by the psychologist Luce and the statistician Tukey [20]. TCA, as well as all the subsequent versions of conjoint analysis, basically deals with the measurement of preferences for product attributes. Instead of asking the participants directly about the importance of attributes, conjoint analysis is based on the evaluation of product profiles. Each product profile consists of several attributes describing the product characteristics (e.g., brand, price, design, etc.). Different product profiles are derived by variation of attribute levels (e.g., high, medium, and low price). An analysis is always carried out in such a way that each product profile or "stimulus" has to be examined and assessed from a holistic perspective or *con*sidered *joint*ly) [21][22]. Instead of asking directly about the importance of a product attribute, conjoint analysis considers products as bundles of attributes on which the customer decides and makes trade-off decisions. The approach is better aligned to real-world purchasing decisions and the part-worth utilities of the attributes can be decomposed by using statistical methods like regression analysis.

For this reason, the conjoint method is well suited to analyse the impact of different app store elements on the customer choice decision. As a result, the relevance of the key app store elements, derived from the practical literature, can be empirically validated based on the example of fictitious messenger app. The analysis also provides the relative importance of the different app store elements for market success. From a more pracitical perspective the results could be used by an app provider to determine the optimal app store configuration for the analyised secure messenger app or to conduct market simulations based on different configurations. However, the study at hand focusses on the relative importance of the app store elements. The reference to fictitious messenger app was required only because the conjoint analysis cannot be conducted based on a non-specific and generic "mobile app".

Since the mid-sixties, conjoint analysis research has evolved and produced several variants that can be divided into traditional and more recent approaches. Traditional Conjoint Analysis (TCA) can be applied by using trade-off or full-profile approaches but its significance in research has been declining since its first appearance due to limitations on the number of attributes as well as other methodological and statistical problems [23]. Of the more recent approaches, Choice Based Conjoint Analysis (CBC) and its variant, the computer-aided Adaptive Choice-Based Conjoint Analysis (ACBC) are taken into consideration for this study.

CBC is the most popular conjoint analysis today. In CBC, unlike TCA, discrete selection decisions are analysed instead of preference decisions [24]. During CBC, the subject is therefore not asked to make an order of precedence of all the product profiles, but must select the preferred product profile within a set of alternatives or, if such an option is included, reject the choice by deciding on a "none option" [21][22] as shown in Figure 2.

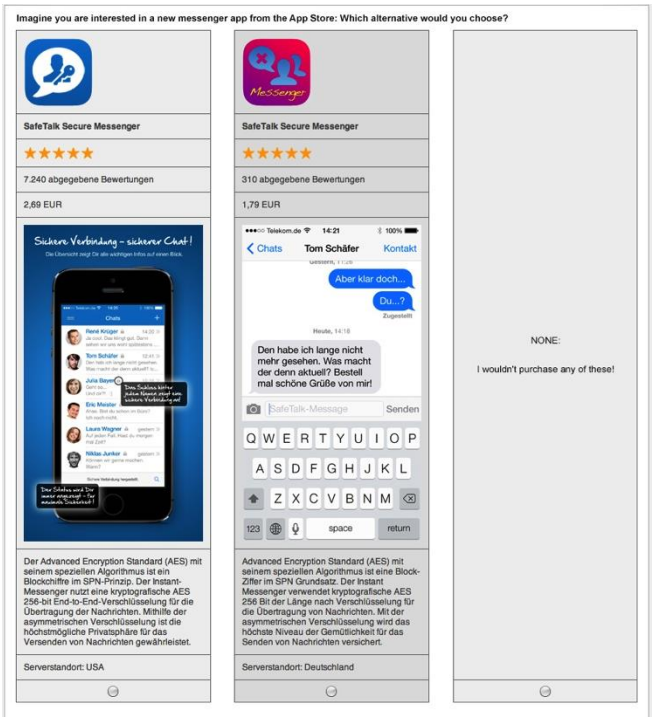

Figure 2. Example of a Choice Set in the Study

The ACBC is a computer-aided enhancement of classic CBC and includes an adaptive approach. This means that every piece of information supplied by the test subject during the course of the interview gradually reveals the formation of his/her preference structure so that the questions posed to him/her can be successively adapted to the answers [25].

In this context, the first consideration for the study was which kind of conjoint analysis should be applied. For best results, CBC is recommended, if the product bundle in question has around six attributes or less; the method can, however, be carried out with up to ten attributes. Adaptive ACBC has proved to be especially suitable if 5 to 15 attributes are to be examined. It is, however, characterised by a more complex and time-consuming questioning process [26].

The number of attributes in this study was eight. We therefore had to determine the feasibility of using a CBC despite the large number of attributes, or if the larger effort of drawing up an ACBC would be needed. The form of the attributes provided an important aspect in making this decision. The amount of information that a test subject has to absorb and process in connection with every single attribute is especially important when calculating the reasonable maximum number of attributes. If the attributes being examined are graphic elements (e.g., app icon) or information which can be quickly understood (e.g., price), it is also assumed in CBC to be feasible to carry out this type of analysis with more than six attributes [26].

Due to these criteria and considering the impact of an ACBC on the interview duration, CBC appeared to be the more suitable choice for the planned empirical survey.

 ISBN: 978-1-61208-369-8

As far as survey design was concerned, particularly the form of the stimuli had to be defined, specifically the question of which combination of attribute variations would constitute the stimuli and how the stimuli should be presented to each test subject. Here, the Full Profile Method was used, in which each product profile consists of all the attributes. As the number of attributes was already very high, we decided to present only two stimuli at a time so as not to overstrain the test subjects with regard to the information they had to evaluate. In order to create a selection situation as close as possible to a real-life purchase situation, a "none option" was also included.

Figure 2 shows a complete selection situation as an example of how it also appeared in the final survey. In addition to the (randomly) created selection sets, so-called hold-out sets were integrated into the survey. These special selection sets serve to analyse the validity of the prognosis. They are not integrated into the benefit evaluation and are used to evaluate the quality of the prognosis of the preference rating. Two of these sets were defined and included.

The conjoint analysis was carried out using the *Sawtooth* SSI Web 7 software package [27]. The main objective of the study was to measure the importance of the presented app store elements for mobile application purchase decisions. The study was conducted as an online survey. The website for the online survey was generated by the SSI Web 7 software, based on the aforementioned study design. The configuration of the CBC analysis and selected configuration parameters are summarised in Table I.

TABLE I. CONFIGURATION OF THE CBC ANALYSIS

Parameter	Value
Number of Random Choice Tasks	12
Number of Fixed Choice Tasks	2
Number of Concepts per Choice Task	2 (and an additional "none option")
Response Type	Discrete Choice (single select radio button)
Advanced Design Module Settings	Traditional Full-Profile CBC Design
Randomise Attribute Position within Concepts	No Randomise of Attribute Order

The survey was online between December 19, 2013 and January 10, 2014. Participants were acquired by using social media and various other online and offline channels of the RheinMain University of Applied Science in Wiesbaden, Germany.

A total of 221 people participated in the conjoint analysis interview. Of these, 163 completed the interview in its entirety and are, therefore, included in the subsequent evaluation. Selected demographic characteristics of the study participants are shown in Table II below.

TABLE II. DEMOGRAPHICS OF THE STUDY PARTICIPANTS

Characteristics	Absolute Number	Percentage
Mobile OS		
Apple iOS	78	47.9%
Android	78	47.9%
Blackberry OS	1	0.6%
Windows Phone / Mobile	5	3.1%
Symbian	1	0.6%
Purchased Apps		
None	32	19.6%
1–5	40	24.5%
6–10	20	12.3%
11–20	19	11.7%
21+	52	31.9%
Gender		
Female	70	42.9%
Male	93	57.1%
Ages		
18–24	66	40.5%
25–34	70	42.9%
35–44	21	12.9%
45–54	5	3.1%
55+	1	0.6%

The demographics show that the study might be biased by the participating media and design students and due to the resulting high proportion of iOS users compared to the lower usage rate in the total population in Germany of around 32 percent at the end of 2013 [28] and the underrepresentation of older user segments.

V. STUDY FINDINGS

The evaluation of the collected data took place in two steps: In the first phase, a counting analysis was conducted. This analysis can be used to calculate an outline of so called main effects. A main effect of an attribute level is calculated here as a proportion and reveals how many times a specific attribute level was chosen, divided by the number of times this attribute level was available for choice in the testing. Counting analysis is a simple way to get a first indication of the relevance of the attribute levels. As a second step, the part-worth utilities of the attribute levels were estimated based on a logit analysis to find the maximum likelihood solution for the data. Based on the results of the part-worth utility estimation, the relative importance of the individual app store elements were finally determined.

A. Counting Analysis

A counting analysis and the proportions that are calculated at this stage can be used to identify the "winner" of the different attribute levels. Table III shows the results of the counting

analysis for all attributes and attribute levels considered in this study. The higher the proportion of an attribute level is, the stronger this attribute level may have influenced the choice of participants. For the app store element "Reviews (stars)" a five-star rating was the "winner" – which is not surprising. However, in comparison, choices with this attribute level were selected more than twice as often (0.421/0.158) than choices with no stars in the reviews.

TABLE III. SUMMARY OF STUDY RESULTS

Attributes and Attribute Levels	**Counts (Proportions of "Wins")**	**Part-Worth Utilities**
App Icon		
High quality	0.312	0.22215
Medium quality	0.262	-0.01639
Low quality	0.234	-0.20575
App Name		
SafeTalk – Your safe messenger	0.277	0.02744
SafeTalk Secure Messenger	0.247	-0.10392
Safetalk with AES-256 Encryption	0.283	0.07648
Reviews (stars)		
5 stars	0.421	0.73209
3 stars	0.229	-0.13465
No stars	0.158	-0.59744
Number of Reviews		
7.240 reviews	0.329	0.31666
310 reviews	0.320	0.26487
5 reviews	0.229	-0.19484
No reviews yet	0.198	-0.38669
Price		
Free of charge	0.385	0.60605
0.89 EUR	0.274	0.02966
1.79 EUR	0.238	-0.14028
2.69 EUR	0.180	-0.49543
Screenshots		
High quality	0.262	-0.02198
Medium quality	0.274	0.01437
Low quality	0.271	0.00760
App Description		
High quality	0.283	0.07434
Medium quality	0.269	0.01472
Low quality	0.256	-0.08906
Server Location		
Germany	0.373	0.52316
USA	0.224	-0.20529
Unknown	0.212	-0.31788

However, as mentioned before, this analysis can give a first indication of the relevance but does not provide measurements for the part-worth utilities of attribute levels and relative importance of the different attributes, i.e., app store elements.

B. Estimation of Part-worth Utilities

Parth-worth utilities were calculated by using the multinominal logit estimation provided by the *Sawtooth* software for the CBC analysis. For the model estimation, a Chi Square of 473.7 was reported. Considering 18 degrees of freedom (26 attribute levels and 8 attributes) the Chi Square is much larger than the required 34.8 for a 0.01 level, which would mean that the choices of the respondents are significantly affected by the attribute composition [24]. The estimated part-worth utilities represent the relative desirability of an attribute level. The higher the value of a part-worth, the greater the impact of the corresponding attribute level on the buying decision. Part-values are automatically standardised, so that the result per attribute amounts to „0". Reciprocally, this means that negative values can also arise. Table III shows the estimated values for all attribute levels. These should be interpreted to mean that a higher number corresponds to a higher part-worth utility and that this attribute variation therefore had a higher preference among the test subjects. If we look again at the attribute "Reviews (stars)", it becomes evident that the attribute level „5 stars" has a very high part-worth value with a positive value of 0.73209. The other two variations „3 stars" (-0.13465) and „no stars" (-0.59744) were less important for the purchase decision of the test subjects due to smaller values of the corresponding part-worth utilities.

C. Calculation of the Attribute Importance

The defined objective of the empirical study was not only to find out the utilities of the attribute variations but also to analyse each individual app store element in terms of its relative importance for an app purchase decision. We must therefore find a unit of measurement to express the relative importance of each attribute. The calculation is carried out by dividing the range of the the part-worth of each attribute by the sum of the part-worth ranges of all the attributes. Hereby, the range is defined as the difference between the highest and the lowest part-value within the levels of an attribute [29]. The results can be seen in Table IV.

TABLE IV. RELATIVE IMPORTANCE OF ATTRIBUTES

Attribute	**Attribute Importance**
Reviews (Stars)	27.8%
Price	23.2%
Server Location	17.6%
Number of Reviews	14.9%
App Icon	9.0%
App Name	3.6%
App Description	3.3%
Screenshots	0.6%
Total	**100.0%**

The values reveal that the reviews according to the star principle have the largest influence on the purchase decision. Almost 28% of the decisions are based on this criterium. The highest part-worth utility and/or the most positive influence

was of course an app review with 5 stars. The distance to the other attribute variations (3 stars, no stars) was the highest with this app store element compared to the other elements. This highlights the extremely high relevance of good reviews and the importance of this attribute for the perceived total utility of the corresponding app presented in the app store. As was to be expected, pricing, too, has a high level of importance for the purchase decision. The test subjects reacted in a very price-sensitive way. It should also be noted that many apps are now offered at the Apple App Store for free or at a greatly reduced price at the beginning or at some stage of their life cycle for a certain period of time. A certain „freebie“ mentality is also reflected in the order of precedence in this study and shows that price is one of the most important criteria for an app.

The app provider's server location differs from the other elements in as far as it is not a standardised app store element but the app developer's company-related element. We can therefore conclude that users not only include the app store's design elements into their purchase decisions, but also consider and evaluate outstanding and specific properties of the app. In this case, there was a particularly positive effect on the purchase decision if the messenger provider was located in Germany.

The number of reviews relates to the reviews according to the star principle. Here, we see the tendency that the part-worth utility is perceived as higher, the more reviews an app has. An interesting aspect here is that the part-worth of the extreme scenario considered in the survey with 7,240 reviews did not substantially differ from the next level with 310 reviews. The distance to the next two steps (5 reviews, no reviews) is considerably larger, however. This means that an optimal number of reviews – which can be attained with a reasonable amount of effort on the part of the app provider – can be assumed to be more than 5, but not significantly higher than 310 reviews.

The app icon is considerably less important than expected. Besides the screenshots and the star reviews, it is the third graphic element and easy for the potential buyer to understand. Nevertheless, the test subjects apparently did not assess the quality of the app on the basis of the icon but stuck to the very much more rational criterium of the reviews when making their purchase decision.

The app name is of very low significance. Many users see it as a "frill" within the overall impression of the app store and it is therefore of little interest. The study results even show that the name "Safetalk with AES-256 Encryption" with the per definition worst variation actually had the highest partial benefit value. However, this could be a result of the specific setup and the sensitivity of the app users towards data security in Germany. The complicated name –event if not understood by the customers – may be associated with a highly sophisticated technological solution to protect the user from the danger of interception.

The app's descriptive text is also of little importance in terms of decision making. This suggests that potential buyers do not take the trouble to read it or may be very familiar with the type of apps that have been tested here. It should be noted at this point that the descriptive texts used in the survey were relatively short. In real life, an app is mostly described in much more detail and using many more characters – the attention span could, therefore, be even shorter than for the texts used in the survey.

With a relative importance of 0.6 percent, the screenshots had the lowest influcence on the purchase decision. Here, too, it was striking that the part-worth of the medium quality screenshots was the highest, followed by those of the worst quality. The highest quality level had the lowest part-worth value for the test subjects. Here we should note, however, that the differences recorded were marginal and the general result, i.e., that screenshots hardly influence purchase decisions, is predominant. This may also be due to the fact that the subject of the study, messaging app functions, is relatively well-known and simple and that therefore screenshots have only minor informational value as far as the app is concerned.

VI. CONCLUSIONS

One of the most important findings of the study was that reviews have a major influence on the user's purchase decision. Average rating according to the star principle as well as the number of reviews given determine the buying decision of an app to a very large degree. These two criteria, however, cannot be directly influenced by the app provider – reviews are made by the app user and are published by the provider with no prior screening. Nevertheless, there are numerous possibilities for the provider to influence the reviews, at least to some extent. Active review management should therefore be conducted. Review reminders within the app can for example help to continuously increase the number of reviews. It is advisable to wait for a certain period of time before displaying review reminders as the probability of receiving a positive review is higher when the app has been used for a period of time. Reviews can also be stimulated by actively reacting to user feedback, i.e., by responding to reported software bugs or considering suggestions for improvements in upcoming updates.

The possibilities for the provider to influence the price are often strongly determined by the costs. In addition, the price decision can depend on the app's life cycle or even some important seasonal factors (special offers on public holidays for example). Thus, a low price level may not be an option and the findings of the conjoint analysis can not be transferred to a general recommendation on an adequate pricing strategy. However, if it makes sense for the type of app in question, a free version can be offered which can be supplemented by additional content per in-app-purchase. This "freemium model" takes the user's initial price-sensitivity into account. Revenue generation is then postponed to a later phase of usage.

Another important finding is that particular attention should be drawn to app-specific properties if these could positively influence sales. In this study, this applied to the server location of the company providing the app and the corresponding messenger service. In this particular case, it appears to have addressed a basic need for security among the test subjects. This may not be directly transferable to other apps. However, such "unique selling prepositions" should be particularly highlighted and communicated accordingly via the other elements.

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The elements not yet mentioned at this point (app icon, app name, descriptive text, screenshots) should by no means be neglected during the course of marketing activities. It can only be stated that these have a smaller influence on the customer's purchase decision. They are, therefore, elements which must indeed be well designed, in order to convince a customer to purchase or to use the app, yet are only to a limited extent suitable for the purpose of setting the product apart from the competition. The descriptive text and the app name, for example, are nevertheless crucial for the app store's search algorithms to enable the mobile application to be found at all. Whether the app name is easy to remember is another factor that plays an important role in the selection process and in word-of-mouth propaganda.

This study has revealed some empirically based recommendations on how to align the elements of the app presentation in app stores to customer preferences. The findings, however, refer to a rather small and not representative sample. Moreover, the generalisability of the study is limited due to the fact that here just one single, specific application was investigated, using the example of select design elements of the Apple App Store. More detailed studies in different application domains and with regard to different app stores will therefore be necessary in order to verify the validity of the findings derived in this study.

REFERENCES

[1] J. F. Hughes, iPhone and iPad apps marketing. Secrets to selling your iPhone and iPad apps. Que Pub., Indianapolis, 2012.

[2] J. Mayerhofer, Apps erfolgreich verkaufen. Vermarktungsstrategien für Apps auf iPhone, iPad, Android und Co. Hanser, München, 2012.

[3] P. Kotler and G. Armstrong, Principles of marketing. Pearson, Upper Saddle River, N.J, 2014.

[4] D. Wooldridge and M. Schneider, The business of iPhone and iPad App Development. Making and marketing Apps that succeed. Apress, New York, 2011.

[5] R. Mroz, App-Marketing für iPhone und Android. Planung, Konzeption, Vermarktung von Apps im Mobile Business. mitp, Heidelberg, 2013.

[6] N. Kuh, Ed., Foundation iPhone App Development. Apress, Berkeley, CA, 2012.

[7] L. Jordan, Ed., Beginning iOS 5 Games Development. Apress, Berkeley, CA, 2011.

[8] E. Kim, The best book on marketing your android app. CreateSpace Independent Publishing.

[9] M. Amerson, The best book on IOS app marketing. Hyperlink Press, 2012.

[10] S.-Y. Ihm, W.-K. Loh, and Y.-H. Park, "App Analytic: A Study on Correlation Analysis of App Ranking Data," 2013 International Conference on Cloud and Green Computing (CGC), pp. 561–563.

[11] H. Zhu, H. Xiong, Y. Ge, and E. Chen, "Ranking fraud detection for mobile apps," Proceedings of the 22nd ACM International Conference on Information & Knowledge Management, pp. 619–628.

[12] H. Zhu, H. Xiong, Y. Ge, and E. Chen, "Discovery of Ranking Fraud for Mobile Apps," IEEE Trans. Knowl. Data Eng., 2014, pp. 1.

[13] B. Ifrach and R. Johari, "Pricing a bestseller," SIGMETRICS Perform. Eval. Rev. 41, 4, 2014, p. 51.

[14] C. Iacob and R. Harrison, "Retrieving and analyzing mobile apps feature requests from online reviews," 2013 10th Working Conference on Mining Software Repositories (MSR). Proceedings, May 18-19, 2013, San Francisco, CA, USA, pp. 41–44.

[15] P. Yin, P. Luo, W.-C. Lee, and M. Wang, "App recommendation," Sixth ACM International Conference on Web Search and Data Mining, WSDM 2013, pp. 395–404.

[16] J. Muller and M. Lillack, "Conjoint Analysis of Software Product Lines: A Feature Based Approach," 2011 37th EUROMICRO Conference on Software Engineering and Advanced Applications (SEAA), pp. 374–377.

[17] D. Eckjans, J. Fahling, J. M. Leimeister, and H. Krcmar, "Mobile Customer Integration: A Smartphone Application Prototype for Conducting Mobile Conjoint Studies," 2011 Tenth International Conference on Mobile Business, ICMB, pp. 129–135.

[18] R. Sandberg and M. Rollins, The business of Android Apps development. Making and marketing Apps that succeed on Google Play, Amazon App Store and more. Apress, New York, 2013.

[19] H. Schmundt and G. Traufetter, 2014, Digital Independence: NSA Scandal Boosts German Tech Industry. http://www.spiegel.de/international/business/german-it-industry-looks-for-boom-from-snowden-revelations-a-950786.html 2014.08.12.

[20] R. Luce and J. W. Tukey, "Simultaneous conjoint measurement: A new type of fundamental measurement," Journal of Mathematical Psychology 1, 1, 1964, pp. 1–27.

[21] C. Breidert, Estimation of Willingness-to-Pay. Theory, Measurement, Application. DUV, Wiesbaden, 2006.

[22] A. Gustafsson, A. Herrmann, and F. Huber, 2007, "Conjoint Analysis as an Instrument of Market Research Practice," Conjoint measurement. *Methods and applications*, A. Gustafsson, A. Herrmann and F. Huber, Eds. Springer, Berlin, New York, pp. 3–30.

[23] P. E. Green and V. Srinivasan, "Conjoint analysis in marketing: New developments with implications for research and practice," Journal of Marketing 54, 4, 1990, pp. 3–19.

[24] Sawthooth Software, 2013, The CBC System for Choice-Based Conjoint Analysis. Technical Paper Series. https://sawtoothsoftware.com/download/techpap/cbctech.pdf 2014.08.01.

[25] P. E. Green, A. M. Krieger, and Y. Wind, "Thirty Years of Conjoint Analysis: Reflections and Prospects," Interfaces 31, 3, 2001, pp. S56-S73.

[26] Sawtooth Software, 2014, The Adaptive Choice-Based Conjoint (ACBC) Technical Paper. http://www.sawtoothsoftware.com/download/techpap/acbctech.pdf 2014.08.01.

[27] Sawtooth Software, 2014, What is SSI Web? http://www.sawtoothsoftware.com/support/downloads/download-ssi-web/what-is-ssi-web 2014.09.19.

[28] StatCounter, 2014, Top 8 Mobile Operating Systems in Germany from July 2013 to July 2014. http://gs.statcounter.com/#mobile_os-DE-monthly-201307-201407 2014.08.01.

[29] B. K. Orme, Getting started with conjoint analysis. Strategies for product design and pricing research. Research Publishers, LLC, Madison, WI, 2006.

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Gender Differences in Gesture-based Interaction

User Studies and Perception of Information Technology

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***Abstract*— This paper presents an empirical study investigating the gender differences in basic hand gestures for the design of user-centric and adaptive systems. Our goal is to target personalization of gesture-based interaction, devices and applications, using this feedback. First, we focus on gender differences in the perception of technology as well as the externalization of thoughts using natural hand gestures. We commence with an overview of what type of gestures are used and how they are defined in a gesture recognition system. In the empirical studies, we use both video analysis and surveys as the methodologies. We conducted a survey regarding the perception of Information Technology (IT) with 20 male and 20 female participants. Second, we focus on gender differences in gestures. We conducted an experiment involving 10 male and 10 female Australian adults whose age range between 25 to 30. In the experiment, they describe an object using hand gestures and speech. We analysed the results of both survey and experiments. In this paper, we point out the gender differences in the perception of IT, as well as gesture types, frequency and occurrences. Drawing conclusions from these comparisons, we discuss the potential effects of gender differences in the design of multimodal interfaces.**

Keywords-gesture analysis; gender differences; human computer interaction; consumer research; perception of technology.

I. INTRODUCTION

Human Computer Interaction (HCI) is a discipline concerned with the design, evaluation and implementation of interactive computing systems for human use. One of the primary goals of HCI is to target the design of user-centric and adaptive systems as well as personalization of devices and applications. Adaptive systems refer to interactive systems adapting their behavior to individual users based on information acquired about users, the context of use and the environment. Therefore, personalization of devices and applications requires a careful analysis of gender differences.

The evolution of HCI has evolved significantly starting from the use of mouse input [1] to multimodal systems including speech, head and eye-tracking, using both static and dynamic hand gestures. Gestures are considered as sign languages to externalize the human thoughts. Humans have an inherent need to use gestures; they complement our ideas. To such an extent that humans are known to gesture even when on the phone. The level of communication between users and their electronic devices has been largely limited to a pointing interface. As computers and technologies become increasingly integrated into our lives, the demand of technology has increased and expanding into new sectors, as seen with the new apps and wider use of the smart phones and tablets. This brings the emphasis on the richness conveyed by gestures as the new media of interaction. Computer vision techniques have improved exponentially: from only detecting simple features like the user's fingers and thumb, to recognizing and responding to the whole body contour, since the first VideoDesk [2]. Hand posture detection has been used to give commands, and hand rotation and movement to indicate the parameters of these commands. Investigation of tangible and proximity based HCI suggested that it is important to be cognisant of gender with respect to the interactions they facilitate [3].

As shown by Nasser and Kavakli [4] culture has an impact on gestures, but does gender have an impact? The goal of this paper is to define the variances in gestures between males and females in order to develop personalized interfaces. Gender differences have been studied by many researchers, leaving much unclear regarding the science behind stereotypes. Our intention is to identify, if there are any gender differences in the perception of technology as well as hand gestures used to explain an object. We defined two hypotheses to test. (1) The experience of using a computer as well as the gender of the user has a significant effect on the perception of the gender of the technology. The objective of the survey in this study is to investigate this research question. (2) Gender differences in gestures have a significant influence on human performance.

The paper is structured as follows: Section II reviews summary of related works regarding gestures and gender differences. Section III describes the methodologies used in the project. Section IV addresses the survey and the experiment. Section V goes into finer details with respect to analysis of the data collected. Section VI presents the findings. The acknowledgement and conclusions close the article.

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II. GENDER DIFFERENCES

Regarding the individual differences in cognitive processing, controversial views exist. Some studies state that there are gender differences in verbal, quantitative and visuo-spatial ability in human cognition [5]. A general view is that men outperform women on visuospatial tasks and women outperform men on verbal fluency. Males show significantly higher mean scores on the arithmetical computations, arithmetical reasoning, and spatial cognition [6]. However, some researchers believe that although there are gender differences in our cognitive abilities (verbal, quantitative, visuospatial) these are quite small, and therefore, insignificant [7]. How small are these gender differences in terms of gesture recognition in multimodal system design?

It was suggested by Kramer [8] that women more often use facial expression and hand gestures to express their thoughts than men. Regarding nonverbal communication, there are differences between females and males. Women use more expressions and nonverbal behaviors than men. Women are more skilled at sending and receiving nonverbal messages [9]. Men are louder and more interruptive and display more nervous, defluent behaviors. The differences in the mean use of hand gestures was statistically significant in a social bar setting [10].

Men are likely to use their hands to express themselves and they rely on more obvious gestures. Women, on the other hand, present more subtle gestures and they restrain and exhibit deferential gestures [11]. No specific studies address whether any gender differences present in use of gestures while people communicate with computer systems. Saucier and Elias [12] reveals that the number of gestures made with the right hand during speech is significantly higher for males, while during listening the number of gestures made with left hand is significantly higher. We have no results regarding the females left or right handed gestures. However some other studies state that their results did not reveal any differences in the degree of hand preference between pointing gestures produced along with speech and gestures produced on their own [13].

Studies on the perception of IT showed that although males and females in the United States have similar experiences with computers, females have an advantage in typing [14]. Workers in general state that they have more experience with computers than non-workers, and, in particular, working females have been using computers for more years than working men. Nonworking females state that they have less experience with computers than working females. However, this perception for the other gender is not verified and there seems to be no perceived difference in the use of computers between nonworking and working men.

A. Use of Internet

In USA, Internet use at various locations increased over time among women relative to men. In 1997 and 1998, women were less likely to use the Internet anywhere or at home than men, but they were more likely to do so by 2001 [15]. Among those who work, women remained less likely than men to use the Internet at work, but the gender gap narrowed over time. People who are employed are more likely than the non-employed to use the Internet at home or anywhere, else with nonworking women the least likely to use the Internet. This is also consistent with our findings in this paper.

B. Use of Social Networks

Tüfekçi [16] found significant differences between males and females on the usage of social networks that females are more likely to use social networks to keep in touch with friends either living nearby or in other schools, while males are more likely to use social networks to find potential friends and find people with have similar interests [17]. However, males tend to make new relationship in social network environments more than females do. On the other hand, Tüfekçi found that females' communication skills are more positive than males' and suggested that females are more social than males. Females state that they use social networks, such as Facebook for maintaining existing relationships, academic purposes and following agenda more than males, while males use facebook for making new relationships at a rate higher than females.

III. GESTURE CLASSIFICATION

The most recognized gesture classification and the one referred to from now on is the one established by McNeill in [18]. He classifies gestures as seen in Table 1. Gestures have also been classified according to their purpose. They could be goal-oriented (change of position, shape), indirect manipulation (set, stop), empty handed gestures (wave, snap, point, take), and haptic exploration (touch, stoke, knock).

A. Gesture Types

McNeill [1] identified the gestures types as summarized in Table I:

Iconic. Iconic gestures were identified as actual picturing, as if drawing. Therefore, if a participant mentioned the word "square" and drew a square, it was considered an iconic gesture.

Beat. Beat gestures were generated by context and marked a gesture or transition. A beat gesture was identified, for example, if a person described the back of a chair and stressed staying back and the hands were put a bit forwards. These were mainly low energy low kinetic gestures.

Repetition. Repetition gestures are part of beat gestures, but for the purpose of the experiment, they were counted separately.

Deictic. Deictic gestures correspond to pointing, but they do not include gestures performed purely with the index fingers. This pointing gestures are normally accompanied by words like "there" or "left" for example.

Metaphoric. Metaphoric gestures represent conceptual subjects. In the experiment they represent an abstract concept like "old" or "retro". A user would not use these as an actual depiction, but they may use them to supplement a word or enhance the meaning of another gesture..

Junk. Junk gestures were identified as gestures without a particular meaning. This could be a gesture that the user takes back (a "mistake") or some transition movements.

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TABLE I. CLASSIFICATION OF GESTURE TYPES

Gesture	Function	Linguistic example
Iconic	Resembles that which is being talked about	Flapping arms like wings when talking about a bird
Metaphoric	Abstractly pictorial; loosely suggests that which is being talked about	Making a box shape with hands when talking about a room.
Beat	Gestures with only two phases (up/down, in/out) indexing the word or phrase it accompanies as being significant	Rhythmic arm movement used to add emphasis
Deictic	Gestures pointing to something or somebody either in concrete or abstract	Pointing while giving directions

B. *Gesture Segmentation*

The technique mostly used for gesture analysis is gesture and speech alignment. In practice, gestures are identified as atomic parts, or, as a sequence of hand shape [19] the latter being harder to measure. Normally the gesture coders are guided by the endpoint localization to perform the segmentation and recognition. The reality is that the spatio-temporal variation comes from the fact that not only do different people move in different ways, but also even repeated motions by the same subject may vary [20]. The issues here are speed and endpoints, making it challenging to know when a gesture ends and when another begins. Within different technologies, there are different methods for detecting a candidate cut. For example, in video games they are based on three criteria: abnormal velocity, a static gesture, and sever curvature [21]. Li and Greenspan [20] focus on how the endpoints are located. They had participants repeat various actions several times in order to document the variances, these variances, they claim, are useful for identifying the range of a given gesture, and therefore a better identification. This way, to build a gesture model, a gesture representation, repeated at a single moderate speed, does not have to be perfect.

IV. METHODOLOGY

This section covers the explanations of the methodologies we used in the project. In this section, we will have a discussion regarding the purpose and the advantage of each methodology.

A. *Survey*

The goal of the survey is to explore the gender differences in the perception of Information Technology (IT). This survey was carried out in the early stages of the project to help us understand the general perception of males and females regarding IT. 20 participants joined our survey the perception of IT. The age range of participants is 25-30 years old. They come from Asian and Australian backgrounds. They are either professional or university students. For the purpose of this survey, we collected the results from the participants based on 21 questions regarding their perception of using electronic devices in their daily lives as well as internet usage.

B. *Video Analysis*

We used the video annotation tool ANVIL [23] for video analysis. ANVIL offers multi-layered annotation based on a user-defined coding scheme (Figure 1). Special features offered by ANVIL are the tracks for time stamp, coding facilities on video footages and a project tool for managing a collection of annotation files. The gestures are separated by pauses. A pause is defined as a temporary stop in action or speech. The purpose of this pause is to eliminate the period of inactivity from the actual gesture time. This pause could appear at the beginning of a video, when the participant explains what he or she might do, or when the participant states that he or she has ended the action. ANVIL permits the creation of a track on the time line where gestures are segmented and coded.

Figure 1: ANVIL annotation track

C. *Experiments*

18 participants including 8 males and 10 females joined our experiment. The participants were divided into two groups. The participants were the ones who did the survey before the experiment. Their age range was 25-30 years old. They were either Australian or Asian. The participants were either employed or unemployed. We have chosen a group of males and females with English as their native language.

Firstly, we explained the task to the participants. They were asked to describe a particular object (Figure 2). We used a camera to record each participant. During the experiment, all participants were given the task to describe a chair, the participants were also instructed to describe the chair as if they were describing the object to someone who cannot see in a videoconferencing session. They were encouraged to use both hands and as many gestures as possible. All participants used words to accompany their gestures, even they were not instructed to do so.

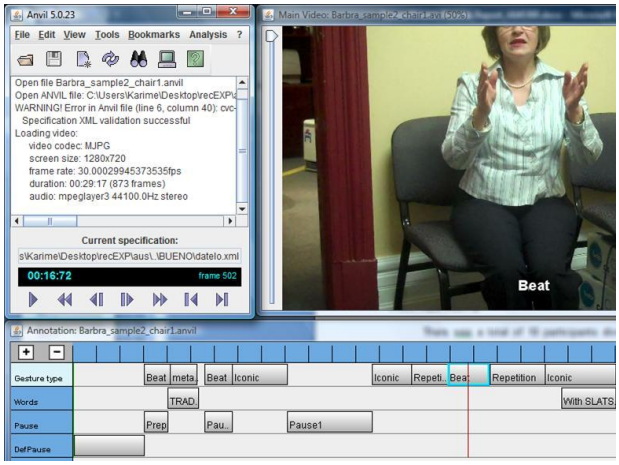

Figure 2: A snapshot from the experiments

D. Video Analysis

In video analysis, we used the gesture classification defined by McNeill [1] and Table I. We considered the gesture type Repetition, as a factor potentially reflecting the culture of the participant, as uncertainty in the language or description could be channelized this way using Hofstede's cultural dimensions [22].

V. RESULTS

This section covers the results of survey and experiments.

A. Survey Results and Demographics

The Analysing the survey, we found that all male participants perceive themselves as having more experience with computers than female participants. According to Table 2, 80% of male participants state that they have more than 10 years of experience in using IT, while the rest opts for 6-9 years. The trend is reverse in females with 86% stating that they have 6-9 years of experience in using IT and 13% with more than 10 years. According to Table 2, either male participants start using technological devices perhaps earlier than females or they consider themselves having higher level of computer experience than females.

TABLE II. PERCEIVED COMPUTER EXPERIENCE

experience of using computer	Male(%)	Female(%)
less than 3 years	0	0
3-6 years	0	0
6-9 years	0.2	0.86
more than 10 years	0.8	0.13

As seen in Table 3, most females consider themselves as beginners in computer use (92%), which indicates that they use computers at a basic level, such as internet browsing, typing etc. However, most males (92%) consider themselves as intermediate or professional users of computer.

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TABLE III. PERCEIVED COMPUTER SKILLS

level of computer skill	Male (%)	Female (%)
Beginner	6	92
Intermediate	26	13
Professional	66	0

According to Table 4, 53.3% of males spend more than 6 hours on a computer each day; however none of the females opts for that. At most, 33.3% of females spend 4-6 hours on a computer each day. This daily experience of using computers seems to have a significant influence on the perception of IT. Perhaps, as a result of this, males feel more confident in using computers than females or at least they state that it is the case.

TABLE IV. TIME SPENT ON COMPUTER

Average time spend on computer each day	Male (%)	Female (%)
Less than 1 hour	0	0
1-3 hours	26.6	66.6
4-6 hours	20	33.3
More than 6 hours	53.3	0

More interestingly, we asked participants in the survey what the gender of their IT device is (i.e., desktop, mobile, laptop or tablet, and the internet) and compared the responses of females to males. Table 5 demonsrates the perceived gender of IT device overall including males and females. According to this table while desktop computers seem to be perceived as a more masculine technology (43.3%), mobile phones are perceived more feminine (50%). Laptops have no gender (68%), neither does the Internet (73%).

TABLE V. PERCEIVED GENDER OF IT DEVICE OVERALL

	Desktop (%)	Mobile Phone (%)	Laptop (%)	Internet (%)
Masculine	43.3	6.6	8	10
Neutral	33.3	43.3	68	73
Feminine	23.3	50	24	16

However, when comparisons are drawn between males and females as in Table 6 and Table 7, we found that there are gender differences in the perception of the gender of technology. We found that all male participants consider the internet with no gender at all. Majority of males think that their IT device has no gender. Still, if there is a gender associated with it, desktop is masculine (40%), mobile phone (20%) and laptop are feminine technologies (14.2%).

TABLE VI. PERCEIVED GENDER OF IT DEVICE BY MALES

men	Desktop (%)	Mobile Phone (%)	Laptop (%)	Internet (%)
Masculine	40	13.3	7.1	0
Neutral	53.3	66.6	78	100
Feminine	6.6	20	14.2	0

More than 86.6% of females think that their desktop has a gender (while more than half of these think that their desktop is masculine, the other half think that it is feminine). Their perception of mobile technology is primarily feminine (80%), but their laptop (36.3%) and Internet (33.3%) are partially feminine, while majority of them think that their laptop and internet has no gender .

TABLE VII. PERCEIVED GENDER OF IT DEVICE BY FEMALES

women	Desktop (%)	Mobile Phone (%)	Laptop (%)	Internet (%)
Masculine	46.6	0	9	20
Neutral	13.3	20	54.5	46.6
Feminine	40	80	36.3	33.3

These findings imply that while males show a tendency to objectify the technology, they do not seem to see the personality or gender behind their IT device. For them, an IT device is an object and nothing more than that, whereas a large proportion of females seem to perceive a personality and gender associated with their IT device. These differences between males and females may be the driving force behind their use of technology.

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B. *Video Analysis Results*

We used the video annotation to analyse the video records of the experiments. We used seconds as the measuring unit for time. In total, we collected 8 males and 10 females' gestures, but only the ones with better expression and comprehension of the task were chosen for analysis. Therefore, the final selection was 5 for each gender group. There are a total of 157 gestures.

In 5 male participants, the average duration of video is 1min 28 sec and the longest video footage is 1:50 minutes. The total number of gestures in the video records is 72. Male participants used only 4 gesture types in the description of the chair in our experiment. According to the Figure 3, the use of iconic gesture type is 50%, then followed by deictic, junk and beat gesture types. We found higher number of deictic and junk gestures 17% each in males video protocols. We also found male participants did not use metaphoric gestures during the description, and only 3 males performed a metaphoric gesture.

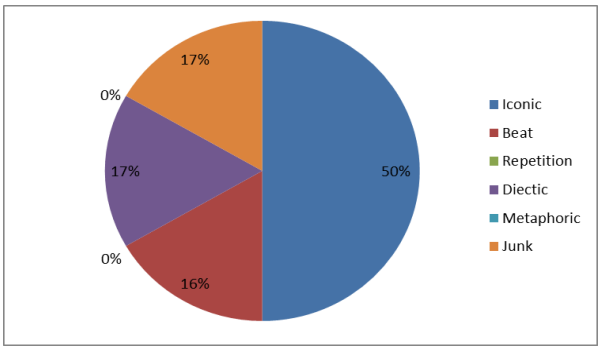

Figure 3: Gesture types used by males

In 5 female participants, the average duration of video is 1 min 48 sec and the longest video is 2:10 minutes. The total number of gestures in the video is 84. Female participants used all 7 types of gestures in the description of the chair in our experiment. According to the Figure 4, the iconic gestures were more than 50% in the all video records, followed by deictic, junk metaphoric, repetition and junk gestures. The beat gestures are used the least by females. Both males and females use plenty of junk gestures but the portion of junk gestures is smaller in females (11% vs 17%) .

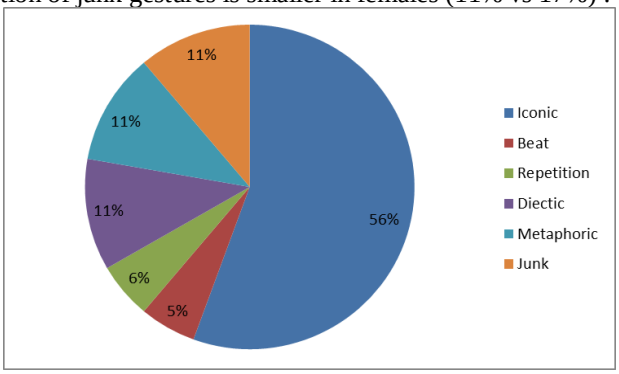

Figure 4: Gesture types used by females

Comparing Figure 3 and Figure 4, we found male participants only use 4 types' gestures out of 7. However, females make use of all 7 types. Some female participants would even use metaphoric gestures. We found that females are more diversified compared to males in their gesture types.

Analysing the results in Table 8, we found that females use more gestures in a longer period (84 vs 72 gestures and 1:48 vs 1:28 seconds on average). We found that frequency of gestures is higher in females (2.39 vs 1.78). On the other hand, males perform less number of gestures in a shorter time frame (25.6 sec vs 40.2sec).

TABLE VIII: COMPARATIVE ANALYSIS

	Total video duration	Avg video duration	Total num.of gestures	Avg gestures per participant	SD	Total gesture time	Ave gesture time	Frequency
Male	384 sec	76.80 sec	72	14.4	8.24	128 sec	25.6 sec	1.78
Female	444 sec	88.75 sec	84	16.8	9.12	201 sec	40.2 sec	2.39

The total duration of video is larger in female participants. The video records comprise both gestures and speech. Females' descriptions are longer. The total gesture time is nearly as twice as male participants in females.

The most significant finding in both genders for a gesture based interface design is the ratio of iconic gestures as these are the most frequent gesture types in both protocols (50% for males and 56% for females).

Detailed description of the abbreviations defined in Table 6 can be listed as follows as in Nasser and Kavakli [4]:

Total video duration: The total video duration is measured as the sum of total duration of each participant.

Average video duration: The average video duration is measured as the number of total video duration divided by the number of the participants.

Total number of gestures: The total number of gestures is measured as the sum of the total gestures of each participant used in the video.

Average gestures per participant: The average gesture per participants is measured as the number of total gestures performed by the participants divided by the number of the participants. This way we get the average gestures performance for each gender.

Total gesture time: The total gesture time in the video records.

Average gesture time: The average gesture time is measured as the number of total gesture time divided by the number of the participants.

Frequency: The frequency is measured as the number of gestures performed by a participant divided by the gesture time period of the same participant. This way we get the gestures per second and it will help assess speed of gesture performance and point out what gestures are most significant for the gesture recognition system

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C. *Structural Analysis Results*

To analyse gender differences in the functional description of a chair, we divided the sample chair into different parts (Figure 5): seat, back, bars and legs. Each part is connected to another part. In Figure 6, we found gender differences in the functional description of a chair . Females tend to describe the chair following a part based description. For example, first they tend to describe the leg followed by the other legs, then they start pointing out the rungs. Then follow by the seat and back of the chair. Females' seem to refer to a structural description in their description. However, males description of these functional parts is random.

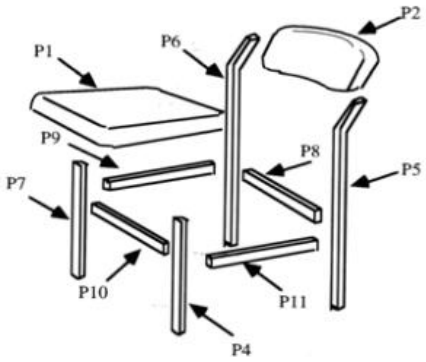

Figure 5: Parts of a chair [24]

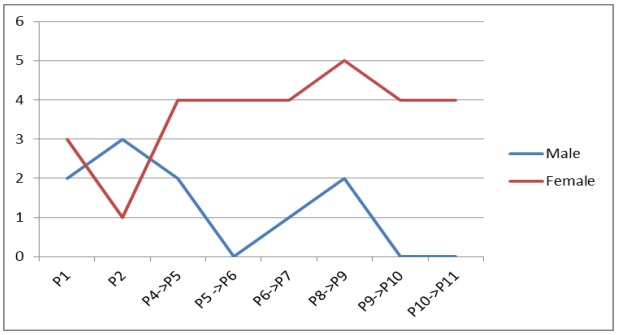

Figure 6: Number of participants and functional parts of a chair

VI. CONCLUSION AND FUTURE WORK

Our motivation to examine gender differences originates from ubiquitous system development for gesture recognition [25] suggesting to use multimodal input for adaptive system design [26]. Gender differences found in psychology, computer science, marketing, neuroscience, education, and economics that strongly suggest that males and females solve problems, communicate, and process information differently.

We defined two hypotheses to test: (1) The experience of using a computer as well as the gender of the user has a significant effect on the perception of the gender of the technology. The objective of the survey in this study is to investigate this research question. (2) Gender differences in gestures have a significant influence on human performance.

Regarding Hypothesis 1, there are gender differences in the perception of the gender of technology. While desktop computers seem to be perceived as a more masculine technology (43.3%), mobile phones are perceived more feminine (50%). Laptops have no gender (68%), neither does the Internet (73%). When comparisons are drawn between males and females, all male participants consider the Internet with no gender at all. Majority of males think that their IT device has no gender. Still, if there is a gender associated with it, desktop is masculine (40%), mobile phone (20%) and laptop are feminine technologies (14.2%). More than 86.6% of females think that their desktop has a gender. Their perception of mobile technology is primarily feminine (80%) but their laptop (36.3%) and internet (33.3%) are partially feminine, while majority of them think that their laptop and internet has no gender. These findings imply that while males show a tendency to objectify the technology, they do not seem to see the personality or gender behind their IT device, whereas a large proportion of females seem to perceive a personality and gender associated with their IT device. These differences between males and females may be the driving force behind their willingness of the use of IT. We also found that 53.3% of males spend more than 6 hours on a computer each day, however only 33.3% of females spend 4- 6 hours on a computer each day. Perhaps, as a result of this, most females consider themselves as beginners in computer use (92%), however most males (92%) consider themselves as intermediate or professional users of computer.

Regarding Hypothesis 2, there are gender differences in the use of gestures. We found male participants only use 4 types' gestures out of 7. However females make use of all 7 types. Females seem to be more diversified compared to males in their gesture types. We found higher number of deictic and junk gestures 17% each in males' video protocols, as well as no use of metaphoric gestures. Iconic gestures are the most frequently used gestures in both protocols (50% for males and 56% for females). The beat gestures are used the least by females. Both males and females use plenty of junk gestures but the portion of junk gestures is smaller in females (11% vs 17%). Females use more gestures in a longer period (84 vs 72 gestures and 1:48 vs 1:28 seconds on average). Frequency of gestures is higher in females (2.39 vs 1.78). We also found gender differences in the functional description of a chair. This implies that males and females may employ different cognitive processing methods. Females tend to describe the chair following a part based description and referring to a structural description. However, males' description of these functional parts seem to be random.

It is important to state that these are only some pilot studies. Future studies require a larger sample size and must focus on the consistency of the annotations using independent coders. It would be useful to collect some psycho-physiological feedback to verify these results. Further, research may also investigate the combined effects of gender and culture on gesture performance.

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REFERENCES

[1] M. Gullberg, 'Methodological reflections on gesture analysis in second language acquisition and bilingualism research'. Second Language Research 26,1; 2010, pp. 75–102.

[2] M. W. Kruger, 'Environmental technology: Making the real world virtual', Commun.ACM 36, 7 (July), 1993, pp. 36 –37.

[3] J. Brewer, A. Bassoli, 'Reflections of gender, reflections on gender: Designing ubiquitous computing technologies'. In Gender & Interaction: Real and Virtual Women in a Male World, Workshop at AVI, 2006, pp .9–12.

[4] K. Nasser, M. Kavakli, 'Influence of Culture in Multimodal Interfaces: Differences in Gesture behavior between Anglo-Celtic and Latin Americans', *the International Journal On Advances in Life Sciences*, v 4 n 3&4, 2012, pp. 1-10.

[5] A. Herlitz, L.G. Nilsson, and L. Backman, 'Gender differences in episodic memory'. Memory & cognition 25(6), 1997, pp. 801.

[6] D. C. Geary, S. J. Saults, F. Liu, and M. K. Hoard, 'Sex differences in spatial cognition, computational fluency, and arithmetical reasoning'. Journal of Experimental Child Psychology 77(4), 2000, pp. 337.

[7] J. S. Hyde, E. Fennema, and S .J. Lamon, 'Gender differences in mathematics performance: a meta-analysis'. Psychological bulletin 107(2), 1990, pp. 139.

[8] C. Kramer, 'Perceptions of female and male speech'. Language and Speech 20 (2), 1977, pp. 151.

[9] N. Briton and J. Hall, 'Beliefs about female and male nonverbal communication'. Sex Roles 32(1), 1995, pp. 79.

[10] E. V. College, 'Gender difference in nonverbal communication', 2014, http://evc-cit.info/psych018/observation_samples/observation9028.pdf [Online; accessed August 2014].

[11] J. Freeman. 'Women: A feminist perspective', (4th ed) Mountain View, CA: Mayfield Publishing Company, 1992, pp. 329–46.

[12] D. M. Saucier and L. J. Elias. 'Lateral and sex differences in manual gesture during conversation'. Laterality: Asymmetries of Body, Brain and Cognition 6 (3), 2001, pp. 239.

[13] H. Cochet and J. Vauclair. 'Hand preferences in human adults: Non-communicative actions versus communicative gestures'. Cortex 48(8), 2012, pp. 1017.

[14] D. Gefen, and D. Straub, 'Gender Differences in the Perception and Use of E-mail: An Extension to the Technology Acceptance Model'. *MIS Quarterly*, 1997 pp. 389-400.

[15] M. Volman, E. Eck, I. Heemskerk, E. Kuiper, 'New technologies, new differences'. Gender and ethnic differences in pupils' use of ICT in primary and secondary education. DOI: 10.1016/j.compedu.2004.03.001, 2004.

[16] S.G. Mazman & Y. Usluel, 'Gender differences in using social networks'. The Turkish Online Journal of Educational Technology, April 2011, Vol.10 Issue 2, (2011).

[17] H. Ono, M. Zavodny, 'Gender differences in information technology usage: A U.S – Japan comparison'. *Sociological Perspectives, Vol.48 Issue 1*, 2005.

[18] D.McNeill. Hand and Mind: what Gestures Reveal about Thought, University of Chicago Press, 1992.

[19] W. Fikkert, P. Van der Vet, G. Van der Ver, A. Nijholt, 'Gestures for large display control . Computer Interaction': 8th International Gesture Workshop, Revised Selected Papers. Germany: Springer, 2009, pp. 245-256.

[20] H. Li, M. Greenspan, 'Model-based segmentation and recognition of dynamic gestures in continuous video streams'. Pattern Recognition, 44, 2011, pp. 1614-1628 Retrieved from ScienceDirect Database.

[21] H. Kang, C. Lee, & K. Jung, 'Recognition-based gesture spotting in video games'. Pattern Recognition Letters 25, 15, pp. 1701-1714. DOI:10.1016/j.patrec.2004.06.016, 2004.

[22] Hofstede G. H., Hofstede G. J., Minkov Michael () *Cultures and organizations: software of the mind : intercultural cooperation and its importance for survival*. (3rd ed) McGraw-Hill Professional ISBN 0071664181, 9780071664189, 2010.

[23] Anvil, http://www.anvil-software.org/, 2014 [Online;accessedAugust-2014].

[24] M. Kavakli, S.A.R. Scrivener, L.J. Ball, 'Structure in idea sketching behaviour', *Design Studies:* The International Journal for Design Research in Engineering, Architecture, Products and Systems, ELSEVIER, 19(4), 1998, 485-517.

[25] M. Kavakli, 'Gesture Recognition in Virtual Reality', *Special Issue on: "Immersive Virtual, Mixed, or Augmented Reality Art" of The International Journal of Arts and Technology* (IJART), Vol 1, No 2, 2008, pp. 215-229.

[26] J. Liu, , M. Kavakli, Towards Accommodating Gender Differences in Speech-Gesture Based Multimodal Interfaces Design, ICITA 2013, 8th International Conference on Information Technology and Applications, Sydney, Australia, 1 - 4 July, pp.1-6, 2013.

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Assessment of Expectations and Needs of a Sensor Network to Promote Elderly's Sense of Safety and Security

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***Abstract*—Many new technologies claiming to support independent living and prolonged possibilities of aging in place have been developed. To support independent living and increase the sense of safety and security both for the elderly themselves and for their relatives, the technologies have to be easily adaptable to match the divergent users personal expectations and needs. The study reported in this paper was conducted as seven case studies where a sensor network was deployed in homes of people with a self-perceived memory decline. We describe problems related to adaptive personalization of such technology in real settings and discuss what consequences these problems may have for the elderly people's and their relatives willingness to use the technology. Our results indicate that a lack of sufficient possibilities to adaptive personalization of the system makes it difficult to address individual user's expectations and needs. This, in turn, leads to a decreased trustworthiness of the technology and a risk of unwillingness to use the technology.**

Keywords–Ambient Assisted Living; Adaptive Personalization; Safety; User Expectations.

I. INTRODUCTION

Being able to feel safe and secure are perhaps two of the fundamental requirements for enabling elderly to continue living independently. In this respect, safety and security involve physical, psychological and existential aspects on well-being, all of which are fundamental when coping with daily life. Associated with feeling unsafe and insecure are feelings such as: worry, fear, anxiety and perhaps even panic according to the Swedish National Board of Health and Welfare [1]. For special groups, such as the elderly, their ability to stay independent at home does not only depend on whether they feel safe and secure at home. It is equally important that the social networks around them, e.g., family, spouses or caregivers feel that their loved ones are safe and secure. Aspects such as safety and security may affect the social structures (roles) in families over time. Children may become caregivers who make decisions on behalf of their parents, a role which may be stressful for the family caregivers [2]. Taking the role as a family caregiver is also associated with a need to balance the care giving with other activities, e.g., work and leisure [2]. Therefore, the new role may have an effect on psychosocial well-being [3], but also have negative consequences on the caregivers themselves, e.g., sleep disturbances [4] and increased blood pressure [5].

Many new technologies claiming to support independent living and prolonged possibilities of aging in place make use of sensor networks and/or mobile robotic telepresence [6]. While most of them can be installed with little changes in the home infrastructure, little is known about whether they lead to an increased sense of safety and security, either for the elderly themselves, or for their family caregivers. Technologies which cannot deliver an increased sense of safety and security will likely have no large impact on the growing market of assistive technologies for an elderly population. Therefore, it is of interest to increase the knowledge on what affects the sense of safety and security. Commonly, commercial sensor networks offer solutions such as alarms, reminders of turning electrical devices off (e.g., the stove or the coffee brewer), but sensor networks can also be used to monitor activities [7][8]. Yet, a key question is whether the solutions support adaptive personalization and whether they can support independent living and aging in place and whether they increase the elderly people's and the family caregivers' sense of safety and security.

This paper describes the first step in a longitudinal study aiming at developing a methodology to measure how an Information and Communication Technology (ICT) affects the sense of safety and security. In the study, we apply the methodology to study how a sensor network deployed in homes of seven people with self-perceived memory decline affects not only these people's but also their spouses' perceived safety and security. The longitudinal study can be divided into three main steps: (1) finding test persons who are suitable for testing the system and deploying the sensor network, (2) evaluation while living with the sensor network, and (3) evaluation after the sensor network has been removed. The results presented in this paper focus on the results from the first step and describes the expectations and the profiles of each of the users. We find that sensor network solutions need to be highly adaptive to the user's personal needs.

The paper is structured as follows. Section II provides a description of the sensor network deployed in this study. Section III outlines the methodology used during the first step of the longitudinal study. Information is provided on how the participants were selected, how they were informed about the project and the sensor network, how each deployment was prepared and how the deployments were made. The results of the first step in the longitudinal study are presented in Section IV. Finally, a discussion and conclusion is provided in Section V.

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II. System Description

The sensor network deployed in this study is Abilia's Homebasic [9], which is a "safety and security" package for those who need a combination of time and memory support, environmental monitoring and alarm functionalities. Homebasic is an advanced cognitive support that aims to support independent living and increase the possibility to age in place. The individuals targeted have a cognitive decline and may be in need of orientation in time, support and structure of daily tasks, reminders for handling electronics in the home (e.g., the stove, coffee brewer, lamps) and reminders when leaving the home. The cognitive decline supported by Homebasic ranges from developmental disorders to Alzheimer.

The core of the system is the digital calendar, Memoplanner (MP, see Figure 1(a)). The MP is a touch-PC that can be hung on the wall or placed in a guitar stand. It is recommended that MP is installed in a room in which the user spends a lot of time during day-time. The MP has several functions:

- F1 Information of time.
- F2 Calendar to provide support and structure of daily tasks. The user (or a remote user) can add new events to the calendar. Each event can consist of sub events.
- F3 Reminders about upcoming events. These can also be sent as SMS reminders.
- F4 Skype

The MP connects to the Internet via WiFi or a LAN-connection to a Vera Gateway [10]. Included in Homebasic are also a number of sensors which are connected to the gateway using the Z-Wave protocol [11]. The MP warns the user with an image and a pre-recorded instruction or a reminder when a sensor is triggered. The solution is marketed as being easy to use, easy to install in all kinds of homes and to be re-used in other homes.

The sensors and actuators included in Homebasic are two motion sensors (see Figure 1(b)), one on/off sensor (see Figure 1(c)), one oven/stove sensor, from here on called stove sensor, one door sensor (see Figure 1(d)), and a lamp actuator.

(a) Memoplanner (b) Motion sensor (c) On/off sensor (d) Door sensor

Figure 1: Examples of Abilia Homebasic components.

The manufacturer recommends that each sensor is plugged to an electric socket rather than running on battery. This means that the stove sensor needs to be connected not only to the stove's electric cord but also to a standard electric socket. Here follows a description of what functions that are provided using the sensors:

A. Kitchen

Situated in the kitchen are typically one motion sensor, one stove sensor and one on/off sensor. The MP issues a warning when:

- F5 The stove is on but no motion has been detected in the kitchen during the past x minutes.
- F6 A chosen electronic device, e.g., a coffee brewer is left turned on during x minutes.

B. Bedroom

Aiming at preventing falls, one motion sensor and one lamp actuator are situated in the bedroom. The motion sensor detects when the user places his/her feet beside the bed. When detecting motion, a lamp is turned on automatically [F7], either for a chosen period of time or until the user turns the lamp off. In case there is no need for an on/off sensor in the kitchen, the sensor can also be used to turn on an additional lamp anywhere in the home.

C. Hallway

Typically, the included door sensor is placed on the entrance door. It can be used to detect that the door has been opened and issue a warning via the MP if:

- F8 The stove is on.
- F9 The door is opened. This function can be used with several options, either it can be always active and remind the user to, e.g., lock the door. Alternatively, it can be active during a specific time of the day and tell the user that it is not an appropriate time to go out.

D. System summary

The functionalities provided by Abilia Homebasic can also be divided into five categories (sensor-based reminders, sensor-based actuation, calendar-based reminders, calendar visualization and communication). Table I summarizes the functionalities of Abilia's Homebasic into categories.

III. Method for preparing deployment of system

The longitudinal study was conducted as seven case studies [12]. The first step of this study, described in this paper, focused on finding people who were suitable for testing the system and deploying the sensor network.

A. Selection of participants

The participants for the project were selected through the Örebro municipality's "Minnesmottagning" (memory center). Every year, several hundred people contact the memory center for consultation and help when they have concerns regarding their own or their relative's memory. We informed the personnel at the memory centers about the project and asked them to help us finding possible participants. The selection criteria for the participants were: they should be 65 or older, live in ordinary housing/private residence outside nursing homes, have self-perceived memory problems, appoint a relative interested in participating in the project and have an Internet

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TABLE I: SUMMARY OF FUNCTIONALITIES OF ABILIA'S HOMEBASIC.

Sensor-based reminders	Sensor-based actuation	Calendar reminders	Calendar visualization	Communication
F5 Stove on but no motion in kitchen for x minutes. F6 An electronic device has been turned on for x minutes. F8 The entrance door is opened while the stove is on. F9 The entrance door is opened. Can be used to remind the user to, e.g., lock the door or to tell the user that it is not an appropriate time to go out.	F7 Lamp automatically turned on when motion beside bed.	F3 Reminders about upcoming events.	F1 Information of time. F2 Calendar for structuring daily tasks.	F4 Skype

connection (3G is ok but only if connected to a router). All the interested people were men (for details, see Section IV). This outcome was rather surprising since according to the personnel at the memory center, men are not in majority among people consulting the center and information about the project was directed to both men and women. We could find two possible explanations for this outcome. Firstly, in all age categories, men use modern ICT to a greater extent than women [13]. Since the project focuses on using new technology, men could be more attracted to participate in the project than women. Secondly, women are affected by dementia and memory decline later in life than men [14]. This means that women consulting memory centers are older than men. Statistics [13] show that interest and usage of technology decrease with age. This might be another reason for why only men were interested in participating in the project.

B. Information about the project

All people showing interest were contacted by phone. During this first contact, we explained the aim of the project and shortly described Abilia Homebasic. Since receiving a description of the system by phone was experienced as abstract and difficult to understand, we invited the people interested in the project and their assigned relatives to a Research and Innovation Apartment in which the system was installed and could be demonstrated. We met each potential participant together with their relatives in the apartment. During the meetings, which lasted approximately one hour, we explained the aim of the project and demonstrated and explained key functionalities of Homebasic. We also distributed fliers including the most important information about the project. During these meetings, all the invited people agreed to participate in the project. Thus, we scheduled meetings with the participants in their homes with the aim to collect necessary information before the deployment.

C. Deployment preparation

We visited each test person in his home. During the visit, the test person and his relative signed the informed consents and were interviewed about their needs and expectations regarding the sensor network. They were also asked about their requests regarding the installation of Homebasic according to a questionnaire (installation scheme) provided by Abilia. To collect data about user's needs and expectations regarding the sensor network, we used the well-known instrument, Individually Prioritized Problem Assessment (IPPA) [15]. IPPA is a long term instrument that supports collecting data through interviews. The test person is asked to identify the up to seven most important problems that he/she hopes will be reduced by using the tool. The interviewee is also asked to estimate how important the problems are and how difficult it is to perform daily activities related to this problem on likert scales. We used IPPA also to collect information from relatives. For each problem identified, they were asked to estimate how important the problem was and how difficult it was for their test person. Additionally, they were asked to what extent they thought that Homebasic could minimize the problem. Using IPPA and the installation scheme, we were able to identify what expectations and needs that the test persons and their relatives had regarding the sensor network. After all homes had been visited, we scheduled the physical installations of the sensor networks.

D. Deployment and training

The physical installations were done by Abilia's technicians according to the requests collected during the home visits which were summarized in installation schemes (for details on expected deployments, see Section IV). During the installations, we were responsible for introducing the test persons on how to use the MP. Most of the users were quite inexperienced in using this kind of tool. Hence, the introduction focused on the basic functionalities of the MP. In the situations where we could see that the users comprehended the basics, we introduced additional functions. Otherwise, we stayed at the basic level and appointed time for additional training. All test persons were provided with manuals where they could learn more about Abilia Homebasic and its functionality.

IV. RESULTS

Table II provides information about the seven test persons ($\mu = 71.6$ years old), their type of accommodation and about relatives ($\mu = 65.7$ years old). All test persons are men and all "relatives" are wives who live with the test persons. All test persons and five of the relatives are retired. Two wives are balancing work and caring for their husbands. The type of accommodation varies, but typically the accommodations are quite large.

In the following subsections, details on each test site are provided. First, the test person is described. Secondly, a table describes what functionalities that the test person expected that the system would have and what functionalities that were actually deployed. In reality, some expectations on functionalities could not be met. Hence, the results for each test site outline also when expectations could not be met.

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TABLE II: DESCRIPTION OF STUDY SAMPLE TP = TEST PERSON R = RELATIVE

Test site	Accommodation	Internet	Age tp	Age r
1	Five room apartment	Cable	77	68
2	Three room apartment	3G/4G	74	69
3	Three room apartment	Cable	82	82
4	Two story detached house	Fiber	54	54
5	Two story summer residence	3G/4G	71	68
6	Four room row house	3G/4G	75	66
7	Three room apartment	Fiber	68	53
μ			71.6	65.7

Finally, a summary of the results from the conducted IPPA-interviews, the expected deployments and actual deployments is provided.

A. Test site 1

The test person experiences a memory disturbance (short term and speech). His expectations on the system relate mostly to the MP. In particular, he hopes that the MP calendar function will make him feel more comfortable while communicating with others. As an effect of having problems expressing himself, he says that his self-confidence has decreased. Due to the fact that the test person and his wife have a summer house, they plan to bring the calendar there over the summer. Table III summarizes the expected deployment and actual deployment for test site 1.

B. Test site 2

The test person who has had a number of strokes feels that his short term memory is a bit weakened. Similarly to the aforementioned couple, this test person and his wife have a summer house to which they plan to bring the calendar over the summer. Table IV summarizes the expected deployment and actual deployment for test site 2.

C. Test site 3

The test person has problems with his back and hip and it often happens that he forgets things (keys, wallet, phone, etc.) when he goes out. Additionally, this is a suitable user for F7 as the test person is occasionally dizzy. The MP is expected to be useful as the person has difficulties writing things down by hand. Table V summarizes the expected deployment and actual deployment for test site 3.

D. Test site 4

The test person lives with his wife and children in a two story detached house. The wife is still working. Prior to being informed about the possibility to participate in the project, the test person is already using an analogous version of the MP. Seen from the wife's perspective, she expects that it will be more time efficient for her to use the digital MP, particularly when scheduling repetitive events, which can be done in a way which is similar to scheduling events occurring only one time. Using the analogous version, she has to continuously add and remove events which do not occur every day. The test person has problems with balance, hence there is a risk of falling, especially in the stairs. For this reason, the test person is a suitable user of F7. The couple has a summer house and plans to bring the MP there. Table VI summarizes the expected deployment and actual deployment for test site 4.

E. Test site 5

The test person has a memory decline. He always carries the calendar with him but according to the wife, it is not sufficient since he does not always know what day it is. Overall, the wife feels that the problems are larger than the test person seems to be aware of. The couple lives in their summer house from May-October; hence, the Homebasic will be installed there. It occasionally happens that the coffee brewer and the oven/stove are left turned on without surveillance. Additionally, the test person often feels unsure about whether or not he has locked the door when leaving the summer house. Table VII summarizes the expected deployment and actual deployment for test site 5.

F. Test site 6

The test person has a declined muscle power and bad balance and is in need of F7. Additionally, he experiences a memory disturbance (short term). The extent of the problem is perceived as larger by the wife than by the test person. Table VIII summarizes the expected deployment and actual deployment for test site 6.

G. Test site 7

The test person lives with his wife who is still working full time. Prior to being informed about the possibility to participate in the project, the test person is already using an analogous version of the MP. The couple has turned off the analogous MP during night time due to it making it too light. Seen from the wife's perspective, she expects that it will be more time efficient for her to use the digital MP, particularly when scheduling repetitive events, which can be done in a way which is similar to scheduling events occurring only one time. Using the analogous version, she has to continuously add and remove events which do not occur every day. Additionally, the MP will enable her the possibility to check whether activities have been done when she is at work. She is currently unsure on whether he showers or remembers to eat when she is working. Table IX summarizes the expected deployment and actual deployment for test site 7.

Table III-IX summarize the expected deployments and actual deployments for each test site. A number of abbreviations are used. E. D. = Expected Deployment, A. D. = Actual Deployment and F1-F9 are the Homebasic functions which are further described in Section II. For each function F1-F8, x = yes and - = no. For F9, a = always active and t = active during time interval. P regards placement of MP (gs = guitar stand or w = wall).

H. Results from Deployment Preparation

Figure 2 provides an overview of the results from the IPPA-interviews. The test persons and wives outlined a total of 28 problems where they expect that Homebasic could be an aid. These problems were divided into the five categories outlined in Section II-D: sensor-based reminders, sensor-based

 ISBN: 978-1-61208-369-8

TABLE III: SUMMARY OF DEPLOYMENT, TEST SITE 1.

	F1	F2	F3	F4	F5	F6	F7	F8	F9	P
E. D.	x	x	x	x	x	x	-	x	a	gs
A. D.	x	x	x	x	x	x	x	x	a	gs

TABLE IV: SUMMARY OF DEPLOYMENT, TEST SITE 2.

	F1	F2	F3	F4	F5	F6	F7	F8	F9	P
E. D.	-	x	-	-	x	x	x	x	a	gs
A. D.	x	x	x	-	x	x	x	x	a	gs

TABLE V: SUMMARY OF DEPLOYMENT, TEST SITE 3.

	F1	F2	F3	F4	F5	F6	F7	F8	F9	P
E. D.	-	x	x	-	x	-	x	x	a	gs
A. D.	x	x	x	-	-	-	x	-	a	gs

TABLE VI: SUMMARY OF DEPLOYMENT, TEST SITE 4.

	F1	F2	F3	F4	F5	F6	F7	F8	F9	P
E. D.	x	x	x	x	x	x	x	x	t	gs
A. D.	x	x	x	x	-	x	-	-	t	gs

TABLE VII: SUMMARY OF DEPLOYMENT, TEST SITE 5.

	F1	F2	F3	F4	F5	F6	F7	F8	F9	P
E. D.	x	x	x	-	x	x	x	-	t	w
A. D.	x	x	x	-	-	-	x	-	t	w

TABLE VIII: SUMMARY OF DEPLOYMENT, TEST SITE 6.

	F1	F2	F3	F4	F5	F6	F7	F8	F9	P
E. D.	-	x	x	-	x	(x)	x	x	a	gs
A. D.	x	x	x	-	x	x	x	x	a	gs

TABLE IX: SUMMARY OF DEPLOYMENT, TEST SITE 7.

	F1	F2	F3	F4	F5	F6	F7	F8	F9	P
E. D.	x	x	x	-	x	x	x	x	a	w
A. D.	x	x	x	-	x	x	x	x	a	gs

actuation, calendar-based reminders, calendar visualization and communication. The figure shows that users provided with a limited amount of information about Homebasic mainly outline problems with activities related to remembering calendar activities and remembering to turn off electric devices.

Figure 3 provides further information about the perceived importance, difficulty and the system's potential to minimize the problem. The test persons and relatives were asked to: (1) estimate how important the problem is on a likert scale 1-5 where 1 = Not at all important and 5 = Very important and (2) how difficult it is to conduct the activity found problematic on a likert scale 1-5 where 1 = Very easy and 5 = Too difficult to conduct. Additionally, it provides information regarding to what extent the relatives thought that Homebasic could minimize the problems (1 = To a very high degree and 5 = Not at all). For each category, the average value of the response to the respective question is presented. To summarize, large

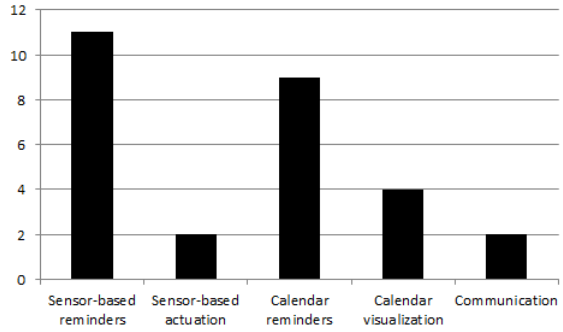

Figure 2: Summary of problems outlined during IPPA-interviews.

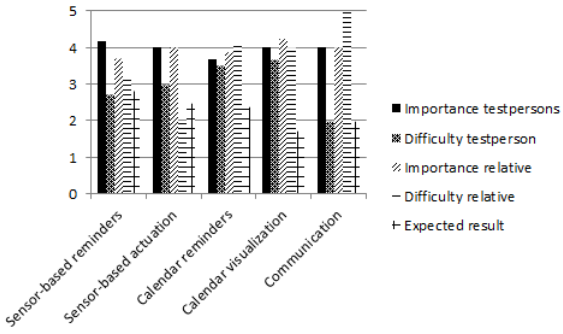

Figure 3: Summary of the importance of problems outlined during IPPA-interviews.

numbers with respect to importance and difficulty indicate a real need and a low number with respect to the potential of minimizing a problem indicates a high expectation. The test persons and relatives perceive that the most difficult activities are related to remembering activities or knowing what day it is. For all categories, except for activities related to sensor-based actuation, the relatives perceive that the test persons have more difficulties than what the test persons perceive themselves.

Figure 4 summarizes the functions that were: (1) expected to be deployed and (2) actually deployed. As can be seen from the figure, the main deviation between the expected and actual deployments was due to the stove sensor which could not be installed at three test sites. According to the IPPA interviews, many expectations on the system relate to sensor-based reminders.

V. Discussion and Conclusion

This paper has focused on presenting a set of tools used to evaluate long term usage of a sensor network at home. The utility of the network in terms of adding a greater sense of safety and security is the ultimate aim of this study. The results so far have provided an indication of which features of the system are more requested when novice users have only a rudimentary exposure to the technology. Most participants valued having sensor-based notifications. Secondly, calendar-based reminders and finally calendar visualization were requested among a subset of the participants. Each test site had further tailored requests regarding which specific events would trigger an alarm, reminder or notification. The variation of requests

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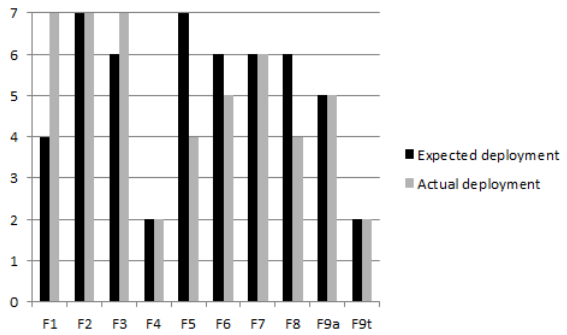

Figure 4: Summary of expected deployments and actual deployments.

from the test sites, despite the relatively homogenous group, indicates that systems such as the one presented in this paper must be highly adaptable. Based on the empirical findings, we identified two areas where adaptation of the system was needed: functionality and environmental aspects.

Functionality : In our case studies, we found that most of the test persons would prefer a lock-switch rather than the door sensor. A lock-switch, indicating if the door is locked or not, would better address the test persons' current needs. A problem that most of the test persons experienced was forgetting to lock the door. To be reminded about it would help them in their everyday life and would increase the sense of safety and security for both the test persons themselves and their relatives. On the other hand, the current functionality implemented together with the door sensor that warns the user that he/she is not supposed to go out at night time was experienced by our test persons as unnecessary. Most of the test persons pointed out that such functionality is rather for people with advance dementia or Alzheimer. This mismatch of functionality in relation to their needs decreased the experienced usefulness of the system. Several of the test persons and their relatives wondered who the system is actually aimed to support. They stressed that the user must still have good cognitive capabilities to be able to understand the warnings from the MP. Yet, the door sensor indicates that the system is for people who do not even recognize if it is day or night.

Another functionality that was experienced as missing in the current solution of Abilia Homebasic was the lack of a possibility to receive sms-warnings when the entrance door is opened or if the coffee brewer and/or stove are on. In the current solution, the MP issues warnings in such situations. Our test persons and their relatives argued that the possibility to receive the warnings by sms when they are not in the neighborhood of the MP would increase their sense of safety and security.

An additional missing functionality was recognized when the system was deployed at test site 7. During the deployment, we identified a need for switching off the light of the MP during the nights. Because the functionality is missing in the current solution, there is a risk that the MP will be installed in locations that are not optimal for it (i.e., where it does not disturb the users but the reminders are not heard) or that it will be switched off during the nights with a risk that the warnings and reminders will not be sent.

Based on our empirical findings, we argue that the lacking functionality lead to decreased sense of safety and security for the elderly and their relatives. We also argue that insufficient adaptability as well as not addressing users' expectations leads to decreased trustworthiness of the system. Additionally, we argue that functionality in a system such as Abilia Homebasic needs to be changeable over time. Abilia Homebasic aims to support people within a wide range of cognitive decline from developmental disorders to Alzheimer. Firstly, this wide range of individuals may have very different needs and thus it has to be possible to adapt the system to the individual user's needs. Secondly, cognitive decline related to dementia and Alzheimer progresses over time. This means that the functionality needs to be adaptable over time to be able to address the user's changed needs.

Environmental aspects : Another category of problems that resulted in mismatch between the users' needs and expectations and the actual installations was related to environmental aspects. As described in Section IV, the desired stove sensor could not be installed in several cases due to: not enough room for the stove sensor when located underneath a cook top, no standard electric socket to which the sensor's adapter could be connected or because the oven was directly connected to the wall. Since the problem occurred in 3 of 7 houses, we consider it as a serious shortcoming in the current solution. Another common problem experienced during the installation was an insufficient WiFi-range of the Vera gateway (4 of 7). One consequence of this problem is that Homebasic cannot be remotely accessed in the case when support is needed. Another consequence is that the MP cannot issue warnings when the entrance door is opened or if the coffee brewer and/or stove are on. Additionally, we found that the MP could not always be placed in the ideal location due to an insufficient WiFi-range or due to no available electric socket nearby the chosen position. Based on our empirical findings, we argue that developers of technologies aimed to support aging in place need to consider the different environmental aspects of the places where the systems may be installed. In our case studies, we could see that the problems with adaptation of the installations to the different environments resulted in an inability to address the users' needs and also in limited functionality of the whole system.

Since the study is based on a small sample of seven test sites, our results cannot be statistically generalized. Even if a number of researchers have argued that case study-based research allows for generalization to theoretical constructs [16][17], our aim is not to generalize the findings from this first step in the longitudinal study. The results from the first step of a longitudinal study which are presented in this paper are of explorative character and describe the expectations and the profiles of each test person. Our aim is to bring to light the importance of understanding and addressing individual user's expectations and needs as well as the importance of enabling sufficient adaptive personalization of the system to these different expectations and needs.

It is argued in literature [12][18] that a case study provides rich context-specific details and in this way reveals important information about the object under study. Using this methodology, we were able to study the users' expectations and needs and the system's possibility to address these needs

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in detail. Despite the relatively homogenous group (common geographical zone, many common characteristics), we found that the requests from the test sites were different and that the environments where the system was deployed were very different. Even though the functionalities of sensor networks may differ from Abilia Homebasic, we argue that systems aiming at supporting aging in place need to be adaptable to different expectations from users and over time in order to address users' changed needs. Thus, although we cannot claim that our findings are valid beyond the cases investigated, we believe that our empirical results highlight sufficient possibilities to adaptive personalization of the system as an important factor to take into account when sensor systems are developed, deployed and used.

Future work will pursue the long term methodology and evaluation at various phases of the usage. In particular, a follow up of the IPPA questionnaire will be conducted and an assessment of the utility of using the sensor network at home will be made. Finally, a series of evaluations will be performed after the sensor network is removed from the home.

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REFERENCES

[1] Socialstyrelsen, Dialog trygghet. The National Board of Health and Welfare, Sweden, 2012, in book: Äldreomsorgens nationella värdegrund ett vägledningsmaterial, ISSN: 978-91-87169-05-2, URL:http://www.socialstyrelsen.se/publikationer2012/2012-3-3 [retrieved: August, 2014].

[2] S. C. Reinhard et al., Ch14. Supporting Family Caregivers in Providing Care. Agency for Healthcare Research and Quality, Rockville (MD), US, April 2008, pp. 341–398, In Patient Safety and Quality: An Evidence-Based Handbook for Nurses: Vol. 1.

[3] M. Stephens et al., "Balancing Parent Care with other Roles: Interrole Conflict of Adult Daughter Caregivers," Journal of Gerontology: PSYCHOLOGICAL SCIENCES, vol. 56B, no. 1, January 2001, pp. P24–P34.

[4] S. Jensen and B. Given, "Fatigue Affecting Family Caregivers of Cancer Patients," Supportive Care in Cancer, vol. 1, no. 6, August 1993, pp. 321–325.

[5] C. Cannuscio et al., "Reverberations of Family Illness: A Longitudinal Assessment of Informal Caregiving and Mental Health Status in the Nurses' Health Study," American Journal of Public Health, vol. 92, August 2002, pp. 1305–1311.

[6] A. Kristoffersson, S. Coradeschi, and A. Loutfi, "A Review of Mobile Robotic Telepresence," Advances in Human-Computer Interaction, vol. 2013, February 2013, 17 pages, Article ID: 902316, DOI: 10.1155/2013/902316.

[7] N. Suryadevara and S. Mukhopadhyay, "Wireless sensor network based home monitoring system for wellness determination of elderly," Sensors Journal, IEEE, vol. 12, no. 6, June 2012, pp. 1965–1972.

[8] S. Coradeschi et al., "GiraffPlus: Combining Social Interaction and Long Term Monitoring for Promoting Independent Living," in Human System Interaction (HSI 2013), June 2013, pp. 578–585, dOI=10.1109/HSI.2013.6577883.

[9] "HOMEbasic i2," 2014, URL: http://www.abilia.no/produkter/produkt.aspx?productgroup=313780&product=330365 [retrieved: August, 2014].

[10] "Vera Smart Home Controller," 2014, URL: http://getvera.com/controllers/vera3/ [retrieved: August, 2014].

[11] "About Z-Wave," 2014, URL: http://www.z-wavealliance.org/about-z-wave [retrieved: August, 2014].

[12] R. K. Yin, Case study research: Design and methods. Sage, Thousand Oaks, California, USA, 2003, 3rd ed.

[13] "Use of computers and the internet by private persons in 2013," 2013, Statistics Sweden.

[14] OECD, Dementia prevalence. OECD Publishing, 2012, in Health at a Glance: Europe 2012, DOI: 10.1787/9789264183896-18-en.

[15] R. Wessels et al., "IPPA: Individually Prioritised Problem Assessment," Technology and Disability, vol. 14, no. 3, January 2002, pp. 141–145.

[16] H. Klein and M. Myers, "A Set of Principles for Conducting and Evaluating Interpretive Field Studies in Information Systems," MIS Quarterly, vol. 23, no. 1, March 1999, pp. 67–94.

[17] A. Lee and R. Baskerville, "Generalizing Generalizability in Information System Research," Information Systems Research, vol. 14, no. 3, September 2003, pp. 221–243.

[18] I. Benbasat, D. Goldstein, and M. Mead, "The Case Research Strategy in Studies of Information Systems," MIS Quarterly, vol. 11, no. 3, 1987, pp. 369–388.

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Towards Universally Usable Smart Homes – How Can MyUI, URC and openHAB Contribute to an Adaptive User Interface Platform?

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***Abstract*—The vision of the Smart Home carries high potential to support us in our daily life and makes it more comfortable. The benefits are relevant to all users including those with special needs like elderly people and people with disabilities. To provide the largest possible benefit to their user, Smart Homes have to adjust to the user and not vice versa. Thereby, it must be taken into account that the user group of the future Smart Home is quite heterogeneous, including users of all ages, different levels of familiarity with computers, and various forms and degrees of disabilities. Hence, universally usable user interfaces are a prerequisite for the success and acceptance of Smart Homes. This paper presents criteria for the provision of universal usability in Smart Homes, based on Schneiderman's research agenda on universal usability for web and other services. Three established frameworks – MyUI, Universal Remote Console (URC) and openHAB – are examined as to how they can contribute to an adaptive user interface platform for Smart Homes. Three possible architectures will be presented on how the three frameworks can be integrated to achieve maximum benefit for the user. We finally propose to use the Global Public Inclusive Infrastructure (GPII) approach for accommodating personal user preferences in Smart Homes.**

Keywords–Adaptive User Interface; Abstract User Interface; Ambient Intelligence; Ambient Assisted Living (AAL); Global Public Inclusive Infrastructure (GPII); Smart Home; Universal Usability; Universal Remote Console (URC).

I. INTRODUCTION

The idea of universal usability is not new and could already be realized, to a great extend, in some traditional public domains like postal codes or telephone numbers [1]. However, the concept of universal usability should also apply in the field of Computer Science and Human-Computer Interaction (HCI). Today, the increasing presence of Information and Communication Technology (ICT) in everyday life situations leads to systems with increasing complexity [2]. Designing appropriate user interfaces for experienced users can be quite challenging, but it becomes even more difficult when considering a wide audience of unskilled users [1]. Hence, the problem of making computers and other ICT based services accessible to everyone extends far beyond the population of disabled and elderly users [2].

An even larger amount of people will be affected when Smart Homes and related technologies become available, yielding a great potential to support us in our daily life. This is true for average users, as well as those with special needs like elderly people, and people with disabilities. Technological developments in the sensor and wireless networks, miniaturization and increased computing power, as well as ongoing research in the field of HCI bring the vision of Ubiquitous Computing [3] and Smart Homes close to reality. This also means that computers, sensors and networked devices will surround us even closer in virtually every situation of our lives. It must be also taken into account that, although the underlying technologies for Smart Homes are already usable, the great breakthrough in terms of broad adoption has not yet taken place. One possible reason – among others – is that a large amount of research effort concerning Smart Homes was spent on technological improvements and pattern recognition so far, aside from some social considerations [4][5]. Only little work can be found concerning Smart Home users and the design of universally usable user interfaces for Smart Homes. Furthermore, we are facing a quite diverse market for smart homes with many proprietary solutions and only a few common standards. Consequently, another major problem is interoperability between different systems [6] and with that a lack of overarching usability concepts. Smart Homes are typically thought of having the following characteristics: context awareness, personalization, adaptive behavior, and anticipatory behaviour. These are without doubt essential elements of Ambient Intelligent systems. However, they frequently refer to the issue of adapting the Smart Home's behavior to the user, instead of focusing on the interaction between the user and their home.

Due to the huge variety of input/output channels in Smart Homes, interaction patterns will range from intended to not intended and from conscious to not conscious ones [7]. Although notable progress in the development of disappearing user interfaces has been made, enabling non-conscious and sometimes non-intended interaction between user and Smart Home (e.g., pattern recognition facilitating automatic control of lights, detection of unexpected situations like emergency situations, and automatic energy management [8]), there will always be situations in which the user wants or has to interact with the system in a conscious, intended and explicit way. Such situations can occur when users have to set up a system

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or when they need to choose between different options offered to them, or when the system needs confirmation. This kind of user interaction should be personalized, taking the users capabilities and needs into account.

Summing up, a solution for Smart Homes providing universal usability to users must on the one hand overcome the problem of providing appropriate interfaces for all types of users, and on the other hand it must integrate all types of Smart Home technologies, devices and services.

One established approach to overcome usage barriers are *adaptive user interfaces*, which can take the user's capabilities and other contextual data into account [9]. However, in most realized systems so far adaptive user interfaces can provide appropriate access to a single system only, solving the first part of the problem. To overcome the second part of the problem – integrating different and rapidly changing technologies – some middleware approaches [10][11] were proposed to mediate between the underlying, heterogeneous hardware.

This paper aims to address both sides of the problem. It discusses how MyUI, URC and openHAB can be integrated and combine the principles of adaptive user interfaces and their specific middleware approaches. Such a system should comprise at least three layers of abstraction. The bottom layer must provide an abstract view on devices, their functionalities and their internal states [10]. The middle layer must provide an abstraction of the tasks which can be performed in such a system and how devices can collaborate [12]. Finally, the top layer must provide an abstract view on the interaction between users and their Smart Home system [13].

The three technologies, which were chosen for investigation, cover all three layers. The URC technology [10] and openHAB [11] are abstracting from devices and services in a Smart Home system and the MyUI framework abstracts from applications and their tasks, as well as from specific interaction modalities.

MyUI [14] and URC [15] were both chosen due to their appropriate abstraction models. MyUI provides an abstraction model on the level of interaction between a user and an application, thus enabling an adaptation of the user interface. URC abstracts from devices and services connected to a Smart Home system so that they can be controlled with personalized user interfaces. Furthermore, the authors are involved in the development of both technologies and work together in the project *Prosperity4All* [16], which is part of the *Global Public Inclusive Infrastructure* and focuses on adaptations of user interfaces of ICT-based systems [17]. Finally, openHAB [11] was chosen due to the fact that it is an open source project that features a modular, extensible design.

The remainder of this paper is structured as follows. The next Section II will give an overview about current Smart Home related issues in HCI and adaptive user interfaces research. In Section III, requirements for a user interface platform are presented. Section IV introduces MyUI, the Universal Remote Console framework and the openHAB platform, and their possible contributions to adaptive user interfaces in Smart Homes. In Section V, we show how these technologies can be combined to harness their individual strengths and avoid their weaknesses, in three alternative architectures. Section VI then explains how the combined system can benefit from the adoption of personal preferences, as defined by the Global Public Inclusive Infrastructure (GPII). Finally, in Section VII, we summarize the content of this paper and draw some conclusions.

II. Related work

With the increasing influence of the Internet [1], as well as increasing importance of Hypermedia in public and domestic places [18], the question arose on how universal usability in electronic information and services can be made available to as many people as possible [1]. In 2000, Shneiderman proposed his research agenda on universal usability for web and other services [1], focusing on three challenges: technology variety, diversity of users, and gaps in user knowledge. Schneiderman and Richter mention that research on features for people with special needs and their inclusion in ICT can bring benefits to all users [1][2]. Particularly, Richter states that providing universal usability support for users with special needs can not be considered as orthogonal to the application [2].

Today, it is widely agreed that Smart Homes and the concept of Ambient Assisted Living can bring great benefit for a wide spectrum of users. Mavrommati and Darzentas present an overview over HCI issues related to Ambient Intelligence [7], and Saizmar and Kim suggest a three dimensional framework on HCI perspectives on Smart Homes [19]. Human, home and technology are pointed out as the main dimensions, and interaction between human/technology, technology/home and home/human are considered as relevant aspects. Saizmar and Kim also claim that HCI research in Smart Homes is limited and biased to specific situations [19]. This view is also shared by Mavrommati and Darzentas [7]. Abascal et al. criticize that, although many scenarios have been described in the field of Ambient Intelligence, the interface between the user and the system still remains unclear [20]. To improve acceptance of Ambient Intelligence and to make it capable to provide better life quality in a non-obtrusive way, Casas et al. point out the necessity to combine ongoing Ambient Intelligence technological developments with user-centered design techniques [21]. In the same vein, Mavrommati and Darzentas point to the necessity of focusing on a more user centered HCI perspective [7].

Studies like [22] and [23] have shown that also elderly people are willing to use Smart Home technologies for a longer independent life. It is acknowledged that Ambient Assisted Living technologies have the potential of providing safe environments for elderly people [24]. Nevertheless, at the moment technologies do not yet meet the needs of elderly people and current solutions overemphasize the importance of smart devices while either neglecting or lacking real implementations on the side of human interaction and human power [21]. Therefore, several authors have argued for a more user-centered view in the Ambient Assisted Living domain [21][25][26].

Kleinberger et al. [27] and Abascal et al. [20] are concerned with the design of appropriate interfaces in the field of Ambient Assisted Living. They come to the conclusion that natural and adaptive interfaces can bring great benefits to this field.

The PIAPNE Environment [20] is an adaptive Ambient Assisted Living system for elderly people based on three

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models: A user model (capabilities, permissions), a task model (user activity) and a context (environment) model. The system consists of multiple layers, including a middleware layer to bridge different network technologies and an intelligent service layer to which intelligent applications (interfaces) can be connected.

The DomoEsi Project is carried out at the Escuela Superior de Ingenieros de Sevilla and is mainly concerned with the problem of interoperability. The system is based on Universal Plug and Play (UPnP) as common interface from which software bridges to other Smart Home technologies can be build. Users can access the system via web browser, a Nintendo Wiimote controller or a voice interface. The different input modalities of the Wii controller (infrared camera, buttons, accelerometers) can be used to provide a simple adaptable interface for people with disabilities and with special needs [6].

Regarding the results from this literature research, we can state that so far a large amount of effort was spent on what is technologically possible rather than on user requirements. There is a growing awareness for a more user centered view on Smart Homes and related user interfaces. Nevertheless, existing systems either try to give a user access to a variety of devices and technologies [6][20] or provide adaptive user interfaces for a specific system [27]. An approach spanning over multiple Smart Home technologies, and providing an unconstrained set of personalized and adaptive user interfaces (for the sake of universal access) is still missing.

III. Requirements for an adaptive user interface platform

It must be taken into account that, when considering adaptation, both runtime and design time are essential parts of the process. At runtime, the user interacts with the system through the user interface. Different users come with different requirements regarding their needs and preferences, and the user interface should be universally usable to them. Before a user interface can be rendered at runtime, an application developer must specify some abstract model of the interaction between the user and the application, leaving some leeway of presentation and behavior to the renderer. This also means that components must be developed and designed during development time that can be later applied to the model and adapted to the user's needs at runtime [28]. It is also crucial that, for the successful deployment of adaptive user interfaces, the designer's requirements are taken into account [9].

A. Requirements from the user perspective

Shneiderman [1] presented a research agenda to achieve the goal of universal usability. Although the paper focuses on "web-based services and other services", the ideas contained therein are applicable to the field of Smart Homes and Ambient Intelligence.

The first challenge mentioned by Shneiderman is *technology variety*. Accordingly, problems exist due to a huge variety of hardware, software and network access technologies. The hardware and software aspects mainly relate to devices like PCs and laptops and the main aspect about network access is speed. Another closely related aspect of this problem is the fact that vendors and innovators like to continuously introduce new features and novelties in order to gain a competitive advantage. Unfortunately, this can have negative effects on usability for some users [1].

In the field of Smart Homes, the following similarities can be found. First, a large amount of devices, services and ideas are just on the edge of entering the market and most markets are expected to grow. Hence, these markets are very volatile. New models and new types of devices might appear or disappear from the market. Also, new companies might enter the market, or new protocols and standards might be introduced to control a Smart Home's appliances and services. Just like in all emerging markets, the succes of the Smart Home market will depend on the compatibility of existing with new evolving equipments. Probably, users can benefit the most by combining different systems and technologies in the same installation. This also includes the integration of already existing devices with new ones [6].

A proper approach to handle this challenge is *abstraction (U1)* – a way of providing a seamless and technology-agnostic view of the Smart Home to the user. The user should not have to care which protocol or home automation platform to use to control a certain device. They should be able to integrate any device easily in their Smart Home and use it according to their needs. Therefore, the installation and integration process should be supported by appropriate discovery mechanisms, and the devices should provide an *abstract user interface* [29] for seamless presentation on a variety of devices and environments. These also constitute important issues in the field of Ambient Assisted Living. The easier a new device can be integrated in an existing system, the lower are the costs for specialized personnel responsible for the installation and integration.

The second challenge mentioned by Shneiderman is *user diversity*. This concerns the different types of users using a certain system with a large variety of skills, prior knowledge, age, gender, and possible disabilities [1]. This becomes even more challenging when considering the heterogeneity of Ambient Assisted Living system users. Frequently, user interface designers have to cope with diverse and sometimes contradictory requirements for potential users; therefore, it is almost impossible to follow a design-for-all approach [20].

The solution to this problem are *pluggable user interfaces (U2)* [10][30]. Every user should be able to plug the user interface fitting best their needs to any system they want to control. Some users may want to use their smartphone with a touch screen to control a target system, others still like a regular remote control with buttons and a third group may want to use a speech interface. Finally, people with disabilities may use totally different ways to control their Smart Homes. One could think about Braille devices for blind people or a head mouse for people with motor impairments, for example. Furthermore, it is possible to employ different user interfaces providing different scopes of functionality.

The third and last challenge mentioned by Shneiderman are *gaps in user knowledge*. Concerns are due to the fact that many users do not know how to begin, what to choose in dialogue boxes or how to handle system crashes. Furthermore, the question is raised if users can begin with an interface that

 ISBN: 978-1-61208-369-8

contains only basic features (say 5% of the full system) and become experts at this level within a few minutes. A closely related aspect of this issue is the different learning speeds of users when handling a new system [1]. In this paper, we want to address these issues in a larger view by looking at the *longterm development of user knowledge and capabilities*. The gap between the functionality a system offers and the functions which can be or want to be used by a user can dramatically vary over time. Users can gain additional knowledge about a system due to continous usage of it, but they can also become more confused due to unexpected updates and new functions. Also, user skills can increase over time (e.g., recovery from accidents or strokes) or decrease due to aging or continiuous proceeding impairments (e.g., hearing, vision, or Parkinson).

An adequate solution to this challenge are *adaptive user interfaces (U3)*, which take the user, the interaction situation and environmental conditions into account. In [28], user interfaces are modeled as layered systems, consisting of three layers: presentation and input events, structure and grammar, and finally content and semantics. Any property of a user interface can be adapted to the context of use, which includes the user, the platform and the environmental context. The latter also includes issues like sunlight or noise. Further context conditions could also be issues like walking or fast driving [29]. Referring to the presentation layer, it can be affected by changing parameters like font size or colors. Due to appropriate underlying structures, also the way how information is exposed to the user can be adapted – less information, displayed on smaller instead of larger screens, or video clips in sign language instead of text for users with hearing disabilities. Finally, it is also possible to change the amount of displayed information. It might be reasonable to increase the amount of information with the experience of the user or adjust dialogues to interaction situations and with that contribute to a decrease in the gap of user knowledge. Anyway, it is crucial that the adaptations made by a System are transparent to the users and do not confuse them. Even more, an apropriate design of such a system and its adaptation mechanisms can help and guide a user to familarize with it [13].

B. Requirements from the designer perspective

Requirements from the designer's point of view are discussed by Peissner et al. [9], and the following relevant criteria are mentioned.

First, *modularity and clearly defined interfaces (D1)* are mentioned. The subdivision of a system in smaller modules and well defined interfaces allows to exchange different components against each other and to build a variety of solutions. Also, more work can be shared in a project team or several teams can work in parallel.

The second prerequisite is *expandability (D2)*. This means that existing system modules can be scaled within the adaptive system or also added and extended at a later stage. At the beginning of a project, a subset of modules can be provided and continuously expanded, also by external experts.

The final prerequisite is *openness (D3)*. In order to fit best the users needs, experts must be able to contribute to the development of appropriate solutions. It is unlikely that one expert has the knowledge about all user groups, so it is important that different experts can make their contributions.

IV. TECHNOLOGIES

For the purpose of this paper, we focus on three selected technologies. We show how each technology can contribute to the requirements presented in the previous section.

A. MyUI

1) Description of MyUI: The European research project MyUI [14] has developed a pattern-based approach of an infrastructure for automatically generated adaptive user interfaces.

The main components of the MyUI infrastructure [13] are:
The Pattern Repository. In MyUI, all knowledge on various user interface design solutions and adaptations is contained in design patterns. There are several types of design patterns in MyUI. Among them, the interaction pattern is a key concept, providing suitable user interface components for a specific interaction situation. All MyUI design patterns are included in the publicly available pattern repository [31]. This enables the integration of the knowledge on design solutions of a broad range of experts for different domains.
The Abstract Application Interaction Model (AAIM). To enable the automatic generation and adaptation of user interfaces, MyUI provides an abstract format to define the interaction possibilities of a user with the application. This format is called AAIM and is based on UML2 State Machine Diagrams. It concentrates on the common aspects of all possible user interface variants and does not contain specific presentation modalities or user interface elements.
The User and Context Management Infrastructure. MyUI adapts user interfaces based on a user and context profile. To create and maintain this profile, it interprets relevant characteristics of the end user and the environment based on events detected by different sensors [32]. These sensors include physical sensors like ambient light and noise as well as virtual sensors which, for example, detect the user's interaction behavior.
The Adaptation Engine. The generation and adaptation during runtime happens in a three-stage process. First, information on the user and context and the currently used device features are compiled into a user interface profile which defines general characteristics of the user interface. In the second stage, this information is used to select the most suitable design patterns according to the current application's AAIM. In the last step, the selected components render the corresponding concrete user interface. Adaptations due to profile changes additionally include mechanisms to manage the transition from the current user interface instance to the new one. Multiple software components, together referred to as the MyUI Adaptation Engine, implement this complex process.
The Development Toolkit. The role of developers significantly changes when implementing applications using the MyUI infrastructure. Instead of implementing the concrete user interface and its interaction logic, the main task is to create the AAIM and to connect it to the underlying business logic. To support this task, MyUI provides an Eclipse-based toolkit for the creation of adaptive user interfaces.

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For demonstration purposes, the MyUI project has built an interactive TV system. Among other things, this demonstrator provides a main menu, an e-Mail client and a weather forecast application. A set of patterns for these applications has been developed and documented in the pattern repository [31]. For example, the developed patterns provide solutions for font-size adjustments as well as for the adjustment of the screen complexity or the way information is displayed.

2) Strengths and weeknesses of MyUI: One of the main strengths of MyUI is its closeness to the user to whom a highly individualized interface is provided. The developed system is able to dynamically adapt the exposed user interface at runtime, taking the user and the environmental context into account (U3). Hence, MyUI clearly contributes to the aspect of adaptive user interfaces. Furthermore, the concept of patterns and their storage in the open repository enables developers to contribute new modules which can be used to support further adaptations for the user. This fits the criteria (D1), (D2) and (D3).

Unfortunately, only a limited number of patterns have been developed as of today. Most of them were developed for the demonstrators and focus on elderly people and patients recovering from strokes. Hence, in practice only a subset of possible users is supported.

Although with the AAIM an abstract model is provided, this does not contribute to an abstraction of the functionality and internal states of controllable devices and services, which can be found in a typical Smart Home. This is due to the fact that AAIM's goal is to build an abstract model of the interaction and the control flow between the user and the application. Still, AAIM might be useful for abstractions on a higher level like building interrelated tasks out of atomic elements.

B. Universal Remote Console (URC)

1) Description of URC: The URC framework is standardized in the international standard ISO/IEC 24752 which was first published in 2008 [15]. Currently, a revision is underway, and a new version is expected to be released by end of 2014. Technical guidelines and implementation guidance with regard to the URC ecosystem have been developed and are maintained by the openURC Alliance [10].

The main idea of the URC technology is to provide pluggable, portable and personalized user interfaces so that any device or service *(Target)* can be controlled by any controller that best fits the user's needs. The standard focuses mainly on electronic devices including the ones which can be found in Smart Homes. Thus, due to the provision of abstract user interfaces, use cases like the following are enabled. A person can change an old household device for a new one (e.g., a TV) while retaining the same familiar user interface, although the new device is produced by another company than the old one. Furthermore, it would be possible to control the same Target with different user interfaces. Also, in a hotel room, every guest could use their smartphone to control the TV and everyone could read all the labels on the screen in their native language [30].

To enable such scenarios, the Targets must provide an abstract user interface and a mechanism through which they can be controlled. In the URC framework, an abstract view on all targets is provided via the concept of *User Interface Sockets (or just Sockets)* and a corresponding description in XML format.

The internal states of a Target are represented in one or several instances of Sockets. These Sockets are the interface through which a target can be accessed by any Universal Remote Control. To familiarize controllers with any target, Targets must provide a corresponding User Interface Socket Description for each of their Sockets. These descriptions can contain:

- **variables:** for exposing dynamic content which can be changed by the Target or by the user;
- **commands:** to give the user access to a certain function of a device which cannot be performed by changing a single variable; and
- **notifications:** to send a message to the user in order to inform them about special situations when their attention is required.

Targets provide an abstract user interface to which any *pluggable user interface* can be connected, to fit the users needs. To build a specific user interface, additional information in form of labels is required. Therefore, the standard specifies an XML language for *Resource Sheets*. A Socket Description's elements can be referenced from Resource Sheets. It is usually possible that for a single Socket Description several Resource Sheets exist, for example one for each language.

The standard does not specify a certain network protocol for the URC technology. Instead, any network protocol can be used providing discovery, control and eventing. Today, we are surrounded by a large number of networked devices. Since it is unlikely that all of them are going to adopt the URC framework, the openURC Alliance follows a middleware approach which is called *Universal Control Hub (UCH)*.

The UCH is a profiling of the URC standard which enables non URC-compliant Targets and controllers to communicate with each other and make the benefit of pluggable user interfaces available to the user. The UCH virtually folds the connected Targets and controllers into a single gateway component. With the UCH approach, the User Interface Sockets no more run directly on the Target. Instead, they run inside the Universal Control Hub . The UCH provides *Target Adapters* and *User Interface Protocol Managers* (UIPMs) to connect Targets and controllers [33].

The internal state of Targets is represented by the corresponding Socket runtime component inside the UCH. A Target and the UCH connect to each other via the Target's preferred protocol (e.g., UPnP, KNX). Inside the UCH, a Target Adapter is responsible for the communication with the Target and for synchronizing the Target's internal state with any connected controller via the UCH. Controllers can communicate with the UCH via any protocol for which the UCH provides a UIPM. The UCH comes with a standard UIPM in form of an HTTP-based protocol (similar to REST) through which a controller can access and manipulate the Sockets running inside the UCH.

 ISBN: 978-1-61208-369-8

Aside from connecting to Targets and URCs, the UCH can provide additional user interface resources (e.g., from third parties) by connecting to a *Resource Server*. The user interface Socket Descriptions, Resource Sheets and other related resources described in the preceding paragraphs are located on the Resource Server.

Thus, the UCH provides a filtered set of pluggable user interfaces to the user, based on a specific use context. For example, this can involve the type of controller that is connected to the UCH: a desktop computer, a smartphone or something totally different like a Braille device or a speech interface. The user can now choose from the already filtered set the user interface that fits best their needs.

2) Strenghts and weaknesses of URC: The main advantages of the URC technology and the UCH infrastructure are: the abstraction from Targets (U1), and the concept of User Interface Sockets which serve as a basis for pluggable, personalized user interfaces – contribution to (U2); the existence of discovery processes and the availability of the Resource Server.

A great advantage is also the availability of the UCH which makes the whole framework accessible to non URC-compliant Targets and controllers. Furthermore, the framework is based on standards maintained by ISO/IEC and the openURC Alliance, thus, providing reliable APIs and XML languages for developers. Everybody is able to develop new adapters for Targets and URCs. The standards specify clear interfaces for these added modules (D1) which can be made available via the Resource Server and loaded at runtime. Hence the criteria (D2) and (D3) are also fulfilled.

One shortcoming is that at the moment only a few Target Adapters, Target Discovery Modules and Socket Descriptions are available for the UCH. However, the openURC Alliance actively promotes the technology and is working on the development of a vital ecosystem.

C. openHAB – Home Automation Bus

1) Description of openHAB: The open-source platform *openHAB* [11] follows a middleware approach addressing the large diversity of devices and network technologies in the field of home automation. There is currently no common language to bridge the different devices and home automation systems, and therefore the dependency on a certain vendor becomes a problem.

openHAB aims at integrating new technologies and devices in an existing home automation system through a community-based approach [11]. Thus, the development of the required software is not dependent on their vendors.

openHAB uses an OSGi based modular system for bridging different technologies and devices. *Bindings* are required to connect to a specific technology and device, which can be developed and deployed as an OSGi bundle.

To provide features like uniform interface or overarching automation rules, openHAB abstracts from specific devices through the concept of *items*. An item is a real or virtual variable of a device or service. Items must be defined and related to specific devices or services (with a specific IP address or unique identifier) in a separate configuration file.

Values of variables are stored inside the runtime system in a *stateful repository*, together with the variable names. The repository is continuously synchronized with connected devices and can be accessed by any component that needs information about the device status (e.g., the integrated rule engine for automation, or a connected user interface).

Beside the stateful repository, openHAB also features an *asynchronous eventbus*. OSGi bundles use the eventbus to inform other bundles about events, and also to be updated by other bundles on external events. Bundles can change items and trigger actions by *commands*, and this change will be disseminated on the eventbus by *status update* messages.

2) Strengths and weaknesses of openHAB: The most important advantage of openHAB is its support for existing and emerging home automation systems. Existing technologies like EnOcean, KNX, Z-Wave and others are supported through special bindings. New technologies can be easily supported through the development of new bindings, which can be deployed at runtime (D2). Furthermore, an already established community is continuously supporting the framework to stay up to date with the latest trends and developments in the field. From its beginning, openHAB focused on a modular approach reflected in the choice of OSGi (D1) and the contributions from a vital community (D3).

Weaknesses of openHAB are especially noticeable in the support of appropriate user interfaces. The framework is following an approach of a unified user interface to the home automation system with all connected devices. There are both native solutions for iOS and Android, as well as Web-based solutions. Some of the user interface components can be manually adapted, but there is very little support for adaptive elements. To define the elements shown in the user interface, a separate configuration file for every user may be created (this could be construed as an *adaptable* user interface). *Adaptive* aspects are only supported in identifying the device on which the user interface is running on, and adapting the user interface properly to the device's capabilities.

D. Contributions of the three platforms to an adaptive user interface platform

Focusing on the requirements adaptivity, personalization and abstraction (see Section III), the following issues are critical for a common platform for adaptive user interfaces in Smart Homes:

1) **MyUI** provides an environment to render and adapt a user interface to the user context during runtime. It also includes mechanisms helping to set up an initial user interface. Hence it serves the goal of exposing an *adaptive user interface*.
2) **The URC technology** with its concept of User Interface Socket Descriptions serves as a basis for pluggable user interfaces and thereby, as a basis on which MyUI can build upon. The User Interface Socket Descriptions provide an *abstract user interface* and with that an abstract view on Targets. The UCH is needed as middleware layer exposing sockets and their descriptions, and it serves as a gateway to the Resource Server which provides User Interface

 ISBN: 978-1-61208-369-8

Socket Descriptions and additional resources required to provide for *pluggable* user interfaces.

3) **openHAB** offers great opportunities to bridge different backend technologies. It is also a middleware hosting component to communicate with different devices using different protocols. Due to its concepts of items, commands and update events it also serves as an additional abstraction layer for heterogeneous home networks.

Although both URC and openHAB are middleware approaches that have some concepts in common, both are equally important and needed. In theory, both frameworks support different home automation system technologies and abstract user interfaces. In practice, openHAB supports more systems than URC does, but URC provides more sophisticated abstraction mechanisms. In addition, URC supports a discovery mechanism that is mandatory for good usability. So both technologies are required, in order to complement each other.

V. POSSIBLE ARCHITECTURES FOR INTEGRATION

In this section, we present three different architectures, reflecting on how the above described technologies may be integrated into a common platform for adaptive user interfaces.

All approaches have the following aspects in common:

- **Stand-alone controller with optional MyUI runtime support:** The controller runs on a separate device that communicates with the UCH. This controller may execute an instance of the MyUI runtime for dynamic adaptations at runtime. Note that the MyUI controller has a light-weight coupling to the rest of the system via the URC-HTTP protocol (U2). Hence, it can be easily exchanged with any other module, providing a different kind of adaptation engine. It is also possible to run a simple Web interface on the controller, without any dynamic adaptation features.
- **Integrated Resource Server:** The UCH infrastructure and the MyUI framework both use an external server to store additional resources. The UCH connects to the Resource Server to obtain Socket Descriptions and additional resources required for building the pluggable user interfaces which are exposed to the controller. The MyUI framework uses the MyUI repository, which includes the patterns required for parameterizing and building the adaptive user interface. Since both servers supply additional resources for building individualized user interfaces, it makes sense to integrate them in a single one. Such a repository (Resource Server) can contain all URC resources, and all MyUI patterns.

A. Architecture 1: The three-component system

The first approach is a very loosely coupled architecture. All three major components, the controller (optionally with the MyUI runtime), the UCH and the openHAB runtime are deployed on their own, connected only via HTTP and appropriate Web interfaces. The controller connects to the UCH via the URC-HTTP protocol. The openHAB REST API is used to connect the UCH and the openHAB runtime.

Unfortunately, the openHAB framework is lacking appropriate functionality for the discovery of new targets. Hence, we have to devise a rather complex discovery process: After the discovery of a new target, the corresponding Target Discovery Adapter notifies the UCH about the new target. The UCH then connects to the Resource Server and obtains the related information. Now, the new target-related variables (as defined in the User Interface Socket Description) must be introduced in the openHAB runtime. However, this functionality is currently not supported by the openHAB REST API. In order to work around this problem, the architecture could be extended by a *Target Discovery Message Sender (TDMS)* (inside the UCH), and a *Target Discovery Message Receiver (TDMR)* (as OSGi bundle in the openHAB runtime). After the discovery of a new device in the UCH, the TDMS would send a message (e.g., via HTTP) with all relevant information to the TDMR. After the reception of a new message, the TDMR would update the openHAB configuration (i.e. the openHAB configuration file where items and related device addresses are specified). From this point, the UCH and the openHAB runtime would be synchronized via the openHAB REST API.

To avoid redundant status information being stored in the openHAB Item Repository, as well as in the Sockets of the UCH, we propose to implement *light-weight Sockets* in the UCH. That way it would be sufficient to store a Target's internal state only in the openHAB Item Repository. A controller request on a Target variable would then be sent to the UCH where the light-weight Socket would forward it to the openHAB REST API Target Adapter. The openHAB runtime would respond to the request, and the response would be forwarded by the light-weight Socket to the controller.

B. Architecture 2: Integration of openHAB into the UCH

For a deeper integration, we could integrate openHAB into the UCH via a Target Adapter. Target Adapters are protocol handlers enabling the control of connected Targets with the UCH by using a Target-specific protocol (e.g., UPnP, KNX). Developers can build Target Adapters for any protocol they want to support and load them at runtime into the UCH.

Since OSGi frameworks run from any Java application, it is possible to embed the openHAB runtime in a UCH Target Adapter serving as a proxy between the two frameworks. This specialized *openHAB Adapter* could be deployed in the UCH as a regular Target Adapter. Internally, it would have full access over the OSGi framework hosting the openHAB runtime. The OpenHAB Adapter would forward all communication from the UCH to the openHAB runtime and vice versa. The openHAB runtime would be responsible for direct communication to connected devices. Again, the discovery of new Targets must be done by the UCH and then configuration updates must be injected into the openHAB runtime, either through edits on the openHAB configuration file, or through messages sent on the openHAB eventbus.

The advantage of this architecture over the loosely coupled version is that the UCH can access the openHAB runtime in a direct way (including the eventbus) through the hosting OSGi framework, and not only through the openHAB REST API.

 ISBN: 978-1-61208-369-8

C. Architecture 3: UCH as openHAB Item repository

The two previously described architectures have the advantage of keeping to a great extend the independence of the three involved systems, but this also implies some disadvantages. Some problems like the discovery process may only be solved with extensive workarounds and the concept of Items and Sockets could lead to redundancies. Hence, a more integrated solution is desirable.

The openHAB framework and the reference implementation of the UCH are both written in Java. Both use similar abstraction models (Sockets, Item Repository), and keep internal states of connected devices. To send messages to devices, openHAB uses commands over the eventbus and appropriate bindings to translate them to the device-specific protocols. In the UCH, commands are described as part of Socket Descriptions and triggered through specific Target Adapters. The main idea of the following approach is to integrate the UCH into the openHAB framework, mainly due to a replacement of the openHAB Item Repository with the UCH Socket repository. This approach is possible because both systems are implemented in Java, and due to the concept of modularization provided by the OSGi framework. To realize such an approach, the following modifications in the UCH system must be made:

- First, it must be assured that there is an interface through which a controller can access the UCH. There must be a bridge between the servlets (belonging to the UCH) and the OSGi framework in which the sockets are deployed and on which the servlets must operate on. Therefore, the UCH's servlets must be registered at the executing HTTPService of the OSGi framework.
- Second, the UCH must publish an OSGi service to give other bundles access to administrated Sockets. The Socket variables now serve as Item variables. The service's key must be the one of the openHAB Item Repository.
- Third, the UCH discovery process must be modified as follows: After the discovery of a new device or service, a new socket must be instantiated, and at the same time, the device's or service's address/ID must be introduced to the openHAB configuration.

VI. Further Integration with GPII

The Global Public Inclusive Infrastructure (GPII) is an initiative for the development and installation of an infrastructure for adaptations of user interfaces of ICT-based systems. As a main component, it introduces a *personal preference set* carrying a user's individual needs and preferences, to be applied across many platforms. For example, a ticket machine in a public space might automatically display a larger font or a high-contrast mode if the user has set so in their preference set. The GPII personal preference consists of simple key-value pairs. It can be stored either locally (e.g., on a USB stick that the user carries around with them) or centrally on a dedicated secure server, depending on the user's choice.

Among the technologies that we have inspected in this paper, only MyUI has its own notion of user preferences. Although the vocabulary differs from that of the GPII preference set, both use a similar format (key-value pairs). Therefore, it should be possible to transform MyUI's vocabulary into the vocabulary used by GPII, and thus, take advantage of the interaction pattern knowledge base of MyUI. In the URC framework, a UCH may carry any user preference set, including the GPII preferences. openHAB does not define any data on user preferences.

In all three architectures described in Section V, the GPII personal preference set can be easily integrated on the front-end, i.e., on the controller code. This will provide additional benefits, such as:

- The system remembers the user's preferences, e.g., the choice of the preferred pluggable user interface.
- When the person uses a new controller for the first time, appropriate user interface adaptations could be suggested to the user based on their preferences for other controllers that they have already used.
- The system could propose advanced user interface settings that the user may not be aware of. The proposed settings would be derived from a rule base or from the analysis of a pool of users (statistical analysis).

VII. Summary and conclusion

Future Smart Homes will offer user interfaces enabling explicit interaction between users and the devices and services they host. These user interfaces should be aligned to principles of universal usability and thus, be made accessible for as many users as possible, including older users and persons with special needs.

We have aligned the three challenges for the provision of universal usability for Web and other services, as described by Shneiderman, to the context of Smart Homes. This resulted in the concepts of abstract, personalized and adaptive user interfaces. Applying these concepts properly to Smart Homes, it is possible to bridge different technologies as well as to provide every user with a user interface that best fits their needs and preferences. Furthermore, the user interface can be adapted to environmental conditions and capabilities of the user that may change over the user's lifetime.

MyUI, the Universal Remote Console framework and openHAB were examined regarding their contribution to the three concepts. It was found that MyUI can provide a powerful adaptation engine and can fulfill the requirement of adaptive user interfaces. The URC framework provides, due to its abstract user interface, a platform for pluggable user interfaces on which adaptation frameworks like MyUI can build upon. Furthermore, the UCH can be used together with the openHAB runtime to bridge different technologies and protocols on the backend.

We have presented three approaches as various combinations of these technologies, ranging from a loosely coupled three-component system to a completely OSGi-based system. All three architectures cover the protocol layer up to the user interface layer. Thus, users are able to control their Smart Home, consisting of any combination of devices and services,

 ISBN: 978-1-61208-369-8

independent of the required protocol, by using a controller that best fits their needs.

Finally, we have described how the personal preference concept of the Global Public Inclusive Infrastructure (GPII) can be integrated with the three architectures. Thus, personalized preference sets, stored locally or in the cloud, could support user interface adaptation, thereby providing personalized and cross-platform universal usability for everyone and wherever it is needed.

In the future, we plan to implement one of the presented architectures, possibly with further modifications, as part of the European Prosperity4all project [16]. In this joint implementation, the user interface shall adapt to the users needs, thereby taking a GPII preference set into account. The preference set will also include data from the AsTeRICS model reflecting a configuration of input devices for people with motor impairments [34]. The resulting implementation will be made available to the public as open-source release.

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REFERENCES

[1] B. Shneiderman, “Universal usability,” Communications of the ACM, vol. 43, no. 5, 2000, pp. 84–91.

[2] K. Richter and M. Hellenschmidt, “Interacting with the ambience: Multimodal interaction and ambient intelligence,” Interaction, vol. 19, 2004, p. 20.

[3] M. Weiser, “The Computer for the 21st Century,” Scientific American, vol. 265, no. 3, January 1991, pp. 66–75, URL: http://www.ubiq.com/hypertext/weiser/SciAmDraft3.html [accessed: 2014-08-15].

[4] S. Solaimani, W. Keijzer-Broers, and H. Bouwman, “What we do and dont know about the Smart Home: an analysis of the Smart Home literature,” Indoor and Built Environment, 2013, URL: http://ibe.sagepub.com/content/early/2013/12/27/1420326X13516350.full.pdf+html [accessed: 2014-08-15].

[5] M. Chan, D. Estve, C. Escriba, and E. Campo, “A review of smart homes - Present state and future challenges,” Computer Methods and Programs in Biomedicine, vol. 91, no. 1, 2008, pp. 55–81, URL: http://www.sciencedirect.com/science/article/pii/S0169260708000436 [accessed: 2014-08-15].

[6] J. M. Maestre and E. F. Camacho, “Smart home interoperability: the DomoEsi project approach,” International Journal of Smart Home, vol. 3, no. 3, 2009, pp. 31–44.

[7] I. Mavrommati and J. Darzentas, “An overview of ami from a user centered design perspective,” in Intelligent Environments, 2006. IE 06. 2nd IET International Conference on, vol. 2, July 2006, pp. 81–88.

[8] A. Schmidt, “Interactive context-aware systems interacting with ambient intelligence,” Ambient intelligence, no. Part 3, 2005, pp. 159–178.

[9] M. Peissner, A. Schuller, D. Ziegler, C. Knecht, and G. Zimmermann, “Requirements for the Successful Market Adoption of Adaptive user interfaces for Accessibility,” in Universal Access in Human-Computer Interaction. Design for All and Accessibility Practice, ser. Lecture Notes in Computer Science, C. Stephanidis and M. Antona, Eds. Springer International Publishing, 2014, no. 8516, pp. 431–442, URL: http://link.springer.com/chapter/10.1007/978-3-319-07509-9_41 [accessed: 2014-08-15].

[10] “OpenURC,” 2014, URL: http://www.openurc.org/ [accessed: 2014-08-15].

[11] “openHAB - empowering the smart home,” 2014, URL: http://www.openhab.org/ [accessed: 2014-08-15].

[12] G. Zimmermann, “Open user interface standards-towards coherent, task-oriented and scalable user interfaces in home environments,” in Intelligent Environments, 2007. IE 07. 3rd IET International Conference on. IET, 2007, pp. 36–39.

[13] M. Peissner, D. Häbe, D. Janssen, and T. Sellner, “MyUI: Generating Accessible user interfaces from Multimodal Design Patterns,” in Proceedings of the 4th ACM SIGCHI Symposium on Engineering Interactive Computing Systems, ser. EICS ’12. New York, NY, USA: ACM, 2012, pp. 81–90, URL: http://doi.acm.org/10.1145/2305484.2305500 [accessed: 2014-08-15].

[14] MyUI Consortium, “MyUI project Official Web Page,” 2014, URL: http://www.myui.eu/ [accessed: 2014-08-15].

[15] “Iso/iec 24752. information technology – user interfaces – universal remote console – 5 parts,” 2008.

[16] Prosperity4All, “Prosperity4All website,” URL: http://www.raisingthefloor.org/prosperity4all/ [accessed: 2014-08-15].

[17] “Home - gpii.net,” 2014, URL: http://www.gpii.net/ [accessed: 2014-08-15].

[18] J. Fink, A. Kobsa, and A. Nill, “Adaptable and adaptive information provision for all users, including disabled and elderly people,” New review of Hypermedia and Multimedia, vol. 4, no. 1, 1998, pp. 163–188.

[19] T. Saizmaa and H. Kim, “A holistic understanding of HCI perspectives on Smart Home,” in Networked Computing and Advanced Information Management, 2008. NCM’08. Fourth International Conference on, vol. 2. IEEE, 2008, pp. 59–65.

[20] J. Abascal, I. F. De Castro, A. Lafuente, and J. Cia, “Adaptive interfaces for supportive ambient intelligence environments,” in Computers Helping People with Special Needs. Springer, 2008, pp. 30–37.

[21] R. Casas, R. B. Marín, A. Robinet, A. R. Delgado, A. R. Yarza, J. Mcginn, R. Picking, and V. Grout, User modelling in ambient intelligence for elderly and disabled people. Springer, 2008.

[22] G. Demiris, M. J. Rantz, M. A. Aud, K. D. Marek, H. W. Tyrer, M. Skubic, and A. A. Hussam, “Older adults’ attitudes towards and perceptions of smart home technologies: a pilot study,” Informatics for Health and Social Care, vol. 29, no. 2, 2004, pp. 87–94, URL: http://dx.doi.org/10.1080/14639230410001684387 [accessed: 2014-08-15].

[23] G. Demiris, D. P. Oliver, G. Dickey, M. Skubic, and M. Rantz, “Findings from a participatory evaluation of a smart home application for older adults,” Technology and Health Care, vol. 16, no. 2, 2008, pp. 111–118.

[24] H. Sun, V. De Florio, N. Gui, and C. Blondia, “Promises and challenges of ambient assisted living systems,” in Information Technology: New Generations, 2009. ITNG’09. Sixth International Conference on. IEEE, 2009, pp. 1201–1207.

[25] O. B. Henkemans, K. Caine, W. Rogers, and A. Fisk, “Medical monitoring for independent living: user-centered design of smart home technologies for older adults,” in Proceedings of the Med-e-Tel conference for eHealth, telemedicine and health information and communication technologies, 2007, pp. 368–373.

[26] C. Röcker, “User-Centered Design of Intelligent Environments: Requirements for Designing Successful Ambient Assisted Living Systems,” in Proceedings of the Central European Conference of Information and Intelligent Systems (CECIIS’13), 2013, pp. 4–11.

[27] T. Kleinberger, M. Becker, E. Ras, A. Holzinger, and P. Müller, “Ambient intelligence in assisted living: enable elderly people to handle future interfaces,” in Universal access in human-computer interaction. Ambient interaction. Springer, 2007, pp. 103–112.

[28] G. Zimmermann, G. C. Vanderheiden, and C. Strobbe, “Towards deep adaptivity a framework for the development of fully context-sensitive user interfaces,” in Universal Access in Human-Computer Interaction. Design and Development Methods

 ISBN: 978-1-61208-369-8

for Universal Access, ser. Lecture Notes in Computer Science. Springer International Publishing, 2014, no. 8513, pp. 299–310, URL: http://link.springer.com/chapter/10.1007/978-3-319-07437-5_29 [accessed: 2014-08-15].

[29] G. Zimmermann, B. Jordan, P. Thakur, and G. Y., "Abstract user interface, Rich Grouping and Dynamic Adaptations - A Blended Approach for the Generation of Adaptive Remote Control user interfaces," in Assistive Technology: From Research to Practice, ser. Assistive Technology Research Series, vol. 33. Vilamoura, Portugal: IOS Press.

[30] G. Zimmermann and G. Vanderheiden, "A dream... The universal remote console," ISO Focus+, 2010, pp. 11–13, URL: http://trace.wisc.edu/docs/2010-URC-ISOFocus/ [accessed: 2014-08-15].

[31] M. Consortium, "Myui pattern browser," 2014, URL: http://myuipatterns.clevercherry.com/index.php?title=Main_Page.

[32] O. Strnad, A. Felic, and A. Schmidt, "Context Management for Self-adaptive user interfaces in the Project MyUI," in Ambient Assisted Living, ser. Advanced Technologies and Societal Change, R. Wichert and B. Eberhardt, Eds. Springer Berlin Heidelberg, 2012, pp. 263–272, URL: http://dx.doi.org/10.1007/978-3-642-27491-6_19 [accessed: 2014-08-15].

[33] G. Zimmermann and G. Vanderheiden, "The Universal Control Hub: An Open Platform for Remote user interfaces in the Digital Home," Springer LNCS. Human-Computer Interaction. Interaction Platforms and Techniques., vol. 4551/2007, 2007, pp. 1040–1049, URL: http://www.accesstechnologiesgroup.com/pubs/ZimmermannVanderheiden2007-HCII/ [accessed: 2014-08-15].

[34] C. Veigl, C. Weis, K. Kakousis, D. Ibanez, A. Soria-Frisch, and A. Carbone, "Model-based design of novel human-computer interfaces – the assistive technology rapid integration & construction set (AsTeRICS)." IEEE, pp. 1–7.

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User Models and Domain Ontologies for Generating Personalized Questions and Answers

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***Abstract*—The incorporation of user models has become more popular in recent years. This paper describes how user models, domain ontologies and natural language generation techniques can be integrated to generate personalized questions and answers related to a particular scenario. For this purpose, a general organization of different types of knowledge involved is proposed, that facilitates its adaptation to different domains, user models and languages. In this proposal, the domain conceptual knowledge is represented by a domain ontology, that provides a framework for representing the user's knowledge and interests. Ontologies provide a powerful formalism because they allow the representation of detailed descriptions of concepts, attributes and relations, thus facilitating richer inferences about user knowledge and interests. Additionally, in the approach presented, the domain concepts in the ontology are also related to a general syntactic-semantic taxonomy that facilitates the generation of more appropriate questions and answers for each user. The proposed organization has been applied for generating personalized questions and answers, that help the user when searching information about university courses**.

Keywords-user models; personalized content generation; domain ontologies, multilingual language generation.

I. INTRODUCTION

The integration of user models and domain ontologies is a relatively new direction of research to personalize different types of contents and applications. Although user models have been used since the 80's, during the last years the interest in adapting the contents to the different types of users is increasing in many areas (as described in [1] and [2]). The huge amount of contents and systems in the web, where user population is diverse, have also increased the interest on the incorporation of users models in different types of systems, such as web communication systems, intelligent web systems, information extraction, e-learning and e-health.

User's models can be used for personalized content generation and can also be incorporated in adaptive systems, that behave different for different users. User's models can incorporate diverse information from the user. Most models use one of the following features about the user: background (i.e., profession), knowledge, interest, goals and individual traits (personality and cognitive factors). Information on the context of the user's work can also be modeled. Additionally, more than one of these features can also be combined.

The use of a specific user's feature is usually related to the type of the application that incorporates the model. Thus, user's background is used most frequently for content adaptation (as in the work on medical domain described in [3]), user's interests are usually incorporated in information retrieval and recommended systems (such as the dialogue system described in [4]), user's knowledge is useful in educational systems, user's goals are incorporated in intelligent interfaces, while individual traits are considered in several commercial systems (such as the system described in [5]).

This paper describes the use of information about the user's backgrounds to generate personalized questions (and their answers) in a specific domain. Information about the user profession or experience is considered when classifying the users in different groups or stereotypes. Specific questions and answers for each group are generated semi-automatically from the domain ontology.

Stereotypes have been used for more than 25 years because they are simple and can be powerful for several domains. Stereotypes have been used in domains where the distinction of two or three user groups is easy and useful, such as the medical domain, where users can be classified as professionals (and subclassified as doctors, nurses and students) and patients (and subclassified considering different knowledge levels). Information necessary to classify the user is provided explicitly, usually by the user.

There are already several research works that integrate user models and domain ontologies [6][7][8]. Ontologies provide a framework for representing the user knowledge (or interest) about different domain concept, or about the attributes describing the concept. Ontologies provides a more powerful formalism than other forms of semantic

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representation, used in previous work on user adaptation (such as concept networks), because they allow the representation of detailed descriptions of concepts, attributes and relations, thus facilitating richer inferences about user knowledge and interests.

The approach described in this paper differs from other works, such as the above mentioned, in that it is focused on the optimization of the generation of questions and answers in several languages. For this purpose, it uses a general syntactic-semantic taxonomy (described in [9]), that establishes general relations between the ontology concepts and the linguistic structures supporting questions and answers about them.

The integration of user models and language generation techniques has also focused several research works, such as the relevant information-systems Ilexand and PEBA-II (described in [10]), that dynamically generates pages according to the user profiles. However, those works used other language generation techniques, not based on ontologies.

The organization of the conceptual and linguistic knowledge that is proposed in this paper was already incorporated in an adaptive dialogue system (described in [11]), where information on how well the communication is doing is used by the system to select the most appropriate respond to a user's intervention: a directed (explicit) question or a more open message. The approach presented in this paper incorporates a user model that uses the domain ontology to represent the user background related to the domain concepts.

In the approach presented, the process to generate the personalized questions and answers consists of four steps: The study of the different types of users, the representation of the domain concepts, the relation of the attributes describing concepts to the syntactic-semantic taxonomy and, finally, the generation of questions and answers.

The work described is being done in the framework of the Spanish project SKATER, for Scenario Knowledge Acquisition by Textual Reading. The personalized questions and answers are generated from the ontology describing a particular scenario, previously built from text.

The next section describes how the proposed approach has been applied for a particular scenario, in which the user is seeking specific information about a particular university course. Then, the last section describes the conclusion and future work.

II. GENERATING PERSONALIZED QUESTIONS AND ANSWERS

As mentioned in the introduction, several systems incorporate user models and ontologies to adapt contents and presentations to different types of users. For example, in several scenarios, the generation of personalized questions, dialogues and summaries can help the adaptation of the web contents and systems to the user's needs.

Domain ontologies have been incorporated in many different types of applications because they provide a great flexibility to represent knowledge and are easy to adapt to different domains. Furthermore, they are especially appropriate for representing conceptual knowledge in multilingual systems, because they provide a common semantic representation for the several languages supported.

Recently, domain ontologies have also been used for personalizing presentation in several communication systems (such as [12] and [13]). Ontologies favor the generation of personalized content because they provide a framework for representing user's domain knowledge (or interest). In more simple semantic representations the user's knowledge about a domain concept is represented as a binary value (known-not known) or as a weighted value. Ontologies allow the representation of more detailed information on the user's knowledge about a specific concept, such as that related to the different attributes describing the concept and the relations with other concepts. Additionally, they also support inference and other reasoning mechanisms.

This section describes how domain ontologies are used to generate personalized questions and answers for several user's stereotypes. In a particular domain, groups of users or stereotypes are distinguished because they have different interests and/or knowledge. This information is represented as an overlay of the domain concepts in the ontology.

The approach presented has been applied to the scenario in which the user searches for specific information about a specific university course. In this particular scenario, the representation of the domain concepts and the interests of the different type of users is simple, as shown in Figure 1. There are only two domain concepts involved and two different types of users: teachers and students. The domain concepts are described by a set of attributes, and user domain interests are represented as a binary value associated with each of the conceptual attributes. When generating personalized questions, only the conceptual attributes interesting for each specific user type are considered.

This approach uses of a syntactic-semantic taxonomy that defines general relations between conceptual attributes and linguistic knowledge to facilitate the generation of the questions for different domains and languages.

The process of generating personalized questions and answers for a particular scenario consists of the four steps:

- Study of the needs of the different types of users.
- Description of the domain concepts involved in the scenario**.** Each concept is described by a set of attributes and those attributes are associated with the specific types of users interested on their values.
- Relating conceptual and linguistic knowledge.
- Generation of the questions and answers from the conceptual attributes for each type of user.

The next subsections describe the adaptation of these four general steps to generate the personalized questions and answers about university courses.

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A. The Study of the User needs

Most web universities incorporate the description of the degrees and master courses the university offers. Those descriptions are usually accessed by both, teachers and students. In this particular scenario, teachers and students can be considered different types of users because the specific information they need about a course is not exactly the same. Although course descriptions in web universities usually include information interesting for both, teacher and students (i.e., the number of the credits of the course), they also can include formal details only interesting for teachers (such as the course code and the responsible unit) and other more practical information mostly accessed by students (i.e., the teaching language and the teacher email)**.**

B. Representing the Domain Concepts

The description of most courses in a web university usually includes similar information. There are two main concepts involved in this scenario: **Course** and **Teacher**. A partial description of those concepts is shown in Figure 1. As shown in the Figure 1, each conceptual attribute is associated with the specific group of users interested on its value: teacher, student or both (represented by **T/S**). The questions (and the corresponding answers) for a group of users are generated by selecting the specific attributes associated within the particular group**.**

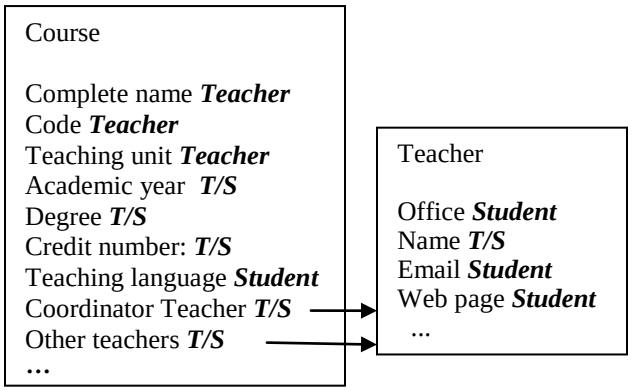

Figure 1. Concepts describing course information

C. Relating Conceptual and Linguistic Knowledge

The concepts and attributes describing the domain have to be associated with the corresponding lexical entries for each language. Additionally, in order to generate more natural language expressions, the conceptual attributes are also associated with the corresponding category in a syntactic-semantic taxonomy. For example, the attribute *Credit number* describing the course is associated with the class *quantity*, the attribute *Coordinating teacher* with the class *who_does* and the attribute *Office address* with the class *where*. Each category in the syntactic-semantic taxonomy is associated with the specific linguistic patterns needed for generating question and answers in different languages**.**

D. Generating Questions and Answers

Two general grammar rules are used to generate questions and answer from the conceptual representations:

Rule 1. questionattribute -> questionpattern conceptname

where *questionpattern* corresponds to the linguistic pattern associated with the sintactico-semantic class of the attribute (i.e attributes in the class *quantity* are associated with the pattern *how many*).

Rule 2. answerattribute -> attributename conceptname verbe attributevalue

Using these two general rules, the questions and answers for the conceptual attributes associated with each user's group are automatically generated. Then, the resulting sentences have to be manually supervised.

```
% generatext (Lex,Para,Lex).
generatext([],_,[]).
generatext([Leftcat1|Rest],Param,[[Leftcat1,Text1]|TextF]):-
        ruletext(Leftcat1,Param,Text1),
        generatext(Rest,Params,TextF).

%ruletext(catlgory,Lex).
ruletext(Leftcategory,Parameters,Text):-
         rule(Leftcategory,Parameters,Rightpart),
         obtainlexentries(Parameters,Rightpart,Text).

% obtainlex(Param,categoriesrightpart,Lex).
obtainlexentries(P,[],[]).
obtainlexentries(P,[Cata|R],[L1|L]):-
     lex(Cata,L1),obtainlexentries(P,R,L).

%rule(Leftcategory,Parameters,Rightpart).
%questionattribute - questionpattern  conceptname

rule(questionattribute,
parameters(language(L),user(U1),concept(C),attribute(A)),
[questionpattern(language(L),user(U),concept(C),attribute(A)),
conceptname(language(L),concept(C))]):-
      member(U1,U).

% answerattribute -
%  attributename conceptname verbe attributevalue

rule(answerattribute,
parameters(language(L),user(U1),concept(C),attribute(A)),
[attributename(language(L),user(U),concept(C),attribute(A)),
of(language(L)),
conceptname(language(L),concept(C)),
verbe(language(L)),
attributevalue(language(L),user(U),concept(C),attribute(A))]):-
            member(U1,U).
```

Figure 2. Grammars for generating questions and answers

The general grammar rules described can be implemented following different formalisms. Figure 2 shows their implementation in Prolog language. The unification mechanism of Prolog is appropriate for working with such conceptual grammars, because the general categories can be augmented with features representing specific information, such as the user group, the language as well as the concept and attribute identifiers.

As shown in Figure 2, Rule 1 and Rule 2 are implemented in Prolog using a predicate (*rule*) with three parameters (*Leftcategory*, *Parameters*, *Rightpart*), where *Leftcategory* is the category in the left part of the rule. The category *Leftcategory* is augmented by the features appearing in the second parameter (the predicate *parameters)*: language (represented by **L**), user (**U1**), concept (**C**) and attribute (**A**). The third parameter of the predicate *rule*, *Rightpart*, is a list containing the categories in the right part of the rule and these categories have been augmented with the corresponding features.

For example, Rule1 is represented as the following predicate:

```
rule(questionattribute,
 parameters(language(L),user(U1),concept(C),attribute(A)),
[questionpattern(language(L),user(U),concept(C),attribute(A)),
 conceptname(language(L),concept(C))])
```

The features associated with the left-part of the rule, *questionattribute*, are *language (L)*, *user(U1)*, *concept(C)* and *attribute(A)*. These four attributes have to be unified with the same features associated with the category *questionpattern*, and the category *conceptname*. That is, the variables associated with the corresponding features (**L** for *language*, **C** for *concept* and **A** for *attribute*) have to be the same, while the variable **U1**, associated with the feature *user*, has to be a member of the variable **U**, associated with the same feature in the category *questionpattern* and that represents a list of user groups interested on the conceptual attribute**.** Figure 3 shows examples of the generated questions and answers for the type of user *students* using Rule 1 and Rule 2.

Q1. How many credits does the course has?
The course has 6 credits
Q2 Who is the coordinator teacher of the course?
The coordinator teacher of the course is Dr. John Smith
Q3 Which is the teaching language of the course?
The teaching languages of the course are Catalan and Spanish
Q4 Where is the coordinator teacher office?
The coordinator teacher office is at U Building Office number 322.

Figure 3. Examples of question and answers for students

E. Considering other Scenarios

Other scenarios where a personalized presentation of web information can help the users have also been considered. For example, in the scenario where users access the web for finding information about a particular medical specialists two different types of users can be easily distinguished: professionals (doctors, nurses and medicine students) and no professionals.

The main concept in this domain is the concept doctor. A fragment of this concept description is shown in Figure 4. A more complete representation of the concepts involved in this scenario is described in [14].

Doctor

Name
Specialization
Visiting at equipment
Visiting timetable
….

Figure 4. A fragment of the concept Doctor

Although the information the two types of users need about the medical specialist can be the same (i.e., the complete name, the specialization and the place of work), the presentation of this information may differ. For example, professionals only need the name of the specialization, while information about the specific parts of the body related to the specialization can be useful for no professionals.

The approach described could also be adapted in scenarios where users can be classified in different groups considering their language level. For example, distinguishing between language natives and not natives can be useful in many different scenarios. The specific lexical words and syntactic patterns selected when generating questions and answers for each type of user would be different.

III. CONCLUSION AND FUTURE WORK

This paper is about how user models, domain ontologies and natural language generation techniques can be combined to generate questions and answers adapted to the different types of users. The approach described is based on the use of a domain ontology for representing the user's background related to the domain concepts. The ontology concepts are also related to a general syntactic-semantic taxonomy that facilitates the generation of the questions and answers in several languages. This modular organization of the knowledge in separated and declarative knowledge bases facilitates its adaptation to different domains, user models and languages.

Future work will also include working with more complex user models, such as those using dynamic information about the user's knowledge and interests that can be combined with user's background. This information obtained dynamically could also be represented as a layout of the domain ontology. The resulting user's model can be incorporated for different purposes, such as for educational

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applications. Furthermore, the same organization can be used to generate other language resources, such as personalized summaries, dialogues and domain-restricted grammars.

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REFERENCES

[1] P. Brusilovsky and E. Millán, "User Models for Adaptive Hypermedia and Adaptive Educational Systems", *The Adaptive Web*, LNCS 4321, 2007, pp. 3 – 53.

[2] P. Brusilovsky, "Adaptive Hypermedia", *User Modeling and User-Adapted Interaction*, 2001, vol. 11, pp. 87-110.

[3] S. Williams, P. Piwek, and R. Power, "Generating monologue and dialogue to present personalised medical information to patients", in.Proc. of the Eleventh European Workshop on Natural Language Generation, 2007, pp. 167 – 170.

[4] M.A. Walker et al. , "Generation and evaluation of user tailored responses in multimodal dialogue", *Cognitive Science*, September–October 2004, vol. 28(5), pp. 811–840.

[5] M. Belk, P. Germanakos, P. Zaharias, and G. Samaras, "Adaptivity Considerations for Enhancing User-Centric Web Experience", in Proc. Of ACHI, January 2012, pp- 348-353.

[6] D.G. Sampson, M.D. Lytras, G. Wagner, and P. Diaz, "Ontologies and the Semantic Web for E-learning" (Guest editorial), *Journal of Educational Technology & Society*, 2004, vol. 7, pp. 26-28.

[7] O. Stock, and al., "Adaptive, intelligent presentation of information for the museum visitor in PEACH", User Model and User-Adapted Interaction, 2007, vol. 17, pp. 257–304.

[8] F. Cena, S. Likavec, and F. Osborne, "Property-Based Interest Propagation in Ontology-Based User Model", UMAP, LNCS 7379, 2012, pp. 38–50.

[9] M. Gatius, "Improving knowledge representation for speed-up the generation of grammars for a multilingual web assistant", in Proc. Of Semdial, December 2013, pp- 188-189.

[10] M. Milosavljevic and J. Oberlander, "Dynamic hypertext catalogues: helping users to help themselves", In Proc. Of the ninth ACM conference HYPERTEXT, ACM, New York, NY, USA, 1998, pp. 123-131.

[11] M. Gatius and M. González, "A Flexible Dialogue System for Enhancing Web Usability", in Proc. Of WWW, April 2009, pp- 1167-1168.

[12] D. G. Sampson, M. D. Lytras, G. Wagner, P. Diaz, M. E. Foster, and M. White, "Assessing the impact of adaptive generation in the comic multimodal dialogue system", In Proc. Of the IJCAI Workshop on Knowledge and Reasoning in Practical Dialogue Systems, 2005.

[13] H. Bosch, D. Thom, G. Heinze, S. Wokusch, and T. Ertl, "Dynamic Ontology Supported User Interface for Personalized Decision Support", in Proc. Of CENTRIC, 2012, pp. 101-107.

[14] M. Gatius and P. Paliwal, "Generating Domain-Restricted Resources for Web Interaction in Several Languages: Hindi, English and Spanish", in Proc. Of INFOCOMP, November, 2013, pp. 94-98.

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Design and Personalisation

By a Person or for a Person?

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***Abstract*: Personalisation permeates our everyday lives. From advertising to healthcare and from clothing to architecture – most services and products can be tailored to suit particular needs and preferences. This paper considers questions including: where does it leave designers when consumers specify their products? Do personalised health services deliver value to the tax-payer? Deriving from a symposium on the topic, it identifes the dimensions of the phenomenon and typologies within it by investigating specific instances of personalised designs, their consequences for users, and for society. The presentations to the symposium will be chapters in 'Design for Personalisation' published by Gower in 2015.**

Keywords: Personalisation; inclusive design; design-led social innovation; mass customisation; co-creation; social policy.

I. INTRODUCTION

To grasp the implications of the personalisation of objects, services and experiences, requires a clear understanding of both what we expect personhood' to be, and of the potential enhancements, and threats, personalisation may bring to it. This is a matter of deciding the scope of the subject. Drawn narrowly personalisation appears to be a largely technical matter with instrumental objectives - to increase sales, to maximise clinical effectiveness; to give users a better experience. But the range of commercial, political and community interests that emerge around it, and the range of academic and professional disciplines to which it is relevant, indicates that if we are to fully acknowledge the implications of personalised designs, such a narrow scope will not do. Reviewing a number of current instances of personalisation [1] [3] [4] [5] [6] [11] [12], a principle emerges related to the relative agency of 'persons' in different scenarios of personalisation. Broadly, personalisation is either done *by* a person, or *for* a person and through this distinction it is possible to delineate some of its implications.

Co-production, co-research, co-design, co-creation are the buzz words of today, with communities and collective 'grass-roots' informal engagement with technologies identified as crucial sources for innovation. The antecedents to this can be found in Pine's work on 'Mass Customization' [24] that challenged the 'one size fits all' assumption of conventional mass production, emphasizing the importance of information for both businesses and consumers. Latterly, and coming from a different direction, Inclusive Design has made understanding and addressing the needs of all consumers increasingly mainstream [7]. Although initially aimed at those excluded from a meaningful interaction with a product due to age or disability, it implies getting all users involved in all stages of the product development, prompting emerging business models that aim at meeting individual needs most effectively.

Nowadays, Mass Customisation, Personalisation and Co-creation (MCPC) strategies commonly aspire to turn customer heterogeneities into opportunities to profit, implying the question whether this 'co-creation', - open innovation and user innovation - should influence our view of mass customisation and personalisation. Many companies state that customers don't just prefer a personalised experience - they expect it [8], which undoubtedly affects approaches to managing the design of both material and 'immaterial' products, and therefore the use of information technologies and the data they collect.

Our online identities, patterns of behaviour and purchasing history, our digital 'fingerprints', are easily traceable and may stay 'out there' forever. Targeted advertising and tailored 'smart' content aims at personalising our experiences and while we are watching we are also watched by 'smart' spies that compromise our privacy. Personalised advertising stalks every Internet user, but the question of whether consumers really want to see it remains largely unanswered. Companies aim to reduce customers' reactance to potentially intrusive marketing activities by improving perceived consumer control, allowing them to personalise the degree of intrusion. However, it remains to be seen whether, as consumers of information, we are actually in control of our privacy.

The increasingly open sharing of personal data creates fears and uncertainties, which exist in tension with the concept of 'personalising' public service provision. In the context of neo-liberal assumptions about the virtue of marketising public services, public institutions face the impulse to both protect individuals' sense of agency, and to share their data. The health information technology sector, for example, is being transformed by big data, aiming to tailor individual clinical programs for every patient and designing devices to create personalised fitness routines and treatment plans. However, the issue of data accessibility colours many such initiatives, raising questions about who should have the right of access to such sensitive information

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(health providers, patients or all) and how it should be regulated.

A full discussion of personalisation must include bottom up innovation by communities of practice that engage with technologies in new ways. It must acknowledge the commercial interests in play as the principle of personalisation plays out in public service provision, and the political background against which this takes place. It must recognise the implications for individuals' sense of agency of the personalisation of virtual experiences. It must inspect the specifics of the technologies that can bring personalisation about – but a key point is that the personalisation phenomenon does not reduce to these technologies, or any of these other factors. Its consequences exist in the relationships between them. This study therefore points to some of the challenges that arise in design for personalisation, looking into how organisations (and individuals) relate to their 'target' groups, examining how their ownership is designed, and exploring how design-led social innovation may influence our 'personalised' experiences of the world around us.

One might argue that all this innovation serves humanity and overlook other species. Recently, however, field biologists have alpstarted using 'personalised' electronic tracking devices to study the behaviour of wild, free-ranging animals. Miniature tags containing video cameras, radio transmitters or physiological sensors are attached non-permanently to the animal, to collect detailed biological data. For ethical reasons, and since the purpose of these technologies is to study natural, undisturbed behaviour, devices are manufactured to be as small and lightweight as possible. Pioneering efforts are being made in this field, to move away from a 'one-size-fits-all' strategy towards complete customisation [25] [26]. Researchers tailor units to suit every individual animal captured, ensuring that safe limits are never exceeded, and that data are strictly comparable across subjects. This is personalisation that goes beyond the human person.

Now follows a discussion of Personalisation in relation to experiences and spaces, marketing and manufacture, provision and processes.

II. DESIGNING EXPERIENCES AND SPACES

An intersection is emerging between material spaces and immaterial technologies in the design of consumers' experiences of retail where a range of technologies from internet to Radio Frequency Identification (RFID) are facilitating the personalisation of shopping [17]. Driven by consumer demand and competition, customisation and co-creation have become increasingly significant to fashion brands not only through the personalisation of physical products, apparel, and accessories, but also through their distribution and the location of the customising activity [17]. This shift from mass to individual fashion means that nowadays any customer can not only borrow someone else's personality (through, for example, customising a famous footballer's T-shirt), they can also influence the perception of what constitutes fashion (or a particular brand or a product) by creating new personalised communication tools such as fashion blogs. Further, the concept stores of fashion brands have evolved from goods-centered to service-centered locations focused on the experience of the brand. Their increasing use of interactive technologies, and omnichannel communication and distribution has led to a higher level of personalization.

This movement of virtual and real fashion spaces towards personalisation resonates with recent art practice and research that focuses on how art interventions may potentially personalise, our engagement with public space and everyday objects. The works of Turner Prize-winning artist Mark Leckey is a good example of the artist's reflection on the effects of personalisation brought by new technologies to inanimate objects [31]. Until recently, however, there has been little research done on, for example, measuring the impact public art has on various aspects of social life. According to Gheorghe [10], most previous studies were concerned with 'local evaluations of effects on the participants in the reception of specific works of public art' (p. 325). From the 2000s, however, the emphasis shifted towards the 'new genre public art' at the heart of which lays the participation and collaboration of community representatives in creating artworks [20] [21]. This approach to art-making aspires not only to facilitate 'social change' within participating communities, but also to influence and reconfigure public policies. Zebracki, Der Vaart and Van Aalst [30] synthesise other studies [13] [14] to identify the following claims about the contribution made by public art to urban spaces: (1) *physical-aesthetic*: aimed at enhancing aesthetic quality and improving the attractiveness of a place to encourage better use of the public space; (2) *economic*: focused on providing marketing and place-promotion opportunities and encouraging public-private partnerships; (3) *social*: directed at addressing community needs and dealing with social exclusion by revealing fundamental social contradictions or undermining dominant meanings of urban space; and, finally, (4) *cultural-symbolic*: aimed at boosting awareness of local history, promoting cultural and civic identities, and at contributing to local distinctiveness (pp. 787-788). There is, however, little empirical evidence to support these claims [2] [13] [15] [30].

The relevance of this analysis of public art to personalised design becomes clear when it is seen alongside design strategies that resemble those found in Fine Art. These are adopted in personalised retail spaces and some contemporary design professionals seek to use 'critical design' practice to raise the profile of current cultural, social and political issues, particularly those that derive from technologies. Critical design de-stabilises habitual ways of engaging with things, requiring any individual encountering such an object to 're-make' it for themselves. Professionals, who use this design practice, frame it as 'an affective and provocative agent and set out to ask more questions than they answer through design', stimulating the production of knowledge [22]. Aligned to this, design-led social innovation

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seeks to provide a set of skills, methods and tools for communities to address a variety of issues including crime, social exclusion and social inequalities. Public participation in such practices enables designers to produce solutions tailored to resolve issues that arise in a particular spatial or community setting.

III. PERSONALISED MARKETING AND MANUFACTURE

These developments imply a distinction in principle between instances when personalisation is done by an individual – where they are able to determine their relationship with a product or service – and cases where personalisation is in effect provided for an individual. This distinction between personalisation *by* and personalisation *for* a person has different permutations in different cases, but may be a useful way to move towards a typology of personalised design.

New 'smart' technologies offer a dimension of personalisation in particular product types, especially in clothing. Body scanning technology and seamless garment production techniques promise personalised garments in the near future. Initiatives that have already taken shape include Mi Adidas or Fila Adatto, where customers can personalise sports shoes in terms of colour, materials and even a personal logo or a name tag. These applications were introduced not only to test consumer demands, but also to experiment with new manufacturing processes. 'Walk in, get scanned, learn about your feet and walk out with a pair of custom fit Fila Adatto shoes' is the description of what a potential purchaser can achieve while using an interactive kiosk in Fila flagship stores [3] [32].

Along with the benefits of personalisation, such innovations generate challenges in how consumers navigate knowledge to make informed and relatively quick decisions about what they want. Web 4.0 enthusiasts predict that intelligent software agents (such as Siri – an application for iPhone OS, or avatars) will be enhance the intuitiveness of navigation, acting as communication interfaces and providing active, personalised assistance. They will be able to learn a user's preferences and interests, make suggestions, function with minimal supervision, customising their assistance to each participant [19]. Personalised applications for mobile phones are already pervasive, and many businesses endeavour to go mobile first, including the option of social media sharing. This inevitably raises the issue of privacy and personal data, an area in which legislation lags behind. Current research on privacy benchmarks in mobile application design seeks to promote responsible business practice by focusing on how to inform users whether an app's developer has allowed it to use illegal personal data [18]. However, protection against this personalisation 'for' a user by an intelligent product, will take some time to implement.

The emergence of smart technologies is transforming the approaches to design and manufacture of new products, in principle allowing personalisation *by* users/ consumers. 3D printing, for example, has enabled the 'publishing' not only of utility items, but also art and sculpture, changing the ways contemporary designers and artists conceive new ideas and think about future projects. Some futurists argue that 3D printing technology is moving towards desktop size, which may enable direct digital manufacturing from one's home office. Others remain less optimistic [1]. Of course customisation is nothing new as people could always modify and personalise products they bought to serve their individual purposes. But the difference nowadays is that with access to the relevant technology people with no skills or specialised training [27] could make an utterly new product from scratch, market it and sell it, which could challenge existing business models.

IV. PERSONALISED PROVISION AND PROCESSES

Today, personalisation is placed firmly in the centre of social policy in the UK [12] and Europe. Its supporters assume that individuals are aware of their specific needs and being able to satisfy them brings a desirable autonomy – personalised clothing or footwear may indeed be more valuable to its owner than items that are just the same as all the others. However, assuming that this principle applies in the same way to all instances of personalisation is contradicted by the example of the negative consequences of the 'automatic' personalisation of mobile apps above. Increasingly users of public services are treated as consumers and an assumption that personalising those services will therefore bring unalloyed benefit is evident in the design of some services – in healthcare for instance. 'Fetishising the 'personal' or individual in a collectively funded service brings many risks and may further entrench undesirable inequalities' [6]. This 'fetishisation' may derive more from political drives to marketise services than a concern for service users – in a medical setting they may not feel capable of making such choices.

This is not to say, however, that particular treatments may not be usefully adapted to deal with variations in ability. Designing services and responsive modes for diverse populations with large in-group variation in terms of physical, cognitive and perceptual abilities [4] may bring direct benefit to individuals with particular personal needs, for example in teaching which is implemented according to the learners' abilities. The aim here is to reverse the logic of the educational system from the disability point of view, balancing the level of challenge for each learner, to ensure a sense of achievement and progress [4] [28].

The prevention of disease by predictive diagnosis emphasises the importance of risk stratification in order to personalise healthcare regimes on the basis of risk patterns [11]. While this approach is underpinned by a discourse of increased choice, empowerment and responsibility [9] it exists in a particular relationship to issues around the provision of personalised public health services. Along with new technologies of healthcare such as antenatal imaging, this approach to personalising healthcare changes everyone into a potential patient – it pathologises states of health in which actual illness is absent. Just as predictive medicine in effect makes everybody a 'medical case' by definition, antenatal imaging 'constitutes the fetus … as a patient' [29] (p. 25).

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However, alongside these consequences in healthcare, technology also facilitates production of language-using systems (e.g., smart trainers) that may communicate to users personally helping them to acquire new knowledge, or change their behaviour. Some researchers argue however, that if such systems are given personalities and human voices, there is a danger that users may start attributing social agency and moral qualities to them – relating to them and having feelings for them [23]. It is entirely possible to have personalisation without personality.

V. CONCLUSION

Personalisation is now ubiquitous and we encounter it at some level on an everyday basis. What is crucial, however, is that we have enough knowledge of this new paradigm to understand it, to adjust to it, to make it serve us and to be aware of its potential consequences for our relationship with designed things, and each other.

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REFERENCES

[1] C. Barnatt, "3D Printing and Personalisation", unpublished presentation at the Design and Personalisation Symposium, NTU, February 2014.

[2] S. Bell, S. Morse, and Shah, "Understanding Stakeholder Participation in Research as Part of Sustainable Development", Journal of Environmental Management 101, pp. 13-22, 2012

[3] C. R. Boër, and S. Dulio, "Mass Customization and Footware: Myth, Salvation or Reality?", London: Springer, 2007

[4] D. Brown, "Design and Personalisation in the Context of Human Computer Interaction, Disability and Rehabilitation", unpublished presentation at the Design and Personalisation Symposium, NTU, February 2014.

[5] D. Burden, "Design, Personalisation and Privacy in Physical and Virtual Worlds", unpublished presentation at the Design and Personalisation Symposium, NTU, February 2014.

[6] K. Checkland, "Personalisation and Health: a Critical View", unpublished presentation at the Design and Personalisation Symposium, NTU, February 2014.

[7] P. J. Clarkson, R. Coleman, S. Keates, and C. Lebbon, Inclusive Design: Design for the Whole Population. London: Springer, 2003.

[8] Deloitte Research The Changing Face of Retail, online, available at: http://www.deloitte.com/assets/Dcom-Germany/Local%20Assets/Images/06_CBuT/2013/CB_R_store_of_the_future_2013.pdf. 2014.04.05.

[9] Department of Health (DoH) Putting People First. London: HMSO, 2007.

[10] C. Gheorghe, "Theories and Uses in Common: Responses of Art in the Public Sphere", *META*: Research in Hermeneutics, Phenomenology, and Practical Philosophy, 2/2, pp. 316-327, 2010.

[11] O. Golubnitschaja, "Advanced Healthcare Tailored to the Person: What is Beyond the Issue?", Unpublished presentation at the Design and Personalisation Symposium, NTU, February 2014.

[12] E. Hall, "Shopping for support: personalisation and the new spaces and relations of commodified care for people with learning disabilities", Social & Cultural Geography, 12:6, pp. 589-603, 2011

[13] T. Hall, "Art and Urban Change. Public Art in Urban Regeneration", In A. Blunt, P. Gruffudd, J. May, M. Ogborn, D. Pinder, (eds.) Cultural Geography in Practice. London: Arnold, pp. 221-234, 2003.

[14] T. Hall, "Opening up Public Art"s Spaces: Art, Regeneration and Audience", In M. Miles, (ed.) Cultures and Settlements: Advances in Art and Urban Futures. Bristol: Intellect, pp. 49-57, 2003

[15] T. Hall, and I. Robertson, "Public Art and Urban Regeneration: Advocacy, Claims and Critical Debates", Landscape Research 26/1, pp. 5-26, 2001.

[16] L. Jancovich, "Great Art for Everyone?", Engagement and Participation Policy in the Arts. Cultural Trends, Vol. 20, Nos. 3-4, pp. 271-279, 2011

[17] A. Kent, "Personalisation, Customisation and Fashion", unpublished presentation at the Design and Personalisation Symposium, NTU, February 2014.

[18] G. Kuk, "Can Android Induce Responsible Practice in Privacy by Design through Featuring Apps?", unpublished presentation at the Design and Personalisation Symposium, NTU, February 2014.

[19] I. Kuksa, Making Sense of Space: The Design and Experience of Virtual Spaces as a Tool for Communication. Oxford: Chandos/Woodhead, 2014.

[20] M. Kwon, Public Art as Publicity. In Sheikh, S. (ed.) In the Place of the Public Sphere? On the Establishment of Publics and Counter-publics. Berlin: b_books, 2005.

[21] S. Lacy, (ed.) Mapping the Terrain: New Genre Public Art. Seattle: Bay Press, 1995.

[22] M. Malpass, Critical design and a history of marginalised practice. Design History Society Annual Conference: Design Activism and Social Change. Barcelona: Universitat de Barcelona, 2011

[23] J. Oberlander, Personalisation and Language: Whose Voice is it Anyway? Unpublished presentation at the Design and Personalisation Symposium, NTU, February 2014.

[24] J. B. Pine II, Mass Customization: The New Frontier in Business Competition. Harvard Business School Press, 1993.

[25] C. Rutz, L. A. Bluff, A. A. S. Weir and A. Kacelnik, "Video cameras on wild birds". Science 318, p. 765, 2007.

[26] C. Rutz, et al, "Automated mapping of social networks in wild birds", Current Biology 22, R669–R671, 2012.

[27] M. Sinclair, The (New Industrial) Revolution Will Not Be Televised, unpublished presentation at the Design and Personalisation Symposium, NTU, February 2014.

[28] P. Standen, P. The ViPi Educational and Pedagogical Framework. Internal Project Report, 2014

[29] P-P. Verbeek, Moralizing Technology: understanding and designing the morality of things, U. of Chicago Press, 2011

[30] M. Zebracki, R. Van Der Vaart, and I. Van Aalst, Deconstructing Public Artopia: Situating Public-Art Claims within Practice. *Geoforum* 41, pp. 786-795, 2010

[31] M. Leckey, The Universal Addressibility of Dumb Things, De La Warr Pavillion, 2013, online, available at: http://www.dlwp.com/event/mark-leckey 2014.04.05.

Firstborn, Fila Adatto Kiosk, available at: http://www.firstborn.com/work/68/fila-adatto-kiosk 2014.04.05.

EMMA: A Context-Aware Middleware for Energy Management on Mobile Devices

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***Abstract*—The rapid increase of smartphones' sensing, computation and communication capabilities is accompanied by a growing demand for energy. Both, short-term and long-term energy allocation is a bottleneck which severely constrains a mobile device's capabilities and usability. It is thus one of the most critical challenges for current device development. Despite of numerous hardware improvements, e.g., concerning the energy consumption of sensors and displays, as well as the development of more capable batteries, this issue remains to be solved. Hence, software-based approaches can be used to optimize the energy management of mobile devices according to a user's preferences, context information and the current energetic state of a device.**

In this paper, we specify the requirements for a modular energy management middleware architecture coined EMMA, which considers the dynamic and modular integration of existing energy improvement concepts in relation to the device's current energy status and active services as well as the users context and preferences. Furthermore, we present a prototype application which demonstrates some of EMMA's core concepts.

Keywords–mobile energy management; contextual service provision

I. INTRODUCTION

Depending on a user's usage intensity, the batteries of today's smartphones often do not last longer than for one or two days. Reasons for that are high performance hardware components leading to high energy consumption, extensive sensor usage for data acquisition, improperly developed applications, etc.. With this being a known problem, several hardware- and software-based approaches for optimizing the energy consumption of a mobile device have been developed. However, typically, only single components of a mobile system are subject of optimization, while there are no approaches covering all existing subdomains and the corresponding possibilites for saving energy. Disregarding all hardware-based improvements, this leads to the necessity of an integrated, software-based energy management approach in order to protect the limited resources of a mobile device.

Improving a device's energy consumption is not only about extending its batteries' life span, however. Additional goals are the increase of the user's usage experience and the usability of an energy management system. In order to achieve these objectives, individual user preferences, current context information and the device's energetic system state, as well as currently active services must be considered. Furthermore, an energy management system must be able to identify and prioritize services and functionalities which are important or critical to the user. At its best, such a system is able to present these services to the user with a dynamically tailored Quality of Service (QoS) whenever they are requested. The QoS is described by individual parameters for each service. For example, the QoS of a data transfer service could be described by the transfer speed and the amount of data transferred, the one of a positioning service by its accuracy and the time span needed for acquiring a location.

In order to describe the user's context and to be able to react to the present situation, context modeling is required first. According to Dey [1], "Context is any information, that can be used to characterize the situation of an entity. An entity is a person, place or object that is considered relevant to the interaction between a user and an application, including the user and applications themselves." Relying on this definition, it is possible to identify the raw data which is needed for context modeling and to specify sources and procedures for its acquirement. In the following, we present four categories of sources for determining raw context data.

1) **Conventional Sensors:** Data about the users environment, specific activities or current whereabouts can be acquired with built-in smartphone sensors such as Global Positioning System (GPS), gyroscope or accelerometer.
2) **Communication Interfaces:** Network technologies like Global System for Mobile Communications (GSM), Universal Mobile Telecommunications System (UMTS) or Long Term Evolution (LTE) plus Bluetooth and Wireless Local Area Network (WLAN) can also be used for determining the user's location in different granularities [2][3].
3) **Media Data Analysis:** Data like taken pictures or surrounding noises can also be analyzed in order to extract information about the user's situation, e.g., concerning his current mood or a visited location [4].
4) **User Data Mining:** Personal user data like emails, played media files or calendar entries could be valuable in the process of extracting context information. Analyzing it can provide knowledge about whereabouts, important dates like birthdays or upcoming appointments.

However, using some of the presented approaches for the acquisition of context information can be very costly. As will be shown in Section II, all of them consume energy during the process of raw data gathering, as well as for the procedure of extracting information from it. Consequently, the energy consumption caused by context acquisition always has to be compared to the savings enabled through context-aware energy allocation. Besides, there are also privacy issues to be

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considered. Especially in 3) and 4), sensitive user data, which may need additional protection by privacy policies, is used for analysis.

We are not aware of any concept for an integrated energy management system, which satisfies all of the aforementioned needs. However, there are a lot of ideas for partial improvements of single components. In the following, we specify the requirements for such a system and introduce EMMA, an energy management middleware architecture which considers the dynamic and modular integration of existing energy improvement concepts, which controls all of the device's services and features and monitors the system's energy status, as well as adapting it according to context, currently active services and user preferences.

Section I supplies an introduction to energy management matters on mobile devices. In Section II, we provide a brief analysis of the energy consumption of smartphones in order to understand which components are responsible for draining the battery and where improvements can be achieved. Based on a literature survey on existing approaches for energy management on mobile devices, as well as context-aware mechanisms for optimizing energy consumption, we present the requirements for an extensive context-aware and user-centric mobile energy management architecture in Section III. Eventually, the concept and implementation of our approach coined Energy Management Middleware Architecture (EMMA), will be described in Section IV. After offering some insights into a prototypical implementation in Section V, a conclusion and upcoming future work are addressed in Section VI.

II. Related Work

In order to optimize the energy consumption of a mobile device, one first needs to understand which of its components or applications are draining most of it. Later on, it is possible to contrive ideas and optimization concepts based on this knowledge, as well as on already existing optimization approaches.

A. Individual measuring of energy consumption

There are two different techniques for measuring energy consumption on smartphones. One relies on software based functions provided by the operating system; the other uses an external power meter. Manweiler et al. describe the installation and usage of the Monsoon Power Monitor for external power consumption measurement [5]. However, this approach does not pay attention to the individual consumption of the devices components since it only identifies the overall consumption. Examples for software based and combined measurement concepts are eProf [6], PowerTutor [7] and WattsOn [8]. They all make use of predefined energy profiles describing the energy consumption of specific device components and indicate, that network and sensor usage, CPUs, displays and media playback are the main consumers of energy. Additionally, Pathak et al. [6] examined the energy consumption of different popular applications like Facebook, Angry Birds and others and figured out, that 65-75% of consumed energy is used by third party advertisement modules. Furthermore, they name typical bugs in operation systems, which are responsible for the dissipation of energy.

B. Optimization concepts

In the following, we review different optimization concepts concerning sensors and data transfer. Furthermore, the usage of prediction and data mining in order to prioritize, schedule and optimize tasks on mobile devices is examined.

1) Sensing optimization: There are several approaches for lowering the energy consumption of mobile devices based on optimizing sensor usage. Adaption of QoS parameters is one attempt that can be used to achieve this goal. In particular, the trade-off between service quality and consumed energy is a relevant matter in this context. Besides the adaption of a services performance, there is also the possibility to substitute sensors. In this case, specific sensors are substituted by other technologies which are capable of providing a comparable service while lowering the energy consumption [9][10]. If a complete substitution is not possible or needed, there is also the way of combining sensors [11][12], e.g., triggering; here, the acquisition of data from one sensor is triggered only when a second sensor reaches some kind of previously defined threshold. An example for this is the combination of a smartphones accelerometer and its GPS sensor in the SenseLess concept introduced by Abdesslem et al. [13]. Their approach is to activate the GPS-Sensor only if the accelerometer detects the user being in motion. For evaluation, a user is equipped with two smartphones, one running the standard iOS positioning methods in a 10 seconds interval, the other one working with the SenseLess algorithm. The results showed, that SenseLess needed 85,5% less energy than the standard approach. The determined locations differed from 0,4m to 41m with an average value of 8m. But because the energy consumption was determined on basis of the battery level, there is cause for inaccuracies through wrong interpreted up-and-down-movement, as well as due to the systems general energy consumption. As shown by Priyanta et al. [14], the combination of different sensors is to be used with caution and after individual evaluation. In their case, the computing of determined accelerometer data, which was gathered in a 10 minutes time interval with a frequency of 4Hz to 6Hz, consumed more energy than the location determination via GPS for 5 minutes, determining one location fix each minute. Chon et al. introduce SmartDC, which not only aims at lowering the energy consumption while determining the users location, but also tries to predict the user's future positions and important places [15]. In order to accomplish that, the authors use unsupervised learning techniques, mobility prediction, as well as prediction of system usage based on Markov models. Using this approach, energy savings of up to 81% and an prediction accuracy up to 80% have been reached. The maximum delay time was 160 seconds.

A complete substitution of sensors is used for Ambience-Fingerprinting [16], a technique which is especially suitable for indoor location determination, where no GPS signal can be received. Therefore, raw data of different kind is checked for specific attributes, so called fingerprints. An early concept of Pirantha et al. enables the user to discover his position via ultrasonic and radio fingerprints with an cm-accuracy [16]. Azizyan et al. present SurroundSense, a system for location determination on basis of environmental fingerprints like the spectral composition of noises or visual signatures [17]. The authors also analyze the cumulation of existing fingerprinting techniques, such as motion, noise, acceleration, brightness, color and spectral contents of WLAN signals. In an evaluation with four users in predefined positioning clusters, 93% of all positions could be determined correctly. However, the consumed energy was not compared to the consumption of

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standard Software Development Kit (SDK) methods.

C. Optimizing data transfer

Due to the extensive energy consumption of data transfer and communication technologies, this field provides a lot of possibilities for achieving energy savings. 2G, 3G and 4G networks each use a different amount of energy for different tasks. Hence, already by choosing the best suited technology for each task, the overall energy consumption can be lowered. For example, 2G networks are suited better for calls than 3G networks, but 3G networks are much more efficient for data transfer [18]. Perucci et al. conclude, that – even though additional power is consumed by the handover process needed for changing networks – significant energy savings can be achieved by consistently switching to a 2G connection for calls [19].

Furthermore, both Balasubramanian et al. [18] and Falaki et al. [20] reveal that not only the overall size of the transferred data is responsible for the consumed energy, but also the size of single transferred packages: Especially, small packages cause a transfer overhead of up to 40%. Moreover, the Transmission Control Protocol (TCP) requires multiple transfers of the same packages due to package loss. To this end, Falaki et al. propose a bigger server side buffer and an optimization of the usage rules for the transfer networks in order to solve these problems, predicting energy savings up to 35%.

Another transfer-related optimization approach is TailEnder, provided by Balasubramanian et al. [18]. TailEnder divides applications into two groups, i.e., applications that tolerate delays in data transfer and those, which can profit from data prefetching. Based on this classification, data is loaded in bundles to minimize the devices staying in the high energy state of the IEEE 802.11 standard. Additionally, TailEnder makes usage of the advantages of the different transfer networks. In comparison to other approaches, 60% more newsfeeds and up to 50% more search results for web requests could be processed while consuming the same amount of energy.

D. History and data-based prediction

The analysis of user preferences and interaction patterns, as well as the usage of data mining techniques on historic or context data can reveal precious insights concerning the energetic regulation of a mobile system. For example, calendar or appointment specific data can be used to predict a user's current and future whereabouts. Predictions about the device's future energy level, combined with the information about upcoming tasks can be used to adapt the energy balance oriented on tasks rated critical by the user [21]. Oliver et al. succeeded in predicting the energy level of mobile devices correctly for a time slot of one hour with an error rate of only 7%. Within 24 hours the error rate was 28%. In order to achieve that, they classified the gathered data of more than 17.300 BlackBerry users and clustered it afterwards [22][23].

Trestian et al. conducted a network-based study which should reveal relations between the user, his movement patterns and used applications in order to predict common interaction patterns. Their results indicate that the usage of specific applications is significantly related to the user's current movements or location [24].

III. REQUIREMENTS

As shown in Section II-B, there are numerous approaches, which address single optimizations for specific system components or services. None of them tries to wrap all existing concepts in one architecture, which organizes them in a modular way and provides requested services with an adequate output quality. In order to create a holistic energy management system, the following requirements for such an architecture can be identified:

1) **Universal validity and responsibility:** The energy management system is solely responsible for managing all resources of the system and the access to them. It receives all service and resource requests and answers them in an adequate and energy efficient way.
2) **Context and user awareness:** Typical context data like the current time and location, upcoming tasks, individual user preferences or social relations, as well as the systems current energetic state are used to provide services in a customized manner respecting the user's situation and whereabouts.
3) **Modularity:** A holistic energy management system is comprised of a multitude of different components, each responsible for different subtasks. In order to benefit from existing and future ideas in each of these areas, functionality is encapsulated in only loosely coupled modules which can be altered or replaced without affecting the rest of the system.
4) **Scalability and extensibility:** New energy optimization concepts or services can get installed in an easy way, the user is able to use improved modules without non-trivial update processes.
5) **Definition of generic interfaces:** To make the integration of new modules possible, a definition of generic interfaces oriented on the lowest common denominator of installable modules is necessary.
6) **Adaptive data collection:** If data collection is required (e.g., sensor data), the system selects a service which acquires data adaptively to given preconditions. These may be the systems current energy state, the service quality as demanded by the service requester or forecasts concerning needed energy for future tasks. Furthermore, collected data needs to be cached for later usage.
7) **Task prioritization:** In order to take the user's preferences concerning critical tasks into account, the system is able to adhere to task priorities and assign more privileges to higher priority tasks.
8) **Clarity and comprehensibility:** The architecture must be structured in a clear and comprehensible way. This is essential to enable developers to integrate new optimization concepts or module packages into the existing system.

IV. EMMA - AN INTEGRATED MANAGEMENT APPROACH

Based on the requirements identified in Section III, we now present our approach coined *EMMA (Energy Management Middleware Architecture)*. EMMA is a holistic approach for an energy management system on mobile devices, allowing for an easy integration of existing and future energy optimization concepts. It provides its services in an adaptive, context- and preferences-aware manner, controls service parameters and monitors the system's energy state. EMMA runs continuously in the background and is the exclusive interface to the system's resources (such as sensors) and services for other applications. Thus, EMMA is able to coordinate resource demands of all

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applications and to fulfill their requests in the most energy-efficient way.

A. Main components

EMMA consists of two main components, namely, the Control Unit and the Service Provider. These and their sub-components are depicted in Figure 1. In the following, the components are described.

1) Control Unit: The Control Unit is the central component dedicated to respond to service requests, select appropriate services based on context, preferences and demands, and monitor services and the system's energy state. If required, it adapts service parameters to ensure execution of critical tasks. In order to make intelligent decisions, the Control Unit employs information obtained from sub-components such as the Energy Manager, the Schedule Manager and the Service Identificator. Service requests and responses and communication with the Service Provider, as well as among the subcomponents themselves is handled by a dedicated Controller.

The Energy Manager analyzes the energy status of the whole system, calculates energy consumption of individual tasks and tries to predict future energy levels. These results can be combined with information about charging opportunities in vicinity or in near future, to reserve energy for future tasks or to preserve execution of critical tasks by performance adaption for the longest time possible.

The Service Identificator selects the most appropriate service for any given service requests from the whole set of available services – as provided by the Service Provider – based on service parameters and quality of service characteristics. In general, service selection algorithms are geared towards a specific subset of services, since service parameters vary for different kinds of services.

In order to monitor active and upcoming services, the Schedule Manager keeps track of currently running and future tasks, as well as respectively associated information.

2) Service Provider: The Service Provider is a passive component which does not contain any logic or executive power. Its core task is the integration and administration of service modules, as well as the provision of all requested services, the registration of needed callbacks and the caching of sensor data. To achieve that, the Registry Manager scans the folders containing all installed modules and corresponding manifest files in order to identify added or removed modules for installation or removal. Afterwards, the current system state is saved in the Registry Cache, which provides these information for module identification matters to the Control Unit. As soon as a module was identified and released for usage by the Control Unit, the Service Provider creates a new service object and integrates the identified module in order to use its unique functionalities. The service is accessible via specific interface methods (see Chapter IV-C). Furthermore, in order to avoid redundant acquisition of raw data, the Service Provider caches sensor data and provides it if needed.

B. Modular service concept

A core feature of EMMA is its modular service concept. A service is defined as any functionality, that a user or an application might request, e.g., data transfer, acquisition of sensors data or media playback. In order to maximize the efficiency of providing these services, EMMA uses a highly modular concept. To this end, for each functionality a service class is defined. Each service class might use different technologies to provide a requested service, e.g.,. depending on the demanded service quality and the available system energy, The internal logics of these different technologies are wrapped completely transparent in a service module. The number of possible service modules per service class is unlimited. Later on, after the best suited module for a specific use case was identified, it is integrated into the service object at runtime. Apart from the growing diversity of available technologies, this simple plug-and-play integration is another advantage of the modular concept. It enables optimized logic and improved concepts being installed without a complete system update (see Chapter V).

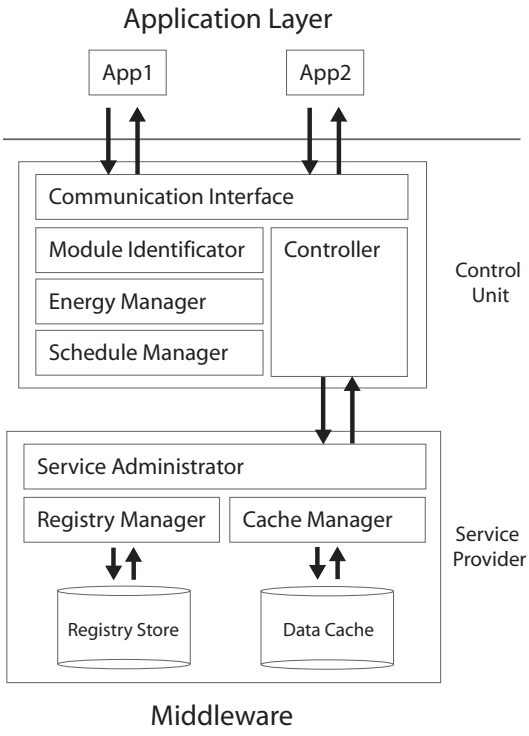

Figure 1. General overview of the EMMA concept and its components.

C. Communication interfaces

The EMMA concept defines a fixed set of internal and external interfaces used for communication. Internal interfaces are used for routing information and services, e.g., to realize a working connection between a service object and its integrated service module (see Section V). In contrast, external interfaces are responsible for processing service requests and responding to them. Therefore, data bundles are used to maintain the communication between EMMA and any applications requesting a service. These bundles contain the ID of the requested service class, as well as information about the requester's priority, the expected service runtime and parameters concerning the requested QoS.

The structure of the corresponding response bundles is similar. If a request is answered positively, the reply contains the requested service, as well as information about its actual instantiation, as the returned service may either be a callback function the requester can use, a dedicated service object or

 ISBN: 978-1-61208-369-8

simply the requested data. The information about its actual instantiation facilitate correct data unmarshalling.

D. Identification of suitable services

In order to be able to choose the most appropriate service module, EMMA executes an individual identification algorithm for each service class. This is necessary to ensure that the performance of the chosen module matches both, the energy deallocated by the system and the demands of the service requester. The reason for having separate selection algorithms for each class is the different numbers and kinds of parameters, which are necessary to describe a service's energy consumption and QoS-characteristics.

The simplest case of describing a module's characteristics is by only two different performance parameters, which form a Performance Set. One parameter always represents the module's energy consumption, the other one describes a corresponding QoS-specific feature. Each module can possess any number of performance sets describing varying pairs of consumption and service quality related to different modes of operation. In this two dimensional space a target area can be identified between the point-of-origin and the intersection of the values of deallocated energy and requested service quality. In the following, the identification algorithm iterates across all existing modules of the requested service class and checks if any set of their performance parameters is located within the target area. If only one module can be found, this module will be selected. If several modules match the given thresholds, the one with the least energy consumption is selected. Otherwise, if no module can be found, the target area is extended and the same procedure is started again.

The complexity of the individual identification algorithms depends on the number of features necessary for describing a module's performance. According to the current concept state, the mere provision of a service is regarded more important than the meeting of given performance parameters or the approved energy consumption. In case that no comparable module is offering the same service at a lower energy consumption, even a module with a much higher consumption than approved can be provided in order to meet the user's demands.

E. Continuous monitoring

In order to adapt the system's performance and to keep critical services running as long as possible, EMMA continuously monitors the system's energy state. Therefore, not only the current energy consumption but also the predicted consumption for future tasks, which can be determined by analyzing the active and upcoming tasks schedules, combined with prediction techniques (see II-D), is included. Additionally, relevant context information is considered, e.g., loading stations near a user's position.

After determining the system's current energetic state and the prediction of the amount of energy needed for upcoming tasks, the system's performance can be adapted in two directions: Given that either more energy than expected is available and the systems performance has been throttled before or a request demands a higher service quality than currently granted, the performance of a service can be increased. In contrast, if there is less energy available than expected or a new high-priority service is started, the performance of active services can be throttled in order to have more power available.

To adapt the performance of a service module, it can be modified within its possible spectrum. If there are more adaptions needed than a specific module can perform, it can be replaced by another of the same service class with different performance parameters. The adaption of service performance commonly results in a change of service quality.

V. Implementation

In order to assess the feasibility of our approach, we developed a prototype application of EMMA with the aid of the Google Android API (target version 18). In its current form, however, the prototype was not yet integrated as an exclusive service manager into the operating system. Instead, due to access and rights restrictions of the Android SDK it has been implemented as part of the application layer. Our goal in this first version was to evaluate the technical feasibility of EMMA's core concepts without analyzing any possible increase in energetic efficiency in detail yet.

In order to cope with EMMA's claim for modularity, the logic of service modules is capsuled in `dex.`-archive files, whose content is described both machine- and human-readable in corresponding `XML` manifest documents. The latter contain all information about a module's performance, nature and energy consumption, and can hence be used to dynamically identify any modules matching a service request. Our prototype is able to respond to incoming requests for either a continuous or a one-time positioning service by selecting the most appropriate service module, taking into account the current energy state of the device, as well as context information and currently active, as well as scheduled services.

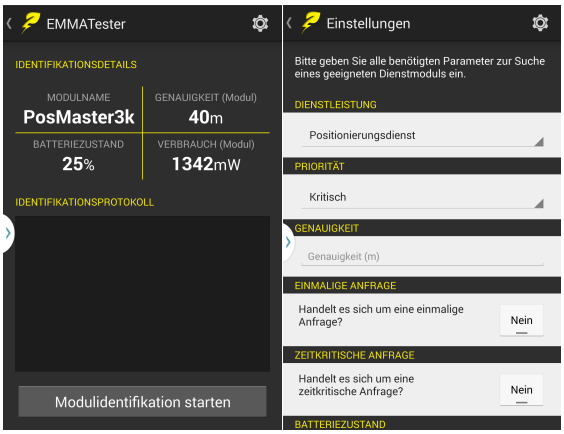

Figure 2. Screens of the EMMA prototype application.

To achieve this, at first the device's current energy consumption is determined. In order to keep the implementation overhead for the energy measurements low, energy consumption is approximated by a simple model based on test results obtained from a HTC Desire using the PowerTutor application [7]. By combining these information with knowledge about active and scheduled services as well es their estimated runtime, it is now possible to calculate the energy remaining for new services. In order to identify a suitable service module, the requested QoS parameter contained in a request bundle and the amount of remaining energy are considered for building a target area (see IV-D). After identification, the chosen module is integrated into a singleton service object. The logic contained in the module archive is loaded dynamically into the program code by using the Android-specific reflection-based

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DexFile [25] and DexClassLoader-classes [26]. According to the current concept, the identified module is not restricted in its energy consumption once it was installed, but it can be replaced by a more economical one if its consumption is extensive.

In order to be able to use the module's functionalities after its integration, a standard LocationListener-callback provided by the Android SDK is installed in the service object, serialized and returned to the service requester. The latter is now able to listen for positioning updates after rebuilding the callback from the serialized version.

VI. Conclusion and future work

By introducing EMMA, we provide a holistic, modular concept for individual and context sensitive energy management which meets the requirements stated in Section III. The modular concept renders the usage of partial optimization concepts and their energetic savings potential, as well as making their integration a trivial task.

EMMA in its current state is to be considered a basic architecture framework. Lots of details need an initial clarification or further composition, e.g., the specification of different service classes and service modules. Furthermore, a capable security concept must be provided due to the possibility of including foreign code dynamically into the system at runtime. This is necessary in order to avoid the execution of malware and to avoid abuse.

In a following expert's discussion consisting of 8 participants with IT background, we found that the procedure of integrating modules and the conventions for developing them, as well as the interface descriptions for requesting services need to become more facilitated. Furthermore, a pending step is a second implementation of the EMMA concept with the goal to evaluate its actual energy savings potential. Especially, the integration of the architecture as part of the operation system proves to be a challenge, since current platforms like iOS or Android do not allow this without significant interventions in their system's core.

References

[1] A. K. Dey, "Providing architectural support for building context-aware applications," Ph.D. dissertation, Georgia Institute of Technology, 2000.

[2] P. A. Zandbergen, "Accuracy of iphone locations: A comparison of assisted gps, wifi and cellular positioning," Transactions in GIS, vol. 13, no. s1, 2009, pp. 5–25.

[3] B. Li, J. Salter, A. G. Dempster, and C. Rizos, "Indoor positioning techniques based on wireless lan," in LAN, First IEEE International Conference on Wireless Broadband and Ultra Wideband Communications. Citeseer, 2006.

[4] M. Schirmer and H. Höpfner, "Senst*: approaches for reducing the energy consumption of smartphone-based context recognition," in Modeling and Using Context. Springer, 2011, pp. 250–263.

[5] J. Manweiler and R. Roy Choudhury, "Avoiding the rush hours: Wifi energy management via traffic isolation," in Proceedings of the 9th international conference on Mobile systems, applications, and services. ACM, 2011, pp. 253–266.

[6] A. Pathak, Y. C. Hu, and M. Zhang, "Where is the energy spent inside my app?: fine grained energy accounting on smartphones with eprof," in Proceedings of the 7th ACM european conference on Computer Systems. ACM, 2012, pp. 29–42.

[7] L. Zhang, B. Tiwana, Z. Qian, Z. Wang, R. P. Dick, Z. M. Mao, and L. Yang, "Accurate online power estimation and automatic battery behavior based power model generation for smartphones," in Proceedings of the eighth IEEE/ACM/IFIP international conference on Hardware/software codesign and system synthesis. ACM, 2010, pp. 105–114.

[8] R. Mittal, A. Kansal, and R. Chandra, "Empowering developers to estimate app energy consumption," in Proceedings of the 18th annual international conference on Mobile computing and networking. ACM, 2012, pp. 317–328.

[9] J. Paek, J. Kim, and R. Govindan, "Energy-efficient rate-adaptive gps-based positioning for smartphones," in Proceedings of the 8th international conference on Mobile systems, applications, and services. ACM, 2010, pp. 299–314.

[10] Z. Zhuang, K.-H. Kim, and J. P. Singh, "Improving energy efficiency of location sensing on smartphones," in Proceedings of the 8th international conference on Mobile systems, applications, and services. ACM, 2010, pp. 315–330.

[11] I. Constandache, S. Gaonkar, M. Sayler, R. R. Choudhury, and L. Cox, "Enloc: Energy-efficient localization for mobile phones," in INFOCOM 2009, IEEE. IEEE, 2009, pp. 2716–2720.

[12] M. Schirmer and H. Höpfner, "Senst*: approaches for reducing the energy consumption of smartphone-based context recognition," in Modeling and Using Context. Springer, 2011, pp. 250–263.

[13] F. Ben Abdesslem, A. Phillips, and T. Henderson, "Less is more: energy-efficient mobile sensing with senseless," in Proceedings of the 1st ACM workshop on Networking, systems, and applications for mobile handhelds. ACM, 2009, pp. 61–62.

[14] B. Priyantha, D. Lymberopoulos, and J. Liu, "Littlerock: Enabling energy-efficient continuous sensing on mobile phones," Pervasive Computing, IEEE, vol. 10, no. 2, 2011, pp. 12–15.

[15] Y. Chon, E. Talipov, H. Shin, and H. Cha, "Mobility prediction-based smartphone energy optimization for everyday location monitoring," in Proceedings of the 9th ACM conference on embedded networked sensor systems. ACM, 2011, pp. 82–95.

[16] N. B. Priyantha, "The cricket indoor location system," Ph.D. dissertation, Massachusetts Institute of Technology, 2005.

[17] M. Azizyan, I. Constandache, and R. Roy Choudhury, "Surroundsense: mobile phone localization via ambience fingerprinting," in Proceedings of the 15th annual international conference on Mobile computing and networking. ACM, 2009, pp. 261–272.

[18] N. Balasubramanian, A. Balasubramanian, and A. Venkataramani, "Energy consumption in mobile phones: a measurement study and implications for network applications," in Proceedings of the 9th ACM SIGCOMM conference on Internet measurement conference. ACM, 2009, pp. 280–293.

[19] G. P. Perrucci, F. H. Fitzek, G. Sasso, W. Kellerer, and J. Widmer, "On the impact of 2g and 3g network usage for mobile phones' battery life," in Wireless Conference, 2009. EW 2009. European. IEEE, 2009, pp. 255–259.

[20] H. Falaki, D. Lymberopoulos, R. Mahajan, S. Kandula, and D. Estrin, "A first look at traffic on smartphones," in Proceedings of the 10th ACM SIGCOMM conference on Internet measurement. ACM, 2010, pp. 281–287.

[21] N. Ravi, J. Scott, L. Han, and L. Iftode, "Context-aware battery management for mobile phones," in Pervasive Computing and Communications, 2008. PerCom 2008. Sixth Annual IEEE International Conference on. IEEE, 2008, pp. 224–233.

[22] E. Oliver and S. Keshav, "Data driven smartphone energy level prediction," University of Waterloo Technical Report, 2010.

[23] E. Oliver, "Diversity in smartphone energy consumption," in Proceedings of the 2010 ACM workshop on Wireless of the students, by the students, for the students. ACM, 2010, pp. 25–28.

[24] D. Willkomm, S. Machiraju, J. Bolot, and A. Wolisz, "Primary user behavior in cellular networks and implications for dynamic spectrum access," Communications Magazine, IEEE, vol. 47, no. 3, 2009, pp. 88–95.

[25] "DexFile - Android Developers," http://developer.android.com/reference/dalvik/system/DexFile.html, 2014, [Online; accessed 25-July-2014].

[26] "DexClassLoader - Android Developers," http://developer.android.com/reference/dalvik/system/DexClassLoader.html, 2014, [Online; accessed 25-July-2014].

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Human-Centric and Privacy-Protecting Trust Establishment over the Internet

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***Abstract*—Security needs to be human-centric if the human context and intent have to be known. Security mechanisms should be hidden whenever automation has all information it needs. In this paper, we present a human-centric, assisted trust establishment mechanism over the Internet. This mechanism expands our previous work that required a physical meeting to exchange identities (public keys) and to establish mutual trust. The goal is identification and authentication, which can then be used for authorization. The mechanism was designed to protect privacy while it utilizes existing trust relationships within small social groups to gain evidence of the trustworthiness of a claimed identity. Our technology is in particular suited for interconnecting users and their home networks as well as for smart environments. Competing solutions with respect to trust modeling are the X.509 standard and the PGP (Pretty Good Privacy) web of trust, with respect to applications cloud computing and social networks like Facebook.**

Keywords–trust establishment, authentication, access control

I. INTRODUCTION

Within the last ten years, home computing has gained a lot of momentum due to various reasons. The first important factor is the availability of affordable computer hardware and fast residential Internet connections. Today, energy efficient computing devices suitable for most home computing tasks, such as the Raspberry Pi [1], can be purchased quite cheaply.

The second important factor for home computing is home automation. Homes are becoming increasingly equipped with networked sensors and actuators able to sense or control lighting and temperature, for instance. Various open-source software projects, e.g., openHAB (open Home Automation Bus) [2], emerged that help users to orchestrate their smart home in order to increase comfort or decrease their home's energy consumption.

Lastly, a growing distrust in Internet Cloud services, such as online file storage, mails, and chats, fueled home computing after large-scale monitoring efforts by international intelligence became publicly known in 2013 [3][4]. Thus, local and human-centric solutions have to be found that can replace distant and centralized Internet Cloud services.

On application level, open-source software projects that recreate the functionality of Internet Cloud services became popular. Examples include OwnCloud [5], Seafile [6] and others. This allows building powerful networked service infrastructures within the privacy of a home network. Yet, services are rarely useful if they cannot be securely shared and used beyond the boundaries of isolated home networks.

An important ingredient for that is identification and authentication. The predominant solution today is the usage of user names and passwords, which are hard to handle and insecure due to massive reuse. There are better security mechanisms like asymmetric cryptography. Our work is focused on human-centric concepts for enabling the use of such strong cryptography on the user-side. The information needed from the user are names, public keys, and what the user thinks of them. Given software that assists the user and mechanisms that are human-centric and follow human ways of acting with each other, the user is a better source for such information than a central authority.

The central contribution in this paper is an approach and a protocol for human-centric secure and privacy-protecting trust establishment over an insecure network, i.e., the Internet. Details on the mechanism are described in Section V.

In the following Section II, we introduce our previous work on the subject. In Section III, we give further information and discuss why established trust models are not suitable human-centric solutions. Section IV presents requirements and Section VI an evaluation. Related work is presented in Section VII. An outlook on current work and a conclusion is given in Section VIII.

II. PREVIOUS WORK: ASSISTED KEY MANAGEMENT

In previous work, we designed a human-centric security concept [7]. In the center of our concept we have so-called *Domains*, which are the "digital homes" of users. As a Domain we understand any small network of devices and services. A typical example of a Domain would be a home network or the devices and services owned by a single person. Users can utilize their equipment to establish relationships with other Domains first. Later, services can be shared between such partner Domains.

Technically, we built client/server components for the sketched assisted key management. Our components automate difficult to perform tasks, hide complexity, and take care of security.

Our *Registration Server* acts as a front-end for a Domain-local X.509 certificate authority, called *Domain CA*. With the help of a tool installed on a device called *Registration Client*, a new asymmetric key can be generated and its public part be certified by the local Domain CA in a secure way. The registration process is controlled (permitted/denied) by the Domain owner using an administrative tool. Further parts of our work [8] extended the resulting basic access control scheme with fine-grained authorization based on XACML (eXtensible Access Control Markup Language) [9].

When services need to be securely shared between two Domains, a problem arises, as a local service is unable to

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authenticate the certificate presented by the "foreign" device. Hence, service access will be refused. In order to solve this shortcoming, the foreign Domain's CA certificate needs to be *trusted* in the local Domain.

To setup a *trust relationship* between two Domains, we developed the *personal trust exchange* protocol in our previous work. The protocol is implemented by a tool that can be executed on a mobile device, such as a laptop or smart phone. When representatives of two different Domains meet, they can use this tool to securely and easily exchange their Domain CA certificates via near-field wireless technologies. After the exchange, the certificate is tagged with a human readable identity (hID) of its owner (e.g., full name) and the social peer group the owner belongs to (e.g., friends, colleagues, etc.). Based on this membership, basic access rights of this Domain can later be derived automatically, e.g., all friends might obtain access to the Domain's photo sharing service. Hence, our notion of "trust" goes beyond the traditional understanding of the term and comprises identification, authentication, and authorization. Later, certificate and meta-data of the foreign Domain are imported into the own Domain and provided to all local services.

The outlined trust establishment method is secure and meaningful as certificates are exchanged in person, which allows the representatives to personally identify their exchange partner. Furthermore, the protocol guarantees that attackers are unable to interfere and, for instance, slip in a bogus certificate. This again could finally lead to an undesired trust relationship, which might be exploited. One major problem with the outlined trust establishment solution is that it can only be executed when representatives of two Domains are able to meet in person. Obviously, this is not always possible, e.g., when the Domain owners live far apart.

III. Analysis and Background

A. Applicability of Existing Personal Key Infrastructures

The standard **X.509** [10], also often referred to as the web PKI (Public Key Infrastructure), is today the most often used method to map an identifier to a public key. As identifiers, for instance, mail addresses or DNS (Domain Name System) names can be used. The common approach is that a trusted third party, called certificate authority (CA), verifies a public key holder's identity and then issues a signed (identity) certificate. Once a software component receives a certificate it can easily verify whether the certificate is valid, whether the certificate contains the expected identity, and finally whether the entity that presented the certificate is the legitimate key holder. Typically, CAs are payed services offered by companies like Verisign, Comodo, or Thawte.

In the scenario of home networking, or other small personal Domains, a public CA, for instance operated by the home's Internet provider, might be used to issue a certificate for the local Domain CA. This again would allow other Domains that trust this public CA to verify the identity of a Home CA. However, there are various issues with public CAs in the scenario of small private Domains: 1) no agreed-on standard for identifiers of small Domains, such as home or personal networks, exists yet. Certificates of Domain CAs might be simply associated with their owner's names. But natural names are often ambiguous and therefore no suitable identifier. The just proposed identifier might also be extended to a format like `country/city/street/name`, which would rule out ambiguity in most cases. But still this is insufficient as being able to authenticate a certificate issued by a foreign Domain does not yet answer the question which ones of all authentifiable foreign Domains are allowed to access a service offered in a Domain. 2) there are general issues with the trustworthiness of X.509 certificates as the verification of identities is done by a third party. Examples exist that show that CAs issued valid certificates to entities that are not the legitimate owner of an identity. In such cases the CA did not pay enough attention or was compromised by some adversary.

PGP/GPG (Pretty Good Privacy/GNU Privacy Guard) [11] is a human-centric alternative to X.509, which is mostly used for mail communication. Participants of PGP/GPG issue signed data structures that assert that a public key represents the identity of a particular person. This is done by mapping a name and mail address to this public key. To increase PGP/GPG's convenience, these data structures are typically published alongside the public keys on so-called *key servers*. Persons that require the public key that represents a specific identity or want to verify the authenticity of a public key they already possess, can query a key server and receive public key and signed data structures that vouch for this keys authenticity.

The PGP/GPG web of trust resolves some issues of the X.509 PKI as it is human-centric and obviously suits the demands of human-centric computing well. But it creates its own new problems. One of the most important problems of PGP/GPG is that social relationships are publicly revealed when key servers are used. Furthermore, the mere ability to authenticate public keys is, as explained in the context of X.509, still insufficient in our scenario.

B. Applicability of the Human-centric Trust Exchange

As outlined in the introduction of this paper, our approach is based on the idea of independent Domain-local small CAs and the establishment of trust relationships between Domains based on human interaction when needed. As explained before, a trust relationship is established by exchanging the certificates of two Domain CAs and marking the received certificate as belonging to a "friendly" Domain. Alongside with importing a certificate, a basic set of access rights to local services can be granted automatically. Later, these default rights might be fine-tuned by the Domain owner [8]. Furthermore, a human-readable, locally meaningful identifier and other meta-information (e.g., social community) can be assigned to the received certificate during the trust exchange.

As globally valid cryptographic identifiers for a Domain or an entity (devices or services) that belong to a Domain, we proposed the usage of *cryptographic identifiers (cID)* derived from public keys. A Domain's identity is the hash of the Domain CA's public key (DomainID = H(pubKey$_{Domain}$). The identity of an entity belonging to this Domain is the concatenation of the Domain ID and the hash of the entities public key (EntityID = H(pubKey$_{Domain}$).H(pubKey$_{Entity}$)). The resulting identifier is hierarchic and reflects the belonging of an entity to a specific Domain.

This approach solves trust issues and possible ambiguities of identifiers as received certificates are locally highly meaningful and trustworthy.

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IV. REQUIREMENTS

The requirements on a trust exchange mechanism that can be performed over the Internet can be split in two groups, namely security and user-friendliness.

A. Security:

Establishing trust to the outside of a Domain is a critical process. When the security of the exchange cannot be guaranteed, unintended trust relationships might be established. In the worst case the falsely created trust relationship can be abused to access services offered within a Domain.

Requirement R1: Secure Identification/Authentication: The aim of a trust exchange is to receive the certificate of a specific friendly Domain. This aim can only be fulfilled if it can be ensured that the received certificate belongs to this Domain.

Requirement R2: Rating of Certificates: The trust exchange must measure the level of trust into a certificate received from a friendly Domain to expresses the strength of the established trust relationship. Furthermore, this allows reducing the chance to accept untrustworthy Domains over, for the purpose of a trust exchange, trustworthy Domains.

Requirement R3: Security: All precautions need to be taken that a third party is unable to interfere with the trust exchange process, e.g., to trick one or both exchange partners to trust a certificate owned by the third party.

Requirement R4: Human-Centrism: The trust exchange must be human-centric, i.e., may not depend on external, central services.

Requirement R5: Privacy-Protection: Leakage of private information must be minimized, i.e., no third party should be able to easily enumerate trust relationships of a given Domain.

B. User-Friendliness:

Performing a trust exchange between Domains must be easy to understand and user-friendly. Therefore, following requirements must be fulfilled:

Requirement R6: High Degree of Automation: The trust exchange must hide all difficult to understand technical details and run mostly automatically.

Requirement R7: Owner Consent: No trust relationship may be established without a Domain owner's permission.

Requirement R8: Low Interference: The amount of interactions between the trust exchange mechanism and the human user involved in the process must be kept at a minimum to avoid repeated disturbance and prevent annoyances.

Requirement R9: Responsiveness: Long waiting times until the trust exchange has finished need to be avoided. As it cannot be expected that the process is computationally expensive, the responsiveness mostly depends on the protocol design and response times of involved human users.

V. TRUST EXCHANGE

A. Approach and Architecture

Our approach for a secure, privacy-protecting and reliable mechanism to exchange trust between Domains over the Internet is based on the idea to propagate already existing trust relationships between Domains that belong to a social community in a human-controlled manner. The exchange process is supported by a publicly reachable *trust exchange service* running within each Domain. A trust exchange service instance processes incoming trust exchange protocol messages, interacts with the Domain owner over a graphical user interface (GUI) and manages a database of known friendly Domains. The information contained in the Domain database includes a Domain's cryptographic (cID) and human-readable identifier (hID), the Domain's Trust and Identification Level (explanation see below), information to which social community a Domain belongs to (e.g., friends, colleagues, sports club, etc.) and finally the Domain's certificate.

The *Identification Level (IL)* is a property of a certificate. It is a numerical value in the range from 0 to 10 that measures the confidence a Domain A can have that a given Domain certificate belongs to another Domain B. The IL is either assigned by the Domain owner herself after performing the personal trust exchange or computed during the Internet trust exchange using our trust metric we introduce later in Section V-C.

The *Reputation Level (RL)* is a property of the human Domain owner. It is a numerical value in the range from 0 to 10 that expresses the expectation of Domain owner A how much care a Domain owner B will take when she is performing a personal trust exchange with a Domain owner C. Hence, the RL expresses A's assessment how reliable B will check the Identity of C and assign an appropriate IL to C's certificate.

A Domain's exchange service needs to be addressable and reachable from the public Internet. We assume that Domains participate in a Peer-to-Peer-style network that constitutes a DHT (Distributed Hash Table) storing key/value pairs. The DHT enables a Domain to store its current public IP under their cID in the DHT (`put(cID, IP)`). Other Domains use the DHT to query the current IP address of a known friendly Domain by performing an DHT query (`IP = get(cID)`).

Lastly, we introduce names for the different roles in the Internet trust exchange, see Fig. 1.

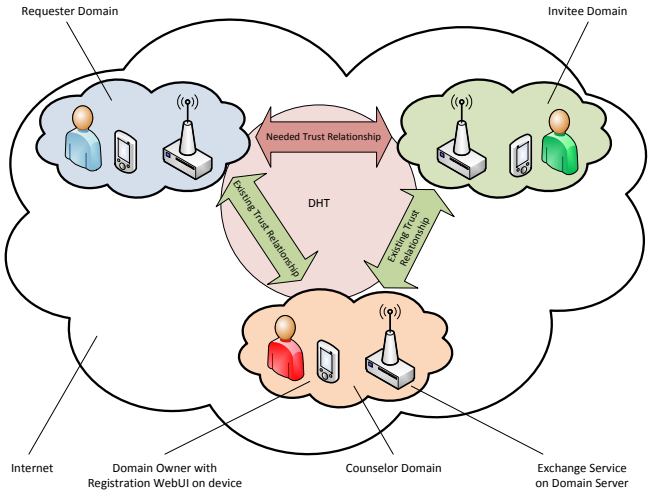

Figure 1. Scenario of the Internet trust exchange

The Domain that wants to establish a new trust relationship between herself and another Domain is called *Requester (R)*. The friend invited to join the new trust relationship is called

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Invitee (I). Finally, common friends that assist Requester and Invitee during the Internet trust exchange are referred to as *Counselors (C)*.

B. Protocol Details

Instead of presenting message sequence diagrams that depict every protocol detail, we explain the crucial steps of the Internet trust exchange using the simple example shown in Fig. 2, part 1. In the example, R wants to establish a trust relationship to her friend I. A trust relationship already exists between R and Counselor C and between C and I. Please note that in real life more than just one Counselor might exist.

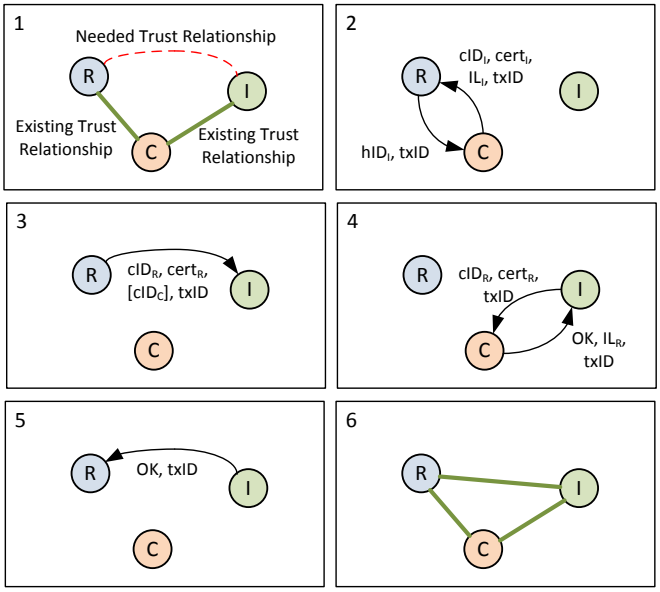

Figure 2. Example and simplified trust exchange message flow

The protocol is started by the Domain owner R by specifying to which Domain I she wants to establish a trust relationship to. This is done by providing I's human readable identifier (hID_I) to the own trust exchange service. Furthermore, the Domain owner must specify which Domains should act as Counselors either by specifying Domains explicitly or implicitly by naming suitable social communities.

The careful selection of Counselors is needed due to multiple reasons. 1) a *Counsel Request* sent to a Counselor will reveal the social contact between R and I. For this reason, the Requester might not want that *all* Domains she has already established a trust relationship to, are queried in order to protect her own privacy. 2) sending a Counsel Request to *all* known and trusted Domains is not useful when we assume the existence of distinct social communities. For instance, it is not useful to send a Counsel Request to a friend when trust should be established to a colleague. The likelihood that a friend might act as Counselor in this case is low. 3) a careful selection of Counselors helps reduce the risk of performing a trust exchange with the wrong Domain. For instance, the Requester might know two John Smiths. By sending Counsel Requests only to Counselor Domains that belong to the right social community, the chance that trust is accidentally established to the "wrong" John Smith's Domain is reduced.

As R and all Counselors already share a trust relationship, R's exchange service knows a Counselor's cryptographic identity. Each cID is resolved to an IP addresses using above explained DHT lookup and a secured TLS connection is established to the Counselor's exchange service. The mutual authentication of this connection is possible, as both Domains have already exchanged their Domain CA certificates. R's exchange service now sends a Counsel Request to C's remote exchange service, which contains hID_I and a random trust exchange ID (txID).

The owner of each queried Counselor Domain must decide whether she wants to reply to a previously received Counsel Request. This permission is required because sending a *Counsel Reply* to the Requester will reveal the existence of a trust relationship between C and I. Various reasons exist why a Counselor might decide not to reply.

The Counsel Reply sent from C's exchange service to R's exchange service contains information needed to securely connect to I, namely I's cryptographic identity (cID_I) and certificate (cert_I). Other meta-information, such as the Invitee's IL (IL_I), as determined by the Counselor, are also included in the message. The IL is important for the R's exchange service to compute the quality of the proposed information using the trust metric explained in Section V-C.

In the worst case, two or more different Invitee Domains might be proposed by different Counselors. In this case, the proposals are sorted and the IL of each proposed Invitee Domain is computed. The result of this operation is presented to the owner of the Invitee Domain. It is the owner's task to select the most promising looking proposal.

In Fig. 2, part 3, the Requester's exchange service contacts the Invitee's exchange service after resolving I's previously received cryptographic identity to her IP address. Over an half-authenticated TLS connection an *Exchange Request* is sent that includes the Requester's own certificate (cert_R) and identity (cID_R), a list of used Counselors ($[\text{cID}_C]$) and txID.

I's exchange service does not yet possess any trusted cryptographic credentials of R that could be used to authenticate the Exchange Request. For this reason I's exchange service will contact the Counselors named in the Exchange Request and ask them to perform the authentication of the Exchange Request by sending an *Authentication Request*. This message includes cID_R, cert_R and txID (Fig. 2, part 4).

The Counselor's exchange service now searches within its state if a trust exchange session was recently started that can be identified by txID, cID_R and cert_R. If the session exists, the legitimacy of the Exchange Request is confirmed. The Counselor Domain's exchange service communicates this fact by sending a positive *Authentication Reply* to I's exchange service. The reply furthermore contains the Identification Level of R (IL_R) as assessed by C and txID.

In the final phase of the trust exchange, depicted in Fig. 2, part 5, the Invitee's exchange service computes the Identification Level of the new trust relationship using the trust metric explained in Section V-C and asks the Domain owner if the trust relationship should be accepted. The purpose of this step is again to assist the Domain owner and to protect her from establishing a trust relationship with a Domain whose identity is not assured. Furthermore, the Domain owner must have the choice to accept the new trust relationship or not.

 ISBN: 978-1-61208-369-8

Finally in Fig. 2, part 6, the new trust relationship between Domains R and I is established.

C. Trust Metric

Trust metrics are generally used to minimize the risk of falsely trusting claims of other peers in a web of trust. Our trust metric reduces the likelihood of falsely established trust relationships in the case of Counselors accidentally or intentionally making wrong assertions about the identity of another Domain. The protocol previously explained makes use of this trust metric in two situations: 1) after the Requester received Counsel Replies from Counselors and 2) after the Invitee received Authentication Responses from Counselors.

The aim of our metric is to compute the Identification Level (IL) of a new trust relationship, i.e., to rate the trustworthiness of a received certificate. As a basis for this computation, Counselors include in their Counsel and Authentication Replies the IL of the Invitee or of the Requester as assessed by herself.

If only one Counsel Reply was received, the Identification Level IL_{RI} of a trust relationship between Requester (R) and Invitee (I) can be computed as follows, see (1) and Fig. 3. Please note that the same formula can be applied to rate IL_{IR} based on one Authentication Reply.

$$IL_{RI} = IL_{CI} \cdot \frac{RL_{RC}}{RL_{Max}} \cdot \frac{IL_{RC}}{IL_{Max}} \cdot d \qquad (1)$$

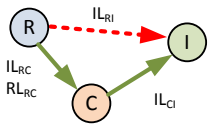

Figure 3. Identification and Reputation Levels between Domains

Explanation of (1): The credibility of a propagated IL_{CI} depends on two properties of the trust relationship to the Counselor. 1) the Reputation of the Counselor, i.e., how sure the Requester can be that the Counselor assigned the right IL to the propagated trust relationship. 2) the IL the Requester has assigned to the Counselor by himself. So, the formula expresses that the IL_{CI} of a trust relationship established over a *securely* identified Counselor that has a *very good* reputation has *high* credibility. If the Counselor is rated *not* to be very reliable or was *insecurely* identified herself, IL_{CI} is decreased by the formula.

Additionally, a dampening factor d decreases the ILs established over the Internet as we argue that exchanging trust indirectly without personal human interaction can never be as reliable as exchanging trust directly in person. Hence, the maximal IL_{RI} of a trust relationship that can be established over the Internet is $IL_{Max} \cdot d$. In the current implementation we use a static dampening factor $0,9$, so the maximum IL will be $10 \cdot 0,9 = 9$.

If more than one Counselor has sent Counsel Replies, the single ILs can be aggregated as follows, see (2). Please note that the same calculation can be applied to rate IL_{IR} based on several Authentication Replies

$$IL_{RI} = \frac{\sum_{C \in Counselors} IL_{CI} \cdot \frac{RL_{RC}}{RL_{Max}} \cdot \frac{IL_{RC}}{IL_{Max}}}{count(Counselors)} \cdot d \qquad (2)$$

Formula 2 computes the algebraic average of the IL_{CI} values propagated by each single Counselor. As in (1) each IL_{CI} is weighted by the Counselor's Reputation and Identification Level. We furthermore propose to adjust the dampening factor d dynamically according to the amount of received Counsel Replies. If more than three Counsel Replies were received that all proposed the same Invitee Domain, the dampening can be set to 1, resulting in no dampening at all.

In Fig. 4, part 1, we have depicted a simple example scenario with IL and RL values where R has established a trust relationship to I.

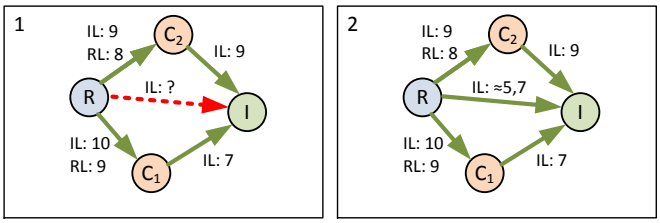

Figure 4. Example: Aggregation of propagated Identification Levels.

The IL_{RI} of the new trust relationship can be calculated by inserting known IL and RL values and propagated IL values into (2). d is set to 0,9 as only two Counselors participated, see (3):

$$IL_{RI} = \frac{7 \cdot \frac{9}{10} \cdot \frac{10}{10} + 9 \cdot \frac{8}{10} \cdot \frac{9}{10}}{2} \cdot 0,9 \approx 5,7 \qquad (3)$$

VI. Evaluation

In the following, we want to evaluate the presented mechanism using the requirements we defined in Section IV. Security requirements R1 and R3 are satisfied as all communication channels are encrypted and authenticated. No third party can interfere with the trust exchange. The trust exchange furthermore queries different independent counselors and rates the authenticity of received certificates with our trust metric (R2). This reduces the likelihood that a willingly or accidentally proposed unintended certificate gets accepted. Furthermore, it reduces the maximum distance in the social graph that can be bridged with repeated Internet trust exchanges. However, we still suggest to strengthen trust relationships established over the Internet with the personal trust exchange when the opportunity is given. Existing trust relationships within a social community cannot be enumerated by attackers that are not already part of this group (R5). The reason for this is that outside attackers are unable to contact exchange services that belong to this social community as their cID and IP are unknown. Additionally, an attacker would not be able to successfully authenticate towards an exchange service. Within the community, trust relationships can be hidden on demand of a Domain owner acting as Counselor. However, the current protocol does not protect an Invitee's privacy yet. In case a Counselor decides to take part in the Internet trust exchange, the trust relationship between this Counselor and the Invitee is revealed to the Requester. However, this issue can be fixed with a slightly modified protocol. The mechanism is also strongly human centric (R4) as there are no central authorities involved and as we always leave the last word to the Domain owner, i.e.,

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whether she wants to assist in a trust exchange or whether she wants to accept a new trust relationship as an Invitee (R7). The proposed system is furthermore fairly easy to use and does not require special skills as we provide a high degree of automation (R6). The Domain owners only need to control their exchange service, which takes care of the rest. The amount of interaction between the exchange service and its owner is minimized. Each involved Domain owner is only bothered once when a trust exchange is performed (R8). This design principle is also good for performance as for each phase of the trust exchange only one waiting period for user input exists. The responsiveness of our system is therefore optimized as well. Nevertheless, we need to point out that performing the Internet trust exchange might need a considerable amount of time when human users do not respond quickly (R9).

VII. Related Work

The mechanism we presented has some similarities with FOAF+SSL (Friend of a Friend + Secure Socket Layer) [12]. Both leverage a user's social graph to establish trust into keying material. Whereas our mechanism is targeted to establish trust in long-term keys, FOAF+SSL is an on-the-fly authorization mechanism for the semantic web. FOAF+SSL's aims can best be subsumed with "friends of my friends may access my website". One problem of FOAF+SSL we see is that the system requires publicly available data structures called WebIDs, which reveal a user's social graph.

The SecBook project, which is to our knowledge a discontinued student project, followed a different approach for trust establishment over social communities. SecBook used the Facebook API to store a public key and other information in a user's Facebook profile. This approach made it quite easy for users to identify their friend and obtain her public key. However, this mechanism was limited to Facebook users and was only as secure as a user's Facebook password. When a weak password was used, an attacker was easily able to hijack the profile and exchange the public key.

Monkeyspere [13] is a tool that addresses (amongst other aims) problems with not authentifiable certificates in the public World Wide Web. Once a user reaches a web page whose certificate cannot be authenticated, as it is self-signed, for instance, friends of the user are queried by the Monkeysphere tool and asked whether they trust this certificate. If they do, trust into this certificate is established locally as well.

VIII. Conclusion and Future Work

In this paper, we pointed out the importance of small-scale private networks and their need for secure identification and authentication as basis for strong network and service access control. We outlined various parts of our past work that focused on secure and user-friendly mechanisms for key and identity management within unmanaged network Domains. Another important concept we outlined is a human-centric trust establishment mechanism performed personally between owners of Domains. As this mechanism is limited to situations where a personal meeting is possible, we introduced in this paper a new trust exchange mechanism that can be performed over an insecure network requiring no personal meeting of participants. The central idea of this mechanism is to leverage Domains that already share a trust relationship to each of the Domains that want to establish a new trust relationship with each other. These so-called Counselor Domains act in our protocol as a specific type of trusted third party and assist the Domains that want to exchange trust. Although these mechanisms were presented in the context of private home networks all concepts are generic and can be adapted to various scenarios.

Currently, we work on including the described mechanisms in our "Living Lab" as security infrastructure. In the Living Lab we explore this and other technologies related to smart buildings and how humans interact with it in a secure and privacy-protecting manner. Furthermore, we work on an extension of the proposed trust exchange mechanism able to establish trust between Domains over more than one hop.

Acknowledgments

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References

[1] S. Hickey, "The Raspberry Pi computer," Article in The Guardian online, http://www.theguardian.com/technology/2014/mar/09/raspberry-pi-computer-eben-upton-cambridge [retrieved August 2014], March 2014.

[2] openHAB UG, "openHAB," Website, http://www.openhab.org/ [retrieved August 2014].

[3] G. Greenwald and E. MacAskill, "NSA Prism program taps in to user data of Apple, Google and others," Article in The Guardian online, http://www.theguardian.com/world/2013/jun/06/us-tech-giants-nsa-data [retrieved August 2014], June 2013.

[4] G. Greenwald, "XKeyscore: NSA tool collects 'nearly everything a user does on the internet'," Article in The Guardian online, http://www.theguardian.com/world/2013/jul/31/nsa-top-secret-program-online-data [retrieved August 2014], June 2013.

[5] ownCloud Inc., "ownCloud," Website, https://owncloud.org/ [retrieved August 2014].

[6] Seafile Ltd., "Seafile," Website, http://seafile.com [retrieved August 2014].

[7] A. Müller, H. Kinkelin, S. K. Ghai, and G. Carle, "An Assisted Device Registration and Service Access System for Future Home Networks," in proceedings of IFIP Wireless Days 2009, Paris, France, 2009.

[8] A. Müller, H. Kinkelin, S. K. Ghai, and G. Carle, "A Secure Service Infrastructure for Interconnecting Future Home Networks based on DPWS and XACML," in proceedings of ACM SIGCOMM Workshop on Home Networks (HomeNets) 2010, New Delhi, India, 2010.

[9] T. Moses, "eXtensible Access Control Markup Language (XACML) Version 3.0," OASIS Standard, 2013.

[10] D. Cooper, S. Santesson, S. Farrell, S. Boeyen, R. Housley, and W. Polk, "Internet X.509 Public Key Infrastructure Certificate and Certificate Revocation List (CRL) Profile," RFC 5280 (Proposed Standard), Internet Engineering Task Force, May 2008, updated by RFC 6818. [Online]. Available: http://www.ietf.org/rfc/rfc5280.txt

[11] P. Zimmermann, "Why OpenPGP's PKI is better than an X.509 PKI," Website, 2012, online articile, http://www.openpgp.org/technical/whybetter.shtml [retrieved August 2014].

[12] H. Story, B. Harbulot, I. Jacobi, and M. Jones, "FOAF+SSL: RESTful Authentication for the Social Web," in proceedings of European Semantic Web Conference, Workshop: SPOT2009., Heraklion, Greece, 2009.

[13] "The Monkeysphere Project," Website, 2013, online article, http://web.monkeysphere.info [retrieved August 2014].

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Security and Safety Composition Methodology

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***Abstract*—One of the main aspects of modern life is the interaction with sensors and other embedded systems. These systems become increasingly more integrated with daily life activities. They enable the interaction between a variety of components or parties (people, actuator, sensor, software, etc.). This interaction causes the appearance of new challenges in the design of security-related aspects of embedded systems. This paper uses the SHIELD methodology of the JU Artemis to provide Security, Privacy and Dependability (SPD) levels of embedded systems. We propose an extension of the methodology to take into consideration interactions between components, and introduce functions describing the significance of the interconnections. The complete methodology enables the composition of SPD as an add-on or as a built-in feature, and is thus applicable to an already built embedded system or to the development of embedded systems.**

Keywords - security composition; safety composition; component interconnection; sensor security; IoT; security attributes; privacy.

I. INTRODUCTION

The Future Internet is transforming from what it is today (a mere communication highway) into a backend system connecting hybrid networks. These hybrid networks will connect people, services, things (sensors, actuators) and computers all together; in other words, it will create the Internet of People, Things and Services (IoPTS) [1]. IoPTS developed from the Internet of Things (IoT) terminology [2], which has traditionally been a subject of intensive research in the area of computing and networking, taking into consideration the impact of things such as sensors, actuators and devices.

IoPTS is seen as an integrator of processes in the domain of computing, communication, data storing, monitoring and control of entities in the physical world. The integration of heterogeneous processes creates new challenges, especially related to security. Process execution without controlling security features will potentially impact people or services, and may create economic loss, reduce privacy or in the worse case scenario, harm human life.

We consider the IoPTS as a system of interacting embedded systems, with the embedded systems being the central unit in the IoPTS. While specific interest is usually given during the design of embedded systems, operational aspects of security are often less announced. Moreover, life-time security of embedded systems is often neglected during system development, thus leaving many devices vulnerable to attacks. The growing number of embedded systems nowadays (mobile phones, smart TVs, household appliances, home automation products, industrial monitoring, control systems, etc.) make them interesting targets for criminal activities. On the other hand, the implementation of security and safety measures is not easy due to the constraints on resources of this kind of systems.

Addressing embedded systems security and safety challenges is considerably complex, resulting from a variety of factors. One of these factors is the interconnection between system components. From the functionality perspective, the interconnection between system components allows a system to provide its services. From the dependability perspective, this interconnection causes the same system to fail as a result of a defect in one specific component, even though other components are working properly. From the security point of view, component interconnection means that a security problem in one component could lead to a problem within other related components. Let us consider a smart vehicle embedded system, as an example: If a vehicle owner can remotely turn the vehicle on/off using a particular software library, vulnerabilities in this software library might be used by a 3rd party to influence the engine availability.

Novel research by the SHIELD projects in the joint undertaking JU ECSEL (former JU ARTEMIS) suggests a distributed architecture for embedded system safety and security [3]. Semantic descriptions of each aspect and a semantic overlay are the core of the SHIELD methodology enabling measurable and composable security. The descriptions include attack capabilities, security functionalities, system components, and security in the perspective of a system of systems.

The supporting SHIELD ontologies are built on the decomposition of the embedded system into components. For each component, the SPD needs are identified as attributes. For the identified SPD needs, the possible techniques (functionalities) to address these needs are identified. Figure 1 provides the view on how embedded systems can be enriched through security attributes to create systems with security, privacy and dependability functionality.

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An embedded system consists of system components, e.g., communication, where each component has certain SPD attributes, e.g., encrypted communication. Through the SHIELD methodology, the attributes are then transferred into

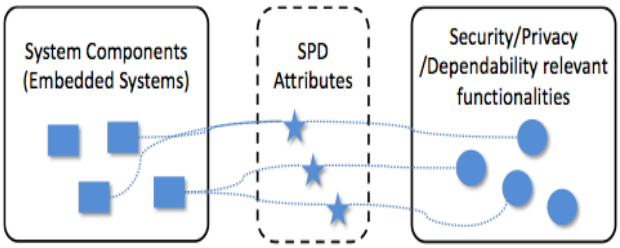

Figure 1. Relation between SPD functionalities and attributes for system component [3].

SPD functionalities, e.g., protection against man-in-the-middle attack. Addressing functionalities through component attributes thus allows matching required security demands of an application.

Possible SPD functionalities addressing SPD attributes could be encryption, redundancy and hash coding (for person ID), satisfying the requirements for confidently, availability, and anonymity of data, for example.

This paper analyzes the interconnection between components, and the impact of the interconnection on SPD attributes. The paper proposes a new composition methodology for SPD functionalities to enhance the SPD level of the embedded system.

The paper is organized as follows: In Section 2, we give an overview of related work. In Section 3, we provide some examples about the impact of interconnection on SPD attributes. In Section 4, we propose our extension of the SHIELD methodology considering components interconnection and SPD attribute interconnection. Section 5 provides a potential use case, and Section 6 presents the composition algorithm for that use case. In Section 7, we present our conclusion.

II. RELATED WORK

Organizations, typically, apply risk management processes for their information technologies in order to mitigate Information Technology (IT) related risks. This way, they assure that their organizational enterprise operates in accordance to their risk appetite [4]-[6].

Recent improvements enhance system security by building security models in their risk assessment. Through security models, they identify attack paths potentially leading to damage. A majority of researchers suggest attack graphs [7]-[9], while others use attack trees to display the attack potential [10].

Attack graphs modeled by administrators could be used to harden a system network through finding critical vulnerabilities whose removal can prevent potential attacks and so improve system SPD level [6][11].

Schneier [5] demonstrated how the attack graphs can help in designing network security metrics. Wang et al. [12][13] propose an attack graph-based probabilistic metric model to quantify the overall security of their network. Xie et al. [14] performed a security risk analysis using Bayesian networks [16] incorporated with Intrusion Detection System (IDS) alerts.

Traditional research concentrates mostly on the discovery of system vulnerabilities and the relation between these vulnerabilities, having the goal to harden the system and to enhance system SPD level. They model these vulnerabilities and their relations to propose security metrics, often based on one semantic description for the specific system.

In this paper we concentrate on the analysis of system components, their interaction and relations to harden the system. Individual ontologies are used to describe the individual embedded systems, their components, SPD attributes and security functionalities. Hardening is achieved through increasing the SPD level of the system by prioritizing system SPD functionalities (e.g., encryption) in the composition process. This prioritization helps system engineers to suit SPD functionalities add-on or built-in based on their SPD cost readiness, so they end up with better SPD level using the same cost.

III. COMPONENTS INTERCONNECTION IMPACT ON SPD ATTRIBUTES

The interconnection between system components makes the SPD attributes of these components dependent on each other. Some examples are provided on how interconnection between system components affect the SPD attributes of these components and their interconnections.

A. *Authentication impact availability*

Let us consider the smart vehicle case, where the vehicle owner could turn the vehicle remote on/off. An attacker might know the authentication and authorization security attributes and their functionalities. Thus, exploiting the vulnerabilities of authentication or authorization functionalities will enable him to take control of the vehicle engine. Thus, the interconnection between remote on/off applications and the engine control makes the availability (SPD attribute) of the engine as a system component dependent on the authentication attributes of the remote application component.

B. *Confidentiality impact privacy*

Let us consider the case of the smart vehicle, where the vehicle owner can monitor the vehicle remotely. With successful attack on the monitoring component confidentiality, the privacy of the vehicle rider is revealed.

C. *Reliability impact privacy*

Let us consider again a smart vehicle, with remote monitoring capabilities that might have engine, position and speed monitoring as part of the functionality. A standard operation would include engine monitoring, while protecting the driver's privacy through hiding speed and position. Improper activation of the monitoring component caused by a functional problem will cause unwanted exposure of the driver's privacy.

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D. Reliability impact authorization

Let us consider again the case of the smart vehicle, with the remote engine control. Incorrect configuration of the remote engine control or the communication protocol might allow a 3rd-party to interfere with the vehicle engine, and thus make the vehicle vulnerable. This example demonstrates that dependability attributes, such as reliability, may impact security attributes, such as authorization.

IV. SHIELD ONTOLOGY CONSIDERING COMPONENTS INTERCONNECTION

As indicated in the previous use cases, interconnection between system components may influence SPD attributes of other interconnected components. Although the SHIELD methodology enables measurable and composable SPD of embedded systems (see Figure 1), aspects of component interconnection are not that well announced. We propose an extension of the SHIELD methodology, concentrating on component interconnections as well as their impact on SPD attributes.

A. Extension of the SHIELD component ontology

For the component ontology, we define component interconnection graphs as a representation for system components and their interconnections. Through these graphs, we considered interconnections between system components being both data and control transactions.

Component interconnection graphs are frequently being used in modeling distributed software architectures [15]. In our paper, we define component interconnection graphs as direct graphs, consisting of one type of vertice, which is a *component*, and two type of edges, which are *data* and *control*. The direction in the graph reflects the relation direction. For instance, if the *data* edge point connects from *C1* to *C2*, it means that the component *C1* sends data to/through *C2*. If the *control* edge point from *C2* to *C3*, it means that component *C2* sends control commands to/through C3. Component interconnection graph concepts are illustrated in Figure 2 and formally characterized in Definition 1.

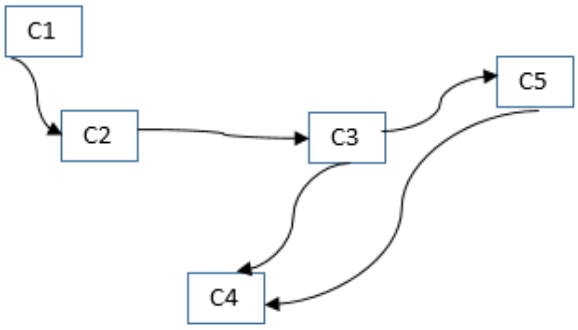

Figure 2. Illustration of a component interconnection graph.

Definition 1. Given a set of Components C, having a set of control relations $R_c \subseteq C \times C$, and a set of data relation $R_d \subseteq C \times C$, then the components interconnection graph G is the directed graph G (C, $R_c \cup R_d$), where C is the vertices set and $R_c \cup R_d$ the edge set.

B. Extension of the SHIELD SPD attribute ontology

In this paper, we define security attributes interconnection graphs as representation for component SPD attributes and their interconnections. Our security attributes interconnection graph is a directed graph having one type of vertices attribute A and one type of edges IMPACT. The direction in the graph reflects the relation direction, e.g. an edge pointing from A to B means that attribute A *IMPACTs* attribute B.

SPD attributes interconnection graph edges are derived from the components interconnection graph edges. If an edge exists between two SPD attributes (vertices) then an edge must exist between these two attribute components in the component interconnection graph.

Security attributes interconnection graphs concepts are illustrated in Figure 3 as SPD attributes, and formally characterized in Definition 2.

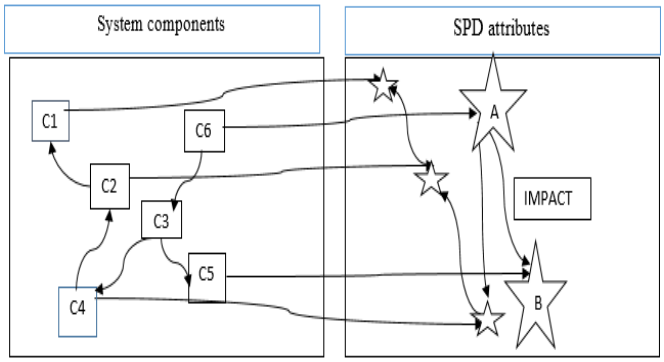

Figure 3. Security attributes interconnection graphs extending the SHIELD methodology.

Definition **2.** Given a set of attributes A, which represent a set of impact relations, $R_{impact} \subseteq A \times A$, then security attributes interconnection graph G is the directed graph G (A, R_{impact}), were A the set of vertices set and R_{impact} the set of edges.

C. SPD attributes interconnections derived from component interconnections

We define an *IMPACT* relation as interconnection relation between SPD attributes of components. This *IMPACT* relation is defined through $DEP_{control}$ and DEP_{data}, connecting the SPD attributes on the control and the data plane. Within these two sets of SPD attributes, the first element of the pair has an impact relation with second element, where:

- DEP_{data}, contains pairs which have an *IMPACT* relation resulted from data transmission.
- $DEP_{control}$ contains pairs which have an *IMPACT* relation resulted from control command transmission.

The formalized description of the relation is seen as follows:

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In a given system, let C be a set of system components, A be a set of SPD attributes and *c be a component c ∈ C. The relations are then defined as:*

ATTB(c) = attb – return attb ∈ ATTB, being the SPD attribute set of component c.

CRTL(c) = crtl – return crtl ∈ CRTL, being a set of components, where c has direct or indirect control relation to.

DATA(c) = data – return data ∈ DATA, being a set of components, where c sends data directly or indirectly to. Then $DEP_{control}$ *and* DEP_{data} *are defined as:*

$DEP_{control}$ *={ (a1, a2) | a1, a2 ∈ A ∧ ∃ c1, c2 ∈C (c2 ∈ CRTL(c1) ∧ a1 ∈ ATTB(c1) ∧ a2 ∈ATTB(c2)*
⇒ a1 IMPACT a2*}*

DEP_{data}*= { (a1, a2) | (a1, a2 ∈ A) ∧ (c1, c2 ∈C) ∧ (c2 ∈ DATA(c1) ∧ a1 ∈ ATTB(c1) ∧ a2 ∈ATTB(c2)*
⇒ a2 IMPACT a1 *}*

Note: While the interconnection relation between components exchanging data is in forward direction, *a1 IMPACT a2*, the *IMPACT* relation is the other way around for components exchanging control commands. Let us consider an example, where an attacker exploits the connection component confidentiality (SPD attributes) in the communication between a sensor and a control unit. By exploiting this connection component, the privacy of the sensor component sending data is compromised. Likewise, exploiting the confidentiality of the connection component transmitting commands reveals the privacy of the control unit.

V. CASE STUDY

This case study investigates the impact of authentication attributes of a remote turn on/off component on the availability attribute of other related components in a smart vehicle. The case is based on the extended SHIELD methodology presented in the previous sessions.

Let us consider that the vehicle owner could turn the vehicle on/off using a mechanical component and remotely by a software application. Let us further consider that a remote turn on/off will disable the mechanical turn on/off.

As a first step, the related components of the engine are identified, based on control command transmission and data transmission. The components might be described as follows:

- C1: software component on mobile phone to remotely turn the engine on/off by the owner.
- C2: software connection transmitting the control command from C1 to C3.
- C3: actuator component responsible for turning the vehicle on/off (C4) and also responsible for deactivating of mechanical turn on/off from C5.
- C4: vehicle engine
- C5: mechanical component (key, button) for turning the engine on/off.

An exploitation of the C1 authentication will impact the availability of C4 and C5. An attacker exploiting the C1 authentication will put him into control of the engine and also disable the mechanical turn on/off component C5. But, at the same time, exploiting the C1 authentication will not impact the connection availability (C2) or the actuator availability (C3).

The extended SHIELD methodology for this use case is shown in Figure 4, with the authentication attribute being represented by circle.

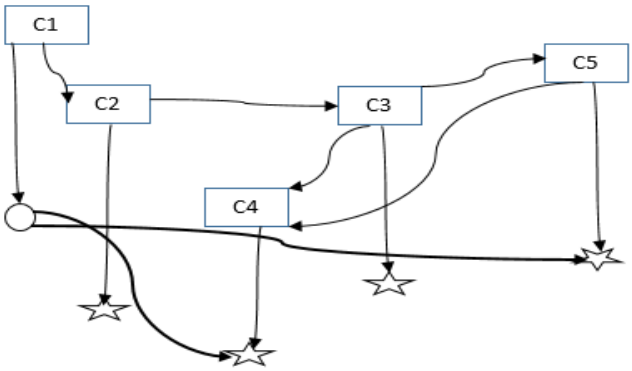

Figure 4. Case representation of the extended SHIELD methodology, exploiting the authentication (circle) on availability of other SPD components.

VI. SPD FUNCTIONALITIES COMPOSING ALGORITHM

The previous section indicated the dependency between components based on their interactions with each other. This section will demonstrate how system component SPD attributes, such as confidentiality, can be composed through SPD functionalities, such as encryption. The composition process using our methodology will also be able to counteract on limited safety and security resources, and will help handle the increasing complexity of systems.

The goal of the risk analyzer is reaching optimal composition of SPD system functionalities. An optimal composition of SPD functionalities has many advantages including:

- Increase system SPD level (through adding of SPD functionalities to most needed places in the system);
- Reduce security cost (through removing of SPD functionalities from less needed places);
- Improve the performance of the system (through removing of SPD functionalities from less needed places).

In our extended methodology, to optimize the composition of SPD functionalities, we weight each component in the system based on its interconnection within the system. Component interconnections will reflect to which degree the failure of component SPD attributes will impact the SPD level of the system. From this perspective, our component weighting algorithm depends on the following factors:

- The number of interconnection relations with surrounding components.
  Here surrounded components increase the weight of a component through direct interconnections. The impact of exploiting the component SPD attributes on the system SPD level increases with the number of direct interconnected components.

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- The number of components reachable from weighted components.
  This factor reflects how many components are reachable through data or control relations from/to this component.
- The number of components between a weighted component and a main valuable component, called key component.
  By a key component, we characterize a component, in which exploiting of SPD attributes will cause a significant reduction of the system SPD level. The identification of key components will be a task for the domain specialist. Our assumption is that a close logical distance to a key component makes the system more vulnerable, letting us consider the logical distance between components.
- Type of relation between a component and other components.
  We identified 'data' and 'control' being the two types of interconnections between system components. In our methodology, we consider control being more vulnerable than data relations, as exploiting data is often related to monitoring, while exploiting control is opening for changes in the system. The worst case exploiting of control components could cause serious accidents (in our vehicle scenario).
- Component activation rate:
  Not all components are active during time of operation. For instance, airbags and eCall applications will only be triggered in a crash situation. In normal operations, these crash components have no impact on the SPD level of the system. Based on this status of operation our methodology considers the component activation rate for the weighting of SPD components.

Using the factors mentioned in the previous list, we propose a weighting algorithm, taking into account the impact of an exploitation of SPD attributes.

Let *C* be the component set of a given system, and
V be the subset of system Valuable components (key component) included in *C*, $V \subseteq C$.
With '*c*' being a component in the system, $c \in C$,
F being the set of *SPD* functionalities, and
A being the set of *SPD* attributes, where '*a*' is an *SPD* attribute, $a \in A$, the following functions are defined to introduced weighted relations:

ATTB(c) = attb – return attb ∈ ATTB, are *SPD* attributes set of component *c.*

CRTL(c) = crtl – return crtl ∈ CRTL, are sets of components, with *c* having direct or indirect control relation with the component.

DATA(c) = data – return data ∈ DATA is a set of components, where c sends data directly or indirectly to the component.

$SPD_{Func}(a) = SPD_{func}$ *– return* $SPD_{func} \in F$ is a set of SPD functions, where the SPD_{func} satisfies '*a'.*

DIST(c1, c2) = n – return is the number of components between *c1* and *c2*

NUM(S) = n – return is the number of elements in S, where S is any set of components (this function just counts the number of set element)

If c2 ∈ CRTL(c1) ∨ c2 ∈ DATA(c1) ∧ DIST(c1, c2) is 1 ⇒ c2 Surrounded c1

Surrounded (c) = s – return s ∈ C is the set of components surrounding *c.*

If c2 ∈ CRTL (c1) ∨ c2 ∈ DATA (c1) ⇒ c1 Reach c2

Reach (c) = R – return R is the set of components reachable from *c*, where $R \subseteq C \wedge \forall\ r \in R$, *c Reach r.*

ActivationRate(c) is the percentage of '*c'* activation comparable for longest activated component.

VAL(c) = v - return v where $v \in V \wedge v \in Reach(c)$, is a set of valuable component reachable from *c*. Using above functions component weight is calculated as

$$Weight(c) = NUM(Surrounded(c)) + NUM(Reach(c)) + NUM(CRTL(c))*2 + NUM(DATA(c)) + AtivationRate(c) + \left(\sum_{v=0}^{n} \frac{1}{DIST(c,v)}\right) * NUM\big(VAL(c)\big), where\ v \in VAL(c)$$

Let c1, c2 ∈ C, if weight (c1) > weight (c2) ∧ ∃ a1 ∈ ATTB(c1) ∧ a2 ∈ ATTB(c2) then the priority of *composing* $SPD_{Func}(a1)$ is higher than (*>*) *composing* $SPD_{Func}(a2)$

The above algorithm calculates the weight of components based on the degree of interconnection with other components in the system. Given an example, the exploitation of SPD attributes of one component being in the close neighborhood of a key component will reduce the SPD level of the system considerably, expressed through the *Reach* and *Weight* functions.

Another example addresses the *Reach* condition of a component, given the comparison of *A* and *B* being components within a given system, where:

- Within the *B* component, data are processed without transmission of parameters to other components.
- The component *A* receives data from components *C, D* and *G.*

Exploiting the confidentiality of component *B* will only impact *B*, whereas exploiting the confidentiality of component *A* will impact the confidentiality of components *C, D* and *G.* Our extended methodology uses the *Reach* function, which will provide component *B* with less weight than component *A.*

Ongoing work applies the weighting algorithms to the calculation of impact of SPD attributes in a system analysis of

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the vehicle use case. We expect that the outcome of the study will enable us to draw relational security, privacy and dependability graphs of embedded systems, and thus better tailor the complexity in a system of systems.

VII. CONCLUSION

This paper provided measures for the interaction between a variety of components or parties in the Internet of People, Things and Services (IoPTS). Interactions between components in a system cause security-related challenges for embedded systems. The paper uses the Security, Privacy and Dependability (SPD) approach developed by the SHIELD Methodology of the JU Artemis. We proposed an extension of the methodology to compose security and safety techniques, taking into consideration the interconnection between system components. The overall, system SPD level will thus become more dependent on the impact of interconnection between system components.

For each component, the impact of exploiting its SPD attributes on the system SPD level is represented by a *Weight* function. Our methodology uses both neighborhood and distance to key components as measures for the *Weight* function. The enhanced SHIELD methodology enables system engineers to compose SPD levels, and, by that, increases the SPD level of embedded systems.

Our methodology opens for a graph representation of security, privacy and dependability between components of embedded systems, and thus, visualizes critical paths.

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REFERENCES

[1] J.H.P. Eloff, M.M. Eloff, M.T. Dlamini, and M.P. Zielinski. “Internet of people, things and services-the convergence of security, trust and privacy”, 2009, Proce. of the third International Workshop IoPTS, Brussels, Dec 2009.

[2] L. Atzori, A. Iera and G. Morabito, “The Internet of Things”, A survey, Comput. Netw. 2010, doi:10.1016/ j.comnet.2010.05.010.

[3] pSHIELD, the pilot SHIELD project, and nSHIELD, the new SHIELD project, are EU Artemis projects in the security domain, Available from http://newshield.eu/ 2014.08.25

[4] B. Schneier, “Attack Trees,” Dr. Dobb’s J., Dec. 1999.

[5] R. Dantu, K. Loper and P. Kolan, “Risk Management Using Behavior Based Attack Graphs,” Proc. Int’l Conf. Information Technology: Coding and Computing, 2004, pp. 445-449.

[6] S. Noel, S. Jajodia, B. O’Berry and M. Jacobs, “Efficient Minimum-Cost Network Hardening via Exploit Interconnection Graphs,” Proc. 19th Ann. Computer Security Applications Conference 2003, pp. 86-95.

[7] P. Ammann, D. Wijesekera and S. Kaushik, “Scalable, Graph- Based Network Vulnerability Analysis,” Proc. Ninth Conf. Computer and Communication Security, 2002, pp. 217-224.

[8] C. Phillips and L.P. Swiler, “A Graph-Based System for Network-Vulnerability Analysis,” Proc. New Security Paradigms Workshop, 1998, pp. 71-79.

[9] S. Jha, O. Sheyner and J.M. Wing, “Two Formal Analysis of Attack Graphs,” Proc. 15th IEEE Computer Security Foundations Workshop, 2002, pp. 49-63.

[10] J. Dawkins, C. Campbell and J. Hale, “Modeling Network Attacks: Extending the Attack Tree Paradigm,” Proc. Workshop Statistical Machine Learning Techniques in Computer Intrusion Detection, 2002.

[11] L. Wang, S. Noel and S. Jajodia, Minimum-cost network hardening using attack graphs, Computer Communications 29(18) 2006, 3812–3824.

[12] L. Wang, A. Singhal and S. Jajodia, “Measuring the Overall Security of Network Configurations Using Attack Graphs,” Proc. 21st Ann. IFIP WG 11.3 Working Conf. Data and Application Security, 2007, pp. 98-112.

[13] L. Wang, T. Islam, T. Long, A. Singhal and S. Jajodia, “An Attack Graph-Based Probabilistic Security Metric,” Proc. 22nd Ann. IFIP WG 11.3 Working Conf. Data and Applications Security, 2008,pp. 283-296.

[14] P. Xie, J.H. Li, X. Ou, P. Liu and R. Levy, “Using Bayesian Networks for Cyber Security Analysis,” Proc. 40th IEEE/IFIP Int. Conf. Dependable Systems and Networks, 2010.

[15] H. Gomaa and D.A. Menascé. “Design and performance modeling of component interconnection patterns for distributed software architectures”. In Proceedings of the 2nd Int. workshop on Software and Performance, Sep 2000, pp. 117-126. ACM.

[16] F.V. Jensen, “An introduction to Bayesian networks”. Vol. 210. London: UCL press, 1996.

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User-centric Recommendation Model for AAC based on Multi-criteria Planning

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***Abstract*—Recommendation algorithms are useful to fast decision-making in complex scenarios. They are based in grasping knowledge from the user and his environment to personalize applications according to a specific domain. However, the complexity of each domain and the dynamic relations between different items and criteria can be challenging. In Alternative and Augmentative Communication (AAC), assistive technologies have been envisaged to help people with neuro-linguistic disorders in stories construction. Nevertheless, there are still many problems to overcome, related to the algorithms and their application. In this work, we present an original approach based on knowledge domain modelling, user archetypes, learning strategies and multi-criteria planning to assist the user in managing a set of decisions. The proposed algorithm was applied in the context of AAC systems, aimed to help aphasic persons in the construction of coherent and semantically correct stories about their daily activities. The system was validated by an aphasic person and several healthy individuals, in terms of the precision and efficiency of the method, compared with other approaches. The results demonstrate that the presented method has a good precision in the recommendation, allows faster decisions and is well adapted to AAC and can be extended to similar applications.**

Keywords–Personalized recommendation; AAC; Multi-criteria; Planning; Hybrid recommender; Phrase Prediction.

I. INTRODUCTION

Communication is an indispensable factor of social behavior. Many people are not able to communicate easily because of different limitations in their intellectual and/or physical abilities. Some disorders, like aphasia, limit the comprehension, production and use of conventional human communication (oral and/or written language) [1].

Augmentative and Alternative Communication (AAC) is a field of assistive technologies which focuses on tools to help people to communicate better. Commonly, computer-based AAC systems are limited to communication boards, with set of symbols or pictograms through navigation menus, for composing messages and synthesizing them [2]. However, computers can in principle do more than this. In fact, current challenges of AAC systems are: first, improving time to generate a message; second, help in keeping a logical semantic and syntactic order, given that people with neurolinguistic disorders can not follow a syntactically correct word order, neither select an exact number and arrangement of symbols [3]; and third, providing support for applications in social environments such as social networks, instant messaging, emails and conversations person to person [4][5][6][7]. Some projects have developed prototypes that attempt to address these challenges. For example, Wiegand and Patel [8], in the SymbolPath project, aimed to enhance the message formulation ease and communication rate by selecting a set of icons, without any specific order, following a path with continuous motion. This system determines the most likely subset of desired icons on the path and rearranges them to form a meaningful sentence. Reiter et al. [9] built a system to support social interaction, which uses external data, knowledge sources, and domain and conversational models, to suggest possible appropriate messages to conversations. Moreover, Ma et al. [10] present a platform for aphasics to find and share information called W2ANE project. It uses an adaptive and adaptable lexical structure, multimodal vocabulary, multimedia content, concepts association and web interfaces.

Particularly, prediction models and recommender systems have been proposed to enhance time generation of messages. Thereby, Wiegand and Patel [11] describe an approach to phrase prediction using semantic grams, which provides relations between message components regardless its word order. Vertanen and Kristensson [12] create a large corpus of fictional AAC messages to suggest phrases by using crowdsourcing and training of language models. Also, Trinh et al. [13] develop a phoneme-based predictive communication system which uses a word auto-completion feature, predicting the word being entered, based on the phoneme prefix and prior words. Finally, Mitchell and Sproat [14] propose a method to predict a whole response given features of previous utterance using an entropy-based measure to find possible phrases on a large corpus of scripted dialogs.

Furthermore, phrase prediction and query expansion methods have been proposed for applications different from AAC. For example, Nandi and Jagadish [15] use a FussyTree structure within a probabilistically driven completion choice model to predict a multi-word phrase. Also, Dong et al. [16] propose an ontology graph based query expansion scheme for biomedical information retrieval, which allows to expand search queries using related specialized concepts. According to Carpintero and Romano [17] those approaches are mainly used in search engines to help users to complete and refine the search queries in order to get better results. Nevertheless, these approaches, regardless of whether or not they are conceived to AAC, are not suitable to withstand the three challenges presented by Wiegand [3] mentioned at the beginning of this introduction. For example, in [11], although there is not an order preferred in input words to guess a sentence, the prediction depends on the size of the training set. In [8], the user does not depend on the selected

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symbols, but the suggested sentences are incoherent. Word and phone-based prediction models [13][15][16] guess terms by assembling letters. This approach requires skills that people with neurolinguistic disorders do not preserve. In addition to the before mentioned, there are requirements of special interest, such as: (1) flexibility in the selection order of different criteria, without affecting the message consistency; (2) richness in the message specificity, (3) focus on social applications and (4) phrase prediction and coherent messages composition.

Accordingly, Mancilla et al. [18] presented a domain ontology focused on AAC systems to manage knowledge related to daily activities. Further, Sastoque et al. [19] proposed an architecture to allow the development of user-centered applications by relating domain representations, intelligent processes and multimedia content. As suggested on [18][19][20] those works are intended to develop a computer-based AAC system to assist the creation of semantic coherent stories about routine activities. To do so, it is fundamental to propose a user-centered recommender model that improves message generation time. Thus, this work presents a novel user-centric recommendation model, for an AAC system, which relates a specific domain knowledge with recommendation techniques, to enhance the communication by allowing the composition of coherent sentences, regardless of the word order and the syntactic structure of the message. The main contribution of this work is the proposal of a recommendation model that improves the time of message generation, by suggesting and predicting the main components of a phrase, based on the user behavior over the time, helping aphasic people to enhance their communication process. Tests were performed with 20 healthy people, measuring user experience and particularly, efficiency in the message composition, compared with traditional communication boards and the word prediction approach, Assistive Express Spanish (AES) [21]. Also, the model was validated through a case study with an aphasic person.

This paper is organized as follows: the next section presents a background for this work. Section III describes the recommendation model with each of its components. Section IV focuses on the case study, including the AAC framework and its modules. Section V explains the tests performed and their results. Finally, the last section corresponds to the conclusion and the proposal for further studies to extend the current work.

II. BACKGROUND

A. Recommender Systems

Recommender Systems (RSs) are software tools and techniques that aim to guide users by providing suggestions in a personalized way to their *"items"* of interest in a large space of possible options. *Items* is the general term used to denote what the system recommends to users [22]. The suggestions are related to various decision-making processes. User preferences can be derived from implicit feedback, i.e., user behavior analysis over time, or explicit feedback, i.e., item rating and supplied information. So, RSs take advantage of this, to calculate recommendations by comparing with predefined rules and previous items rates, (Content-based RSs), or to other users preferences (Collaborative-based RSs) [23]. RSs have been classified in the literature according to the way they perform the recommendation process as follows [22][23]: **Demographic RSs** are based on the idea that people with given demographic characteristics (age, sex, level of education, residence) have similar preferences. **Collaborative RSs** exploit collective intelligence by predicting the user ratings to an item, based in those users with similar preferences. **Content-based RSs** recommend based on the past ratings from the same user to similar items. **Knowledge-based RSs** suggest items based on specific knowledge domain, about how certain item features meet user needs and preferences and how the item is useful for the user. **Community-based RSs** follows the aphorism "Tell me who your friends are, and I will tell you who you are" to suggest items based on the preferences of the user friends. **Utility-based RSs** model the user preferences and items using a utility function to predict the user behavior by matching similar utilities values. **Memory-based RSs** continuously analyze changes over time of the user preferences in past item selections. **Critiquing RSs** act like an artificial salesperson which guide the user in the selection, by asking and recommending specific item features. **Conversational RSs** engage the user in an extended dialog, making suggestions based on the users initial query and refining them based on their feedback. **Hybrid RSs** are based on the combination of the RSs listed above, using their advantages to perform a robust recommendation.

Finally, the techniques and algorithms used by RSs depend on the specific recommendation need. They vary from statistical data analytics to complex artificial intelligence processes. In their survey, Ricci et al. [22] mention different applications and methods, such as: modelling user patterns in tree structures for predicting navigation criteria in the web; representation of web page contents on a cellular automaton using their information and structure to provide recommendations; use of the Longest Common Subsequence algorithm (LCS) in clustering web content to model web pages as a graph; application of the nearest neighbors methodology in collaborative filtering techniques; and construction of two clustering-based models using K-means algorithm and the Term Frequency - Inverse Document Frequency (TF-IDF) representation to calculate weights and domain knowledge to each item of a recommendation model. These methods have been widely used in recommendation apps for movies and music, text classification, prediction of the users web surfing and for improvement of search engines, among others. However, they are not suitable to solve the challenges mentioned above in the introduction. That means, they lack a strategy for item recommendation that consider multidimensional criteria, to provide a good support on scalability and adaptability over the time.

B. Planning

The definition of planning varies according to the context. Commonly is defined as the process of thinking about and organizing the activities required to achieve a desired goal, or as an abstract, explicit deliberation process that chooses and organizes actions by anticipating their expected outcomes [24]. The basic elements of planning are [25]: a **State** that is the current condition of the environment and captures all possible situations that could arise; a **Time** which is the sequence of decisions that must be applied over a temporal length to achieve the goal; an **Action** that is the way to manipulate the

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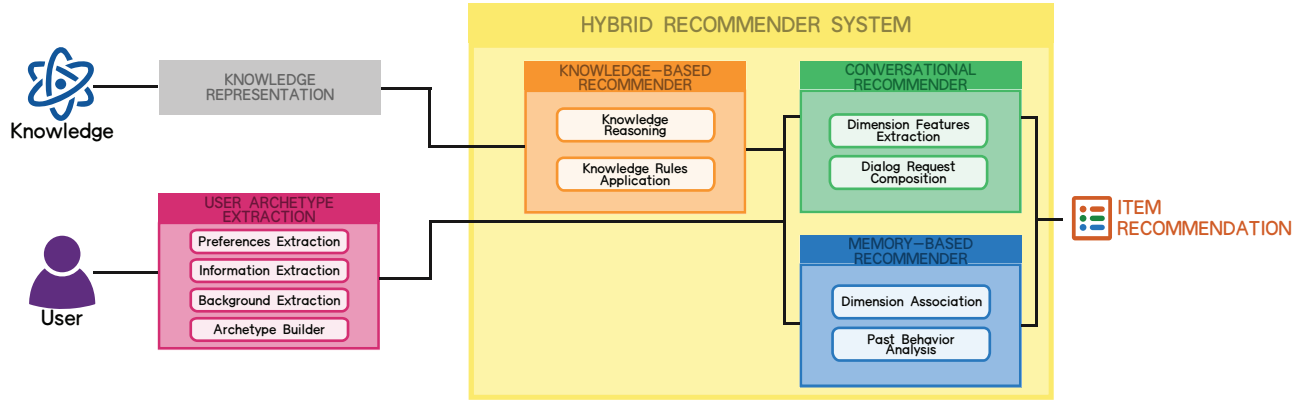

Figure 1. User-centric hybrid recommendation model for AAC based on multi-criteria planning

current state to change it; an **Initial and Target State** which is the starting point and the arriving point to accomplish a goal; a **Plan criterion** which encodes the desired outcome of a plan in terms of the state and actions that are executed; and a **Plan** that imposes a specific strategy or behavior on a decision maker, i.e., the sequence of action to be taken. Planning algorithms have been applied to many problems as pathfinding, motion planning, game solving, biological modelling, robotics and scheduling. A clear example of planning in recommender systems are the popular navigation systems which offer near real-time traffic information and routing. These systems use different features like traffic, user alerts, path planning and time to reach a place in order to recommend and guide a user to its destination.

C. Ontologies

In computer science, ontologies are the formal (machine readable) modelling of knowledge, through the hierarchical representation of relevant entities and their relations. In this sense, an entity refers to anything that can be represented (objects, ideas, processes, etc.) [26]. Gruber [27] defined an ontology as "an explicit specification of a conceptualization", understanding by conceptualization a consensus of knowledge and not a particular view. Thanks to this, an ontology is meant to be reused, independently of its initial purpose, by keeping some design criteria such as clarity, coherence, extendibility, minimal encoding bias and minimal ontological commitment [27]. Ontology engineering focuses on capturing significant information of a domain and seizing it to a higher abstraction level, keeping clarity and expressiveness. As a result, ontologies need to be formalized maintaining the predicate logic that encloses semantic richness [26].

III. User-Centric Hybrid Recommendation Model

The proposed recommendation model was designed and evaluated for AAC applications where users are assisted to accomplish efficient and effective communication processes by the composition of coherent messages. However, it could be extensible to several contexts with similar conditions. Thus, the proposed recommendation model is based on: (1) knowledge representation of a specific domain, (2) user depiction through an archetype and (3) a hybrid recommendation system made up of knowledge-based, memory-based and conversational RSs, as shown in Figure 1. In contrast to previous works, this model overcomes different issues, such as: support to multiple criteria recommendation; adaptive training over time; coherent relations between criteria of choice, regardless the selection order; and, uses a knowledge representation to add contextual information to the recommendation.

A. User Archetype Extraction

The archetype represents behavior patterns, goals and user needs by obtaining implicit and explicit information. The purpose of the archetype extraction process is to obtain user data related with her preferences, background and information. The *Preferences extraction* component is related to get user particular desires, as for example, displaying modes, font sizes or colors and media settings. The *background extraction* process retrieves information about the behaviour and records of the user, which is used to help in prediction and recommendation processes. *Information extraction* consists in gathering user personal and environmental data, such as relatives names, home address, etc. All this data could be extracted by interviews or surveys and stored in specially designed data structures, through an *archetype builder* process, allowing user representation, tracking his evolution and forecasting his behaviour.

B. Hybrid Recommender System

The *Hybrid Recommender System* consists of three approaches based on Knowledge, Memory and Conversation RSs, which allow: use of a domain knowledge (which in most cases is multi-criteria), bidirectional dialogue with the user, monitoring user behavior, and item suggestion. Each of the recommender systems are described below.

1) Knowledge-based RS: The use of *knowledge representation* enables personalized and tailor made prediction processes. This brings to recommendation the possibility of applying rules and particular information of a specific domain. Thus, the knowledge-based RS uses information and rules of a domain, to relate different items, that will be recommended in a logical and coherent way according to real scenarios. Items with similar features are clustered in groups (known as criteria or dimensions) and connected by relations

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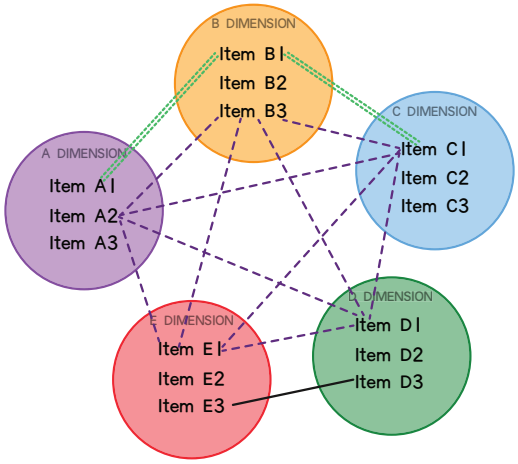

Figure 2. Example of set of rules to manage dimensionality

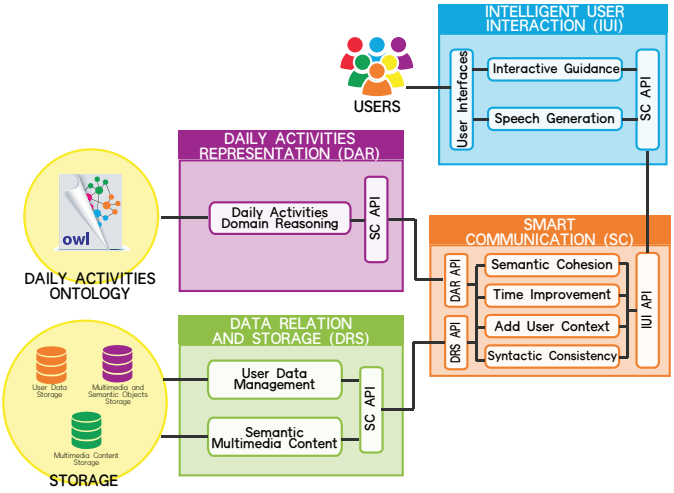

Figure 3. Components of an Augmentative and Alternative Communication System for generating syntactically and semantically coherent messages.

between different dimensions. The features and dimensions extraction depends on the way knowledge is represented, e.g., using formal techniques for ontologies conceptualization to model a specific domain. For example, in [18] the domain is divided into several dimensions (aka classes) representing the daily activities and their associated information, e.g., Place, Activity, Feeling and Person, etc., using its own features, i.e., the criteria of Place has features like address, city and country, among others.

This system consists of two main processes, *knowledge reasoning* which draws inferences and generates new information from relations between criteria; and *knowledge rules application* that organizes this information through a set of predefined steps and guidelines.

2) Conversational RS: In many cases, people have no clarity about which item they want to select from a set of possibilities, needing to be guided in the selection of the items features that satisfy their desires. To allow this, conversational RS uses a dialogue flow with the user, employing the ask and answer method, to guide through the selection process. This system uses domain knowledge to extract the main features of each dimension (*Dimension Features Extraction*) and use them to pose specific questions for refining those items to be recommended (*Dialog Request Composition*).

3) Memory-Based RS: User behavior is essential to establish personalized recommendation processes. For this, memory-based RS tracks users over time and thus suggest the items that best meet their preferences. In this way, the processes, *Dimension Association* and *Past Behaviour Analysis*, use user archetypes in conjunction with artificial intelligence and statistical methods, specifically a decision tree and a probabilistic model, to predict and suggest items. To overcome the problem raised by multi-dimensional criteria, in this work it is proposed a set of rules (exemplified in Figure 2) that permits efficiently manage dimensionality.

1) The final product of a recommendation consist of a set of items, each from a different criterion (dimension).
2) A ***Connection*** is the relation between two items of different dimensions. (Black straight line in Figure 2 - Items E3 and D3)
3) Two items of the same dimension are not connected.
4) A connection defines a statistical weight to mean the strength of a relation.
5) A new connection could be created with the user intervention.
6) A ***Path*** is a set of connections (Pointed double green line in Figure 2 - Items A1, B1 and C1).
7) A Valid Path is one which has all of its items interconnected (Dashed purple line in Fig 2. - Items A2, B3, C1, D1 and E1).
8) ***Valid paths*** are scored by an optimization criteria based on the statistical weight of all their connections.
9) The recommendation is performed by ordering valid paths according with their strength, i.e., global scores.

4) Recommendation Model Operation: The recommendation process follows a planning technique with the next characteristics:

- The goal is to sequentially selecting one or several items among the set of criteria considered. However, it is possible to skip any criteria.
- A state is a situation in which the user has already selected items, from some dimension, and is ready to select a suggested item from an ordered list.
- The initial state occurs when no selection has been made.
- The target state is when all dimensions have been covered.
- An action is the selection of an item by the user.
- The plan criterion is that the user has selected at least one item.

At the initial state, the recommendation system prompts the user for a starting dimension. After this, the following processes are accomplished for each of the remaining dimensions: first, the system asks for the next dimension. Second, the knowledge-based system uses the domain rules

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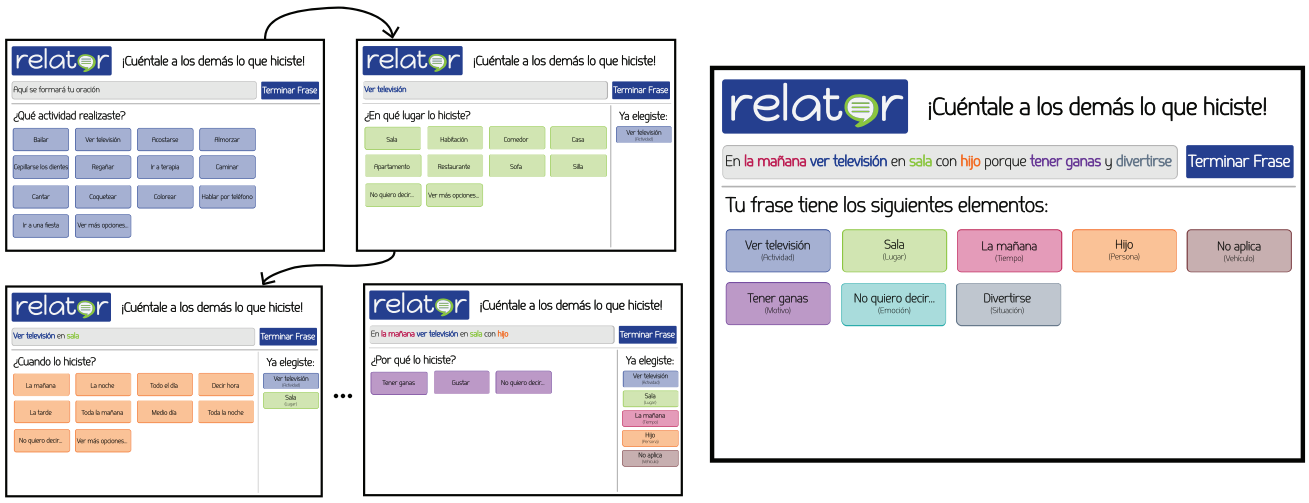

Figure 4. Screenshots of the actions taken to create the sentence *"In the morning to watch T.V. at lounge with son because to have desire and have fun"*.

and inferences to send the items that are related to the other two RSs. Third, the memory-based system carries out the *Dimensional Association* process for retrieving all those items that are in the current valid paths. Fourth, the items that are not in the valid paths, are ordered by using the *Past Behavior Analysis* and the *Knowledge Rules Application*. Fifth, the recommender system suggests a list of items, ordering first those belonging to valid paths and then the remaining ones. Sixth, the user selects an item and the recommender system evolves the archetype by creating or updating user records. The plan is repeated until the goal is achieved. Finally, the system uses all the selected items to perform prediction operations.

IV. Case Study

For the recommendation model validation, a case study based on a previous developed system was carried out, which helps people with language impairments in telling stories related with their daily activities [18]. The system is designed under an ontology-based architecture [19], which consists of the following components (Figure 3): The *Intelligent User Interaction (IUI)* provides interactive assistance for message construction; *Smart Conversation (SC)* drives the creation of semantically coherent messages through recommendation strategies; *Daily Activities Representation (DAR)* focuses on the formalization of daily activities domain through an ontology and its reasoning; and finally, *Data Relation and Storage (DRS)* refers to user data storage related to recommendation process and the management of textual, sound and pictographic representations of concepts.

The recommendation model is related to three components of the proposed AAC system. The *Interactive Guidance* leads the user in the message construction by using questions as ***"What activity did you do?"*** or ***"Who accompanied you to do that activity?"***. Also, the *Daily Activities Domain Reasoning* and *Semantic Cohesion* processes infer information from the ontology, e.g., if the user selects the activity ***watching tv*** the system suggests only ***indoor places***. Finally, *The Time Improvement* process predicts user preferences and suggests the most probable item, i.e., ***every time the user goes to therapy uses a taxi as transportation***.

Moreover, the system is aimed for Spanish speakers and it is supported by the Google App Engine (GAE) platform. The graphic user interfaces provide sequential guidance while communicating, through color schemes that represent each dimension. Also, the system predicts and composes telegraphic sentences with the selected words, relating them by specific connectors, as shown in Figure. 4.

V. Tests and Results

The AAC system and the recommendation model were validated, regarding prediction times and user experience factors. Three tests were performed: computational experiments, verification with healthy people and validation with an aphasic person.

A. Computational Experiments

The accuracy of the recommender model was evaluated by cross-validation and measurements of the Mean Reciprocal Rank (MRR). MRR is the average of the reciprocal ranks of results for a sample of queries, as shown in equation 1, where Q is the number of queries and $rank$ is the item position in the order list.

$$MRR = \frac{1}{Q}\sum_{i=1}^{Q}\frac{1}{rank_i} \quad (1)$$

For this experiment, we used the corpus of daily activities obtained by Sastoque et al. [28]. From this corpus, 400 phrases were extracted and translated into ontology concepts. For cross-validation purposes, 300 sentences were randomly selected for training and 100 for testing. For each sentence, the MRR was calculated by querying for each word in a phrase. The Prediction Rate (PR) was assessed by averaging the MRR over the whole set of test sentences. The experiment was conducted 30 times, the results are shown in Figure 5. The main prediction rate of the recommender system is $PR = 0.7687$ with standard deviation, $\sigma = 0.1372$.

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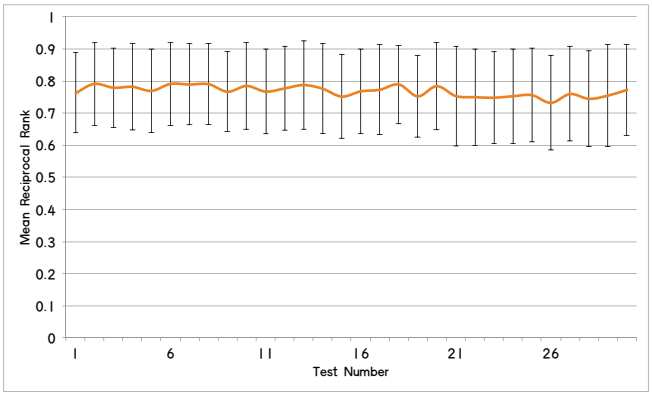

Figure 5. Mean Reciprocal Rank average for each computational experiment.

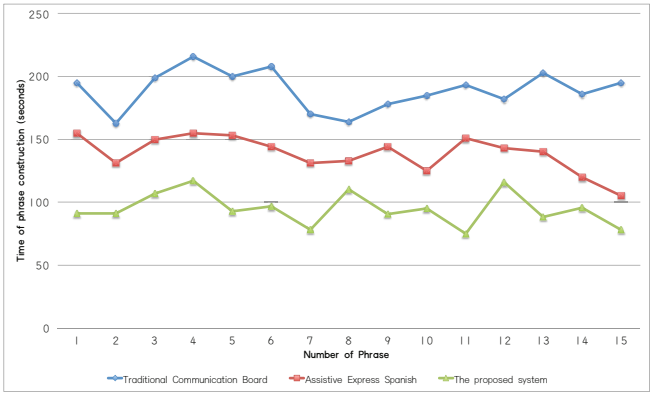

Figure 6. Time taken for healthy people to create phrases with three different AAC systems.

B. Validation with healthy people

Some tests were performed for 20 people with higher education (12 female, 8 male, aged from 21-35, M=27, σ=3.66). All participants were Spanish native speakers without speech, physical, perceptual or intellectual impairments. Also, all participants have standard and similar skills using computers. The study involved the comparison of three different systems to create phrases, using: Traditional Communication Boards (TCB), the AES application [21] (word prediction) and the presented application. Three different tests were performed in which participants were inquired to: (1) transcribe five sentences, (2) create five sentences from a specific set of words and (3) create five sentences freely. The systems order was randomly set. The time spent in creating a sentence was measured, the results are shown in Fig 6. The time averages for each system are: $t_{TCB} = 189s$ - $\sigma = 15.75$, $t_{AES} = 139s$ - $\sigma = 14.43$ and our approach $t = 95s$ with $\sigma = 13.04$.

C. Validation with an aphasic person

A case study was carried out with a 55-year-old woman, who will be called *"Katherine"*, with a neuro-linguistic disorder characterized by Broca's aphasia. Katherine preserves comprehension skills and her biggest communication difficulties are given by the impairment in the production of oral and written language. For the purpose of this study, we relied on the help of a Katherine's relative, who provided important information related to her common practices and routines and gave us useful feedback about the validation process. For over four years, Katherine has used AAC paper books, mime and point out to tell a story. Currently, she takes between 4 to 6 minutes approximately to pass a message about her routine, in an effective way. Before this study, Katherine was trained, during a week, in the use of the proposed system. Setting up was performed with Katherine's most frequently activities.

Katherine's daily activities were monitored during 15 days. At the end of each day, she was asked to use the system to create five sentences corresponding to the most relevant performed activities. Her relative followed the process and, in a few cases, helped her in the message composition. For the sake of validation, the efficacy of the communication process was measured by validating the message content with the Katherine's relative and by asking to 20 receivers if they could understand the messages. The efficiency was estimated by gauging the time taken by Katherine to create an utterance; and, the user experience was evaluated by asking to Katherine her judgment about the application.

The study showed promising results considering that: (1) the communication process could be established between Katherine and other people through the system, the receivers understood on average the 81% of the 75 sentences analyzed. The main issues for the messages understanding were due to their telegraphic structure. (2) The average time used by Katherine was $t = 3.11min$ - $\sigma = 0.63min$, revealing, a significant reduction in time spent on message composition, achieving an effective and efficient communication process. (3) According to her own perception, confirmed by her relative, Katherine enjoyed the experience of using this technology, considering that she could improved her communication process and she was excited about the possibility to use this system at home or to take it with her everywhere. Actually, according to Katherine's review, she said: ***"I liked how I did it, it is great, I can talk better. Of course it is very useful and very good. I want to use it. It is beautiful. I can use it here or there and tell him or her. Thank you"***. The moments that she required help were due to problems related with understanding words, which are typical limitations of her disorder.

VI. Conclusion and Future Work

This paper proposed a novel approach about a user-centric recommendation model for an AAC system, which improves the message generation time by suggesting and predicting the main components of a phrase. In addition, the proposal can be adapted to other applications as it is considered as a general recommendation model. The model relates specific domain knowledge with recommendation techniques to enhance communication process for people with language disorders. The model supports multiple criteria recommendation, adaptive training, coherent relations between criteria, regardless the selection order; and it uses knowledge representation to add contextual information to the recommendation. Results of the verification and validation test

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demonstrated that the model led to significant improvements in user performance in terms of efficiency and effectiveness. The prediction rate of 76.87% shows that the system has good performance in recommendation processes. However, the PR can be increased over time as the user uses the system. Also, through the verification with healthy people, it is exposed that the proposed AAC system has the potential to provide an effective mean of generating novel messages in less time. In addition, the validation with the aphasic person lets make evident promising results in the improvement of the communication processes of people with language disorders.

From this work, it can be proposed the following studies as future work: first, the validation and verification process showed that the participants had difficulties at the interpretation of the telegraphic style of the messages. Therefore, further studies aims to create a method for language structuring in order to improve syntactic coherency. Second, messages created are very general and lack of specificity in the user's personal information. Hence, it is required to customize the ontology to add specific information for each user. However, this presents a major challenge in terms of the knowledge domain scalability and information coupling. Finally, to improve system usability, it is necessary to conduct user experience studies to design and develop an adapted Graphical User Interface (GUI) and multimedia content (animations, pictures, videos, texts) to represent concepts of the ontology.

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REFERENCES

[1] P. Watzlawick, J. B. Bavelas, and D. D. Jackson, Pragmatics of human communication: A study of interactional patterns, pathologies, and paradoxes. WW Norton and Company, 2011.

[2] S. Baxter, P. Enderby, P. Evans, and S. Judge, "Barriers and facilitators to the use of high-technology augmentative and alternative communication devices: a systematic review and qualitative synthesis," International Journal of Language and Communication Disorders, vol. 47, no. 2, 2012, pp. 115–129.

[3] K. Wiegand, "Semantic disambiguation of non-syntactic and continuous motion text entry for aac," ACM SIGACCESS Accessibility and Computing, no. 105, 2013, pp. 38–43.

[4] J. Light and D. McNaughton, "The changing face of augmentative and alternative communication: Past, present, and future challenges," Augmentative and Alternative Communication, vol. 28, no. 4, 2012, pp. 197–204.

[5] L. Janice and M. David, "Putting people first: Re-thinking the role of technology in augmentative and alternative communication intervention," Augmentative and Alternative Communication, vol. 29, no. 4, 2013, pp. 299–309.

[6] J. Light and D. McNaughton, "Communicative competence for individuals who require augmentative and alternative communication: A new definition for a new era of communication?" Augmentative and Alternative Communication, vol. 30, no. 1, 2014, pp. 1–18.

[7] A. Stent and S. Bangalore, Natural Language Generation in Interactive Systems. Cambridge University Press, 2014.

[8] K. Wiegand and R. Patel, "Symbolpath: a continuous motion overlay module for icon-based assistive communication," in Proceedings of the 14th international ACM SIGACCESS conference on Computers and accessibility. ACM, 2012, pp. 209–210.

[9] E. Reiter, R. Turner, N. Alm, R. Black, M. Dempster, and A. Waller, "Using nlg to help language-impaired users tell stories and participate in social dialogues," in Proceedings of the 12th European Workshop on Natural Language Generation. Association for Computational Linguistics, 2009, pp. 1–8.

[10] X. Ma, S. Nikolova, and P. R. Cook, "W2ane: when words are not enough: online multimedia language assistant for people with aphasia," in Proceedings of the 17th ACM international conference on Multimedia. ACM, 2009, pp. 749–752.

[11] K. Wiegand and R. Patel, "Non-syntactic word prediction for aac," in Proceedings of the Third Workshop on Speech and Language Processing for Assistive Technologies. Association for Computational Linguistics, 2012, pp. 28–36.

[12] K. Vertanen and P. O. Kristensson, "The imagination of crowds: conversational aac language modeling using crowdsourcing and large data sources," in Proceedings of the Conference on Empirical Methods in Natural Language Processing. Association for Computational Linguistics, 2011, pp. 700–711.

[13] H. Trinh, A. Waller, K. Vertanen, P. O. Kristensson, and V. L. Hanson, "iscan: a phoneme-based predictive communication aid for nonspeaking individuals," in Proceedings of the 14th international ACM SIGACCESS conference on Computers and accessibility. ACM, 2012, pp. 57–64.

[14] M. Mitchell and R. Sproat, "Discourse-based modeling for aac," in Proceedings of the Third Workshop on Speech and Language Processing for Assistive Technologies. Association for Computational Linguistics, 2012, pp. 9–18.

[15] A. Nandi and H. Jagadish, "Effective phrase prediction," in Proceedings of the 33rd international conference on Very large data bases. VLDB Endowment, 2007, pp. 219–230.

[16] L. Dong, P. K. Srimani, and J. Z. Wang, "Ontology graph based query expansion for biomedical information retrieval," in Bioinformatics and Biomedicine (BIBM), 2011 IEEE International Conference on. IEEE, 2011, pp. 488–493.

[17] C. Carpineto and G. Romano, "A survey of automatic query expansion in information retrieval," ACM Computing Surveys (CSUR), vol. 44, no. 1, 2012, p. 1.

[18] D. Mancilla, S. Sastoque, J. Mendoza, and M. Iregui, "Conceptualizing a daily activities ontology for an augmentative and alternative communication system," in 5th Latin American Conference on Networked and Electronic Media (LACNEM-2013). Universidad Nacional de Colombia - Sede Manizales, 2013.

[19] S. Sastoque, C. Narváez, and M. Iregui, "Ontological knowledge based model for personalizing multimedia applications," Ventana Informática, no. 30, 2014, pp. 175–191.

[20] S. Sastoque, D. Mancilla, C. Narváez, and M. Iregui, "Case study to validate the knowledge representation in user-centric web applications through multimedia enriched content," in 8th research meeting. Universidad Militar Nueva Granada, 2013.

[21] "Assistive Express Spanish," https://itunes.apple.com/au/app/assistive-express-spanish/id816122415?mt=8, 2010, [Online; accessed June-2014].

[22] F. Ricci, L. Rokach, and B. Shapira, Introduction to recommender systems handbook. Springer, 2011.

[23] J. Bobadilla, F. Ortega, A. Hernando, and A. Gutiérrez, "Recommender systems survey," Knowledge-Based Systems, vol. 46, 2013, pp. 109–132.

[24] M. Ghallab, D. Nau, and P. Traverso, Automated planning: theory and practice. Elsevier, 2004.

[25] S. M. LaValle, Planning algorithms. Cambridge university press, 2006.

[26] S. Staab and R. Studer, Handbook on ontologies. Springer, 2010.

[27] T. R. Gruber, "Toward principles for the design of ontologies used for knowledge sharing?" International journal of human-computer studies, vol. 43, no. 5, 1995, pp. 907–928.

[28] S. Sastoque, D. Mancilla, and M. Iregui, "A bag of words based method for information extraction in simple texts," in 3rd International Multimedia Congress. Universidad Militar Nueva Granada, 2013.

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Towards an Integration of Process Modeling and GDSS for Crisis Management

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***Abstract*—Crisis situations impose a number of special challenges for group decisions including separation of decision participants by time and/or location, difficulties in obtaining and maintaining a proper understanding of the crisis situation, time pressure, and a high workload. Based on predefined process templates for group decision making Group Decision Support Systems (GDSS) can effectively support crisis management teams. The GDSS can, for example, bridge the separation of the decision participants, perform information management and information sharing tasks, and even automate specific group moderation activities. In this article, first results of a research project that targets a combined use of process modeling technology and enhanced GDSS are described. A new general feedback-driven and iterative process pattern for group decision making is proposed. When a prompt decision is not required, several group decision cycles can occur and every cycle may benefit from better information quality, as well as training and learning effects.**

Keywords-Crisis Management; Process Modelling; Process Automation; Group Decision Support Systems

I. INTRODUCTION

Collaborative work processes are common in crises management situations. Typically the members are drawn from disciplines such as fire, police, health, and hazardous materials management. The members of the group are expected to complete actions together. For example, the team members need to collaboratively keep track of the crisis situation and assess the severity of the crisis, make recommendations to others, find different courses of actions to handle crisis issues, and to solve problems. From the actors it is expected that they make and communicate decisions together. Two important types of crisis management decisions are selection decisions (e.g., selection of the best fitting response plan from a set of predefined plans) and allocation decisions (e.g., determination of resources to be sent to the crisis scene).

The design and use of Group Decision Support Systems (GDSS) as a decision making aid for crisis management organizations has been investigated by several research groups [2][5] [10][13]. Crisis management teams can obtain a number of benefits from GDSS including an instant access to shared information, support of remote members, support of crisis communication plans, and coordination support for group decision making processes.

The still ongoing research that is described in this article is focused on asynchronous group decisions in crisis situations. A novel general decision pattern is proposed that can help to overcome the spatial and temporal separation of crisis management actors. The proposed iterative adaptive group decision pattern especially targets crisis situations that do not require a prompt decision. In each process iteration cycle, the group decision is obtained based on a revised decision model and/or a revised set of process execution steps. The revisions are driven by feedback that is gathered from the participants. A human moderator based on the feedback determines if a further process re-iteration should be completed or if the process should terminate. This approach can lead to better decision results because iterations will be performed based upon a broader information base with an improved information quality. Also learning and training effects can contribute to better results.

In the next section, different general patterns of group decision making and especially the adaptive group decision pattern are described. It is then exemplified through corresponding models how such patterns can be encapsulated as process models using the BPMN standard [7]. Following that, how these models can be used in combination with an enhanced GDSS in crisis management scenarios is described. The current status of the ongoing research and concluding remarks are contained in the last section.

II. CRISIS MANAGEMENT AND GROUP DECISIONS

Crisis management often involves the use of crisis management plans. These plans describe the actions and considerations to be followed by the crisis management organization [8]. This can include the action to set up an infrastructure that is needed by the crisis management team such as a stationary or mobile control center, Information and Communication Technology (ICT) equipment, or unmanned aerial systems. It is often the case that in different crisis management plans identical actions and even identical arrangements of multiple actions can be found. Our research is focused on decision patterns where several different courses of actions and criteria to evaluate these alternatives are defined in a corresponding decision model.

Multi-criteria decision models based on the Analytic Hierarchy Process (AHP) of Thomas Saaty [9] are often considered for solving complex selection problems [10]. The decision model serves as basis for the selection of the best alternative by the completion of a multi-person decision process. It is expected from the participants that they score the available alternatives in terms of given evaluation criteria. The total score corresponds to the group decision result. One major advantage of group decisions over single person decisions is the fact that group decisions are based on

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a broader expertise and also a broader information base. Another advantage is that group decisions impose a lower risk for a bad decision due to human factors (e.g. the responsible decider can be over-challenged by the decision problem). Of course, there exist also drawbacks of group decisions such as the needed extra time, a relatively large coordination effort, and the demand for a professional moderator. Furthermore, group decisions can be biased by so-called Group Think Effects [3], such as a lower attention to risks as compared to single person decisions.

Crisis management plans can include the pattern of a synchronous group decision which requires a face-to-face meeting. They can also include an asynchronous group decision in which some participants are separated by time and/or location from other participants. For example, in crisis situations, it can be required that some of the group members have to stay where they are due to legal regulations or because they are indispensable somewhere else. Sometimes even in crisis situations time and/or budget restrictions may not allow a personal meeting. For some group decisions, it can be a rather natural approach to use an asynchronous decision process in order to adequately cope with a crisis situation. In general, the consideration of remote participants can lead to more complete and accurate information and, henceforth, to a better decision. For example, first-hand information and impressions of the crisis status can be gained through dislocated decision participants that are situated close to the crisis scene and that are equipped with mobile communication devices [6].

Group decisions to select the best course of action for crisis handling are an interesting subject of research especially when focusing on groups where participants are separated by both location and time. For these cases that we refer to as “complete asynchronous group decisions” – the word “complete” is used to signify that the focus is on a dual separation (time and location) and not on a partial separation – special novel ICT solutions are required.

The pattern of complete asynchronous group decisions is certainly not applicable to all crisis situations. Apart from the dual separation of the group participants at the time and space dimension, the time pressure is another major criterion to be considered. When a prompt decision is demanded and the actions are to be carried out right away then the pattern is not applicable. However, when neither a prompt decision nor directly following actions are required the pattern can prove to be useful. The decision can be post-phoned and other tasks can be completed in the meantime. Instead of just shifting the (start) of the decision process to a future point in time, for certain situations another approach can be more suitable. To start the decision process and to iteratively obtain decision results in which changes of the situations are considered can lead to certain benefits. Because of the longer time spend on the decision process and other advantages it is more likely that the best choice will be made. We refer to a correspondingly refined process pattern as “adaptive complete asynchronous group decision”.

Through an iterative adaptive process approach it is possible to improve the probability that a group decision will lead to a well-fitting choice. By “iterative approach” in this context it is meant that a group decision process is repeated several times. The process repetition terminates when the crisis situation demands a prompt action. The re-iteration can contribute to training effects in the form of faster iteration times for the group decision making process. Learning effects are another type of effects that can be obtained from the process repetitions. It can be assumed that these effects promote improved decision results as compared to non-iterative decision processes. It is the underlying idea of the iterative approach to not just repeat the same group decision process as completed earlier. It is expected that specific adaptations that will presumably improve the result are applied before a next iteration is completed. One possible adaptation is the use of a richer information basis that includes additional new information found in the previous iteration. Further modifications can be a more accurate process model and more accurate decision model. In our approach, the particular set of modifications to be considered is driven by feedback obtained from the previously performed process iterations. Among others, the feedback from the participants can include important background information, background knowledge, opinions, judgments, additional decision alternatives, new evaluation criteria, or a proposal for additional group members. The participants’ feedback can be the result of learning progress, new insights, new ideas inspired by shared information, and other intellectual effects of re-considering a decision problem.

III. PROCESS MODELS FOR CRISIS MANAGEMENT UNDER CONSIDERATION OF ENHANCED GDSS

To demonstrate the general approach of adaptive complete asynchronous group decisions two corresponding generic process models (i.e., process templates) are described in this section. The models are given in the popular BPMN standard modeling notation [7]. A possible organizational context for these crisis management models is a chemical plant in which a too high concentration of hazardous particles has been detected in a production hall. A more complete description of this case study is available in an earlier article [12]. The templates may also be helpful in river flood situations where crisis managers need to decide about the evacuation of river regions. Apparently, there exists a good fit between the typical characteristics of such evacuation decision and the properties of the proposed adaptive group decision patter.

Crisis management organizations typically include a crisis incident manager, further crisis management staff with specific roles, and specific ICT equipment. The process templates prescribe the flow of actions to be performed by the crisis management organization in order to effectively cope with the crisis situation. Furthermore, the templates supply a decision model to support needed group decisions.

Through a description of the generic process models not only the modelling approach for the proposed adaptive group decision pattern is exemplified in this article. Especially the description of the second process model provides insights into the GDSS enhancements that are targeted in our research. It is assumed that the GDSS is able to create and manage individual process instances (proxies for real world

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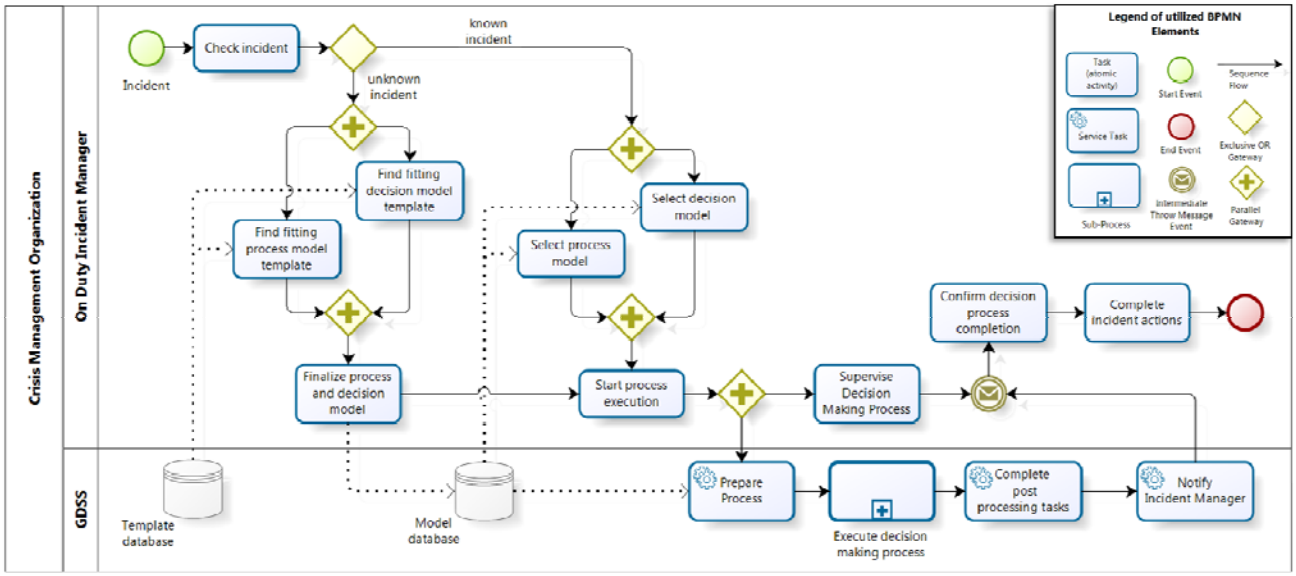

Figure 1. BPMN Model of a crisis incident management process.

group decision processes) from process templates. Managing the execution of individual process instances involves GDSS actions, such as the notification of participants, the collection of the participants' decisions, the aggregation of the single decisions to a corresponding group decision, and also central data management and group moderation tasks (e.g. sending reminders). An example of such an enhanced GDSS is the GRUPO-MOD system [11].

Note the connection between the two models. The on duty crisis incident manager of the first model initiates an adaptive complete group decision process as given in the second model. Depending on the process template database other kinds of processes with other, group decision patterns can also be initiated by the crisis incident manager.

Crisis incident management. The outer frame of the BPMN diagram in Figure 1 (called pool) represents the crisis management organization which consists of two actors (called lanes). There is first of all a human on duty incident manager. The second actor is a GDSS system with the above described enhancements. This includes a template database that stores templates for crisis management processes and templates for group decision models. In case of an unknown incident, the template database services as a repository from which a best-fitting process model and decision model is obtained as starting point. In a subsequent second further step, the models are refined and adapted in order to reflect the conditions of the given crisis situation. The model database of the GDSS stores ready to use process and decision models for known crisis situations.

In the initial activities of the process model in Figure 1, the fitting templates for the group decision process and the group decision model are determined. When the incident is not known the best fitting process template and best fitting decision template are selected from the template database. This selection task can for example be supported by a proper decision tree. After the process model and decision model are selected, the incident manager starts a partially automated execution of the asynchronous group decision process. The GDSS plays an active role in this process execution by performing the activities defined in the process model (blue rounded boxes positioned in the lane "GDSS") labeled Prepare Process, Execute Decision Making Process (this activity is modeled as a BPMN sub-process), Complete Post Processing, and Notify Incident Manager.

During the GDSS-based execution of the decision process, the incident manager supervises the process and performs actions that cannot be handled by the GDSS. Also, the process completion is confirmed and the incident actions

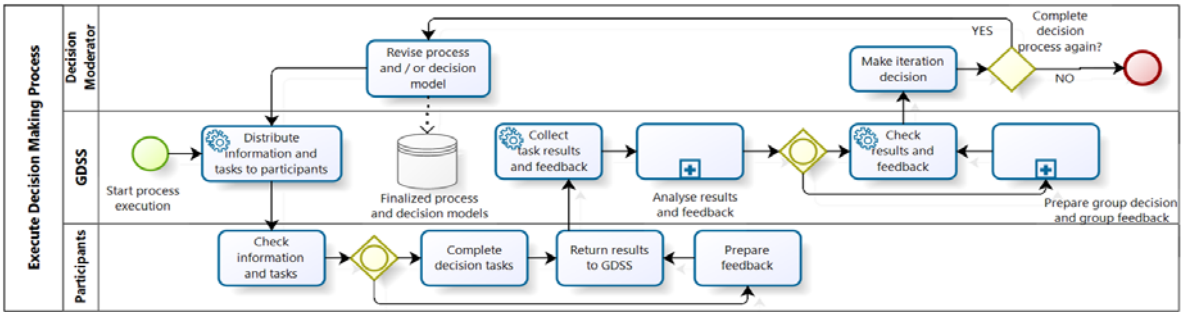

Figure 2. BPMN Process model of an adaptive complete asynchronous group decision.

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are completed by this person.

Adaptive complete asynchronous group decision making. The process model of Figure 1 contains an activity labeled "Execute decision making process". The little plus sign as part of the graphical symbol marks this elements as a so-called sub-process. In general, the details of sub-processes are modeled in separate self-contained process models. Figure 2 contains the process model of the mentioned sub-process and it exemplifies an adaptive complete asynchronous group decision process. The two activities of the decision moderator reflect the aspect of adaptation that can contribute to the earlier described advantages of the proposed new adaptive group decision pattern.

The pool consists of three lanes referred to as Decision Moderator (not necessarily the same person as the Incident Manager), GDSS, and Participants. Note that the latter lane does not mean that there is only one participant involved. The GDSS distributes the relevant information and decision tasks to the participants. It also collects the decision results and feedback, applies respective analysis such as consistency checks on the results, and prepares the group result through an aggregation of the individual decision results.

The participants check the information and decision tasks assigned to them by the GDSS. Following that they complete the decision tasks, prepare feedback, and return all results (such as judgments of the decision alternatives) to the GDSS for further processing. Recall that the participants' feedback will influence the further process continuation. The next steps of the decision process are performed by the GDSS. Following the collection of the participants' tasks results and feedback an analysis of the now available information base is performed. The analysis result is used to compute the group decision and corresponding feedback information for the group members. The sub-process "Prepare group decision and group feedback" subsumes that the GDSS distributes the group decision and feedback information to the participants who are called to give further feedback. The system collects and checks the participants' feedback and uses the further updated information base in order to prepare the iteration decision. It is the decision manager's responsibility to decide if the process is terminated or if it is re-iterated again.

IV. CURRENT STATUS AND CONCLUSIONS

The research focus has, so far, been on a high-level integration framework for the combined use of process modeling techniques and GDSS. In the next steps, the framework will be refined especially in two directions. First, the BPMN standard will be investigated. It will be studied if group decision processes in the crisis management domain can be properly modelled based on BPMN. For this purpose international crisis management studies will be considered, by including the Deepwater Horizon case [1] and the Elb River Flood [4] of the year 2002. Also, the possibility to combine BPMN-based process models with other modeling concepts such as decision trees will be evaluated. The possibility to include domain specific modeling primitives will be an area of the intended study, too.

Another direction of future refinements will address technical integration issues and novel enhancements of GDSS systems. New concepts are required that will enable GDSS systems to act like process execution engines. This includes the GDSS capabilities to perform information distribution activities, domain-specific feedback gathering and processing activities, and group moderation activities. In this context we will investigate if the GDSS enhancements can be achieved through the common approach to map BPMN models into the execution oriented BPEL language.

REFERENCES

[1] P. Anastas, C. Sonich-Mullin, B. Fried, "Designing Science in a Crisis: The Deepwater Horizon oil spill". Environmental Science and Technology, vol. 44(24), July 2011, pp. 9250–9251, DOI: 10.1021/es200963x

[2] T. Comes, M. Hiete, N. Wijngaards, and F. Schultmann, "Decision maps: A framework for multi-criteria decision support under severe uncertainty," Decision Support Systems, vol. 53, Elsevier, 2011, pp. 108-118

[3] J. K. Esser, "Alive and Well after 25 Years: A Review of Groupthink Research", Organizational Behavior and Human Decision Processes, vol. 73, nos. 2/3, February 1998, pp. 116–141, DOI: 10.1006/obhd.1998.2758.

[4] German Committee for Disaster Reduction, „Flood Risk Reduction in Germany - Lessons Learned from the 2002 Disaster in the Elbe Region", Bonn, February 2004, ISBN: 3-933181-34-8

[5] N. Kapucu and V. Garayev, "Collaborative Decision-Making in Emergency and Disaster Management," International Journal of Public Administration, vol. 34, Taylor & Francis Group, May 2011, pp. 366–375, DOI: 10.1080/01900692.2011.561477.

[6] D. Mendonça, R. Rush, and W. A. Wallace, "Timely knowledge elicitation from geographically separate mobile experts during emergency response," Safety Science, vol. 35, Elsevier Science, June 2000, pp. 193-208, DOI: 10.1016/S0925-7535(00)00031-X.

[7] Object Management Group. *Business Process Model and Notation (BPMN): Version 2.0*. [Online]. Available from: http://www.omg.org/spec/BPMN/2.0

[8] A. Harand, G. Peinel, and T. Rose, "Process Structures in Crisis Management", Proc. of the 6th Conference on Future Security, Berlin, September 2011, ISBN 978-3-8396-0295-9

[9] T. L. Saaty, "The Analytic Hierarchy Process: Planning, Priority Setting, Resource Allocation," New York: McGraw Hill, April 1980, ISBN 0-07-054371-2

[10] Y. Song and Y. Hu, "Group Decision-Making Method in the Field of Coal Mine Safety Management Based on AHP with Clustering," in Proceeding of the 6th International ISCRAM Conference, J. Landgren and S. Jul, Eds. Gothenburg, Sweden, May 2009, ISBN - 978-91-633-4715-3

[11] H. Thimm, "Cloud-Based Collaborative Decision Making: Design Considerations and Architecture of the GRUPO-MOD System," in International Journal of Decision Support System Technology, vol. 4, 2012, pp. 39-59, DOI: 10.4018/IJDSST.

[12] H. Thimm and R. Katura, "An adaptive group decision pattern and its use for industrial security management", American Journal of Environmental Protection, vol. 1 (1), Science Publishing Group, December 2012, pp. 1-8, DOI: 10.11648/j.ajep.20120101.11

[13] M. Turoff, M. Chumer, B. Van de Walle, and X. Yao, "The Design of a Dynamic Emergency Response Management Information System," in Journal of Information Technology Theory and Application (JITTA), vol. 5, January 2004, pp. 1-36.

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Interaction-based Ontology Modeling for User-Centric Social Networks Environments

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***Abstract*—Social Networks are nowadays the most relevant source of information in terms of scientific challenges and proposed computational models. This is due to the huge availability of user data, ranging from interactions, activities, and multimedia messages. The Big Data era is relatively new, and the emergence of user- and scalibility-centered solutions is particularly influenced by these novel and ever-growing data, that need to be carefully organized to remain manageable. In this contribution, we propose a novel approach to deal with social networks data representation that is able to model such complexity without affecting the flexibility of who can interact within the environment, and how. In particular, we revisit the standard methodology of computational ontologies proposing a framework where objects and agents are defined as compositions of atomic semantic information, avoiding preventive and static identification of the system's players. Our method is inspired by the work of James Gibson, who defined an ecological view of the human perception based on objects' natural *affordances*, in which objects spontaneously give cues about how they can be used depending on the agent who is actually interacting. The idea is that while objects and agents can potentially grow without any constraint, the spectrum of all the individual interactions can be the product of limited (and much more simple to represent) links between users and objects' atomic semantic information. In this sense, if an agent 'x' acts on an object 'y', it means that some property of 'x' are activated by the action (i.e., the user embodies a specific role), and some property of 'y' makes the action physically possible (i.e., it allows the action to be performed). In this paper we demonstrate how an interaction-based ontology view with the use of vector spaces can reduce manual efforts while preserving control of dynamic data in social networks.**

I. INTRODUCTION

Social Networks are web-based platforms where users with different interests and properties interact and *live* in a kind of virtual *second life*. Indeed, this has been a real name for one of them, SecondLife, where people used to build *avatars*, i.e., 3D self-personifications in an invented world. The aim of this paper, however, is not to overview all the range of the existing platforms, nor to to make distinctions and, least of all, not to face social aspects and problematics related to the use of such technology. Actually, we want to focus the attention on how these data coming from users interactions in social platforms are of scientific interest in terms of knowledge representation and ontology modeling.

We usually refer to the term ontology as a set of formal descriptions and tools to represent a specific domain (or a part of it) in an objective way. This is usually reflected in a definitions of objects with fixed properties, and relations among them that depict the dynamic aspect of the representation. For instance, we can think at the following description for a generic object A:

> *An object A is defined by some attribute p_1, p_2, and p_3 which can have some values within a specific numeric range like $[1, 10]$ or among a set of nominal values, e.g., $low, medium, high$. Then, A can exhibit the functionalities f_1 and f_2 to the external world, representing its dynamic part, i.e., its behaviour.*

Representing the world by starting from objects and relations between them is a classic and intuitive way to make the things working both conceptually and at an application level. Object-Oriented programming (OOP) is one of the most successful programming paradigms that uses this architecture to represent internal data structures. Each object carries its own functionalities with itself or it inherits them from a superclass. While this perfectly works in several scenarios, we want to stress the fact that the dynamic part of the architecture (let us now use terms like *actions*, *interactions*, *messages*, *functionalities*, and *operators* for identifying this concept) must inhabit inside the objects. In other words, what can happen with an object has to be defined in the object itself. This somehow freezes the high variability of how an object can be used, and, in general, how agents can interact with it. Centering Social Networks data, functionalities and visualization directly on users needs the *rest of the world* to be as much flexible as possible from a representational point of view.

Most of the times, working on objects as main concepts to be defined is both practical and sufficient. However, this strictly depends on the nature of the domain under definition. For example, social networks are extremely dynamic environments where OO-style objects like users, interests, and locations could be secondary with respect to the interactions that make them active and communicating.

Our idea regards an ontological modeling of the behavior of intelligent agents, built on top of the concept of *affordance* introduced by [1] to describe the process underlying the perception. In his work, Gibson [1] claimed that objects assume different meanings depending on the context, and more specifically, taking into account the *animal species* that interact with them. Implementing this concept in a social network environment would lead to ontologies based on *interactions* rather than on objects. For instance, let us quickly consider an example where a user (data creator) publishes on the network

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some comment about a hole in a specific street. Then, let us assume we have two types of users (consumers), a cyclist and a public-transport passenger, respectively. While the object under consideration has an high priority for the formers, it can be probably worthless for the latters. In a classic representation scheme, each object-user combination needs to be thought and formalized a priori, manually checking all the possible cases with the relative contraints. Note that this can be extremely consuming in terms of manual effort (creation / management of interventions) and carry to unflexible and redundant representations which do not embed the concept of knowledge sharing. In addition to this, not only objects (like street holes) and user types can create a large space of representation, but other dimensions can be added, further multiplying the problem. For instance, the basis of the network is the type of interaction, i.e., what people can do, creating a three-dimensional space user-interaction-object which results to be untreatable with classic First Order Logic-like representations [2].

Along this contribution, we will talk about ways of thinking at knowledge by means of objective and subjective representations, highlighting limits and workarounds. Afterwards, we will present our idea of interaction-based computational ontologies as an approach to solve some of the discussed issues, proposing an implementation to represent social networks data. We, finally, conclude the paper with a list of future work directions and open problems.

II. Research Questions

Social networks have the need of structuring all the data in efficient ways, not only from a computational perspective, but rather considering conceptual schemes that better enhance the user experience itself.

In real-life scenarios, it is common to find complex cases where data coming from different sources can cross several aspects, ranging from bureaucracy issues to restaurant reviews. Managing both the quantity and the sparsity of the data is the first problem to tackle with advanced techniques. Then, spreading the data to users according to interests, actual and current needs, and with the right priority is even more challenging. Still, not only social networks usually have to notify users autonomously, but they also have to answer to specific user queries. Indeed, the concept of *search* in social networks is crucial and partially different from standard information retrival tasks of common search engines. In fact, the latters have to index data (text, images, videos, etc.) to be retrieved by means of classic few-words user queries, whereas, in social networks, queries connect locations with people, crossing communities, events, and specific time ranges. All this is even made more complicated by the presence of continuously-changing information like hashtags, emotional states, and smartphones application data.

From a computational and ontological perspective, the challenges faced by this contribution are the following:

RQ #1 how to minimize manual efforts in building computational ontologies

RQ #2 how to represent such complex data maximizing the sharing of the whole knowledge in a social network

RQ #3 how to represent the data without affecting the flexibility of objects and agents interactions

RQ #4 how to capture and shape the dynamism and the variability of the interactions depending on who/what is interacting

RQ #5 how to enable smart access strategies in dynamic and multimensional data (fuzzy search, graph search, cross-aspects search, etc.)

In general, in social networks, a multitude of combinations of aspects must be taken into account depending on several factors like time, locations, interests, and so on. These are not well represented by classic paradigms where the world is a matter of objects and relationships, since this does not cope with the explosion of cases to define a priori.

III. Cognitive Background and Related Work

In this section, we overview the main foundations from which our contribution is mostly inspired. Since our proposal has to do with how ontologies can be used in information systems, it is worth to cite important works like [3][4] that deeply describe main issues and state-of-the-art approaches. Fiske and Taylor [5] highlight important features related to Social Cognition, and computational approaches are needed to better fit users' activity.

The starting point of the discussion is the use of formal ontologies. In general, formal ontologies are inspired to the basic principles of the First Order Logic [6], where the world is explained by the existence of defined objects and fixed relationships among them. This belongs to a physical and static view of the world, since this representation is able to treat only the existence of objects and relationships. The same actions are offered to all agents interacting with the object, independently of the properties of these agents.

Our aim is to manage concepts which have different perspectives depending on the kind of agent or species is interacting with them, instead of having an object duplicated in different classes according to the different possible behaviors afforded to different agents. A social-driven ontology would lie between two extremes, as the first-person ontology mentioned by Searle [7].

For example, the door provides two different ways to interact (the set of methods, if we want to use a programming language terminology): a way for a *human* user and on the other side the one for a *cat*. These two ways have some common actions with different implementations, but they can also offer additional actions to their agents or players. For example, a human can also lock a door with the key or shut it, whereas a cat cannot do it. The behavioral consequence of "how to interact with the door" can be "opened by the handle" rather than "pushed leaning on it", and the way the action will be performed is determined by who is the subject of the action.

The second example has a different character, since it refers to a technological artifact, i.e., a printer. As such, the object can have more complex behaviours and above all the behaviours do not depend only on the physical properties of the agents interacting with it but also with other properties, like the role they play and thus the authorizations they have. The printer provides two different roles to interact with it (the set of methods): the role of a *normal user*, and a role of *super user*. The two roles have some common methods (roles are

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classes) with different implementations, but they also offer other different methods to their agents. For example, normal users can print their documents and the number of printable pages is limited to a maximum determined (the number of pages is counted, and this is a role attribute associated to the agent).

The third example we consider is of a totally different kind. There is no more physical object, since the artifact is an institution, i.e., an object of the socially constructed reality [8]. Let us consider a university, where each person can have different roles like professor, student, guardian, and so forth. Each one of these will be associated to different behaviours and properties: the professors teach courses and give marks, and have an income; the students give exams, have an id number, and so forth. Here the behaviour does not depend anymore on the physical properties but on the social role of the agent.

Mental models have been introduced by Laird [9], as an attempt to symbolic representations of knowledge to make it computable, i.e., executable by computers. This concept is the basis of the most important human-computer cognitive metaphor [10].

Another related work which can be considered as a starting point of our analysis is about the link between the Gestalt theory [11; 12] and the concept of affordance in the original way introduced by Gibson for the perception of objects. Wertheimer, Kohler and Koffka, the founders of the Gestalt movement [12], applied concepts to perception in different modalities. In particular, it is important to remind the principle of complementarity between "figure" and "ground".

The same concept is applicable in natural language understanding. For instance, let us think at the sentence "The cat opens the door". In this case, our basic knowledge of what the cat is and how it moves can be our ground to understand the whole figure and to imagine how this action is performed. In other words, the Gestalt theory helps us say that the tacit knowledge about something (in this case, how the cat uses its paws) is shaped on the explicit knowledge of "what the door is". Following this perspective, the concepts are not analyzed in a dyadic way, but in a triadic manner.

Considering the literature in Object-Oriented programming (OOP), it is worth citing Powerjava [2], i.e., an extension of the Java language where an objective and static view of its components is modified and replaced on the basis of the functional role that objects have inside. The behavior of a particular object is studied in relation to the interaction with a particular user. In fact, when we think at an object, we do it in terms of attributes and methods, referring to the interaction among the objects according to public methods and public attributes. The approach is to consider Powerjava-roles as affordances, that is, instances that assume different identities dependeing on the agents.

Weissensteiner and Winter [13] focus on landmarks contained in texts to analyze their role in the general understanding of routes. Distributional Semantics [14] represents a novel way of estimating kind of affordances at natural language level relying on statistical analysis. Finally, it is important to refer to [15], where the authors demonstrated that natural language grammar and planned actions are related systems.

Dynamic taxonomies [16] exploit a set of instances classified in a taxonomy to create latent connections between nodes belonging to different paths. In fact, if one instance is classified under two concepts on different paths means that there is some link between them that the original taxonomy was not aware of. This approach is useful to browse a taxonomy by iteratively selecting nodes for filtering the data, and in this sense it has some relations with every work on making structured knowledge dynamic and changeable with respect to some context.

IV. The Approach

Social networks are a modern way people use to communicate and share information in general. Facebook, Twitter, Flickr and others represent platforms to exchange personal data like opinions, pictures, thoughts on world-wide facts, and related information. All these communities rely on the concept of *user profile*. A user profile is generally a set of personal information that regard the user in itself as well his activity within the community.

Understanding the reference prototype of a user is central for many operations like information recommendation, user-aware information retrieval, and user modeling-related tasks. In this context, the concept of *affordance* can be used in several scenarios. First, it can be a way to personalize the content to show to the user according to his interests and activity. This is massively done in today's web portals, where advertising is more and more adapted to the web consumers. Secondly, the whole content shared by 'user friends' can be filtered according to his profile, in the same way as in the advertising case. Notice that this does not have to do with privacy issues. In fact, a user may be not interested in all facts and activities coming from all his friends. Social networks started taking into consideration these issues, and our proposal regards an ontological modeling of the data that could autonomously and naturally work in this sense.

Commonly, we can think at the interactions in a network as classes managing rules and constraints to match users with fixed categories or objects (the terms *object* and *category* are interchangeable, referring to "things" that "lives" in the network around the users. A scheme of this scenario is illustrated in Figure 1. Notice that this approach creates one class for each combination user-category (when it is semantically allowed), and it produces a large set of unflexible and predetermined interactions to be formally defined.

For example, if we consider the class StreetHole representing the street holes instances in the platform, we need to model all the agents that can interact with it, like CarAgent (a class modeling the instances of people moving with cars), BikeAgent, and so forth. The problem is that, with this methodology, all possible agents and objects have to be defined a priori in the ontology, without an appropriate *uncertainty management*. In our approach, we do not look for a complete coverage of the interacting agents/objects, since we actually do not represent them as physical concepts, while we only manage sets of fine-grained semantic information units that *everything* (i.e., agents rather than objects) can have in a specific context/time scenario.

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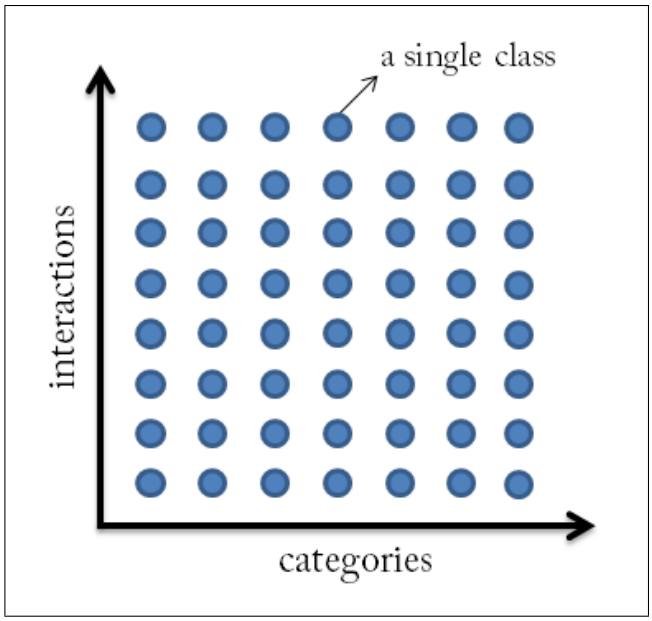

Figure 1. Classic view of single interactions connecting users and categories. Each interaction has its own "life" and it is different from the others, in the sense that it does not share any information nor overlapping degree with the other ones. The distance between the points do not carry any information.

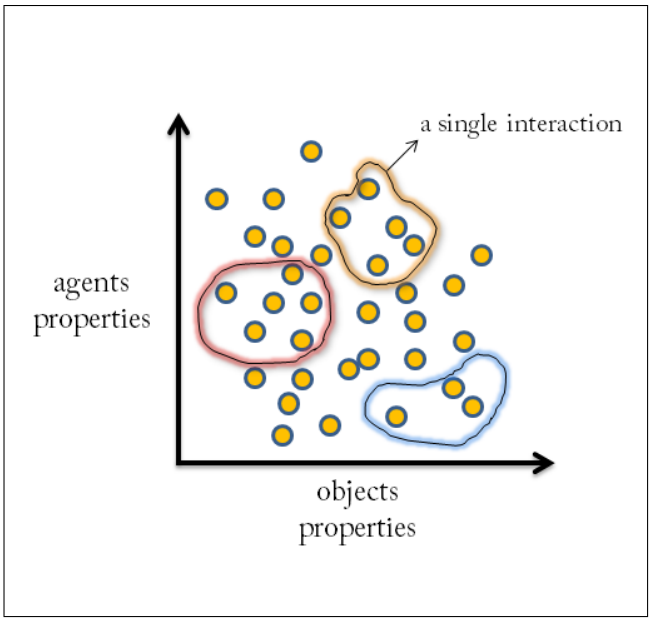

Figure 2. In a property-based interaction scheme, categories and users disappear from the graph since they become simple compositions of features, while the latters constitute the new basis of the representation. Each interaction is thus defined as a set of user/agent properties connecting a set of category/object properties, producing area-like representations. However, notice that each interaction is actually formed as multiple and non-contiguous areas, while the figure has been only created to easily communicate the concept.

Our idea is illustrated in Figure 2. Objects and users are substituted by the concept of property (i.e., a semantic information unit), on which interactions directly lie. More in detail, each interaction is defined as a set of user features connecting a set of object features, producing area-like representations. This way, the need of constructing classes for managing all the possible $users * actions * objects$ falls into an $m + n$ space, where m is the number of user properties and n is the number of object properties (m and n may have a certain overlapping degree, however).

In this section, we propose a way to model social networks data in a flexible way. As we already anticipated, in most social networks people can participate in the network through a set of interactions. For instance, some of them could be the following:

> {*to buy, to read, to sell, to eat, to drink, to pay attention, to work, to learn, to play, to know, to relax, to participate*}

Each interaction is defined as two sets of *properties* or *features* or *semantic information unit*, for the users and for the objects, respectively. A agent/user or a category/object can be associated to a property with a certain weight. More in detail, the value for a property can be a value in the range $[0, 1]$ representing a degree of affinity within the social network environment, or a nominal value from a given set S (Figure 3).

All the users (also called agents and subjects in our examples and figures) share a set of properties $A = a_1, a_2, ..., a_n$. Some example of user features are:

> *age, sex, marital status, type of work, location*, and a value of affinity for all the objects in the environment (her/his *interests*)

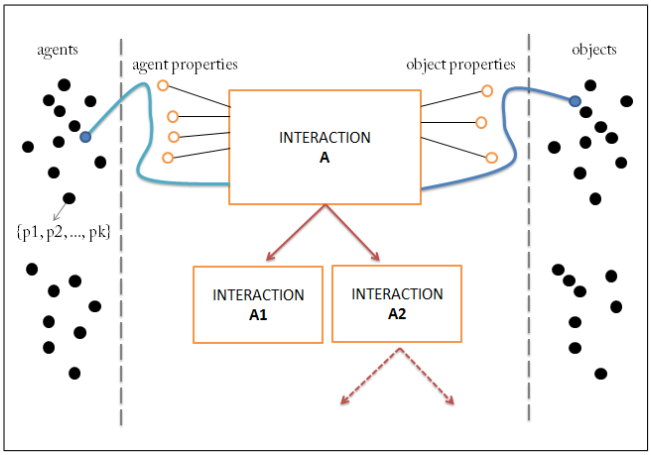

Figure 3. Interaction-centered knowledge representation. Interactions are defined by means of two sets of properties, i.e., for the users and for the categories. Users (black nodes on the left) and categories (black nodes on the right) satisfying these constraints can participate to the interaction. All the interactions are structured in a taxonomy, where subclasses inherit both sets of properties from the superclass. Secondary, users and categoriess are defined as simple sets of properties / features.

In the same way, objects share a set of numeric and nominal property $O = o_1, o_2, ..., o_m$. Examples of them are:

> *bureaucracy, building, city mantenance, sport, education, news, kids, nature, tourism, shopping, lost and found, public transport, personal transport, hotels, restaurants, culture, entertainment, animals.*

An example of object vector is the following, representing a thermal spa in the city centre:

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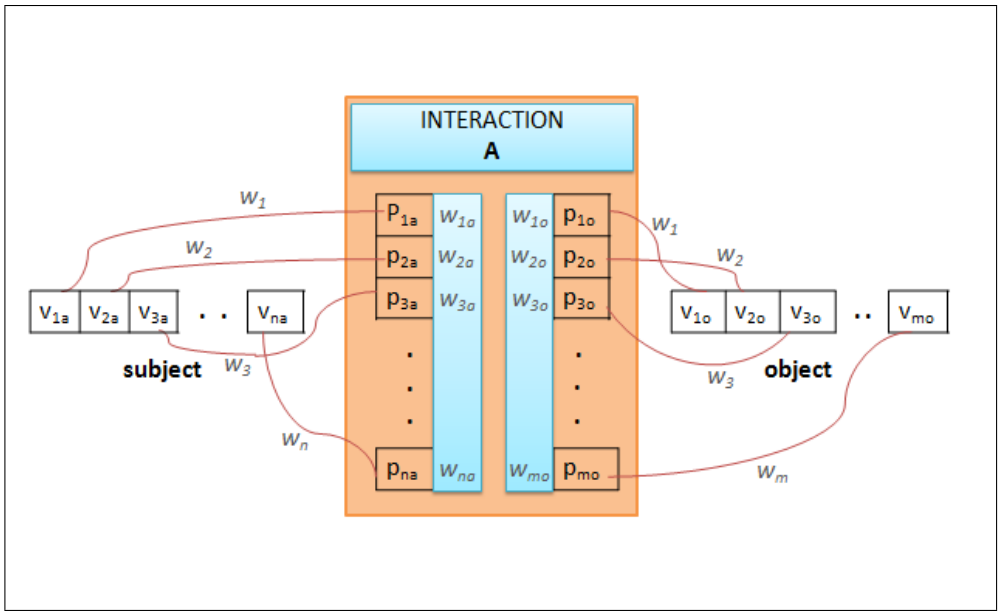

Figure 4. Subjects/users and objects/categories can assume a value in the range $[0, 1]$ for each specific property in the social network environment. All users and objects are thus represented as vectors. In the same way, a specific interaction becomes a two-vectors model that represents the association weights with the subjects and the objects properties, respectively. If a property is not set for a certain user-vector / category-vector / user-interaction-vector / category-interaction-vector, this is treated as a constraint of having a 0-value for any other vector that will be compared with it (otherwise the total similarity value between the two vectors will be set to 0).

> **object-vector** (a thermal spa) *public transport:0.4, bureaucracy:0.0, building:0.2, city:0.5, mantenance:0.0, sport:0.4, education:0.2, news:0.0, kids:0.2, nature:0.7, tourism:0.5, shopping:0.2, lost and found:0.4, personal transport:0.6, hotels:0.3, restaurants:0.6, culture:0.0, entertainment:1.0, animals:0.0*

The wights represent a value of how a specific object is related to a property. In the example, a thermal spa results to be more related to entertainment and transportation rather than to bureaucracy and animals. This way, users and objects are defined as vectors in these two multi-dimensional spaces, according to the Vector Space Model [17]. Notice that, in this manner, objects that present a similar conceptual nature may change its *property status* and so becoming different things depending on the context.

Each interaction, in the same manner, is defined as two vectors of weights (one concerning the user side, and one for the objects), and it can be placed within a taxonomy inheriting all the properties from its parents with some tuning of the weights. Notice that in case of non-numerical attributes, the weights can be numerical transformation obtained by techniques like Multi-Dimensional Scaling [18] and Self-Organizing Maps [19], or by manually-computed ranges.

The first phase concerns the development of the interaction ontology, where the domain experts have to edit a first sketch (even if this can be tuned by users activities dynamically) of the taxonomy of the interactions. Initially, we considered a flat organization where interactions work independently, but the system can work with hierarchy-based constructions as well. In detail, the knowledge engineer has to create the two vectors of the model (the one for the user and the one for the object) for each interaction. An example is shown later in this section.

At this point, once the interaction ontology with all the model vectors are created, a user in the network can act according to the *adherence* between his/her properties with the ones of the existing interactions (their left-side vector in Figure 4), dynamically, and in real-time. The adherence is computed by means of the well-known cosine similarity. From the other side, all the objects are represented as vectors of features as well. One object can be represented by a value of affinity with all the other objects. This is both practical and plausible, since one object can be related to others in some way. For example, the category *public transport* has a significant degree of affinity with the category *private transport*, and it is much higher than what it could be with the category *sport*. There are several ways for computing such graded categorizations in automatic ways also in taxonomy structures as in [20]; however, we think that such process must be done manually (or with a manual support), trying to capture the actual semantics according to the specific domain of application.

To sum up, the initial modeling efforts lie in the configuration of the interactions by weighting user and object vector weights. An example of user-vector model for the interaction *to relax* is the following:

> **user-vector** *age:'any', location:'any', sex:'any', public transport:0.4, bureaucracy:0.0, building:0.2, city:0.5, mantenance:0.0, sport:0.7, education:0.2, news:0.3, kids:0.2, nature:0.8, tourism:0.8, shopping:0.8, lost and found:0.0, personal transport:0.6, hotels:0.4, restaurants:0.6, culture:1.0, entertainment:1.0, animals:0.3*

Then, users dynamically change their feature vector through their own activity in the network (and therefore they constantly change their interaction scenarios). In addition, as in the basic idea of Dynamic Taxonomies [16] by which

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instances classified under different objects are viewed as latent connections between the latters, a real-time adjustment of the weights is not only done by user-side, but also on the object vectors. In fact, initial manually-constructed object vectors can exploit the real use carried by users activities to find unknown affinity connections (or to moderate the ones already known). This prevents from incorrect configurations in the cold start.

V. Definitions and Validity of the Approach

The entities involved in our proposal are the following:

- **Property**. Also called semantic information unit, it represents the central brick of the world under representation. Every agent/object/interaction is built on top of it.

- **Agent/Object**. It is a set of pairs $< p, v >$ where p is a property and v is a value within its domain $D(p)$.

- **Interaction**. An interaction is a pair of left and right property sets, defining who interacts with what.

- **Interaction Taxonomy**. Interactions are organized in a taxonomical structure such that if an interaction I_p is parent of an interaction I_c, then all left and right property sets of I_p are inherited by I_c.

Agents and objects are compositions of properties, so there is no need to build user- and object ontologies. This *minimizes manual efforts in building computational ontologies* (see Research Question (RQ) #1 in Section II) exploiting the efficacy of the vectorial representations. In the same way, the model *maximizes the sharing of knowledge* since objects and agents use the same feature space (RQ #2). Then, *the flexibility of the interactions is not affected by such representation* (RQ #3) since they directly rely on them by being modeled in the same fashion by two feature vectors. In addition, the actions that the platform can take can be easily defined with constraints on the agent- and object vectors, so it is possible to *shape the behaviour of the social network* (for the same interaction) depending on who/what is interacting (RQ #4). Finally, the use of numerical vectors *completely fits the requirements of smart access strategies*, since it is the model used for queries and retrieval by definition (RQ #5).

VI. Conclusions and Future Works

In this paper, we proposed an idea for representing the knowledge of highly dynamic environments like social networks and Web Sharing sites. Indeed, these kind of information need to be carefully organized to remain manageable while making the interaction itself enhanced. We first started the discussion by thinking at a classic Social Network scenario where users are associated to interests and locations, acting over (virtualized) real-life objects. Then, multiple interactions can take place by means of several combinations of these concepts, thus the knowledge complexity and the relative management becomes interesting as much as it gets harder.

In future works, we will implement these ideas on a real Social Network named First Life, an innovative social network that enables every resident to really live in the neighbourhood by creating a networked platform where citizens can receive and submit useful information. *First Life* has been selected as one of the *Smart Cities and Social Innovation and Communities projects* for the development of smart cities at national (italian) level.

References

[1] J. Gibson, "The concept of affordances," Perceiving, acting, and knowing, 1977, pp. 67–82.

[2] M. Baldoni, G. Boella, and L. Van Der Torre, "powerjava: ontologically founded roles in object oriented programming languages," in Proceedings of the 2006 ACM symposium on Applied computing. ACM, 2006, pp. 1414–1418.

[3] N. Guarino, Formal Onthology in Information Systems: Proceedings of the First International Conference (FIOS'98), June 6-8, Trento, Italy. IOS press, 1998, vol. 46.

[4] T. R. Gruber, "Toward principles for the design of ontologies used for knowledge sharing?" International journal of human-computer studies, vol. 43, no. 5, 1995, pp. 907–928.

[5] S. T. Fiske and S. E. Taylor, Social cognition: From brains to culture. Sage, 2013.

[6] R. Smullyan, First-order logic. Dover Publications, 1995.

[7] J. Searle, Mind, language and society: Philosophy in the real world. Cambridge Univ Press, 1998.

[8] J. R. Searle, The construction of social reality. Simon and Schuster, 1995.

[9] P. Johnson-Laird, Mental models: Towards a cognitive science of language, inference, and consciousness. Harvard University Press, 1983, no. 6.

[10] D. Gentner and A. L. Stevens, Mental models. Psychology Press, 2014.

[11] W. Köhler, "Gestalt psychology." 1929.

[12] M. Wertheimer, W. Köhler, and K. Koffka, "Gestaltpsychologie," Einfuhrung in die neuere Psychologie. AW Zickfeldt, Osterwieck am Harz, 1927.

[13] E. Weissensteiner and S. Winter, "Landmarks in the communication of route directions," Geographic information science, 2004, pp. 313–326.

[14] M. Baroni and A. Lenci, "Distributional memory: A general framework for corpus-based semantics," Computational Linguistics, vol. 36, no. 4, 2010, pp. 673–721.

[15] M. Steedman, "Plans, affordances, and combinatory grammar," Linguistics and Philosophy, vol. 25, no. 5, 2002, pp. 723–753.

[16] G. Sacco, "Dynamic taxonomies: A model for large information bases," Knowledge and Data Engineering, IEEE Transactions on, vol. 12, no. 3, 2000, pp. 468–479.

[17] G. Salton, A. Wong, and C. S. Yang, "A vector space model for automatic indexing," Commun. ACM, vol. 18, no. 11, Nov. 1975, pp. 613–620. [Online]. Available: http://doi.acm.org/10.1145/361219.361220

[18] J. B. Kruskal, "Multidimensional scaling by optimizing goodness of fit to a nonmetric hypothesis," Psychometrika, vol. 29, no. 1, 1964, pp. 1–27.

[19] T. Kohonen, Self-organizing maps. Springer, 2001, vol. 30.

[20] J. W. Kim and K. Candan, "Cp/cv: concept similarity mining without frequency information from domain describing taxonomies," in Proceedings of the 15th ACM international conference on Information and knowledge management. ACM, 2006, pp. 483–492.

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Centricity in Project Risk Management: Towards a Conceptual Framework for Improved Practice

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***Abstract* – Most organisations engage in major projects during their life cycle, and effective project management is increasingly accepted as a necessary competence in larger companies. Nevertheless, a considerable proportion of projects continue to fail to meet their due dates, exceed budget, do not deliver to specification, miss quality standards, or fall short on customer expectations. The effective management of project risk is a major component of this problem, and central to its resolution, and yet the theory of risk management remains relatively undeveloped and its practice is often poorly executed. This paper examines how the concept of centricity can be applied to some key elements of risk management to develop a conceptual framework that highlights some of the shortcomings of current practice and suggests alternative ways forward. This model will be tested and evolved through primary case studies of risk management in major projects in the automotive industry.**

Keywords - project management; centricity; risk; risk identification; risk management; risk assessment; subjective construct; conceptual model

I. INTRODUCTION

Project management is part and parcel of business operations in a wide range of industry sectors, including information technology (IT), engineering, construction, education, and health management [1]. It is now viewed as of strategic significance, and the management of risk is an integral part of the project management process. Despite the recognized criticality of project success for organizations, a considerable proportion of projects continue to either not meet their due dates, exceed budget, do not deliver to specification, miss quality, or do not meet customer requirements.

Project failure remains an area of considerable interest in contemporary project management literature, and effective risk management has been identified as one of the major criteria for project success [2]. Yet it remains an area where there is neither a clearly defined theoretical underpinning nor an agreed approach to support the development of a universally agreed method for managing risk. Nevertheless, risk management has become a central component of some of the most widely deployed industry standard methodologies, such as Project Management Body of Knowledge, PRINCE2®, Systems Development Life Cycle, Integrated Capability Maturity Model, and Information Technology Infrastructure Library. Comprehensive risk management increases the probability of project success [3]. It is considered as the means by which the effects of unexpected events can be limited, or even how such events can be prevented from happening. Risk management, as an integral component of project management, can make a significant contribution to overall project success [4]. This article attempts to develop some new directions in this debate through applying the concept of centricity to a number of themes that run through existing risk management literature – risk identification, risk assessment, and the nature of the management process itself. The overall aim of the research is to assess the validity of centricity as a key concept in the development of project management practice. This will also inform policies aimed at enhancing current project risk management, particularly in the automotive industry.

This introductory section is followed by a discussion of the theoretical framework for this paper. The application of the centricity concept to different aspects of risk management is presented in section three, and this is further developed in an analysis section which examines the implications of this model for contemporary risk management practice. Finally, the concluding section summarises results to date and looks at how this research can be further progressed.

II. THEORETICAL FRAMEWORK AND RESEARCH METHOD

The risk management process is often viewed as comprising five main activities (see Figure 1) [5], and this provides a useful frame of reference for this study. Our focus

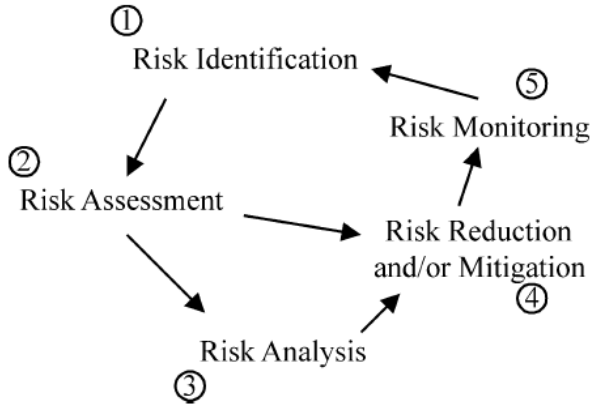

Figure 1. Generic overview of the risk management process

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is on risk identification, and then risk assessment; and finally, we look at the process as a whole, comprising all five activities.

Risk identification is the starting point for risk management in projects, and the way in which risks are identified is considered to be a major influencing factor in project outcomes [6]. There are two main schools of thought regarding risk identification – "risk as an objective fact" and "risk as a subjective construct". The former considers risk as epistemologically probabilistic, whilst risk in the subjective construct perspective allows multiple epistemological dimensions of risk [7]. "Risk as an objective fact" considers risks to objectively exist. In the case of "risk as a subjective construct" risk phenomena are subjectively constructed by observers themselves. Risk as a subjective construct may thus be considered to be "person-centric", originating from a subjective perception of risk, rather than from an objective assessment of whether the risk exists and the significance of it.

As regards risk assessment, the choice of a particular industry prescribed project management methodology can have a major impact on how risks are assessed, and on overall project outcomes. Project management methodology can be defined as the application of knowledge, skills, tools, and techniques to project activities to meet the project requirements [8] or, using the widest definition given by Cockburn [9], anything that the project management team relies on in order to successfully deliver project results.

All of the mainstream methodologies have their own techniques and tools for assessing risks. These methodologies include the Project Management Body of Knowledge (PMBoK), Project Risk Analysis and Management (PRAM), PRINCE2 and the Scrum Agile Standard. The first three of these are generally considered to belong to the so called traditional project management approach, whilst Scrum is the most prominent of the new project management approaches [9].

PMBoK, published by the Project Management Institute (PMI) is the project management guide most widely followed by international organizations. PMI's outreach, its proximity to project management core theories and formalization of processes compared to the other standards, make it to the optimum standard guide for many authors [10]. One major criticisms of PMBoK is its mechanistic approach, making it suitable for routine or technical situations [11], but not so appropriate for unusual or one-off situations. The methodology entails the use of its Probability and Impact Matrix for qualitative risk assessment. Some authors, such as Chapman and Ward [12], challenge the value of this tool for risk assessment. The experience of the risk assessor can determine the so-called probability estimate starting values, and thus estimates become biased. This effect is known as "anchoring" [13].

The development of risk matrices for assessment has taken place isolated from academic research in decision making – risk matrices produce arbitrary decisions and risk-management actions. These problems are difficult to overcome because they are inherent in the structure of the matrices [14]. Their theoretical basis is superficial and the validity of the qualitative information they employ is highly suspect [15]. The use of risk matrices for assessment illustrates the potential impact of project management methodologies on risk management and project outcomes.

Looking at the risk management process as a whole, many risk management professionals see the control of risk management as being dependent on the project manager. This leads to the conclusion that the effectiveness of the risk management process depends on the project manager's skills, experience and management style [16]. This can be viewed as project-centric risk management, with the project manager seen as the key individual in operational delivery of project outcomes. An alternative perspective highlights the criticality of allocating risk ownership to a range of individuals, who may not be in regular contact with the project manager [17]. Practitioners' responses suggest that an alternative system that encourages all project members to participate in the risk management process is normally missing. The consequence is the failure to create a collective responsibility to manage risk [16].

The aim of this research is to explore how the concept of centricity can be applied to the three dimensions of risk management discussed above. Centricity in a managerial context can be defined as the mind set or attitude that characterises the managers or organisation's outlook and motivation in the relationship to others [18] [19]. In recent years, qualitative research has found increasing recognition in many areas of project management practice. A large number of empirical studies using qualitative data are available in academic literature and specialized journals [2][4][6]. At the same time, management researchers and practitioners in particular rely on evidence-based policy. In fact, most of the existing generally accepted standards in the project management field as a whole are built around evidence-based policy and best practice.

Through an analysis of existing literature, allied to empirical data and observations in large project environments, this paper looks to develop a conceptual framework for research in the following areas:

- Person-centric risk identification vs. objective risk identification
- Methodology-centric risk assessment vs. multi-disciplinary/eclectic risk assessment
- Project-centric risk management process vs. devolved risk management process

This approach assumes that it is feasible and sensible to cumulate findings and generalize results to create new knowledge. The application of the centricity concept to the aspects of risk management discussed in this paper will be tested and developed further through primary research case studies as part of an on-going research project.

III. CONCEPT DEVELOPMENT

The identification of risk as a subjective phenomenon coincides with its creation – the risk exists only once the stakeholder has identified it. This is particularly noticeable for risks linked to an organization's own qualities and deficiencies [20]. This subjective or person-centric risk

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identification can often produce inefficiencies in the management of risk that may impact detrimentally on project cost and overall project success (see Figure 2).

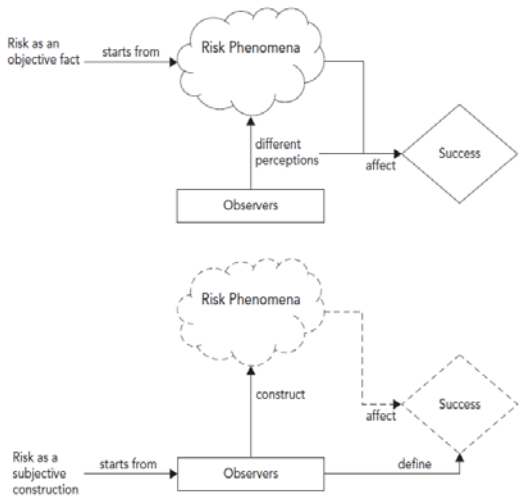

Figure 2. The two means of risk identification [7].

If we now view risk identification against risk assessment, it is apparent that most projects adopt a person-centric approach to risk identification and adopt a methodology centric approach to risk assessment. Yet we suggest that a combination of objective risk identification and eclectic risk assessment is likely to produce the most successful project outcomes (see Figure 3). The use of risk matrices for risk assessment illustrates this well. Their apparent simplicity and transparency are reasons for their popularity; however, they potentially entail serious mathematical defects and inconsistencies. Different risk assessors may assign greatly different ratings to the same exposure [21]. Such different ratings are due to fundamentally different worldviews, beliefs, and other psychosocial factors, the consequences of which are not minimized through reflection and learning.

There are a number of evident shortcomings in the use of these matrices. These include instability resulting from categorization differences, and the lie factor, which suggest that they can obscure rather than enlighten communication. The ranking produced was shown to be unduly influenced by the matrix design, which is ultimately arbitrary. It is suggested that other means of assessing risk based on decision-analytical methods could produce improved outcomes [14]. Marmier, Gourc and Laarz [22] present a decision-making tool in order to help the project manager choose the best way to improve project success rate while controlling the level of risks. Other authors combine the content analysis with cluster analysis or decision trees to build risk management guidelines [23]. These scientific decision analysis tools could be an alternative to the popular but inefficient use of risk matrices for risk prioritization. The establishment of systematically maintained lessons learned datasets could also provide quantitative reliable data to estimate the likelihood of potential events.

If we now examine risk identification in conjunction with the nature of the risk management process, a similar picture emerges (see Figure 4). The different approaches to the risk management process often appear as a conflict between centralized project risk management and the empowerment of sub-project teams [24]. The complexity of certain projects makes it difficult to understand the consequences of central decisions for the team members. The project manager alone will struggle to comprehend the details of all potential risks, oversee these and control their management. Yet most projects are project centric in terms of risk management process and person-centric as regards risk identification. The ongoing monitoring and maintenance of the risk register in which project risks are listed tends to be controlled by the central project manager [25]. It is suggested that overall project outcomes would be improved by appropriately combining centralized and decentralized risk management

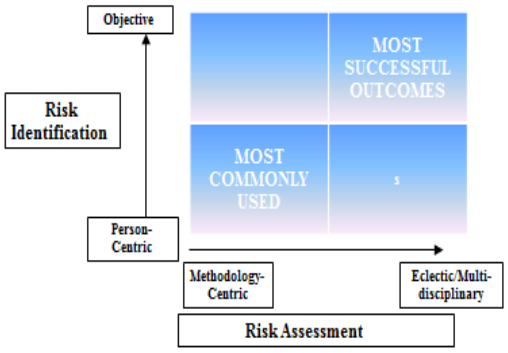

Figure 3. Risk identification and risk assessment: basic model

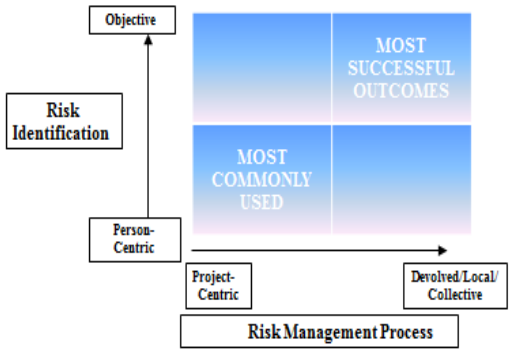

Figure 4. Risk identification and the risk management process: basic model

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activities, especially in complex projects [16]. More particularly, project management practitioners in industries which require intense collaboration - such as automotive product development - complain about insufficient development of risk management methods and about methods and processes not being integrated and synchronized. Lack of collaborative risk management, together with miscommunication, is the main reason for project failure in the automotive industry [26].

IV. MODEL PROGRESSION AND IMPLICATIONS

The basic conceptual model can be developed further in the light of literature analysis and project experience, indicating the downsides and upsides of operating in each quadrant of the model (see Figures 5 and 6). This also has implications for the use of some of the mainstream project management methodologies in their treatment of risk issues. For example, PMI's project management guide, although considered as the best in class among all available

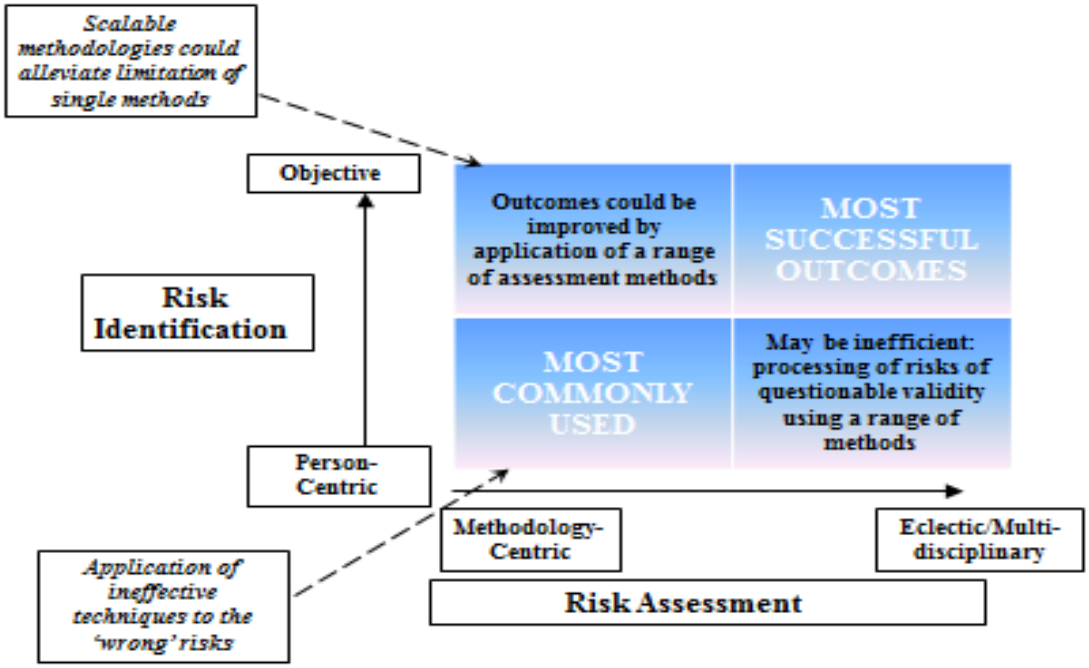

Figure 5. Risk identification and risk assessment: model development

Similarly, in major information systems projects, the IT function has traditionally owned and lead information risk management and security operations. However, the move to user ownership of systems requirements, process change issues and data access and maintenance, have changed the risk and security paradigm. Business managers, systems users and the IT function are now required to understand and learn others risk-reward trade-offs. The IT function must now share ownership of the risk management process and transfer accountability for some key areas of risk to business partners [27].

As Peter Drucker has put it, "when intelligent, moral, and rational people make decisions that appear inexplicable, it's because they see a reality different to the one seen by others" [28]. This phenomenon, in the case the risk management process, requires further research into the interaction and communication between project teams and their contexts. If it can be successfully harnessed to enhance the risk management process, it has the potential to significantly enhance eventual project outcomes.

methodologies and guides, could be enhanced with some early risk identification tools and techniques from more minor project management methodologies such as Scrum. Such enhancements would help reduce project uncertainty. In addition, experience gained by specific industries' customized methodologies can increase risk management effectiveness. These could provide quantitative data to support estimations of the probabilities of risks occurring. Equally, decision analysis tools are an alternative or complement to the inconsistent but widely used risk matrices. Decision analysis tools may be initially difficult to adopt; however, they can provide objective data to support risk assessment as an alternative to the use of risk matrices with all their inherent deficiencies.

The popularity of new project management approaches, such as that embodied in Scrum, resides in their adaptability to accommodate change and the unexpected, as opposed to the quest for risk predictability which is the basis of the traditional approaches [9]. These new approaches also highlight the importance of both formal and informal

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communication, collaboration between project team members, and their involvement in decision making, suggesting a more devolved and collective risk management process is generally beneficial.

Context, such as the projects organization's size and complexity, may play a significant role in tailoring and adapting any project risk management methodology when applying the different standards. Generally speaking, the traditional approach is more appropriate for projects with very low level of uncertainty in which emphasis will be on planning. Conversely, agile project management, with a more flexible approach to a collective risk management process, fits best in environments characterized by a high level of uncertainty [9].

The two standards with a higher emphasis upon early risk identification are PRINCE2 and Scrum. Traditional project management practices struggle to deal effectively with uncertainty. In highly uncertain environments, approaches such as Scrum and lean methods can help manage residual uncertainty about risk not addressed by traditional project management practices [29].

The model developed using centric concepts suggests a combination of risk management based on traditional standards and more flexible approaches typified by Scrum would be beneficial for most projects. However, this would imply significant mindset changes in the organisation [30]. Project teams need to be empowered to effectively use a range of different methodologies and techniques, which may involve team members adopting new roles. This may result in teams creating their own, tailored, risk management process and activities [31].

V. CONCLUDING REMARKS

This article has explored how the concept of centricity can be applied to some key aspects of project risk management to aid understanding and develop alternative perspectives. The concept of centricity has been used as a key component in the development of a conceptual model that will now be tested and refined through primary case study research of risk management in information technology and new product development projects in the automotive industry. This will entail action research through which the conceptual framework will be applied and further developed in major pan-European projects.

Harnessing and applying the concept of centricity suggests that, in most projects, risk identification is person-centric, risk assessment is methodology-centric, and the overall risk management process is project-centric. Yet current literature, recent trends and personal observation suggest that a move away from centricity in these components of risk management would benefit project outcomes. The integration of traditional and agile project management to tailor project management methodologies to

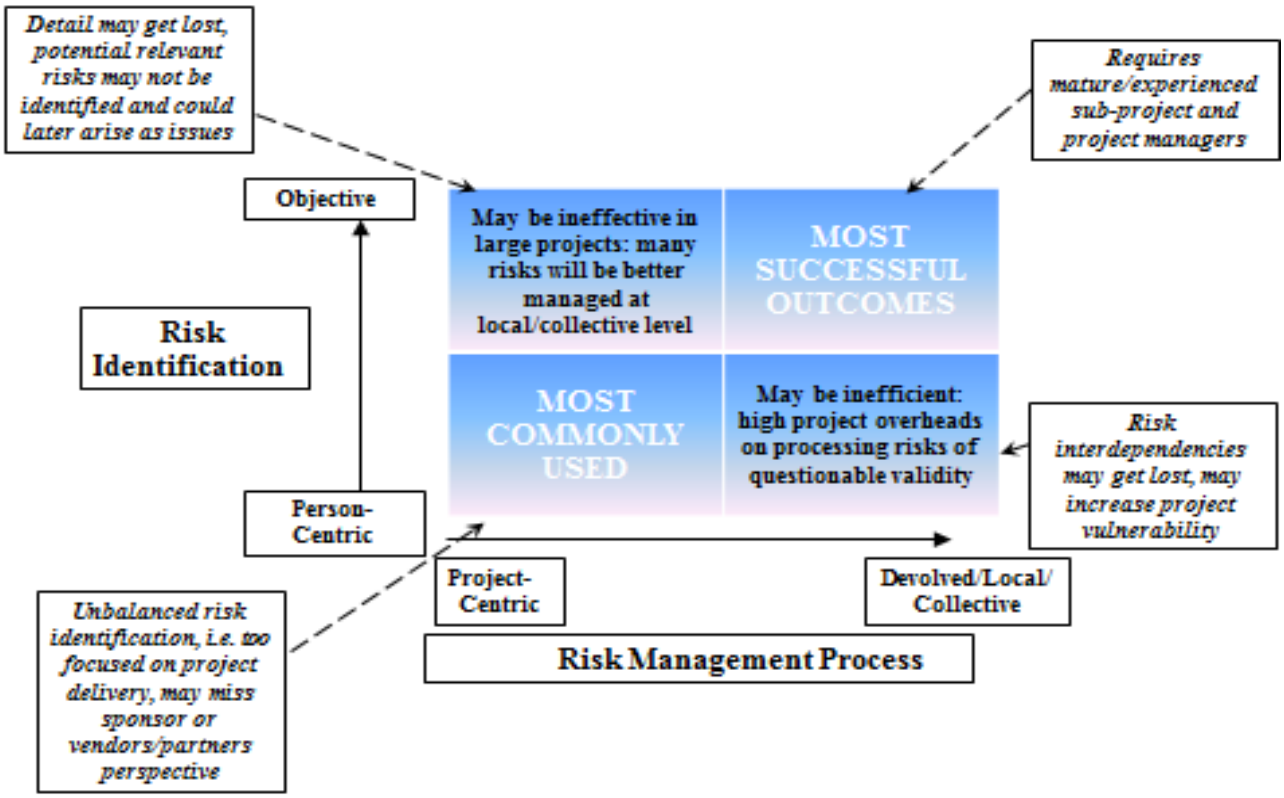

Figure 6. Risk identification and the risk management process: model development

the specific needs of the organization is gaining wide public attention. For the project manager considering how to manage overall risk, the question is not just which project management risk approach should be adopted, but more how to select a "best of breed approach", choosing the most suitable techniques, templates, tools and artifacts out of the different standards and methodologies. It is hoped that this article, by using the concept of centricity to analyse current practice, will engender this process and lead to better overall project outcomes.

REFERENCES

[1] D. E. Hodgson, "Disciplining the professional: The case of project management," Journal of Management Studies, 39(6), 2002, pp. 803-821.

[2] D. McClure, From the CIO trenches: Why some projects fail and others succeed, Gartner Industry Research, 2007.

[3] R. Jen, Visual Ishikawa Risk Techique (VIRT) - An approach to risk management, PMI Virtual Library, 2009. Available: http://www.pmi.org/en/Knowledge-Center/Knowledge-Shelf/~/media/Members/Knowledge%20Shelf/Jen_2009.ashx. [Retrieved: July, 2014].

[4] K. de Bakker, "Risk management affecting IS/IT project success through communicative action," Project Management Journal, 42(3), 2011, pp. 75-90.

[5] F. D. Patterson, K. Neailey, "A Risk Register Database System to aid the management of project risk", International Journal of Project Management 20, 2002, pp. 365-374.

[6] K. de Bakker., A. Boonstra, and H. Wortmann, "Risk managements' communicative effects influencing IT project success," International Journal of Project Management, 30(4), 2012, pp. 444-457.

[7] H. Zhang, "Two schools of risk analysis: A review of past research on project risk," Project Management Journal, 42(4), 2011, pp. 5-18.

[8] PMI, A guide to the project management body of knowledge (PMBOK®) (Fifth ed.) Project management institute, Inc., 2013.

[9] M. Špundak, "Mixed Agile/Traditional Project Management Methodology – Reality or Illusion?" Procedia - Social and Behavioral Sciences, 119, 2014, pp. 939-948.

[10] M. J. Thaheem, "Project Risk Management for Sustainable Restoration of Immovable Cultural Heritage: Lessons from Construction Industry and Formulation of a Customized PRM Model." (Doctorate of Philosophy), 2014 Politectnico de Torino. [Retrieved: July, 2014].

[11] P. W. G. Morris, L. Crawford, D. Hodgson, M. M. Shepherd, and J. Thomas, "Exploring the role of formal bodies of knowledge in defining a profession – The case of project management." International Journal of Project Management, 24(8), 2006, pp. 710-721.

[12] C. Chapman and S. Ward, Project risk management: processes, techniques and insights: John Wiley & Sons, 2003.

[13] A. Tversky and D. Kahneman, "Judgment under uncertainty: Heuristics and biases", science, 185 (4157), 1974, pp. 1124-1131.

[14] P. Thomas, "The Risk of Using Risk Matrices", Masters thesis, University of Stavanger, 2013. http://brage.bibsys.no/uis/bitstream/URN:NBN:no-bibsys_brage_45899/1/Thomas_Philip.pdf. [Retrieved: July, 2014].

[15] K. D. Wall, "The Trouble With Risk Matrices", DRMI Working Papers Ongoing Research, 2011, pp. 11-23.

[16] C. M. Harvett, "A Study of Uncertainty and Risk Management Practice Related to Perceived Project Complexity." (PhD), 2013. Avalilable: Bond University, ePublications@bond. [Retrieved: July, 2014].

[17] T. Raz and E. Michael, "Use and benefits of tools for project risk management.", International Journal of Project Management, 19 (1), 2001, pp. 9-17.

[18] H. V. Perlmutter, "The Tortuous Evolution of the Multinational Corporation.", Columbia Journal of World Business, 4 (1), 1969, pp. 9-18.

[19] M. Olsen and A. Roper, "Towards an Understanding of Centricity: Profiling International Hotel Groups", International Journal of Hospitality Management, 17 (2), 1998, pp. 111-124.

[20] J. Irizar and M. Wynn, "Risk as a Subjective Construct: Implications for Project Management Practice." The Fifth International Conference on Information, Process, and Knowledge Management (eKNOW 2013) IARIA, Feb. 2013, pp. 135-141, ISBN: 978-1-61208-254-7.

[21] D. J. Ball and J. Watt, "Further Thoughts on the Utility of Risk Matrices", Risk Analysis, *33*(11), 2013, pp. 2068-2078. doi: 10.1111/risa.12057.

[22] F. Marmier, D. Gourc, and F. Laarz, "A risk oriented model to assess strategic decisions in new product development projects", Decision Support Systems, 56, 2013, pp. 74-82.

[23] V. Holzmann and I. Holon, Analyzing Lessons Learned to Identify Potential Risks in new Product Development Projects. Paper presented at the 6th European Conference on Information Management and Evaluation, 2012, pp. 127-134.

[24] T. M. Williams, "Empowerment vs risk management?" International Journal of Project Management, 15, 1997, pp. 219-222.

[25] P. L. Bannerman, "Risk and risk management in software projects: A reassessment," The journal of systems and software, 81(12), 2008, pp. 2118-2133.

[26] K. Niebecker, "Collaborative and cross-company project management within the automotive industry using the Balanced Scorecard." (Doctor of Philosophy), 2009 Available: University of Technology Sidney. [Retrieved: July, 2014].

[27] E. Chobanova, "Why You Should Share Your Risk With Business Partners." [Online]. Available from: http://www.executiveboard.com/it-blog/why-you-should-share-your-risk-with-business-partners, 2014. [Retrieved: July, 2014].

[28] Bud Baker, "The fall of the firefly: An assessment of a failed project strategy," Project Management Journal, 33(3), 2002, pp. 53-57.

[29] C. Besner and B. Hobbs, "The paradox of risk management; a project management practice perspective." International journal of managing projects in business, 5(2), 2012, pp. 230-247.

[30] M. McWha, "Agile is a Mindset, not a Methodology." [Online]. http://www.executiveboard.com/it-blog/agile-is-a-mindset-not-a-methodology, 2014 [Retrieved: July, 2014].

[31] R. Rodríguez Gutiérrez, J. Minguella Canela, F. Fenollosa i Artés, B. Ventayol Femenias, and M. A. d. l. Santos López, "Experiences in Agile R&D Project Management for New Product Design and Development in the Automotive Industry." The 16th International Research/Expert Conference on Trends in the Development of Machinery and Associated Technology, TMT 2012, pp. 223-226.

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***Abstract*—This paper presents the development of a customized surveillance system to counter the vandalism of transmission line equipment on Uganda's national transmission operator's network. The system is based on the Raspberry Pi platform and incorporates a Minisense Piezo-vibration sensor, an Infrared-capable Camera board and a Huawei General Packet Radio Service (GPRS) modem. The system is able to detect vibrations arising from cutting of angle bars on steel pylons, take an evidentiary snapshot of the camera's field of view and annotates the snapshot with details such as Tower number, time and date. The system then relays this snapshot to a workstation in the monitoring centre and triggers an alert in the form of a blinking display. This surveillance system will be deployed on about 4800 steel tower pylons that are currently maintained by the transmission operator country-wide.**

Keywords - UETCL; Surveillance; Machine Vision; GPRS.

I. INTRODUCTION

Uganda Electricity Transmission Company Limited (UETCL) is responsible for transmission of high voltage power (above 66kV), bulk purchase from Independent Power Producers and bulk sale to Distributors and Concessionaires in Uganda [1]. Currently, the transmission network in Uganda spans a total length of 1600km with a total number of approximately 4800 steel towers. UETCL faces a major problem of vandalism of pylon equipment along its transmission network causing financial losses to the tune of $41,000 monthly [2].

The vandals steal tower angle bars, nuts, stay and earth wires and barbed wires, which in turn leads to weakening and possible collapse of the pylons [3]. The collapse of one tower on the network leads to uneven stresses on the two adjacent tower leading to a possibility of a domino effect. This leads to severe power outages, which in turn, would lead to loss of revenue to the company as well as adverse socio-economic challenges. An additional revenue loss is incurred as a result of the capacity charge for the period that the available power cannot be evacuated from the generating plants. It should be noted that replacement of towers is a very time-consuming process requiring about 4 to 6 months for concrete foundations to cure.

Investing in the energy sector is very costly, and therefore, installations should be protected from vandalism so as to safeguard value for money spent. To overcome the problem, UETCL has ensured construction of access roads along the transmission lines to enable routine inspection to detect weak towers and spot welding of the angle bar nuts. There are intensified military patrols into the heavily-affected areas. Sensitization campaigns with District Local Councils have been carried out to reach an objective of co-opting Whistle-blowers to safeguard the transmission lines. UETCL provided for special anti-theft Huck-bolts and fasteners on the towers constructed (up-to 3m above the foundation cap) and an anti-climbing spike system [3].

Surveillance has typically involved the placement of analog cameras in sensitive or strategic areas of a particular business for live monitoring [4]. This serves not only as a deterrent to crime, but also to record the movement of people and property [5][6]. Automated visual surveillance is becoming an increasingly important area of research in computer vision. Interest has been motivated by commercial applications, such as surveillance of airports and office buildings, as well as military ones, such as monitoring the battlefield to automatically collect strategic information [7][8].

Detecting humans in images is a challenging task owing to their predominantly variable appearance and the wide range of poses that they can adopt. The first need is a robust feature set that allows the human form to be discriminated cleanly, even in cluttered backgrounds under difficult illumination [9].

Machine vision has been defined as the use of devices for optical, non-contact sensing to automatically receive and interpret an image of a real scene in order to obtain information and/or control machines or process [10][11]. Histograms of Oriented Gradients (HOG) are feature descriptors, used in computer vision and image processing for the purpose of object detection [9].

A system that incorporates detection of vibrations arising from hacking actions of the vandals, automated capturing of images, Human Detection in Images, as well as relaying evidence and alerting monitoring personnel in real-time would go a long way in combatting of the vice of vandalism.

This paper presents the design and development of a customized surveillance solution in two sections. The methodology discusses the specification of a logical framework, design of a physical model, as well as the implementation of a working prototype. The final section deals with the assembly of individual components, power requirements, tamper-proofing and cost implications of the system.

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II. METHODOLOGY

A. Context Diagram

The prototype is deployed on individual steel tower pylons. It consists of a camera placed at the top of the tower, trained downwards towards the base. A vibration sensor is attached to the steel frame of the tower so as to detect the vibrations caused by the cutting action of the vandals.

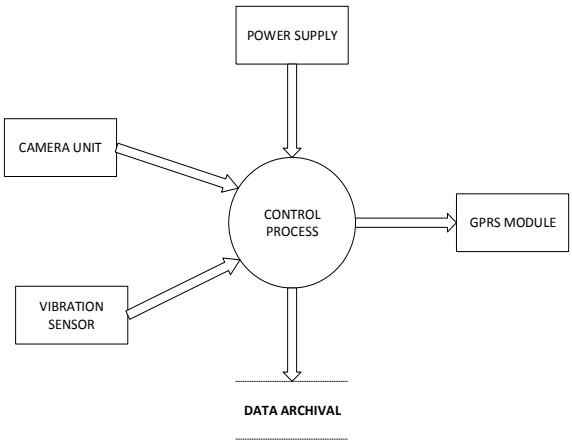

Figure 1. Context Diagram.

A microprocessor provides for implementation of the analytic algorithms to sift through the image data, as well as to take signal input from the vibration sensor. In addition, external storage is provided for the image data captured as well as a GPRS module to facilitate communication between the system and the command centre. A solar panel and battery unit is sized to provide the power requirement of the system setup. This is illustrated in the context diagram in Figure 1.

B. Technology Architecture

The Technology architecture model of the system is illustrated in Figure 2. The customized surveillance system is built upon the 512MB Raspberry Pi (R-Pi) Model B Single-board computer [12]. A single Pi NoIR infrared camera provides the image input at high resolution 1080pixel quality frames at a rate of 30 frames per second. The Pi NoIR unit communicates with the R-Pi via the Camera Serial Interface (CSI) located on the body of the R-Pi unit.

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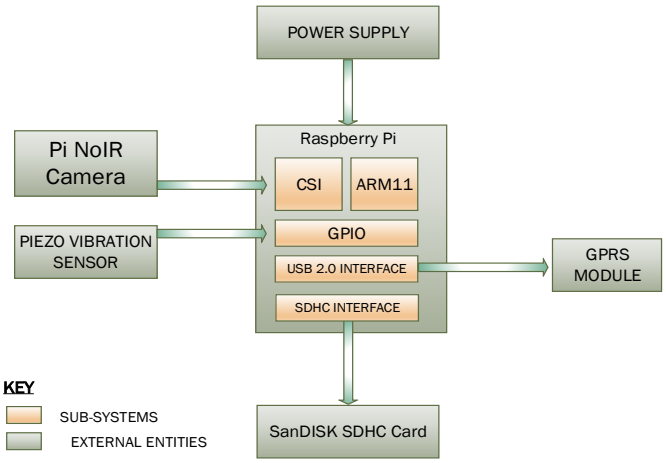

Figure 2. Technology Architecture.

A Piezo Vibration Sensor is connected via the General Purpose Input / Output (GPIO) interface and provides sensory input pertaining to the mechanical vibration of the steel frame to which it is attached. A battery power supply provides the power requirements of the R-Pi unit, as well as the attached external hard drive. The R-Pi requires a steady 5V and draws 2.5W during peak operation.

A 4GB San Disk Secure Digital High Capacity (SDHC) memory card is attached to the ARM11 microprocessor via the SDHC Card slot that is provided on the R-Pi unit to handle the storage requirements of the system. Finally, a generic GPRS module is connected to the USB interface on the R-Pi unit to provide communication capability to the system.

C. 3D-Modeling

The 3-dimensional model of the proposed surveillance unit was created using SketchUp®Tools. The layout includes visualizations of the Raspberry Pi, a GPRS Modem as well as a deep-cycle Lead Acid battery and its associated Charge Controller and Voltage Regulator. All components were enclosed in a stainless steel box. This is illustrated in Figure 3.

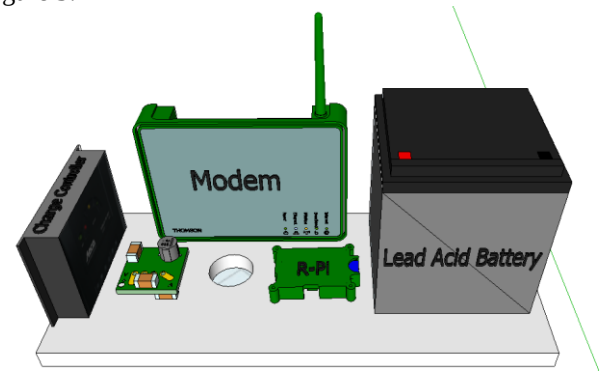

Figure 3. 3D Model.

A visualization was created of the proposed surveillance unit, and its intended mounting on the transmission line towers. The enclosing box is placed on the highest possible bracing of the steel pylon making considerations of maximum camera viewing angle. This is illustrated in Figure 4.

 ISBN: 978-1-61208-369-8

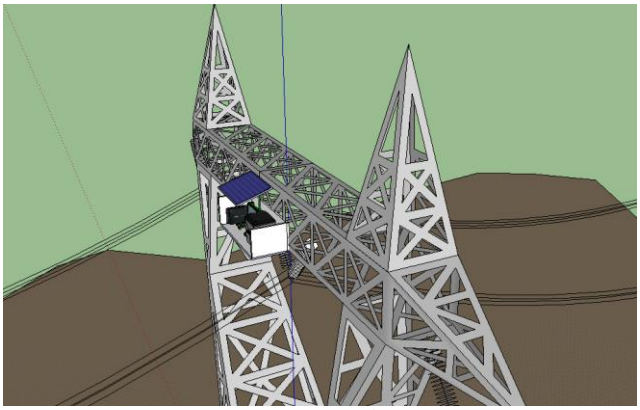

Figure 4. 3D Model of deployment.

It is screwed or welded to the bracing angle bars securely to prevent attempts by vandals at circumventing the security system. Also, placement at the height of the live conductors reduces the accessibility of the surveillance system and hence safeguards it against tampering. This placement is illustrated in the 3D model in Figure 4.

A solar panel was thus included in the visualization in Figure 4 to cater for the energy requirements of the system. It is placed vertically above the enclosing box to provide shadowing against direct sunlight and unnecessary heating. In addition, the placement of the solar panel above the enclosing box provides protection against the effects of direct precipitation (rain or hail).

D. Vibration Sensor Interrupt

A wiring schematic was generated using the TinyCAD software package. Of paramount importance was the specification of the connection of the Piezo-Vibration sensor to the GPIO pins of the Raspberry Pi. The circuitry was based on the implementation of a Monostable vibrator based on the 555 timer. This is illustrated in Figure 5.

This circuit layout is necessary to amplify and to shape the output of the vibration sensor into a clean square wave whose Positive going transition can be used to trigger the GPIO interrupt. A resistor between the Vibration Sensor terminals alters the sensitivity of the device while the Operational Amplifier ensures that the voltage output of the sensor is of the correct magnitude to trigger operation of the 555 timer Integrated Circuit (IC).

The Vibration sensor interrupt was implemented using Python, making use of the RPi.GPIO library. This was done by setting up the Pin 23 of the GPIO on the Raspberry Pi to wait for a Positive-going transition of a pulse occurring on the input to the pin. On the rising edge of the pulse generated by the 555-timer circuit, the microprocessor starts the camera routine by running a call to the peopledetect.py script. This is followed up by a system call to the ftpsync.py script.

E. Automation of Camera Routine

The Pi NoIR camera board is provided without an IR Filter. This allows it to take images or record video illuminated with IR Light, even in low visible-light conditions.

It is capable of producing 2592 X 1944 resolution still images, although this markedly slows down machine vision algorithms. Optimal performance was achieved with the camera limited to 600 X 450 resolution images.

A Human Detection Algorithm was written, based on Dalal Triggs' work [9] with HOG. The algorithm used in this project was heavily based on the examples included in the OpenCV 2.4.7 library distribution for Python. Upon detection of each instance of vibration, the camera is prompted to capture a single snapshot of the current field of view exposed to the camera.

Raspistill [13] is the command-line-driven application provided to take still photos using the Pi NoIR Camera board. The extra flags used with this command specify the output image name, photo resolution, exposure time (30 microseconds) and night time exposure mode. In addition, the command specifies that no preview window should be opened. All these flags were necessary to ensure an instantaneous capture of the still photograph. The final output of the image capture and processing routine is illustrated in Figure 6.

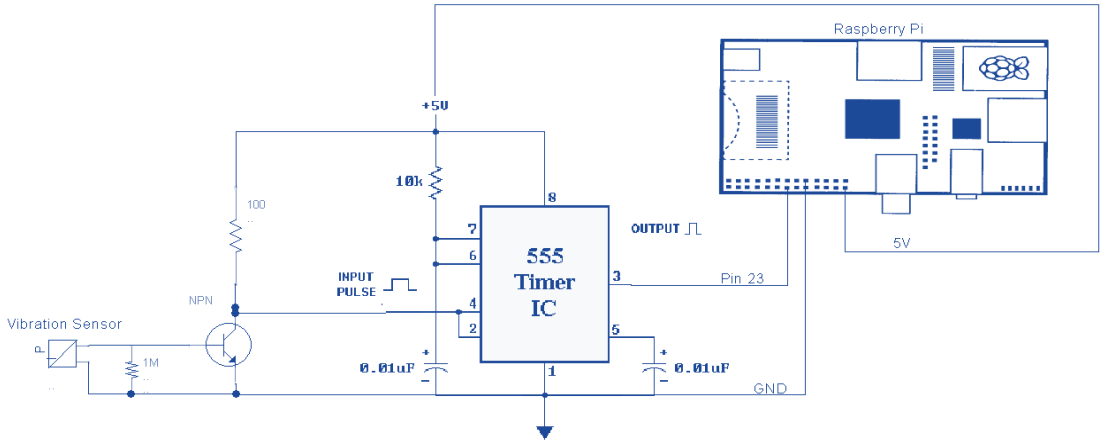

Figure 5. Schematic of Vibration Sensor Circuit.

 ISBN: 978-1-61208-369-8

Figure 6. Annotated Critical Evidence Snapshot.

The HOG algorithm implemented by the python program to carry out the detection of Human forms within the captured image is run first. A yellow rectangular boundary is drawn around the region of the image within which the human form detection has been made.

Captioning of images is carried out by a sequence of commands. The first line places a black solid filled rectangle near the bottom of the input image. The second line of code is responsible for generating the text to place over the black rectangle.

The metadata text generated by the code includes the Tower number and location information. For purposes of this example, the code generated a random integer between 0 and 500 to simulate actual tower numbers attached to steel pylons on the transmission network.

In addition, the code creates a Timestamp including date and time information for accurate reference. The text is generated in white on top of a black background for maximum contrast. The SaveImage function is then invoked to store the output image, henceforth referred to as a Critical Evidence Snapshot (CES) [14], in a uniform output image and directory to allow the FTP transfer script to access it.

F. Automation of GPRS Dialup Connection

The Raspberry Pi supports usage of the Huawei E220 USB GPRS Modem. WV Dial is a script that facilitates initiating a dial-up connection from the Raspberry Pi to create an Internet connection via the Modem. USB Modeswitch, on the other hand, is a utility that toggles functionality of the USB device from Mass storage (which is enabled by default) to GPRS Modem (which is required for this purpose)

The WVDial Configuration file is edited via a command-line-based text editor, so as to configure the operation of the WV Dial script. The carrier-specific settings required to set up a Dial-Up connection to the internet are specified in this file.

G. Automation of FTP File Transfer

The File Transfer Protocol (FTP) is a standard network protocol used to transfer computer files from one host to another host over a TCP-based network, such as the Internet. The transfer was done by using two Python scripts. The upload of the Annotated Critical Evidence Snapshot from the remote surveillance unit was automated with a system call to the ftpupload.py script.

The preliminary program routines in the script are responsible for creating a string value for the file name associated with the image being uploaded. This string value conforms to a uniform naming criteria including the current date and time of the snapshot capture. This is important for the proper curating of the CES archive on the monitoring station.

On the monitoring station, the download of Annotated Critical Evidence Snapshot was accomplished by a repeated call to the ftpsync.py script. This essentially synchronizes the directory contents on the FTP file server and the folder hierarchy on the local monitoring station. The download function queries the ftp file server directory and only downloads files that are currently on the server but are not listed on the local directory.

H. Implementation of a Front end monitoring panel

The actual GUI (Graphical User Interface) for the Front End Monitoring Panel was coded via Python, making particular use of the TkInter graphics library. The ordering of the widgets was achieved by nesting of several containers in varying orientations.

A single image is loaded from a directory, after being provided with the image file name. The image is then loaded into memory as a local variable. Finally, the variable is packed into the Frame container which was defined previously. Orientation and padding information was passed as variables to the pack function.

To implement a flashing alert signal, the color of the Text canvas item was repeatedly changed from the base Gray-95% to red and back to capture the users' attention every time a new CES image is acquired and registered on the system.

The <False Alarm> and <Action Taken> buttons were bound to the stop_blinking function. The complete layout of the monitoring panel is illustrated in Figure 7.

Figure 7. Front End Monitoring Panel.

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The Front End Monitoring Panel was designed to achieve the following functionality:

- Access and display locally stored CES images
- Allow browsing through the CES images in a sequence
- Continuously update the directory of CES images via FTP synchronization
- Alert the monitoring personnel of new CES images and prompt personnel to take action
- Allow personnel to flag CES as "False Alarm" whenever system presents False Positive
- Allow browsing through CES image archive

III. PROTOTYPE

A. Assembly of components

The assembly of components is as illustrated in Figure 8. A cast-steel casing was chosen for the housing of the system to protect the setup from attempts at vandalism. Furthermore, shock-proofing was provided by cushioning the components in a Styrofoam mould that was secured to the stainless steel case as illustrated in Figure 9.

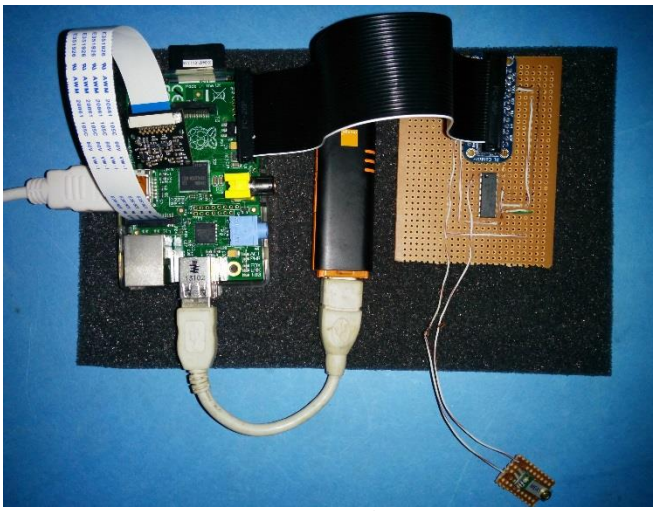

Figure 8. Prototype before Encasing.

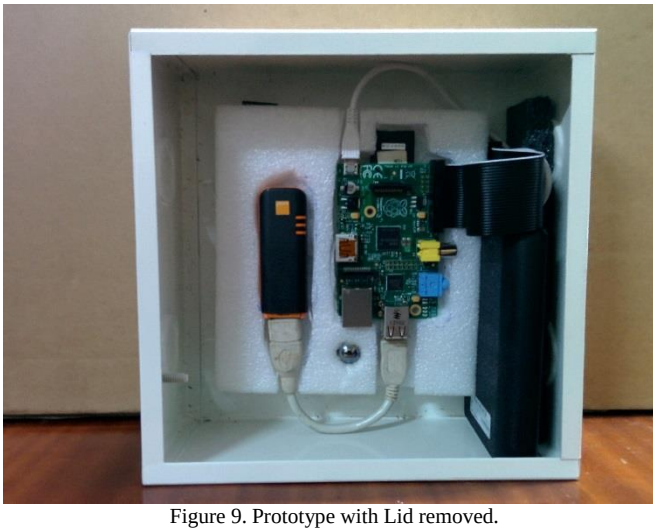

Figure 9. Prototype with Lid removed.

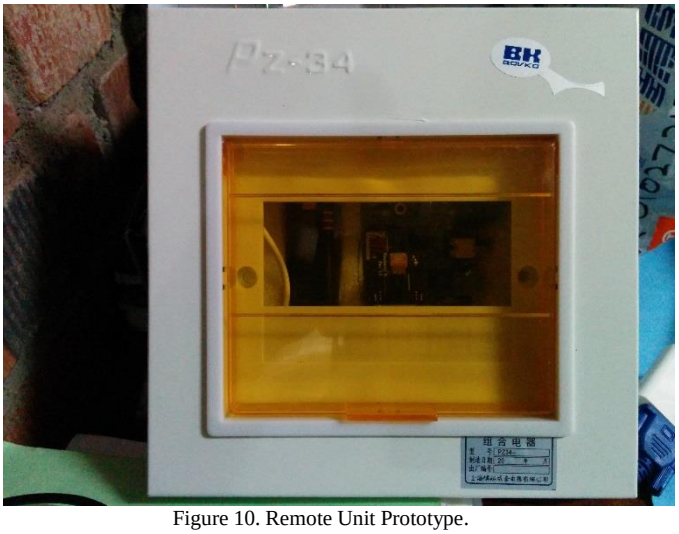

Figure 10. Remote Unit Prototype.

For purposes of this prototype, a 12000mAh battery bank was included to provide the powering requirements of the system. This is to be replaced with a deep-cycle Lead acid battery, charge controller and Solar panel before deployment and field tests.

A clear plastic window in the housing provided a viewing portal for the camera to ensure unobstructed viewing angles for the entire field of view. The final assembly of components and housing of a single surveillance unit is demonstrated in Figure 10.

B. Sizing of solar panel

The Raspberry Pi model B draws 3.5W of power. Even with a very efficient voltage regulator, there will still be some losses in our power system. It is best to assume 80% efficiency, and therefore approximately 4.0 Watts (the battery needs to give more power to cater for inefficiency in the regulator) will be taken from the battery to keep the Raspberry Pi powered. Following a rigorous sizing procedure, it was decided that a 30W/12V/2A mono-crystalline solar panel is required. A 40W mono-crystalline solar panel can also serve this purpose.

C. Sizing of the Battery

The Raspberry Pi will be taking approximately 8Ah of charge from the battery each day, and there may well be days (or multiple days in a row) without any sunshine and therefore, the battery should be sized to provide at least 7 days of power for the Raspberry Pi without sunshine and without the charge of the battery falling below 40%. Therefore, as 7x8=56Ah is at most 60% of the charge of the battery we need a battery of at least 56/0.6=93.33Ah. Thus, a 95Ah or 100Ah battery may be used. Hence, a 12V, 95Ah or 12V, 100Ah battery is used.

D. Testing of the system

The prototype has not yet been tested in a realistic deployment environment. This was mainly because it does not meet the minimum weather-proofing requirements for outdoor deployment. In addition, the national transmission operator was reluctant to effect the shutdown necessary to deploy the system on one of the live towers.

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Possible test cases for the prototype system upon deployment on a remote tower would be designed to assess the accuracy and reliability, depending on mounting height, weather and conditions of illumination. Of further importance is the sensitivity of the system to different magnitudes of vibration, and the ability of the system to discriminate and discard different naturally occurring vibrations, such as those due to wind or earth tremors.

E. Tamper-proofing of prototype

No single solution can be considered as "tamper-proof". Often multiple levels of security need to be addressed to reduce the risk of tampering. Some considerations might include the following:

- The proposed surveillance unit is enclosed inside a steel casing which is either screwed or welded shut to prevent unauthorized access and improve tamper resistance.
- It is deployed at a height, 3m below the lowest hanging conductor to control or limit access to products or systems of interest.

F. Cost of the system

One of the motivations for this research was the need for a cost-effective solution to the problem of vandalism. The cost of hardware requirements for the prototype including the solar powering and battery was computed to be $700 per unit of the surveillance system. Assuming that installation is to proceed on all the 4800 transmission towers on the transmission network, this would total up to a rough cost of $3,360,000 for the initial investment.

This is easily justified by the capital cost of replacement of vandalized tower angle bars or the cost associated with the loss of supply due to power outages. Further, assuming a 100% efficacy of the system after installation and a total eradication of the problem of vandalism, this would imply a payback period of up to 7 years.

IV. Conclusion and Future Work

In this paper, the development of a remotely deployed surveillance unit and its accompanying central monitoring station software was presented. The justification for the proposed system was discussed at length in the introduction. The functional and design requirements of the system were presented in detail and then the methodology followed in implementation of the system specified by the functional and design requirements.

Finally, the outcomes of the research endeavor were laid out in the Prototype section. In addition, the final costing of the proposed system was done basing on the cost of the cost of implementing the prototype. The basis for further research and testing of the system was also presented.

This research has dug deep into the potential for the utilization of machine vision algorithms on the cost-effective platform of Raspberry Pi for Surveillance applications. However, we were unable to fully optimize the Human Detection algorithm to allow an acceptable frame-rate for live video analysis, as opposed to the still image analysis used in this project.

In addition, integration of the system into the widely accepted SCADA (Supervisory Control and Data Acquisition) would greatly facilitate its adoption in most transmission network operators. This is motivated by the fact that a similar system is already in place to monitor the different power flow parameters on the transmission network.

Securing of the communication channel is another important research area that needs deeper consideration. This will effectively deter technology-savvy criminals from compromising the integrity of the surveillance data relayed from the remote monitoring units. In addition, reliability of the GPRS network over the entire span of the transmission network needs to be ascertained.

Acknowledgment

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References

[1] UETCL, “UETCL Official Website,” [Online]. Available: http://www.uetcl.com/. [Accessed 05 August 2014].

[2] OPM, “Office of the Prime Minister,” June 1999. [Online]. Available: www.opm.go.ug/. [Accessed August 2014].

[3] UETCL, “Vandals, a cost and menace to the energy sector,” *The Transmitter,* pp. 11-12, October 2007.

[4] IPVM, Video Surveillance Book, 1st ed., Chicago, 2012.

[5] S. Mubarak, J. Omar and S. Khurram, “Automated Visual Surveillance in Realistic Scenarios,” *IEEE Computer Society,* pp. 30-39, 2007.

[6] S. Russo, “Digital Video Surveillance: Enhancing physical security with analytic capabilities,” California, 2008.

[7] Motorola Solutions Inc, “Motorola Optimized Video Security,” Illinois, 2011.

[8] Seagate Technology LLC, “Security Gets Smarter With Intelligent Video Surveillance Systems,” New York, 2012.

[9] N. Dalal and T. Bill, “Histograms of Oriented Gradients for Human Detection,” Paris.

[10] N. Zuech, Understanding and Applying Machihe Vision, 2nd ed., New York: Marcel Dekker, 2000.

[11] B. Gary and K. Adrian, Learning OpenCV, 1st ed., Cambridge: O'Reilly, 2008.

[12] Raspberry Pi Foundation, “About Us,” [Online]. Available: http://raspberrypi.org/about/. [Accessed 13 August 2014].

[13] Raspberry Pi Foundation, *RaspiCam Documentation,* London, 2013.

[14] D. Gorodnichy and M. Tony, “Automated video surveillance: ACE Surveillance (Annotated Critical Evidence) case study,” Ontario, 2008.

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Communication Behavior Modification

Application for Promoting Wi-Fi Network Usage by Visualizing Usage History

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***Abstract*— With the rapid increase in the use of high performance Information Communication Technologies (ICT) devices, the control of network quality for congestion avoidance has become increasingly important in network service design. Service quality should be discussed from a user experience perspective and the same holds for network quality. However, it is less common to integrate a human-centered design viewpoint when improving network performance. In this paper, we discuss a concept that allows users to choose an appropriate network by visualizing network usage history. The main contribution of this paper is to show quantitatively the effect of this concept by developing a prototype application for smart phones. The application visualizes network usage history through entertaining content. Users enjoyed it and consequently were able to improve network performance by modifying their communication behavior. Field studies show that 47% of participants enjoyed using the application and 28% of participants increased their use of Wi-Fi networks.**

Keywords-service quality; user experience; human-centered design; human-network interaction; field study.

I. INTRODUCTION

The rapid change in mobile usage has brought about greater diversity in lifestyles [1]. People more frequently use high-performance Information Communication Technologies (ICT) devices, such as smart phones and tablet computers, and traffic volume is showing a sharp increase, which is a primary cause of traffic congestion in Internet Protocol (IP) networks and degradation of network quality. To achieve better service quality, controlling network quality becomes increasingly important in ICT service design.

One way this congestion problem is being tackled is through an engineering strategy, i.e., strengthening network infrastructure in terms of both quantity and quality. It makes a direct contribution to solving the congestion problem. However, this strategy is costly because of the vast size and complexity of implementing a cutting-edge network; consequently solving this problem weighs heavily on telecommunications operators. On the other hand, users sometimes develop a cognitive strategy to alleviate their dissatisfaction. A typical strategy is called multitasking whereby users move their attention away from the waiting process and try to reduce their sense of dissatisfaction.

In order to understand users' cognitive strategies, it is necessary to analyze network services from a user perspective. One approach is called Quality of Experience (QoE). In ITU-T Appendix I to P.10/G.100 [2], QoE is defined as "The overall acceptability of an application or service, as perceived subjectively by the end-user." Several studies have analyzed network services taking this definition into consideration. For example, Niida et al. [3] have reported on user tolerance for waiting time in mobile communications. While this approach is very useful for providing quality criteria for network planning, a new perspective is required to deeply understand cognitive strategies. Users' behavior when using devices connected to information networks (we call it communication behavior) is a contiguous judgment process embracing not only waiting, but also migration, cancellation, and so on. Users are influenced by past experiences and change their behavior accordingly. They are not static evaluators. To evaluate such dynamic communication behavior in order to understand cognitive strategy, the authors introduce the concept of "network usability".

Usability of ICT devices has been studied for a long time. In the earlier studies, it was mainly discussed in terms of time efficiency performance [4]. Subsequently, Norman defined a cognitive artifact as "an artificial device designed to maintain, display, or operate upon information in order to serve a representational function" [5], and the importance of human cognitive processes in interactions between users and artifacts was pointed out. The authors define network usability as the usability in Human-Network Interaction (HNI). Figure 1 shows a conceptual diagram of HNI which regards the network as a cognitive artifact. The network maintains and displays information which indicates network status. It is also controlled by users by selecting a preferred behavior. Users modify their communication behavior depending on the situation. If the network has a high degree of usability, this means that people can control network services with a low cognitive burden to accomplish their goal or solve their problem.

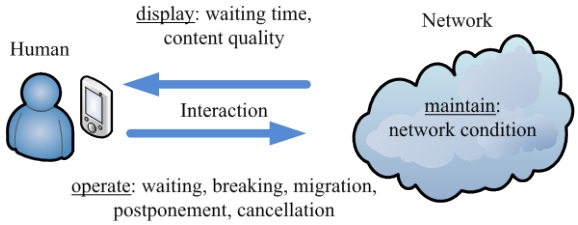

Figure 1. Conceptual diagram of human-network interaction.

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This paper proposes a concept that allows users to choose an appropriate time and place for using a wireless network based on their past experience. By learning from past experience, users are encouraged to use a high quality network. From the perspective of network usability, the authors designed an application that visualizes the network usage history as a form of entertainment and which allows users to understand past experiences easily. The main contribution of this paper is to demonstrate quantitatively the effect of the application by two different field studies conducted sequentially.

This paper is organized as follows. In Section 2, related work is summarized. In Section 3, the proposed concept is presented. In Sections 4, the evaluation process based on the results of the field experiment using a prototype is presented. Finally, Section 5 concludes the discussion.

II. RELATED WORK

There are three related areas to our research; the cognitive processes that are involved when using a network service, usability and communication behavior modification.

Subjective quality assessment is one of the approaches utilized to analyze cognitive process when using a network service. It has been studied for a long time in the area of international standardization activities. For an interactive service such as web browsing and downloading, ITU-T Recommendation G.1030 [6] defines the procedure for subjective quality assessment of website access on PCs. Some research has also been conducted on QoE for web access services on personal computers [7] and downloading services [8]. There has also been some research on the cognitive processes related to waiting. Some studies have aimed at reducing the dissatisfaction associated with waiting by reporting the situation [9][10]. Antonides et al. [11] and Munichio and Rafaeli [12] analyzed the effect of various time-fillers in telephone queues (fillers include music, apologies, and information about location in the queues) based on the results of field experiments. These studies succeeded in explaining the change in users' impression but not the change in user's behavior.

Many studies have evaluated the usability of a mobile computing environment [13]. With regard to usability during multitasking, Nagata [14] has estimated the effect of interruption on web task performance, and Parlangeli et al. [15] evaluated the effects of a teaching system for distance learning in a multitasking context. These studies revealed the negative effect of multitasking on task performance. On the other hand, Uemura et al. [16] reported the positive effect of multitasking in reducing the dissatisfaction associated with waiting time. These studies did not address the question of network usability.

There are few studies on communication behavior modification. Motoyoshi et al. [17] and Murase et al. [18] proposed a navigation system for behavior modification. They introduced a method called Comfort Route Navigation (CRN) which provides users with the optimal route for maximizing throughput in a heterogeneous network. This method can modify users' behavior by anticipated throughput but does not take past experience into consideration. Another approach is utilizing pricing mechanisms to avoid network congestion [19]. This can be effective for modification of communication behavior in usage based pricing. However, with the popularization of flat rate pricing, we need different concept.

III. PROPOSED CONCEPT

We propose a concept that allows users to choose an appropriate network by helping them to understand network usage history. Recent mobile terminals support various wireless interfaces such as 3G, LTE, Wi-Fi and WiMAX. While people can use the terminal unconstrained by time and place, network performance depends on the time and place of use. For example, users can utilize a better quality network at home if they install Wi-Fi. In this case, users can improve average throughput by preferentially using Wi-Fi at home, meaning it is better if they download or upload large files at home. However, many users are not conscious of the correlation between throughput and time and/or place. Accordingly, they try to use a network whenever they want to and become frustrated if the network condition is poor.

The authors have designed an application in which a city map expands based on network usage history data. It is not like gaming but more like entertainment. This will belong to concept of "gamification" [20]. Users can easily understand their usage history as the city map expands. Users cannot operate directly any items in this application. However, users can influence the application by changing their behavior in daily life. They can maintain the motivation to check network usage history while enjoying the entertainment application. In this paper, we will discuss a relation between users' involvement level to this application and feedback level from this application. The design of the application is described in specific detail in the next section.

IV. IMPLEMENTAION AND FIELD TRIAL

A. 1st Implementation

Figure 2 shows screen shots of the application used in the first implementation. This is an entertainment application in which parts of city maps are added based on the cumulative amount of use of a network. In the initial state, the sea areas are displayed on all screens as shown in Fig. 2(a). The areas comprising the city will be arranged on a screen if the cumulative amount of use of a Wi-Fi network increases as shown in Fig. 2(b). There are about a hundred types of city parts and the algorithm of this application chooses city parts and adds them on the map. The more user uses Wi-Fi over the smart phone, the more city parts arrange on the map. The city parts are selected based on the types of applications which user has used over the smart phone. Then the ambience of the city differs depending on users' behavior. It is expected that a user will feel motivated to connect with Wi-Fi spontaneously by promoting the growth of the city. Users enjoy the growth of the city and view it as entertainment and consequently improve the network performance they experience.

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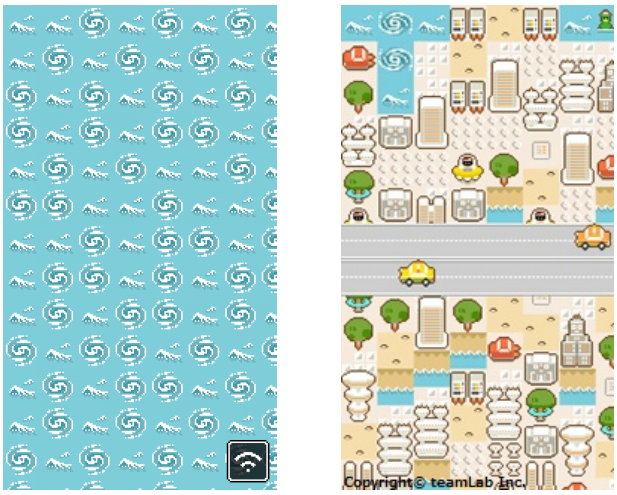

(a) Initial state (b) Steady state

Figure 2. Screen shot of 1st implementation application

We conducted a field study using this application. There were 31 participants (19 males, 12 females) in this experiment. The participants were all Japanese nationals and registered with an online survey company. They were aged from 20 to 34 years and used a smart phone in daily life. They were asked to use the application for one week and answer the questionnaire below after that.

- Q1: Do you think the application helped you to understand the Wi-Fi usage history? (a five-point scale: very much = 5 to not at all= 1)
- Q2: Did you increase the frequency of connecting to a Wi-Fi network at home? (a three-point scale: increase = 3, same as before = 2, decrease = 1)
- Q3: Did you increase the frequency of connecting to a Wi-Fi network outside the home? (same as Q2)
- Q4: Do you want to continue to use the application? (a five-point scale: very much = 5 to not at all= 1)

Table I shows the percentage responses to each question. 19.4% of participants had a positive response to Q1. 71.0% of participants increase the frequency of connecting to a Wi-Fi network outside the home.

TABLE I. RESPONSES TO 1ST TRIAL (%)

Question No.	Answer				
	5	*4*	*3*	*2*	*1*
Q1 (understand NW usage history)	6.5%	12.9%	38.7%	29.0%	12.9%
Q2 (increase Wi-Fi usage at home)	-	-	9.7%	90.3%	0.0%
Q3 (increase Wi-Fi usage outside)	-	-	71.0%	29.0%	0.0%
Q4 (continuation intention)	0.0%	22.6%	12.9%	38.7%	25.8%

Table II shows the correlation of each answer. Q1 showed a weak correlation with Q3 and Q4. This indicates an increasing number of participants thought the application helped them to understand Wi-Fi usage history the more they increased their use of Wi-Fi and these participants also felt positive about continuing to use the application. However, only 22.6% of participants felt positive about continuing to use the application.

TABLE II. CORRELATION BETWEEN ANSWERS IN 1ST TRIAL

Question No.	Question No.			
	Q1	*Q2*	*Q3*	*Q4*
Q1 (understand NW usage history)	1	.09	.36*	.36*
Q2 (increase Wi-Fi usage at home)	-	1	.21	.20
Q3 (increase Wi-Fi usage outside)	-	-	1	.26
Q4 (continuation intention)	-	-	-	1

* 5% level significance

From these results, it has confirmed that communication behavior was modified by visualizing network usage history. However, the impact of the application did not reach the anticipated level. We redesigned the application based on the comments participants freely made about the questionnaire.

B. 2nd Implementation

Figure 3 shows a screen shot of the revised application used in the 2nd implementation. We added two new features. The first feature comprises two indicators which show cumulative traffic volume passing through a wireless network. These are the tree type indicator located in the center of the city map and the bar type indicator located on top of screen. Participants can check how much traffic is being transmitted over a Wi-Fi network more easily than with the 1st implementation. The second feature is cooperation with SNS (Social Network Service). It enhanced the entertainment property by arranging followees' statements on the city map and expect to increase the frequency to check the application.

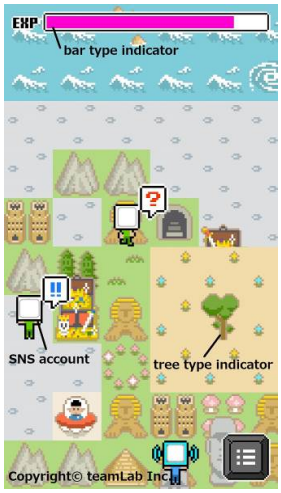

Figure 3. Screen shot of 2nd implementation application

There were 32 participants (18 males, 14 females) in the 2nd experiment. The participants were all inhabitants of Japan and registered with an online survey company. They were aged from 20 to 33 and used a smart phone in daily life.

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They were asked to use this application for one week and answer the questionnaire after that. In the 2nd field trial, we added the question below.

- Q5: Did you enjoy using the application? (a five-point scale: very much = 5 to not at all = 1)

Table III shows the percentage response to this question. 31.2% of participants had a positive response to Q1. 21.9% of participants increased their frequency of connecting to a Wi-Fi network at home or outside. 28% of participants increased their Wi-Fi usage at home and/or outside.

TABLE III. RESPONSES TO 2ND TRIAL (%)

Question No.	Answer				
	5	*4*	*3*	*2*	*1*
Q1 (understand NW usage history)	3.1%	28.1%	15.6%	21.9%	31.3%
Q2 (increase Wi-Fi usage at home)	-	-	21.9%	75.0%	3.1%
Q3 (increase Wi-Fi usage outside)	-	-	21.9%	78.1%	0.0%
Q4 (continuation intention)	6.3%	25.0%	15.6%	21.9%	31.3%
Q5 (enjoy using application)	15.6%	31.3%	12.5%	15.6%	25.0%

Table IV shows the correlation of each answer. Q1 showed a medium correlation with Q4 and Q5. There were more positive responses to the 2nd implementation compared to the 1st implementation. From these results, it can be seen that the new features improved the performance of the application.

TABLE IV. CORRELATION BETWEEN ANSWERS IN 2ND TRIAL

Question No.	Question No.				
	Q1	*Q2*	*Q3*	*Q4*	*Q5*
Q1 (understand NW usage history)	1	.05	-.03	.62**	.55**
Q2 (increase Wi-Fi usage at home)	-	1	.60**	.45*	.20
Q3 (increase Wi-Fi usage outside)	-	-	1	.13	.01
Q4 (continuation intention)	-	-	-	1	.74**
Q5 (enjoy using application)	-	-	-	-	1

** 1% level significance

This indicates that an increasing number of participants thought the application helped them to understand usage history of Wi-Fi the more they felt positive about the application and continued to use it. However, the correlations between Q3 and other questions, which were apparent in the 1st field test, disappeared.

V. CONCLUSION AND FUTURE WORK

We proposed a concept that allows users to choose an appropriate time and place for using a wireless network based on their past experience. We evaluated this concept by developing an application which visualizes the network usage history. The results from two field studies show that our concept has the potential to modify communication behavior. However, the impact of the application did not reach our expected level. We will redesign the application interaction again and confirm if users offload traffic to Wi-Fi by using this application.

RESSFERENCES

[1] M. Ito, D. Okabe, and M. Matsuda (Eds.) "Personal, Portable, Pedestrian: Mobile Phones in Japanese Life," MIT Press, 2005.

[2] ITU-T Appendix I to P.10/G.100, "Definition of QoE," 2007.

[3] S. Niida, S. Uemura, and H. Nakamura, "Mobile services - User tolerance for waiting time-," IEEE Vehicular Technology Magazine, vol. 5, no. 3, pp. 61-67, Sept. 2010.

[4] S. K. Card, T. P. Moran, and A. Newell, The Psychology of Human-Computer Interaction, Erlhaum, Hillsdale, 1983.

[5] D. A. Norman, "Cognitive Engineering," In D. Norman and S. Draper (Eds.) User Centered System Design: New Perspective on Human Computer Interaction, Hillsdale, NJ: Lawrence Erlbaum Associates Inc., pp. 31-62, 1986

[6] ITU-T Recommendation G.1030, "Estimating end-to-end performance in IP networks for data applications," 2005.

[7] E. Ibarrola, F. Liberal, I. Taboada, and R. Ortega, "Web QoE evaluation in multi-agent networks: Validation of ITU-T G.1030," Proc. ICAS'09, pp. 289-294, Apr. 2009.

[8] K. Nomura, K. Yamori, E. Takahashi, T. Miyoshi, and Y. Tanaka, "Waiting time versus utility to download images," Proc. APSITT 2001, pp. 128-132, Nov. 2001.

[9] C. Harrison, Z. Yeo, and S.E. Hudson, "Faster Progress Bars: Manipulating Perceived Duration with Visual Augmentations," Proc. CHI 2010, pp. 1545-1548, Apr. 2010.

[10] S. Niida, S. Uemura, and E. T. Harada, "Design Requirements for Improving QoE of Web Service Using Time-Fillers," IEICE Trans. Commun., E96-B, pp. 2069-2075, Aug. 2013.

[11] G. Antonides, P.C. Verhoef, and M. van Aalst, "Consumer perception and evaluation of waiting time: A field experiment," Journal of Consumer Psychology, no. 12, pp. 193-202, 2002.

[12] N. Munichor and A. Rafaeli. "Numbers or apologies? Customer reactions to telephone waiting time fillers," Journal of Applied Psychology, no. 92, pp. 511-518, Mar. 2007.

[13] C. K. Constantinos and D. J. Kim, "A Meta-Analytical Review of Empirical Mobile Usability Studies," Journal of Usability Studies Vol. 6, no. 3, pp. 117-171, May 2011.

[14] S. F. Nagata, "Multitasking and interruptions during mobile web tasks," Proc. the Human Factors and Ergonomics Society Annual Meeting, pp. 1341-1345 , 2003.

[15] O. Parlangeli, G. Mengoni, and S. Guidi, "The effect of system usability and multitasking activities in distance learning," Proc. CHItaly, Sep. 2011.

[16] S. Uemura, S. Niida, and H. Nakamura, "Service control system based on behavioral characteristics of user multitasking," Proc. CENTRIC 2011, pp. 22-27, Oct. 2011.

[17] G. Motoyoshi, Y. Sudo, T. Murase, and T. Masuzawa, "Advantages of Optimal Longcut Route for Wireless Mobile Users," Proc. IEEE ICC 2011, pp. 1-6, Jun. 2011.

[18] T. Murase, G. Motoyoshi, K. Sonoda, and J. Katto, "Quality of service of mobile users for longcut routes with congested access points," Proc. ACM ICUIMC '13, no. 40, Jan. 2013.

[19] J. K. MacKie-Mason and H. R. Varian, "Pricing Congestible Network Resources," IEEE J. SAC, pp. 1141-1149, Sept. 1995.

[20] S. Deterding, D. Dixon, R. Khaled, and L. Nacke, "From game design elements to gamefulness: defining gamification," Proc. MindTrek '11, pp. 9-15, Sept. 2011.

 ISBN: 978-1-61208-369-8