SERVICE COMPUTATION 2016

The Eighth International Conferences on Advanced Service Computing

ISBN: 978-1-61208-459-6

March 20 - 24, 2016

Rome, Italy

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SERVICE COMPUTATION 2016

Forward

The Eighth International Conferences on Advanced Service Computing (SERVICE COMPUTATION 2016), held between March 20-24, 2016 in Rome, Italy, continued a series of events targeting computation on different facets.

The ubiquity and pervasiveness of services, as well as their capability to be context-aware with (self-) adaptive capacities posse challenging tasks for services orchestration, integration, and integration. Some services might require energy optimization, some might require special QoS guarantee in a Web-environment, while others a certain level of trust. The advent of Web Services raised the issues of self-announcement, dynamic service composition, and third party recommenders. Society and business services rely more and more on a combination of ubiquitous and pervasive services under certain constraints and with particular environmental limitations that require dynamic computation of feasibility, deployment and exploitation.

The conference had the following tracks:

- Web services
- Empirical methods in system and service management
- Service innovation, evaluation and delivery

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 SERVICE COMPUTATION 2016 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 SERVICE COMPUTATION 2016. 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 SERVICE COMPUTATION 2016 organizing committee for their help in handling the logistics and for their work that made this professional meeting a success.

We hope SERVICE COMPUTATION 2016 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 computation. We also hope that Rome provided a pleasant environment during the conference and everyone saved some time for exploring this beautiful city.

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The Methodology of Text Messaging Quality Assessment

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***Abstract*— Telecommunication services are expected to be of good quality and offered for reasonable price. Operators, competing strongly for the customers, always present their products in the best light, and underline the highest service quality, which is often measured in incomparable circumstances, using different procedures and measurement methods. The paper presents the efforts of European standards institutions, regulators and operators in scope of improving telecommunication services provisioning and quality ensuring. Authors present the main parameters influencing the quality of Short Message Service which represents a wide range of text messaging services. The authors present methodology and the environment for measuring end-to-end delivery time. The measurement scenarios performed in both, the real network and in a laboratory environment are presented. The results of measurements, performed in real networks of four operators in Poland, show that the message delivery time fluctuates during the course of the day and also depends on the operator, but generally the short text service is of good quality and is highly assessed by the users. Authors present also the quality of experience model for text messaging.**

Keywords- text messaging; SMS; QoS; QoE; quality assessment.

I. INTRODUCTION

In just a few decades, mobile telephony has reached a deeper level of penetration worldwide than cars, radio or TV. From over 700 million registered users in 2000, mobile cellular industry has grown widely and exceeded 7 billion subscriptions in 2015. With the increased number of mobile subscribers over the world, Short Message Service (SMS), has also gained a huge popularity [1], i.e., around 8 trillion messages a year [2][3]. Moreover, after voice, messaging is the biggest revenue-generating mobile service on the telecommunication market [4]. Although, in some countries SMS has peaked, and the traffic volumes are in decline, there are more countries where overall SMS traffic and its use-per-subscriber is still growing. A significant growth in mobile subscribers is observed in the Middle East, Asia, Africa and Latin America, thus the dominance of SMS in the immediate future is unthreatened. According to [4] SMS will be one of the major communications tools worldwide for the next decade, despite progressive extension of user equipment utility. The increase in the processing power of mobile devices has made them significantly more multi-functional and allows Internet browsing, emailing, multimedia and instant messaging. Despite the rapid growth of so called Over-The-Top (OTT) messaging apps and Voice over IP (VoIP) services, SMS is still generating more than half of the total mobile messaging revenue (see Figure 1) [5].

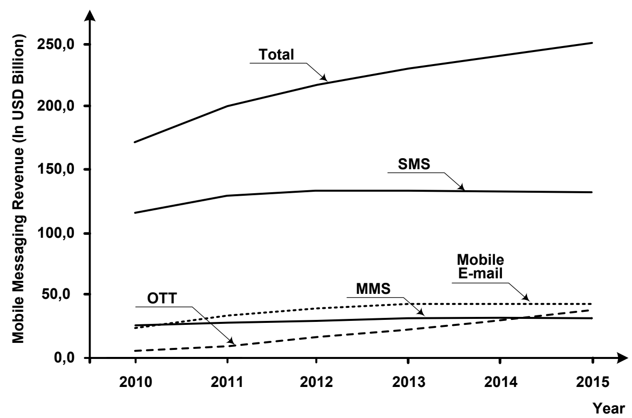

Figure 1. Mobile messaging revenue in recent years

Such large revenues mean that SMS will remain an important service for mobile operators for years. While Instant Messaging (IM) and SMS are both text messaging, there are differences that encourage different user behaviors. IM is rather two-way communication with many quick responses in contrast to SMS, where individual paid-for messages are used just to send information. While there are low to zero costs for the user when using IM, travelers stick to using SMS as it is cheaper than purchasing a mobile data package or subscribing for a data roaming plan in order to send a few messages. SMS is common to all phones and almost all users [5] while IM usually requires smartphones with dedicated apps and specific knowledge how to use it, which can be a barrier for some (older) part of society. Moreover, the market for IM is fragmented by different services which cannot communicate with each other. Besides, users also choose IM apps based on their geographical location. While WeChat is clearly the leader in China and Line for Japan, WhatsApp is also far bigger in East and South-East Asia than the USA. One of the major factors that allows service providers to keep their customers is the price, which is diminishing year by year, while the next ones are common availability, simplicity. and good quality. Service quality is becoming an increasingly more important factor to users at the moment when choosing the network operator or service provider [1][6][7].

 ISBN: 978-1-61208-459-6

Thus, many operators' efforts are concentrated on the efficient mechanisms for handling the message traffic [8]. On the other hand, a service oriented management is focused on service quality rather than network performance [9]. An effective evaluation of service quality can help service provider to increase customer satisfaction. Quality of Experience (QoE) based research mechanism for control and management of resources is getting more attentions in literature [10][11][12]. The SMS quality evaluation is also important in case of professional deployment of the service [13]. It is especially of great importance to many local governments (eg., in Poland) implementing SMS to notify inhabitants and all the guests in the area of the emergency states [14]. On the other hand, growing competition among service providers and network operators forces these entities to provide high quality services. The question of how to describe this quality and what parameters should be used, is asked not only by operators but also by regulators of the telecommunications market in the European Union [15]. One of the factors motivating telecommunications industry operators to act in this direction are regulations undertaken both at the European level [16][17], as well as in individual Member States [18][19]. A particular example of this can be seen in case of Poland, where on the Electronic Communications Office's initiative (2012), a Memorandum on Cooperation for Improving the Quality of Services in the Telecommunications Market has been signed. The first stage of works was finalized in the form of an official report [20], which was published by the Electronic Communications Office in February 2014. Despite long discussions, the current edition of this report does not define any QoS requirements for SMS, but there is a hope for a gradual expansion of the scope of this document. Although, SMS is not a real-time service, it is often perceived as such (a near-real-time) service [21] by a huge amount of users. Therefore, two factors seem to be important from the QoS point of view, these are: delivery rate and time of delivery. Nowadays, the delivery rate is mostly at a high level, reaching, in case of many operators, values around 95% [14]. However, these factors are correlated with each other, because the delivery rate also depends, among other things, on the delivery threshold time after which the message is considered as lost. Therefore, delivery time seems to be a key performance indicator (KPI), which is much more crucial for the service quality perceived by the users. They want the information to be delivered in acceptable time. But what does it mean? In the era of information and communication technologies with more and more bandwidth and rich service offerings, user demands concerning the service are also growing. Today SMS is more often treated as an almost instantaneous communication medium for rapid exchange of information, and even a form of text dialogue between people [21]. It seems that a relatively short time of message delivery is one of the main factors describing SMS quality affecting its popularity among users.

In Section II, Authors present the basics of SMS functionality and the main parameters and statistics describing quality of the service, according to the ETSI standards [22]. Section III presents the methodology and tools used during measurements in the real network. The message delivery time distributions are also presented and discussed. In Section IV, the Authors propose, on the basis of measurements results, the Quality of Experience model for SMS. Section V presents conclusions and the plans for the future work.

II. SHORT MESSAGE SERVICE QUALITY

SMS, belonging to the so-called "non-real-time" class, is a "store-and-forward" type of service [23]. Communication between two users is done via at least one server, acting as an intermediary unit. A user's equipment transmits a message to the server which optionally sends it to the next server and so forth. The end server, after receiving the message, informs a recipient's equipment of receiving a message and, finally, the user can read the message. SMS was originally designed for transmission of text information, where the length of single data unit cannot exceed 140 bytes and, according to ETSI standards [24], remains constant regardless of the number of characters transmitted in a single message. Depending on the alphabet used, the maximum message length may vary between 70 and 160 characters. When the information is longer, then it is divided and encapsulated into several 140-byte data units, and sent as separate messages. The quality study presented in this paper takes into account only the information that does not exceed the size of a single data unit. ETSI standards give a very detailed information regarding SMS quality parameters and their computation. The most important parameters are:

- SMS Successful Ratio - the ratio of correctly sent messages, expressed by the probability of correct message sending and its delivery to a service center,
- Completion Rate for SMS - indicator of properly delivered messages, expressed by the percentage of messages successfully sent and delivered to a recipient,
- End-to-End Delivery Time for SMS - time to deliver a message from end to end, expressed as the time measured from the moment of sending a message by a sender to a service center until it is received by a recipient.

Monitoring of the parameters, mentioned above, is crucial for the operator who has to watch over the process of service delivery at every stage of its implementation. It gives the knowledge of network performance, which in turn impacts the quality of service [25]. Message loss and message integrity are valid concerns, however, they are handled by lower layer network mechanisms and protocol, which are outside the scope of this paper. From the user's point of view, it is very important that messages are delivered to the recipient as soon as possible and in an unchanged form. From this perspective, it can be seen that the parameter which probably has the strongest impact on the SMS quality, perceived by the user, is the End-to-End Delivery Time. According to the ETSI standard [22], the following statistics should be provided separately:

- the mean value in seconds for sending and receiving short messages,
- the time in seconds within which the fastest 95% of short messages are sent and received,
- the number of observations performed.

It should be noted that, concerning the mobile environment, the values of QoS parameters mentioned above can be affected not only by congestion in the SMS system or signalling channels but also by network or service non-accessibility in the claimed area of coverage. In that case, operators may wish to distinguish the effects of coverage and access congestion, but from the user's point of view there is no need to do it, because all these phenomena impact on the end-user perception.

III. Measurements in the Real Network

This Section presents the methodology, measurement environment, results, and evaluation of SMS quality provided by leading mobile operators functioning in Poland, i.e., Orange, Play, Plus and T-Mobile.

A. *Methodology and the Measurement Environment*

Data were collected from more than 120 000 tests (individual observations) performed during one week in Wroclaw - one of the biggest Polish cities (650 000 inhabitants). The test environment (see Figure 2) consists of measuring robots (one for the operator), each covering a Personal Computer with a 3G modem and specially designed application, managing the measurement and data collection process. Each robot plays both roles: sender and receiver. Initially, the first one sends a previously prepared text message to the Short Message Service Center (SMSC) located in the operator network, inserting in the destination address field its own number (i.e., both: sender and receiver belong to the same network). The measurements of SMS delivery time for the messages exchanged between users of different networks are not in the scope of this article. The time of message sending is written down into a special record of a log file on the robot's hard disk. Then the SMSC sends the message further, i.e., to the receiver, which in this situation is the same robot that sent the message before. Next, the receiving part of the robot is informed of the incoming message and then it also records the current time in the log file. In this way, the file collects a number of records with the times of sending and receiving the particular messages. Each robot works independently of the others. However, the individual robot sends the messages sequentially, i.e., sending of the next message is possible only after receiving the previous one. The robot software allows the setting

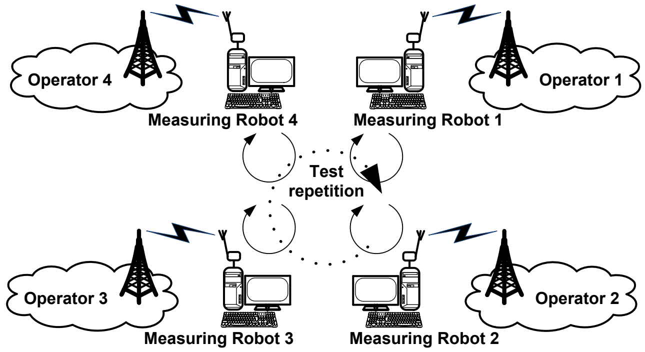

Figure 2. The test environment for the SMS parameter measurement in real mobile networks

of the time interval between the received and sent messages (see Figure 3) in order to control the frequency of message sending. It should be noted that such a solution causes the risk of substantially reducing the number of tests when the delivery time increases enormously. In order to eliminate such phenomenon, it is possible to limit the maximum acceptable delivery time and, if it is overrun, the expected message may be recognized as lost. Then the sending of the next message can start. In this phase of the measurements such a time limit was not used so that the robots were able to capture all delivery time cases.

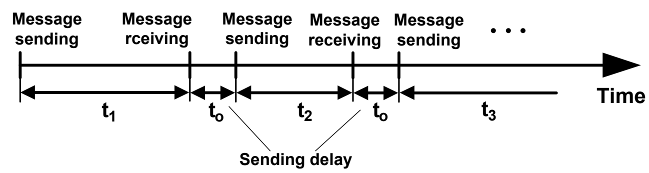

Figure 3. Sequential message sending scenario

B. *Message Delivery Time Distributions*

The measurements performed in real networks, mentioned before, allowed the message delivery time distributions in each network to be determined (Figures 4-7). After analysis of the distributions it can be stated that although very long delivery times occur in case of some operators (e.g., Play), which may be irritating to somebody who experiences that. From statistical point of view, however, they are not of considerable importance (it concerns about 10^{-4} cases). Moreover, it is negligible especially in the case of discarding 5% of the highest values before further analysis. The majority of the captured message delivery times do not exceed 10 seconds which means that SMS users should be satisfied. Moreover, almost 99% of the messages were delivered, in case of three operators, in time not higher than 6 seconds. Only in the Play network message delivery time distribution was different. The question is: are the captured message delivery times satisfying in case of real time text messaging applications? More detailed analysis will be shown in the Section IV, where the scores of subjective measurements will be taken into account.

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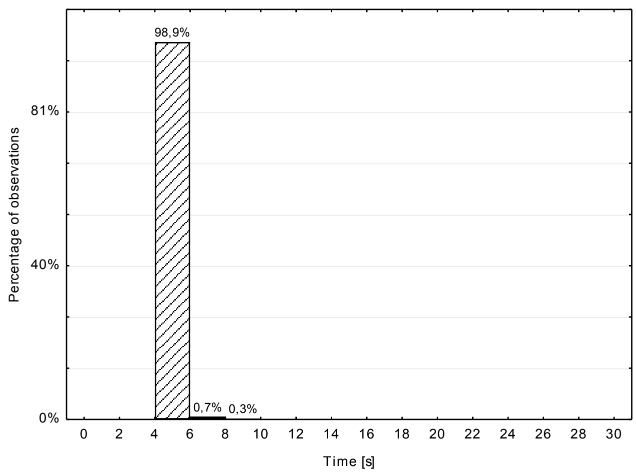

Figure 4. Messae delivery time distribution in the Orange network

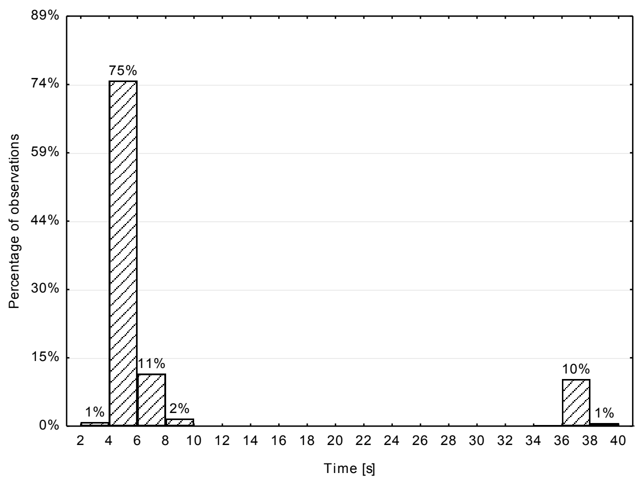

Figure 5. Message delivery time distribution in the Play network

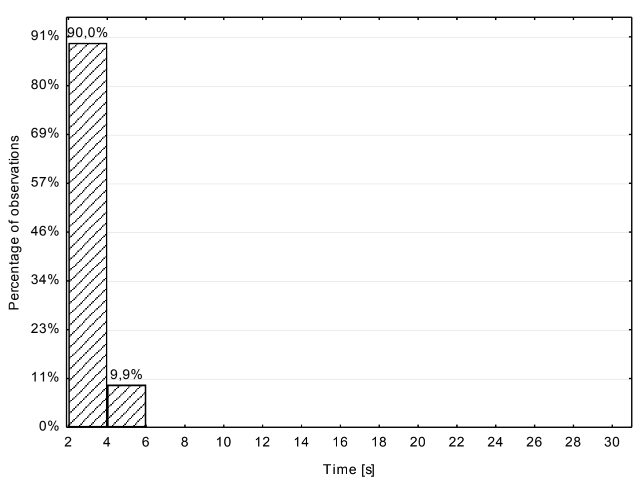

Figure 6. Message delivery time distribution in the Plus network

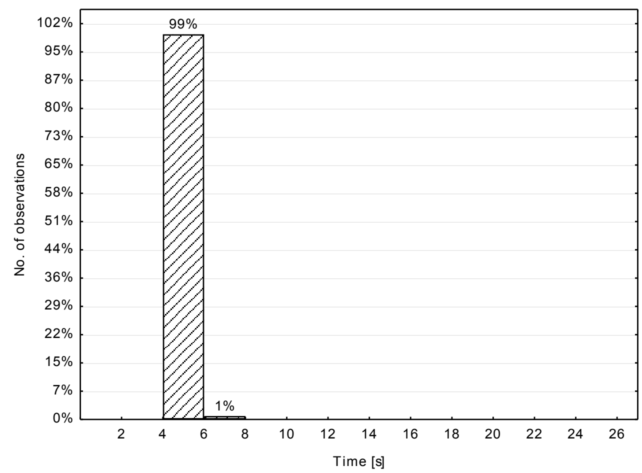

Figure 7. Message delivery time distribution in the T-Mobile network

C. Message Delivery Time as a Function of the Time of Day

Analysis of the results showed that message delivery time, as expected, is not stable and is diversified depending on the operator (see Table I).

It can be noted that the lowest mean value of the message delivery time (3.6 s) occurred in case of operator No. 3.

TABLE I. COMPRARISON OF MESSAGE DELIVERY TIMES

Operator (number)	Delivery time [s]				
	Mean	**Min.**	**Max.**	**Std. dev.**	**Median**
Orange (1)	4.66	2.8	26.1	0.47	4.6
Play (2)	15.79	3.1	**10815**	**256.4**	4.5
Plus (3)	**3.6**	3.3	65.7	0.68	3.5
T-Mobile (4)	4.96	3.1	23.7	0.39	4.9

A slightly worse score can be seen in networks 1 and 4. The longest delivery times, and standard deviation as well, was offered by operator No. 2. Such rough analysis can lead us to the conclusion that the SMS does not work properly and many of users may be dissatisfied with the service. On the other hand, when we take into account the median, which is by definition the value located in the middle of the population, it can be noted that it is comparable with the appropriate parameters of the other operators. Moreover, the median value seems to be a better parameter describing the service quality experienced by the users in the case of high standard deviation of QoS parameters. As mentioned before, ETSI proposes to describe the message delivery time by presenting the time within which the fastest 95% of short messages are sent and received [22]. According to the above, the distributions of message delivery times as a function of the time of day are presented in Figures 8-11. The black points represent median values, whereas the dashed boxes show the ranges of delivery time after discarding 5% of the lowest and highest values, respectively. In another words, they represent 90% percent of the captured samples population. Moreover, the top level of each dashed box

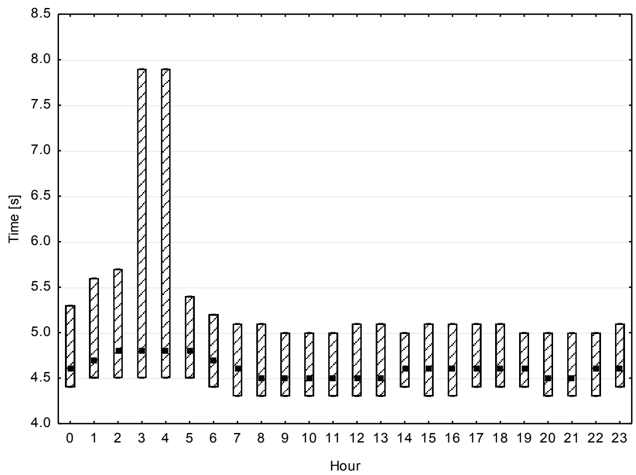

Figure 8. Short message delivery time in Orange network as a function of the time of day

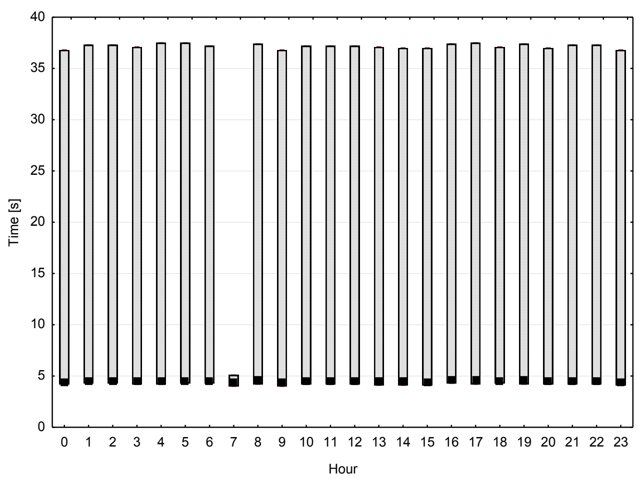

Figure 9. Short message delivery time in Play network as a function of the time of day

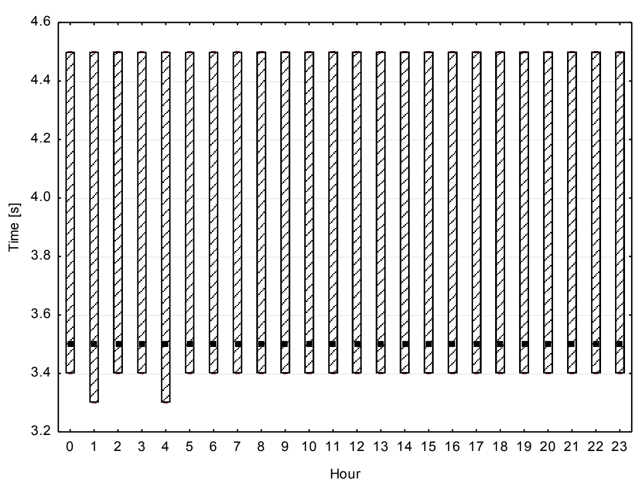

Figure 10. Short message delivery time in Plus network as a function of the time of day

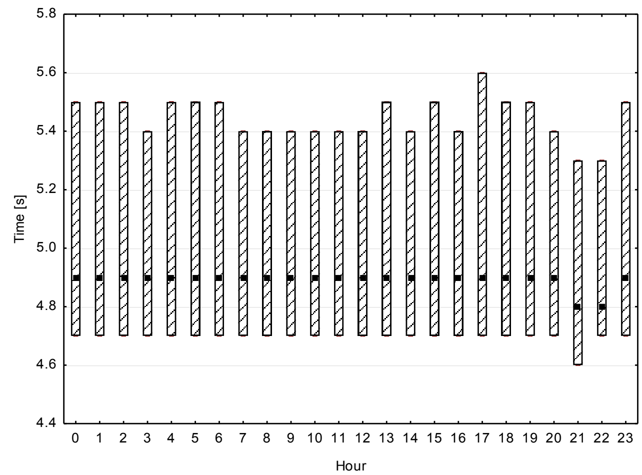

Figure 11. Short message delivery time in T-Mobile network as a function of the time of day

denotes the highest limit of delivery time for 95% of messages sent in the relevant hour [22]. As presented in Figure 4, fluctuations of the message delivery time experienced by almost all SMS users of the Orange network, do not exceed the value of 6 seconds. The highest deviation is observed around 3 and 5 o'clock in the morning. The results of the observations performed in Play network show the values of delivery time deviation which are almost at the same level, except one hour (7 a.m.), during the whole day. However, comparing to the Orange network, the range of deviations, observed in the individual time intervals, is much wider here. It means that users of the Play network still experience relatively high fluctuations of message delivery times previous network, but comparable with them and better than obtained in Play network. It should be noted that the median values and deviations of the message delivery times, presented in Figures 8-11, are valid for 90% of observations and may slightly differ from the values shown in Table I, which takes into account all the captured data. Although the median (or even the mean) values of the message delivery times and their deviations can be used to compare the different operator's network performances or QoS parameters, they do not answer the question concerning the quality assessed by the users. For this reason, the relation between objectively measured QoS parameters and the quality of experience (QoE), which is subjective, should be determined.

IV. QoE Model

This paragraph presents the methodology and test-bed (Figure 12) for assessing the quality experienced by users (QoE) of text messaging services. The concept of the measurement environment is based on the server emulating service provider and several test positions representing users of the service. Each position consists of a Personal Computer (PC) with a special application emulating the mobile phone that sends and receives short messages. In the experiment all test messages have the same
messages. In the experiment all test messages have the same

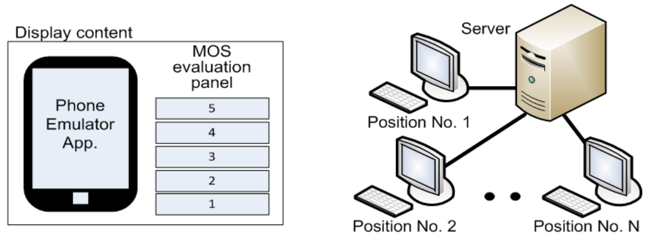

Figure 12. The laboratory test environment for the evaluation of text messaging Quality of Experience

format and content. Users send a number of messages which are passed through the server to the destination addresses after a period of time which may be controlled during the test. After receiving the message, users assess the service quality by evaluation of end-to-end delivery time and choosing the appropriate marks from the MOS evaluation panel, where MOS stands for Mean Opinion Score, expressed in a 5-level scale (0 – the worst case and 5 – the best one, respectively). All the test parameters and user marks are stored on the server and saved for further analysis. Several dozen users took part in the experiment and more than 1.2 thousand tests were performed. The results of the tests allowed building a QoE model (see Formula 1) which indicates a relationship between end-to-end message delivery time and service quality perceived by the users. Statistical analysis shows significant correlation (almost 80%) between message delivery times and the users' evaluation grades. Next, a regression analysis was performed and, using ordinary least squares (OLS) estimation, the approximate relation between message delivery time and users' grades (in MOS scale) was determined:

$$MOS = -0{,}1 \cdot T + 4{,}97 \quad (1)$$

where: *T* - message delivery time.

Due to the distribution of the data was not normal (checked by Shapiro-Wilk test [26]), authors made a validation of the model, using Mann–Whitney–Wilcoxon (MWW) test [27], which can be applied on even unknown distributions, contrary to t-test which has to be applied only on normal distributions [28]. This test showed a good estimation of the users' quality perception, under assumption of 95% confidence interval (significance level $p<0.05$).

As it was mentioned before, the mean value of the QoS parameter sometimes might not be the best indicator of the network performance or the quality perceived by users. Therefore, authors presented the SMS QoE model which shows the relation between the message delivery times and the median values of user ratings (Figure 13). Thus the authors proposed a new name for the scale, i.e., Median Opinion Score (MedOS). The black points represent the median value, whereas upper level of the dashed boxes determine the scores given by the 95% of users experiencing the specific message delivery times. Four levels of the quality, acceptable by users, were defined, i.e., excellent quality (EQ), good quality (GQ), fair quality (FQ) and poor quality (PQ), respectively.

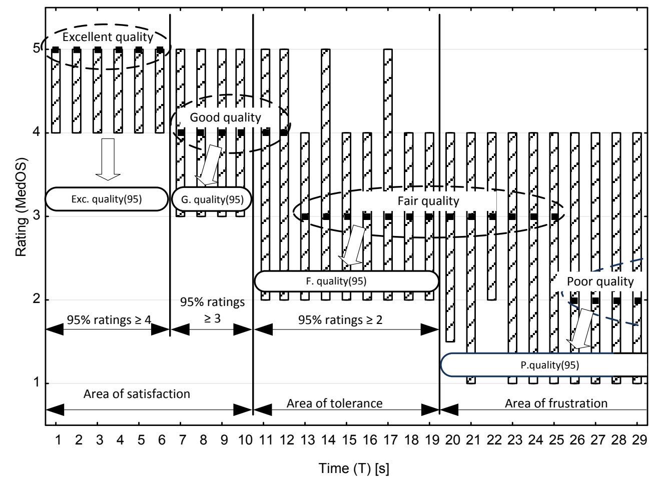

Figure 13. The quality experienced by the users majority (MedOS scale)

of the message delivery times are assigned to the proper quality levels (EQ, GQ, FQ or PQ) on the basis of median values of user scores, given for those times (see the dashed ellipses in Figure 13). According to ETSI [22], the quality levels should take into account the best 95% of samples. Excellent Quality level, denoted by EQ(95), is reached when the median of the user scores is equal to 5, and 95% of the samples have ratings equal or higher than 4.

TABLE II. SHORT MESSAGE DELIVERY TIME DISTRIBUTION FOR 95% CAPTURED SAMPLES

Operator	Percentage (P) [%]			WAQF
	EQ	GQ	FQ	
Orange	100	0	0	5
Play	80	13.7	6.3	4.74
Plus	100	0	0	5
T-Mobile	100	0	0	5

The same procedure is applied to the other quality levels, respectively. In this way, the relations between the message delivery times (QoS) and proper quality levels (QoE) were determined. Table II presents, according to the MedOS scale, the measurement results obtained from the four examined real networks.

$$WAQF = (P_{EQ} \cdot 5 + P_{GQ} \cdot 4 + P_{FQ} \cdot 3)/100 \quad (2)$$

Next, the Weighted Average Quality Factor (WAQF) can be calculated using (2). It can be used as a parameter that allows a comparison of the SMS quality provisioned by different operators.

V. CONCLUSION AND FUTURE WORK

Nowadays, the text messaging is one of the most popular means of communication. Therefore, the high quality of the service is crucial in today's competitive market. Operators should continuously monitor network performance parameters in order to detect and isolate the problems and different kinds of threats which can impact on the quality experienced by the end-users. Thus, it is very important to have not only the knowledge about the values of objectively measured performance parameters, but also about their influence on the service quality subjectively perceived by the users. The results presented in the article show that the SMS provisioned by the operators functioning on the examined area of the Polish telecommunication market is of very good quality and can be used, to some extent, as a medium which supports also other kinds of text communication, especially those that requires short end-to-end delivery times and immediate user-to-user interactions. Obviously, the message delivery time fluctuates during the course of the day and also depends on the operator, but generally brings great satisfaction for the users. It should be also noted that such, a relatively small, amount of collected data does not allow to make a general statement about the whole Polish network. Such generalization would be made after collecting data from a bigger and representative number of selected areas, which is to be done in the next step of the investigations. Authors want to underline that although SMS cannot be treated as a real-time messaging service, in some cases it can be used as an alternative. The main strengths of SMS are world-wide availability and no special requirements for the user equipment or specific software applications. Further work will be devoted to developing the QoE model towards more comprehensive investigation of the quality issues regarding not only intra- but inter-operator communication, as well.

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The Experience of Software Reengineering by Using Haptics through Tangible User Interface

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***Abstract*—The need for software reengineering is ever increasing. To satisfy the need, several metrics and tools are developed. We developed the toolkit which reorganizes the software programs using the haptics through tangible interface. The toolkit decomposes the Java source programs into small classes, and integrates them into the harmonized classes by using the haptic device. The metrics analyzed are mapped to the attributes of the virtual objects, and can be touched and perceived by the haptics through tangible interface and integrated into the harmonized object by coupling objects. This paper describes the way that software programs are reengineered by the toolkit. Software reengineering methodology using the toolkit is proposed. Sound coupling and cohesion coupling by using haptics through tangible interface are introduced, and some experiments performed are presented.**

Keywords-Software Reengineering; Toolkit; Metrics; Haptics; Tangible User Interface.

I. INTRODUCTION

Most of the programs are not newly written; they are reused, and the systems are maintained. The objective of reengineering is to produce a new maintainable system with least efforts [8]. Many tools are developed [5]. Metrics analysis and visualization help to reorganize programs [1][4]. The reorganized program must have adequate modularity; modules with high cohesion and low coupling must be maintained [2][3]. M. Lanza, etc. express the metrics of the program by 3D visualization and by the metaphor of cities [6][7].

We developed the software reengineering toolkit with tangible user interface by using the haptic device [9]. The program modules are visualized as 3D objects like spheres and cubes; each objects having its tangible attributes, mapped from the program metrics. The program module structure is reorganized by decoupling and coupling modules by using the tangible user interface. It supports two types of interfaces, the active interface and the passive interface. In this paper, we focus on the active interface. Especially, the sound coupling interface and cohesion coupling interface are presented. The toolkit was developed not only for software reengineering but also for learning programming.

In this paper we make the following contributions.

- We propose the metrics schema that integrates objects into the harmonized programs and observe its effectiveness.
- We present the tangible user interface that is easy to manipulate, easy to evaluate and easy to undo the coupling operations, adding the cohesion coupling to the toolkit [9].
- We present some experimental results and observe the effectiveness of the toolkit for software reengineering.

The rest of the paper is organized as follows. Section II presents the reengineering toolkit. Section III describes the experiments of the sound and cohesion couplings. Finally, Section IV concludes the paper with future works.

II. REENGINEERING SOFTWARE

Disharmonized programs, those are the programs that may have intensive coupling, shotgun surgery, dispersed coupling, god class, etc. [1], must be recognized and reorganized on the point of software maintenance.

A. Toolkit

This section summarizes the toolkit we developed. More detail of the toolkit is described in the reference [9].

The motivation of the toolkit developed can be summarized as follows.

- Flexible and simple tool for software reengineering is required, as the direct metrics manipulation is too complex
- The operation of several module couplings and decouplings must be performed easily , understood easily, and undone easily
- Everybody, including software non-professionals, can manipulate the module couplings and decouplings easily

Figure 1 shows the system structure of the toolkit. It consists of three parts: the program analysis part, the object perception part, and the code generation part. The program analysis part analyzes the Java source programs, and produces the metrics of the programs. Numbers of classes, lines, methods, fields, dependency of classes, etc. are analyzed. It can also decompose a class into smaller classes. A class can be decomposed into more small classes.

 ISBN: 978-1-61208-459-6

Decomposed classes are represented as the objects in the object perception part. The metrics of a class are mapped to the attributes of the corresponding object. The haptic device, shown in Figure 2, the physical device which provides the tangible user interface to the toolkit, is used to manipulate the object couplings. The toolkit provides several coupling methods [9]. The sound coupling, color coupling, undo coupling and cohesion coupling are provided. This paper introduces the cohesion coupling. The other coupling are described in the previous paper [9]. In the code generation part, the Java source code is automatically generated from the results of object integration manipulated either in the object perception part or in the analysis part.

Figure 1 also shows the way that the program is reengineered using the tangible user interface. There exists three cycles in the Figure 1. The first cycle is depicted by the arrows ① and ②. This cycle directly uses metrics to reorganize the modules. In this cycle, the metrics such as overviewPyramid, complexity, hotspots and blueprint [1] are visualized, and the program is reorganized. The second cycle is depicted by the arrows ③,⑤, ⑦ and ②. The third cycle is depicted by the arrows ④, ⑥ , ⑦ and ② .The analyzed metrics are passed to the object perception part, and those data are mapped to the attributes of the haptic objects.

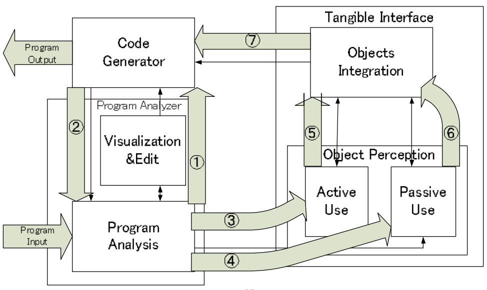

Figure 1. Toolkit Structure

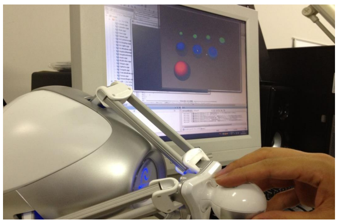
Figure 2. Haptic Device

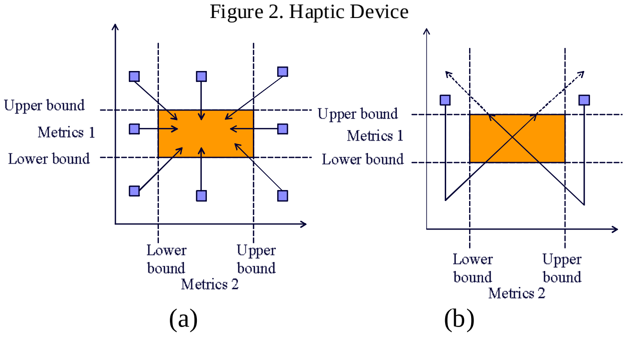

Figure 3. Object Integration Schema

B. Metrics Schema

The program must be reorganized to have the metrics to be the appropriate value. The value of the metrics can be normalized by decomposing and integrating the program modules step by step.

Figure 3 shows the metrics schema for software reengineering using the toolkit we developed. Two metrics, metrics 1 and metrics 2, and their appropriate domains, which is under the shadow area within the rectangular, are shown in Figure 3. Figure 3(a) shows the way that both metrics, metrics 1 and 2, are converging into the appropriate values. Figure 3(b) shows that the metrics 1, which is out of the appropriate domain and have higher value, is first decreased by decomposing a module. And, second, the decreased value is increasingly changed to the appropriate value by coupling modules. This is performed by adjusting the metrics 2 which must be also situated within the shadow area.

Assuming that, the number of methods in a class is assigned to the metrics 1, and the lines of code in a method is assigned to the metrics 2. In this case, the schema adopted for reorganizing the modules works as follows:

Operation1. Assign the metrics M1 to the modules of a program. Decompose the program. The toolkit we developed can analyze and decompose a class into smaller units of module, and create the corresponding objects. This operation always decreases the value of M1, and it is repeated until the M1ôs value becomes lower than the threshold of the lower bound predefined.

Operation 2. Integrate the objects. Use the metrics M2 to integrate the objects. The coupling operations provided are performed to lead the M1 and M2ôs value to converge into the shadowed rectangular area.

C. Coupling & Decoupling in Java

It is possible to decompose the program into smaller elements, to the subclasses or submodules in Java. One class can be decomposed into several subclasses, and integrated into one large class with the combination of different modules. Figure 4 shows the decomposition of the Java program. It shows that class 0 can be decomposed into two classes: class 1 and class 2, because of the reason that the method A and B only access the field a, and method c only accesses the field b and c. Figure 4 also shows the integration possibility of two classes, class 1 and class 2, into a class 0. The basic policy for program decomposition is the fact that the program can be decomposed into the smaller unit if there exists no dependency among units, namely if no units interaction occurs. Figure 5 shows an example of the program coupling and decoupling in Java. These are performed by using the toolkit we developed [9]. In Figure 5, Program AB is decomposed into program Aa and Bb, and Program CD is decomposed into program Cc and Dd. Then, class Aa and Cc are coupled into one program AC, and Bb and Dd are coupled into another program BD.

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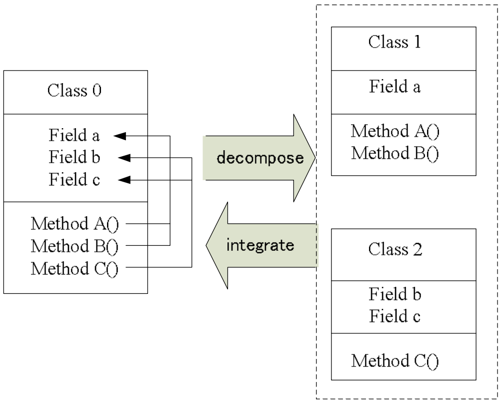
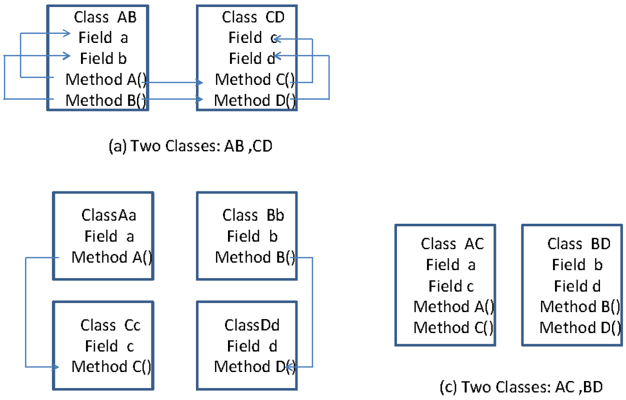


Figure 4. Class Decomposition & Integration



(a) Two Classes: AB ,CD

(b) Four Classes: Aa, Bb, Cc, Dd

(c) Two Classes: AC ,BD

Figure 5. Program Integration Example

III. EXPERIENCES

This section describes the coupling methods of the objects. The sound coupling and the cohesion coupling in the toolkit are introduced, and some experiments using these couplings are examined.

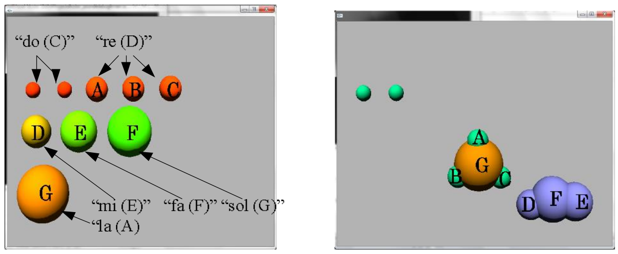
A. Metrics

The attributes of the object, visualized and touched by the haptic device, are gravity, magnetism, spring, color, transparency, etc. The metrics analyzed in program analysis part are mapped to those of the attributes of the object.

Table I shows the metrics mapped to the object in the experiment. Two metrics, metrics 1 and metrics 2, are used in this experiment. The metrics 1, M1, is the average number of lines per method in a class, and the metrics 2, M2, is the number of methods per class. The metrics M1 is mapped to the size of an object. In the sound coupling, M2 is mapped to the sound of the object. In the cohesion coupling, M2 is mapped to the distance among the objects. According to the metrics schema described, the metrics 2 is used to decompose the modules, and metrics 1 is used to integrate the modules.

TABLE I. METRICS MAPPING

Metrics	Sound Coupling	Cohesion Coupling
Number of classes	Number of objects	Number of objects
(M1) Average lines /method/class	Size of the object	Size of the object
(M2) Number of methods/class	Sound of the object	Distance among objects



(a) Sound Objects (b) Sound Coupling

Figure 6. Sound Coupling

B. Sound Coupling and Cohesion Coupling

In the sound coupling, the metrics 2 (M2) is mapped to the sound attribute of an object. Figure 6 shows an example of the sound objects, Objects A, B and C have the sound óreô, D has ómiô, E has ófaô, F has ósoô, and G has sound ólaô. Touching and moving the objects, object A, B, C and G are merged into one object, as is shown in Figure 6(b), and the sound of the object changes to ómiô, that is assigned as the average height of the objects merged.

Cohesion refers to the degree of tightness to which module components belong together [10][11]. Cohesion coupling visualizes the class tightness by the distance of classes. The class tightness is the dependency of the objects. The number of run time accesses among objects, which represents the class tightness, is measured and logged by using ASPECT-J. And, the distance among the objects is calculated by using the following formula (1) [10]:

$$dis(x,y) = 1 - |b(x) \cap b(y)| / |b(x) \cup b(y)| \qquad (1)$$

with $b(x) := \{P_i \in B \mid x \text{ possesses } P_i, P_i \text{ is a method}\}$
and {b(x) is the set of methods accessed by an object x.}

The similarity of the two objects x, y with respect to a property subset B is calculated from the similarity measure, that is represented by $|b(x) \cap b(y)|/|b(x) \cup b(y)|$. The distance calculated by formula (1) is visualized by the multidimensional scaling method (MDS), which uses the Young-Householder translation [12]. The detail of the MDS is shown in the Appendix. Using MDS, the object are situated into the similarity-based distance, where the tighter objects be located closer. Figure 7 shows an example. The Figure 7(a) shows that object 1 and 2 have the tighter relation, and so is the 3, 4 and 5, and 6 and 7. Figure 7(b) shows the cohesion coupling. Object 1 and 2 are coupled into one module, and the object 3, 4 and 5 are merged into

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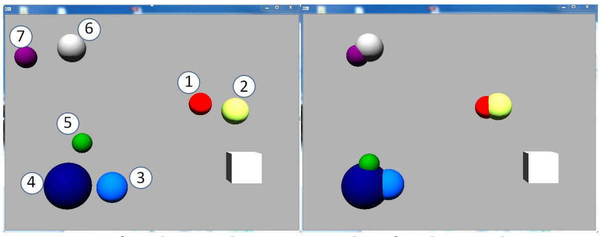
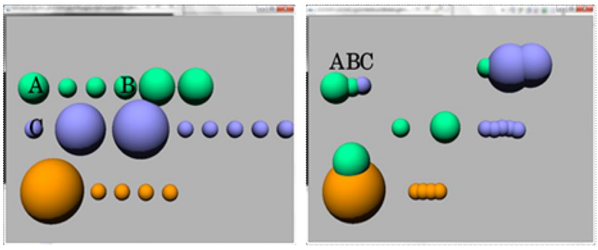
one module, because they have the close distance. Object 6 and 7 are also merged into one module with the same reason.

When the control of the toolkit is passed to the code generation part, the code of the merged objects is automatically integrated into the one class, and it is reformed into the one object. Figure 8 shows the example of several couplings performed sequentially. Figure 8(a) is the original structure of the program. Figure 8(b) shows the sound coupling, where the object A, B, and C are merged into one module, and the other modules are also merged. And, the structure of the program changed to be shown in Figure 8(c) when the program is reorganized. Nineteen modules are reorganized into the seven modules, as shown in Figure 8(b), and the structure of the program is changed to be shown in Figure 8(c). Then again, another coupling, color coupling, is performed, as is shown in Figure 8(d). These coupling can be performed repeatedly any time with any operations including decoupling operation [9].

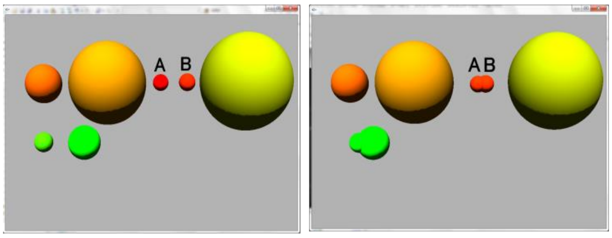


(a) Before the Coupling (b) After the Coupling

Figure 7. Cohesion Coupling

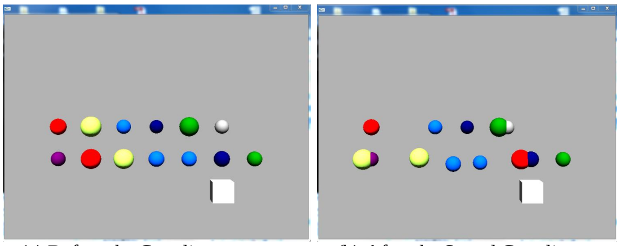


(a) Before the Coupling (b) After the Sound Coupling



(c) Reformed Objects (d) After the Color Coupling

Figure 8. Several Coupling Repeated



(a) Before the Coupling (b) After the Sound Coupling

Figure 9. Sound Coupling Visualized

TABLE II. RESULT OF THE SOUND COUPLINGS

(a) BEFORE THE COUPLING

Class name	Metrics M1	Lines	Metrics M2
Bullet	6	48	6
Enemy	7	109	13
Game	2	21	9
GameObject	2	9	1
KeyInput	6	91	13
Level	3	18	4
MyBullet	4	23	4
Mycanvas	7	101	11
Objectpool	12	149	10
Particle	4	41	7
Player	4	33	6
Score	8	43	3
Title	3	29	7
Average	5.2	55	7.2

(b) AFTER THE COUPLING

Class name	Metrics M1	Lines	Metrics M2
Bullet	8	48	6
EnemyMy	11	132	8.5
Game	2	21	9
GameObjKe	8	100	7
Level	3	18	4
MycanSco	15	144	7
Objectpool	12	149	10
Particle	4	41	7
Player	4	33	6
Title	3	29	7
Average	7	71.5	7.2

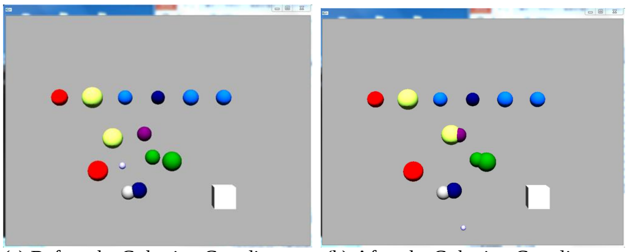
C. *Experimental Results*

The sound coupling and the cohesion coupling are examined, and the results are presented.

Figure 9 shows the before and the after of the structure of the modules of the reengineering program. Figure 9(a) shows the original program structure, and (b) shows the structure of after the sound couplings. The cube in Figure 9 shows the object that has the typical sound in which the coupled object to be met. In the experiment, we assumed the appropriate value for M1 is 10, and M2 is 7, taking the experimental values from the reference [1]. Table II shows the metrics of the before and the after of the sound coupling. The program that has 13 classes has changed to the 10 classes. The metrics M2, which is the number of methods per class, did not change. On the other hand, the metrics M1, which is the number of lines per method, changed from 5.2 to 7. This means the reengineering performed by sound coupling has been succeeded.

The second experiment, which is the cohesion coupling, was performed using the same program as the sound coupling. Figure 10 and Table III show the experimental results performed. Figure 10(a) shows the original program structure. The location of the objects is calculated using the cohesion distance formula (1) and the MDS. The detail of the MDS is shown in the Appendix. The metrics M1 has changed from 5.2 to 7.5, and metrics M2 has changed from 7.2 to 7.6. This means that the M1 is improved, and the structure is well organized.

 ISBN: 978-1-61208-459-6



(a) Before the Cohesion Coupling (b) After the Cohesion Coupling

Figure 10. Cohesion Coupling Visualized

TABLE III. RESULT OF THE COHESION COUPLINGS

Class name	Metrics M1	Lines	Metrics M2
Bullet	6	48	6
Enemy	7	109	13
Game	2	21	9
GameObject	2	9	1
KeyInputTi	9	120	10
LevelSco	11	61	3.5
MyBulletOb	18	172	7
Mycanvas	7	101	11
Objectpool	12	149	10
Particle	4	41	7
Player	4	33	6
Average	7.5	78.5	7.6

IV. CONCLUSION

This paper described the experiences of the software reengineering using the toolkit we developed. The sound coupling and the cohesion coupling for reorganizing the program were introduced. And, some experiments for software reengineering for using these coupling were presented. The results showed that the reengineering was performed well by the couplings using the haptics through tangible interface.

The toolkit was built on the concepts of easy to understand, easy to use, and being use not only for the professionals but also for every person who is unfamiliar with the software metrics. Therefore, the tool can be used not only for the software professionals but also for everybody, for the student who is learning the programming, and for the children who likes to operate the computer just for fun.

The toolkit we developed can be used by the following procedures.

- Metrics are selected according to the metric schema described in section II-B. At least, two metrics are selected.
- The typical values of the metrics for the application are settled.
- Program is analyzed by the toolkit, and the modules that have disharmonized and large metrics value are found. Then, these modules are decomposed into small modules.
- Looking at the two metrics, several modules are coupled together.

The above procedures are repeated until both of the metrics stabilize into the appropriate values.

We are testing more cases for software programs using the toolkit. Reengineering the software depends a lot on the program properties. We need more experiences for the validation of the toolkit to be useful. The other aspect of the toolkit, the programming toolkit for education, is our next concern.

ACKNOWLEDGMENT

This work is supported by JSPS KAKENHI Grant Number 15K12174.

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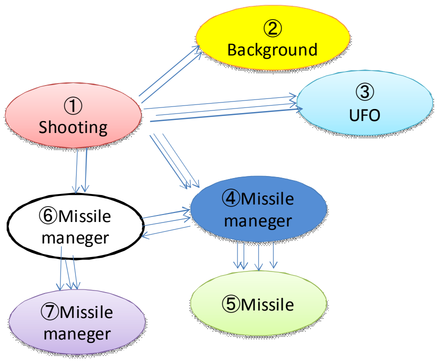
ISBN: 978-1-61208-459-6

APPENDIX



(a) Class Dependency

Similarity	1	2	3	4	5	6	7
1	0.00	0.90	0.80	0.79	1.00	0.91	1.00
2	0.90	0.00	1.00	1.00	1.00	1.00	1.00
3	0.80	1.00	0.00	1.00	1.00	1.00	1.00
4	0.79	1.00	1.00	0.00	0.63	0.79	1.00
5	1.00	1.00	1.00	0.63	0.00	1.00	1.00
6	0.91	1.00	1.00	0.79	1.00	0.00	0.57
7	1.00	1.00	1.00	1.00	1.00	0.57	0.00

(b) A Similarity Matrix among Classes

In.P.	1	2	3	4	5	6	7
1	0.329	-0.015	0.061	-0.003	-0.136	-0.094	-0.141
2	-0.015	0.459	-0.054	-0.125	-0.071	-0.116	-0.077
3	0.061	-0.054	0.433	-0.138	-0.084	-0.129	-0.089
4	-0.003	-0.125	-0.138	0.291	0.143	-0.009	-0.160
5	-0.136	-0.071	-0.084	0.143	0.399	-0.146	-0.106
6	-0.094	-0.116	-0.129	-0.009	-0.146	0.309	0.185
7	-0.141	-0.077	-0.089	-0.160	-0.106	0.185	0.389

(c) An Matrix of the Inner Product

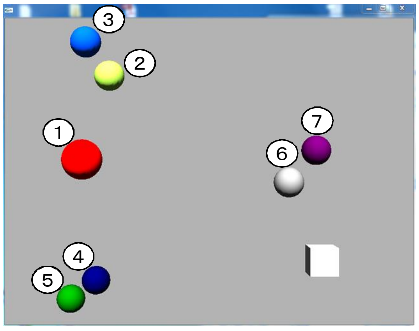
Eigenvector	x	y
1	-0.263	0.292
2	-0.157	0.34
3	-0.249	0.478
4	-0.208	-0.49
5	-0.306	-0.566
6	0.539	-0.092
7	0.645	0.037

(d) Eigenvector

The class dependency of the program, shown in Figure (a), is transformed to the similarity matrix, shown in Table (b).
The inner product, Table (c), is calculated from the similarity matrix by using the Young-Householder translation theorem [12].
The eigenvalue and eigenvector, Table (d), are calculated from the inner product. Two eigenvalues are selected. The eigenvalues selected are 0.756 and 0.690.
Table (e) shows the x and y coordinate of the objects calculated from the eigenvector. Finally, the distance of the similarity is visualized as the program structure, as is shown in Figure (f).

Coordinate	x	y
1	-0.23	0.243
2	-0.137	0.283
3	-0.217	0.397
4	-0.181	-0.407
5	-0.266	-0.47
6	0.47	-0.077
7	0.561	0.031

(e) Location of the objectS



(f) Program Structure Visualized by cohesion

Figure 11. Multidimensional Scaling Method (MDS) based on the Similarity Matrix

A Service Model using Bluetooth Low Energy Beacons

-To Provide Tourism Information of Traditional Cultural Sites -

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***Abstract*—A large amount of information is not always appealing to tourists. While the provision of information may lessen the anxiety experienced by tourists, the promise of the unexpected is one of the things that make travel attractive. We developed a new application using Bluetooth Low Energy (BLE) beacons that not only provides a guide to a specific location but also summarizes the traditional customs and history of the area. A trial at the Nikko world heritage site in Japan demonstrated the effectiveness of the BLE beacon for sightseeing on foot. The application made tourists notice new points on the route. Owners of shops en route to the main shrine cooperated by providing information regarding their goods and information on local traditions. Our system enhanced the tourist experience of a traditional cultural city, especially for foreign visitors and young Japanese.**

Keywords- Location-Based Service; BLE Beacon; Smartphone Application; World Heritage; Zeigarnik effect.

I. INTRODUCTION

We introduce our remarkable points for tourist information and technology.

A. Services using Information and Communication Technology

Information and communication technology (ICT) is widely used for travel and tourism and has now made considerable information available. Tourists get information about maps, shops, accommodations, museums, events etc. However, the plethora of information available on the Web is not always appealing to tourists. We have to consider what information is appealing to tourists, when they should receive it and who the target audience for this information should be. Before using big data by GPS signals for tourists, we should re-inspect and analyse the information contents.

In this study, we investigated the information needs of tourists in Nikko and tested the provision of information using a Bluetooth Low Energy (BLE) beacon system.

This study was selected as one of the research themes of SCOPE [1] and was funded by the Ministry of Internal Affairs and Communications of Japan [2].

B. Psychology of Tourists

Many previous studies have investigated environmental psychology and tourism. Pearce and Stringer [3] studied the issue from the viewpoint of physiology, cognition and individual variation. It has been shown that among the factors that drive people to travel to new places, the expectation of experiencing the extraordinary plays a leading role [4]. The term 'extraordinary' here means experiences clearly different from the usual lifestyle. Thus, busy workers may crave relaxation, while bored young people may crave excitement. Therefore, separately identifying specialized target audiences and providing them with the unique information that matches their expectations is necessary.

C. Cultual Differences

Tourism involves encounters with people and places. Each place has its own characteristic culture, and these differences between cultures make travel interesting and exciting. However, some tourists do not recognize the cultural significance of traditional sites.

For example, Japan has ancient temples, many of which are located far from train stations. While this may at first appear to make visits inconvenient, travelling the route to the temple has traditionally been a central feature of the visit. There are often a series of wells en route to the main temple, at which visitors to the shrine purify themselves by washing their hands and their hearts, as well as smaller temples surrounding the main one. Tourists who are unaware of this tradition may not sense the full experience. Information on this is, however, difficult to find on the Web, and if it exists, it is often buried among the numerous photographs and comments left by visitors unfamiliar with the location.

The rest of this paper is structured as follows. Section 2 discusses the previous literature. Section 3 sets out our proposal. In Section 4, we report the results of our trials and explain the role-played in Nikko. Finally, we discuss ways of providing information appropriate to traditional cultural sites and suggest future studies.

 ISBN: 978-1-61208-459-6

II. Related Works

A. Our Previous Work

Students go on school trips in Japan [5]. While such outdoor activities are valuable, students cannot fully grasp the artistic or cultural value and meaning of the objects or scenery by simply viewing them [6]. To address this problem, we developed a new learning model for outdoor study [7][8].

Human beings do not always recognize what they see. For example, in the game of photo hunt, we may not be able to tell the difference between two similar photographs. However, once a particular object is noticed, our attention is focused on it. We exploited this concept by developing a quiz to be used as a trigger to draw attention to a particular object in the scenery that the students were viewing. The quizzes encouraged positive responses. We argue that such methods will be beneficial for other tourist groups as well.

B. Related Works

Many sightseeing applications for smartphones already exist in Japan [9], which allow tourists to access information about restaurants, souvenir shops and local weather, as well as to download maps. Counting only local applications, 666 such applications were identified in a 2015 study. Although 96% of these were free, 91% were downloaded only 10,000 or fewer times [10]. The EU's TAG CLOUD project (Technologies lead to Adaptability and lifelong enGagement with culture throughout the CLOUD) used smartphone technology to provide information about traditional cultural sites [11] and to investigate ways of enabling cultural engagement using cloud-based technologies. While the TAG CLOUD uses a cloud-based service, our application was designed to work without requiring access to the cloud, since Internet connections may be limited in rural areas.

III. Service Proposal

We administered questionnaires to the visitors to Nikko [12], in order to know the focus points for our new system, on September 2014. A total of 606 questionnaires (534 in Japanese and 72 in English) were completed.

TABLE I. ROTATED MATRIX

	Component		
	1	2	3
Nature・landscape	.008	.810	.189
History・culture	.017	.853	.053
Street	.478	.680	.049
Traditional performing arts	.473	.676	.122
Food	.644	.269	.157
Activity	.716	.173	.226
Shopping	.835	.154	.093
Night spot	.760	-.005	.209
Personal exchange	.647	.053	.294
Easy booking	.151	.037	.868
Quality and price of hotels	.307	.039	.771
Transportation	.116	.147	.639
Prices	.279	.346	.477

Extraction Method: Principal Component Analysis
Rotation Method: Varimax with Kaiser Normalization.
a. Rotation converged in 5 iterations.

A key finding was that young people reported that they would like to have enjoyed Nikko more completely and that most of them were smartphone users. Cluster analysis was used to confirm this pattern. Respondents were asked to evaluate sightseeing activities in Nikko on a scale of one to five. As shown in Table I, the responses were clustered into three main groups:

- A group who valued its own active experiences
- A group who valued nature, history, or traditional factors
- A group who valued the quality of accommodation or the price of goods and services

Using Ward's method, the data were then classified into five clusters. As only three persons belonged to the 5th cluster, we classified the results into the following four clusters, as shown in Fig. 1.

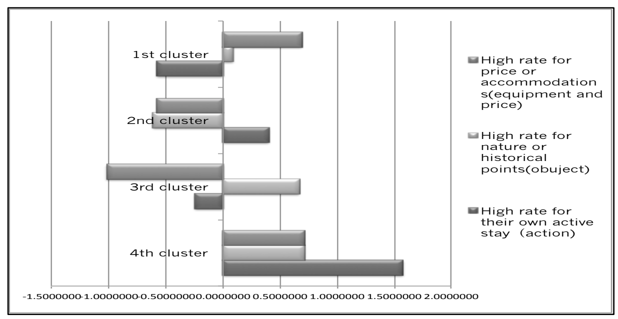

Figure 1 Evaluation of the preferences of the four clusters.

1 Tourists who do not wish to be active, or who are mainly concerned about prices and accommodation (n = 140)
2 Tourists who do not have any special interests, but who wish to stay active (n = 103)
3 Tourists interested in nature or history (n = 62)
4 Tourists who give a high rating to almost everything in Nikko or who particularly wish to stay active (n = 37)

Tourists in the 1st cluster would like to visit the famous hot springs in Nikko and are unlikely to be interested in extensive information about Nikko, since they visit Nikko primarily for rest. Tourists in the 4th cluster are active and have many interests, but are less numerous than those in the 1st cluster.

The age composition of the groups is shown in Fig. 2. Over 70% of those in the 4th cluster were under 30 years old

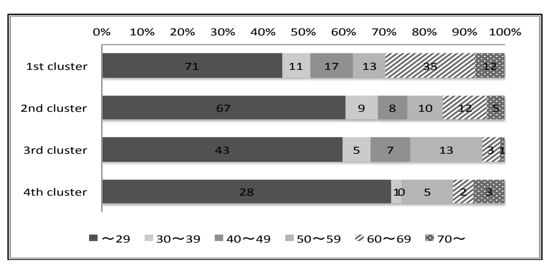

Figure 2 Ages of tourists in the four clusters (%).

Young tourists tend to plan active trips to Nikko. Their characteristic tendencies are as follows:

- They come to Nikko by train and navigate Nikko by bus or on foot
- They are smartphone users
- They know little about traditional culture
- They like to experience new things

Responses from foreign tourists showed the same profile.

IV. SERVICE PROPOSAL FOR YOUNG TOURISTS AND FOREIGNERS

We explain our system and report the results of our trials and explain the role-played in Nikko.

A. *Service Flow*

Tourists who know little about the area and the history currently exchange comments using SNS. We therefore addressed the use of beacons to allow residents of the tourism area to recover information from such tourists. We designed our service system as shown in Fig. 3.

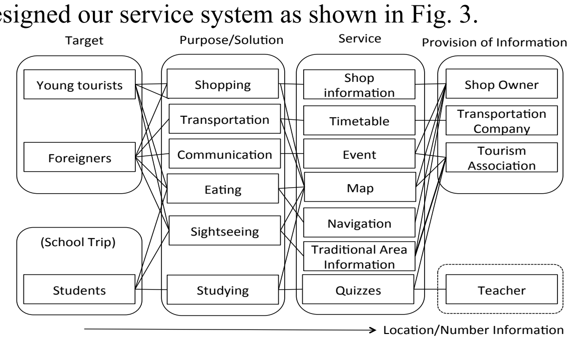

Figure 3 Service flow.

Shop owners gave us information about the goods they stock, seasonal festivals and other information. Tourists could access this near the beacon, which was located in front or at the entrance of the shop. Bus timetables were furnished by the local bus operator and information about local attractions was supplied by the tourist association. This information was displayed on a map in the smartphone application. In addition, we devised several quizzes using the Zeigarnik effect, aimed at young students on school trips. Shop owners could then access customer traffic diagrams, and teachers could monitor the location of their students.

B. *Comparison of Technologies that can be used for Sightseeing in Historic Areas*

Current smart phones incorporate a range of sensors. Table II lists the functions of these devices and their potential use in tourist information services. Several of the devices can be used to collect information and identify the location of smartphone users.

However, foreign tourists rarely use roaming data communication services because of their high cost, so we also designed a service that did not require the use of 3G/LTE. As both GPS and the camera quickly deplete the battery, we designed our service to work without them. The use of AR was a potentially interesting alternative navigation method; however, it proved impossible to run this in the background. The final design of our application was as shown in Fig. 4. We assumed the following design constraints:

TABLE II. FUNCTIONS AND DEVICES IN A SMART PHONE

Functions	Devices in a smart phone	Relation between tourist information
Comunication	3G/LTE	Download Info.
	WiFi	Download Info./Find Location (Indoor)
	BT	Find Location (Indoor)
Location	GPS	Find Location (Outside)
Near Field Communication	NFC	Get Smallt Information
	RFID	Get Smallt Information
	BLE	Get Smallt Information
Motion Sensor	Accerelometer	Detect Stpes
	Gyro	Detect Movement
	Compus	Detect Direction
Picture	Camera	Get picture/Get Small Information through 2D barcode

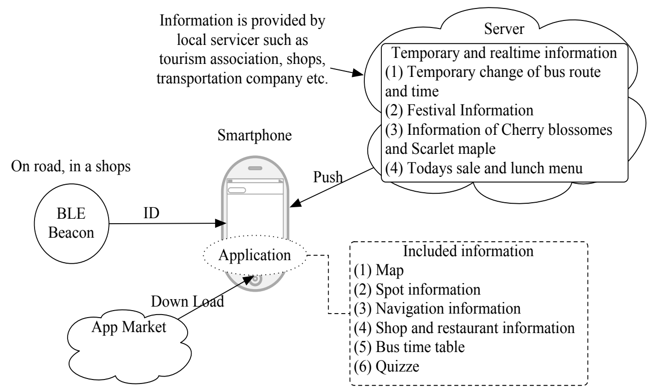

Figure 4 System diagram.

(1) Information should be displayed using the BLE beacon. For near-field communication, NFC and RFID may also be used. NFC requires activating a tag, which is inconvenient for tourists. RFID works in a similar way to a BLE beacon, but no smartphone has the RFID function.

(2) If 3G/LTE is not available, it must be possible to download applications and information using Wi-Fi. In the Nikko area, the City of Nikko provides a free Wi-Fi service at the railway station and in some shops, allowing tourists to download applications. Wi-Fi provides location data, in order to replace GPS.

(3) The application should provide a full range of information including location, shopping information and bus timetables. Real-time information such as temporary changes to bus routes because of festivals or the blooming of cherry blossom should be downloadable using free Wi-Fi.

C. *Information on Nikko as a World Heritage Site*

Using beacons, we sent location-specific information within a range of 2.3–10 m [13], which transformed an anonymous road into a zone immersed in Japanese culture.

This reflects the traditional Japanese method of attending services of worship, in which the journey to and from the service are not the same. Before entering a temple or shrine, tourists purify themselves. After leaving the shrine, they eat or go shopping. This is an established Japanese cultural custom, which has long been taken for granted.

The erection of signboards is seldom permitted in Nikko, following the Convention Concerning the Protection of the World Cultural and Natural Heritage (UNESCO, 1972). Using beacons, we were able to show the information on a smartphone. We created a traditional road, 'SANDOU' (it means a road approaching the main temple or shrine in Japanese), for the Nikko cultural heritage site. Using our beacon system, tourists could pause on the road, some to read information about the traditional temple there and others to find shops selling Japanese sweets, while young students answered a quiz. The road became a pilgrimage route to the shrine.

D. *Designing the Application and Locating the Beacons*

Many trials using BLE beacons have been reported in which location-specific and shopping information was provided in shopping malls and train stations. However, the BLE beacon has rarely been used for outdoor sightseeing.

Figure 5 Beacon map at Nikko.

Beacons send advertising messages at prefixed intervals using channels 37, 38 and 39. iBeacon, defined by Apple, sends advertising messages every 100 ms [14]. An important characteristic of BLE is its low power consumption. BLE requires only 1/10 to 1/100 the power of classic Bluetooth signalling, and a beacon may function for a year or more without a battery change.

To improve the visitor experience, we imposed the following requirements on the system:

- Reduce power consumption by avoiding the use of GPS
- Provide sightseeing information related to the BLE beacon location
- Have navigation operate in both foreground and background while displaying the distance from the station to the Shinkyo Bridge entrance to Toshogu (the main shrine)
- Display a timetable of main bus routes

Fig.6 displays screenshots of the application. This application was implemented on iPhone (5 or later models).

Figure 6 Screenshots of our application.

Fig.7 explains the software components of this application. In the operating system (OS), BLE access function always scans advertising message. If the OS catches an advertising message, the information of the advertising message is forwarded to the application. For example, Core Location framework of iOS (7 or later) provides three properties such as proximity UUID, major and minor. Android 5.0 or later also provides similar function. If the information such as UUID, major and minor is received from a beacon, the application retrieves information that matches triples (UUID, major and minor). For example, if UUID=cb86bc31-05bd-40cc-903d-1c9bd13d966a, major=1, minor=1, the information relating to the beacon located in the Nikko Station is retrieved from DB and it is displayed on the screen of the smart phone.

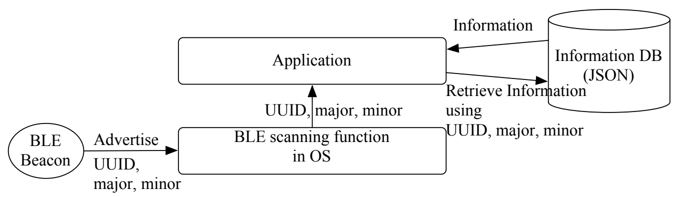

Figure 7 Software design to use BLE beacon

Each beacon provided information related to its location. For example, when the application received a signal from beacon #13, it displayed 'On the left, there is a slope. At the end of the slope, there is an old temple named Kannonji; 180 m to Shinkyo Bridge and 1,250 m to Nikko train station'. The visitor could use this information to find a small, historic temple.

To ensure stable reception of signals between the Nikko station and Shinkyo Bridge, we calculated the distance between the beacons as follows. In order to receive a signal from a beacon in the background, a smartphone must receive the signal for one minute or longer. We set a beacon to send a one-directional message using a steel signboard.

E. *First Trial: Discovery of Beacons*

Six students and three faculty members participated in the first trial, conducted on November 9, 2014.

1) Discovery of the beacons

We tested the beacons under three scenarios:

Scenario 1: Walking from Nikko station to Shinkyo Bridge

Scenario 2: Taking a bus from Nikko station to Shinkyo Bridge

 ISBN: 978-1-61208-459-6

Scenario 3: Walking to the Nikko visitor centre from Shinkyo Bridge while visiting shops where a beacon was located

In Scenario 1, users located approximately 95% of the beacons while walking. The beacon system worked as expected.

In Scenario 2, the results were *prima facie* unstable. If the user sat in the back of a bus, the smartphone was located near the window, but if the user sat in a front seat, the smartphone was below the window. In the former case, the smartphone could easily capture signals from beacons, but in the latter case, the metal body of the bus blocked the signal. As the smartphone captured the beacon signal once a minute, the signals from some beacons were missed. Detailed testing of the relationship between the position at which the smartphone is held and the bus speed is a subject for future study.

In Scenario 3, about 80% of the beacons were found, although in one case, only 33% were found. This suggests that the beacon system works best when users have already decided which shops to visit.

2) User awareness of the beacons

We asked subjects to monitor their awareness of the vibration and sound emitted by the smartphone when a beacon was found. The results showed that if users were holding the smartphone in their hand, awareness of the beacon was high, at approximately 60%. However, if the phone was in the user’s pocket, awareness fell to about 40%. Because it is dangerous to use a smartphone while walking on the road, different ways must be found to alert users to the beacon. In this regard, wearable devices such as smart watches might prove useful. This will be addressed in the next phase of our study.

3) Overall evaluation

We asked the participants to record their overall impression of sightseeing using the BLE beacon. The most common responses were ‘useful’ and ‘fun’.

The map, in particular, contributed to a feeling of safety (2.77 in 3 grades) and the information about shops was appreciated (2.70 in 3 grades). Key comments on the ‘SANDO’ (a Japanese road approaching the main shrine) included the following: ‘I found a small spring on the road’ and ‘The information on the little temple was good’. The participants appreciated the information triggered by the beacon.

F. Second Trial: The Zeigarnik Effect

Using the same beacons, we created quizzes about the road. These were tested on September 26 and 27, 2015.

Twenty eight students participated in the test, of whom 23 completed ten quizzes on the road to Toshogu Shrine and a control group of five students walked the route without the application. The participants were first asked to complete quizzes about the area, whose answers could be found by observing objects at the site. This study was based on a previous experiment using the Zeigarnik effect [15]. The participants were also asked to draw a map and to check some points on it. It is said that memory is mainly visual [16].

After the walk, the participants were first asked to complete a questionnaire and to draw a map of the area [17]. The answers given by users of the application were more concrete than those of the control group. Application users were able to place an average of 9.18 objects on the map from the station to the shrine, whereas the controls identified an average of only 5.80. Application users could not only remember the answers to the quiz questions but could also recall the shops near the beacon sites where they had answered the quiz.

After a gap of a month, the participants completed another questionnaire and checked three points on a photograph from the route they had walked in Nikko. Heat maps were created on the basis of the responses. Four photographs of the route to the main shrine were used: two in the main shrine itself and two showing several characteristic points.

Fig. 8 shows a heat map of the route to the main shrine. The participants paid no heed to the architecture along the route. This is in contrast to the photographs in the shrine where the gaze of the participants was directed to lettering. The red point is a restaurant sign with very big letters. Attention was also paid to written signs on the road. The street was recognized as the way to the main shrine. The yellow point shows that little attention was given to the BLE beacon in which no letters were present in the photograph.

Fig. 9 shows that the participants paid heed to the architecture of the shrine, particularly to the upper part on the right side. This was in contrast with the approach route.

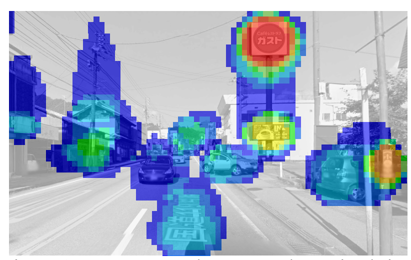

Figure 8 Heat map on the way to the main shrine.

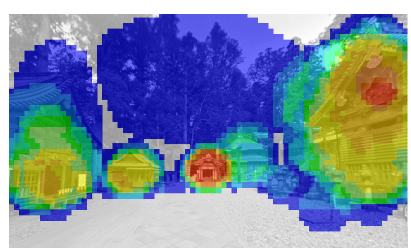

Figure 9 Heat map in the shrine.

The results confirmed that the use of the quizzes exploiting the Zeigarnik effect improves recall. Students remembered both the BLE beacon and the objects used in the quizzes.

The use of quizzes in the application helped users to recall the shops around the beacons immediately after the trial. In the future, we will expand the scope of our study to include 'SANDO' on the route to the main Toshogu Shrine.

V. CONCLUSIONS

Smartphone sightseeing applications offer several types of information. However, tourists visit sites to see real places and experience the real environment, while the smartphone is only a tool to enhance the experience. Thus, the information provided to the target audience must be refined. Tourists are not primarily motivated by convenience; in fact, unfamiliar experiences or inconvenience may actually arouse their curiosity.

Traditional cultural locations have special historical or cultural significance. Introducing tourists to relevant cultural information about these locations helps to create a strong impression. Our application aims to provide such information. Owners of shops en route to the main shrine provided us with not only information concerning their shops but also local traditions and seasonal events, enriching the information available to tourists. A web questionnaire showed that tourists found the information about shops useful. In the survey, 89.2% of the respondents were under 30 years of age. Foreigners could access the information using the English pages.

Local information can be used to attract visitors to other cultural sites around the world, particularly in world heritage sites designated as special protection areas, where signboards are banned.

Japanese students studied the history and specific artworks of the area before their school trip. By creating quizzes for their classmates and tackling quizzes that the others had prepared, interest was sparked. This provided the basis for our use of the Zeigarnik effect, in which completed tasks are less well-remembered than uncompleted tasks. Thus, we deliberately created incomplete experiences.

We are planning a collaboration with Toshogu, the main shrine at Nikko. Each autumn, a portable shrine is carried along the 'SANDOU' route to the Toshogu Shrine in a procession of one thousand samurai. We will use our beacon technology and application to provide descriptions and explanations of the traditional clothing and customs. In this case, the participants in the procession will carry the beacons.

Our main goal is to inform tourists about traditional cultures. Our system allows knowledge of the culture of a location to be transmitted to the next generation and to foreigners. Such travel information will inspire tourists and encourage them to treat the culture respectfully. We are planning to extend our collaboration to other world heritage sites as well.

ACKNOWLEDGMENT

We would like to express special thanks to Mr. Funakoshi (Nikko Tourism Association), members of the 'Study group on School Trip', Mr. Yoshida (Hatsuishi-kai: An association of Nikko shopping streets), Mr. Nakagawa (Kounritsuin Temple) and Mr. Takao Masuda (Chuo Univ.).

This research was performed as a SCOPE (Strategic Information and Communications R&D Promotion Programme) project funded by the Ministry of Internal Affairs and Communications (MIC) in Japan.

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Applied SOA with ESB, BPM, and BRM – Architecture Enhancement by Using a Decision Framework

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***Abstract*—To keep their competitive edge, enterprises need to change their operational processes in a flexible and agile manner. A Service-oriented Architecture (SOA) may help to meet these needs. One key feature of a SOA is the externalization of business process logic. However, process logic is often complex, hard to understand and difficult to adapt. This issue is due to a mingling of process and decision logic. In order to ensure flexibility and agility, decision logic should be moved to a separate service. In a previous work, we provided a decision framework, which recommends an approach to actually realize such a "rule service" conceptually. As the key contribution of this paper, we now apply our framework in particular to the German insurance domain. We show the resulting SOA architecture, which has an Enterprise Service Bus (ESB), a Business Process Management (BPM) / Workflow Management System (WfMS), and a Business Rules Management System (BRMS) / rules engine as key components. Moreover, we apply a standardized insurance process scenario working within this architecture.**

Index Terms*—Business Process Management (BPM); Business Rules Management (BRM); Business Rules Management System (BRMS); Enterprise Service Bus (ESB); Service-oriented Architecture (SOA); Workflow Management System (WfMS)

I. INTRODUCTION

A. Motivation

Workflow Management Systems support companies in the management and execution of business processes [25]. Nowadays, the latest challenges for insurance companies such as the dynamic business environment and compliance with legal requirements highlight the need for business agility [2][24]. Business agility requires the individual, quick, and flexible composition and adoption of business processes [9][10]. This can be done in the context of Business Process Management (BPM). As a result of the composition and adaption, the number of decisions may rise within the processes. Hence, the complexity of the business processes can lead to a lack of business agility [10].

Business rules provide an opportunity to reduce the complexity of the processes, whilst the complex decision logic is encapsulated. The necessary changes with respect to agility often relate to the complex decision logic and not to the process or business logic. Thus, the separation of decision logic and process logic on the modeling and implementation level is a useful approach to reduce complexity.

Comprehensive service-oriented approaches have the potential to create business agility [27]. Thus, a service-oriented architecture (SOA) can help to address challenges like the dynamic business environment. The service-oriented integration of BPM and Business Rules Management (BRM) provides potential to change business processes in an agile manner [11].

The results of interviews with experts of the insurance service sector emphasized the issue to choose an adequate approach to automate the execution of business rules within service-oriented architectures with respect to a missing decision support. Considering the dynamic business environment in the insurance services sector, the topics of the presented work are of potential value for several insurance companies (at least) in Germany [2][24].

B. Contribution

Our previous work [11] presents a decision framework, which recommends an approach to realize a "rule service" conceptually. It serves as the groundwork for the key contributions of this article, which are as follows:

- The application of the decision framework to scenarios particularly suitable to the German insurance domain, but easily transferable to similar environments.
- A resulting SOA, which has as key technical components an ESB, a BPM system/WfMS, a business activity monitoring (BAM), and a BRM system.
- The detailed design of our SOA includes four steps: (1) initial design, (2) design decisions, (3) product evaluation for key components of the architecture, and (4) a resulting final architecture.
- Moreover, our SOA is applied to a standardized insurance process application scenario ("Goodwill Process") working within the overall architecture from the German "Versicherungsanwendungsarchitektur (VAA) [28]". The VAA is a set of standardized insurance processes, the "insurance application architecture".

Our work takes place within the context of the current research activities of the "Competence Center - Information Technology and Management" (CC_ITM) [5]. The CC_ITM is a cooperation between IT departments from German insurance companies and our faculty. The purpose of this cooperation is knowledge transfer and the combination of scientific research with practical experiences.

The remainder of the paper is structured as follows: In Section II we present prior and related work. In the following main sections we first show the application scenario in Section III, then our initial architecture in Section IV, implementing design decisions in Section V, an evaluation of products in Section VI, and eventually the resulting target architecture of the system in Section VII. Section VIII finalizes the article with some conclusions and and an outlook to future work.

II. Prior and related Work

The concept of a complex software architecture is always influenced by several factors. For handling the variability of decisions between those factors, a quantitative evaluation method can reduce complexity. In a previous work of the CC_ITM, different concepts and technologies were discussed with such a quantitative evaluation method [18][16]. Therefore, different factors have been specified to build up a decision framework for identifying suitable business rule execution approaches. Further on, potential application scenarios have been identified by the CC_ITM and the collaboration partners. As a result of this, the standardized insurance process application scenario (”Goodwill Process”) was selected. The scenario, introduced in Section III (cf. [1][18] for an extended version), is inspired by a common insurance application architecture used by the German insurance industry [28].

The required elements, which are to be implemented with a rule-based approach, were determined within this scenario. Within the process of identifying the required elements, the business rule set goodwill adjustment was identified. An extraction process for business rules identification from business process models is mentioned in [20]. This process is useful, because business rules are often not explicitly included in the process models. A decision guideline for distinguishing between business process and business rule is presented in [22]. Requirements concerning business rules technologies are defined in [2][24]. The variables for determining suitable solutions for business rule implementation are illustrated in [23]. As a result of the literature review, the decision guideline, the requirements and the variables provide a contribution to the decision framework. Since no previous research allows a simple choosing of an adequate business rules execution approach this decision framework is the first to extend the current state of research through the linking of factors, indicators and business rules execution approaches. The determination of the specific business rules execution approach depends on the elements, which are to be implemented with a rule-based approach.

Concerning our project, the software architecture has to fit the demands of the insurance business. Requirements such as privacy and security protection of customer data excluded peer-to-peer (P2P) solutions despite the advantage of the high availability P2P solutions could offer. Thus, solutions with discrete data storage options and a higher reliability concerning requests were considered. Especially, the service-oriented approach with an agile business rules solution was identified as most fitting for the insurance sector. The combination of high cohesion and lose coupling increases the flexibility and maintainability of complex and highly distributed software architectures [12]. In particular, an ESB can fulfill the requirements of highly distributed SOAs [6].

The physical integration instead of a logical one was identified as the most fitting solution in [16], regarding the general SOA approach of the CC_ITM project. Further on, reliable messaging and security aspects of a physical ESB are also supporting the general demands of the insurance business in terms of security. Because of the whole software architecture consisting of distributed software components, a cloud solution was determined as potential extension for the current BPM solution [16]. The paper [7] highlights the benefits of migrating BPM solutions into the cloud, to fulfill the increasing future demand of adaptive solutions in a dynamic business environment. As a result of all these findings, the following Section III presents our application scenario from the German insurance domain. With this standard scenario, we will analyze its underlying SOA-, BPM-, BAM-, and BRM-based architecture.

III. Application scenario

A special application scenario has been applied to evaluate the prototypical implementation, which we have described in [11]. This scenario is depicted in Figure 1. The scenario is a sub-process of the overall process ”claim processing”. This overall process implements a standardized insurance companies use case, namely ”handle a goodwill request” from the German ”Versicherungsanwendungsarchitektur [28]”.

A goodwill payment is a compensation voluntarily granted by the insurance company without any obligation. The company checks whether compensation should be provided and - if so - determines its amount. The triggering event is the repudiation of cover. Its goal is to preserve the business relationship with the partner (customer). The task ”Set goodwill adjustment” determines the goodwill amount and is a typical case for a business rule in the German insurance domain.

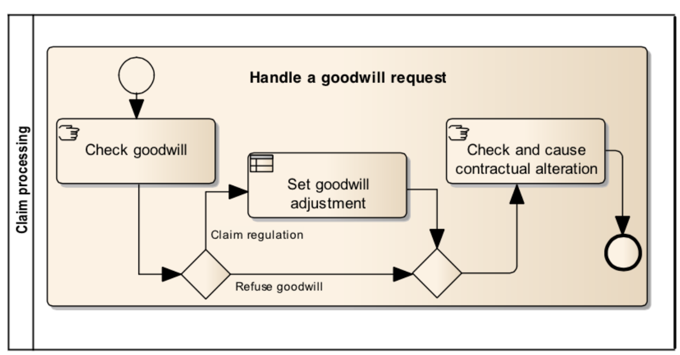

Figure 1. The Goodwill Process

Within a process it makes sense to introduce certain tasks as business rules to gain flexibility or better maintainability. For example, some conditions at a certain decision point can change significantly more often than the overall business process. So, a flexibly changeable rule might offer more agility. These different requirements in flexibility directly influence the technically decisions about the actual rule realization/implementation.

IV. Initial architecture of the system

To address these different requirements in flexibility regarding the implementation of business rules, we presented a decision framework in our prior work [11]. This paper compared different technical approaches for business rule execution (inference machine, database, configuration file and business applications) based on certain factors and indicators. By applying this decision framework, we decided to use a dedicated BRM inference machine for rule execution [11][16]. This approach has been identified as the most flexible one, especially with respect to the implementation of complex rules and larger rule sets. Next we will show the initial architecture of the system and will discuss its individual architectural components in detail. This architecture will process the described standard "Goodwill process" from Section III.

The architecture of the system for the "Goodwill Process" was composed from the following components (cf. Figure 2):

- The **WfM-Engine** (workflow management engine) was and still is the core of the whole architecture. It manages the business process, verifies the execution order of activities and routes the information flow between client and back-end. It contains a logical ESB to orchestrate different services. As concrete WfM-Engine, we use the product "Infinity Process Platform" (IPP) provided by SunGuard [13].
- The **BAMS** (business activity monitoring system) composes stored procedures and triggers. It is placed in an Oracle database and monitors the executions of activities used by the business processes. The BAMS is similar to complex event processing systems (CEP) but uses a special form of logging. The monitoring allows the evaluation of business rule executions to improve the processes. It was designed and implemented by the CC_ITM project.
- The **Client** component provides the functionality of the system to the user. It us currently a command console and menu based application, which allows the activation and execution of processes in the system. Currently, this client component is developed by the CC_ITM and supports only the goodwill-scenario in a console-based user interface.
- The **Applications** provide the automatic execution of an activity or a single task. When they are invoked by the WfM-Engine, they execute the business logic that underlies the corresponding activity and report their result to the engine. Because the WfM-Engine only supports Enterprise JavaBeans (EJB) 2.x- and Web service calls, all applications are implemented as EJB 2.1 Beans.

Other components in Fig 2 are just supporting management and development background tools, which do not require a more detailed explanation here. The overall design decision and the composition of all its components to fulfill the requirements in flexibility and maintainability is described next.

V. Design Decisions

The general big-picture of a software project is always the sum of every single design decision. The single decisions have to be chosen carefully. Therefore, a quantitative evaluation will help to support the decision-making.

A. Business activity monitoring system and business rules management system

To further improve the SOA aspect of the design, the introduction of a BRMS was considered. The BRMS would be responsible for managing the business logic and would also reduce some workload of the WfMS. Moreover, the BRMS would "user friendly" support modifications of business rules. Overall, the BRMS is another "active rule" system, technical similar to the BAMS but with a different application-oriented purpose within our architecture.

Regarding the responsibilities of these two systems, the introduction of a redundant component makes sense; the BAMS has to monitor the whole WfMS architecture, while the BRMS only takes care of domain specific rules. This means, there will be two similar components for completely different tasks, combining both responsibilities would intermingle rules concerning different domains - a perilous path to take.

B. Enterprise service bus

The logical ESB, provided by the WfMS in use (IPP), was very restrictive in terms of supported applications and is not adaptable to offer security and transport protocols. Therefore, the advantages and disadvantages of a "home-made" physical ESB were compared with the advantages of the already existing logical ESB.

As presented in Table I, the advantages of using a physical ESB are significant and are outweighing the disadvantages. Replacing the logical ESB with a physical one results in a more flexible architecture supporting the approach of lose couplings within the SOA. Therefore, the CC_ITM team evaluated several solutions. For the concrete evaluation of the advantages and disadvantages of the different products, we will next discuss this evaluation with a quantitative approach.

VI. Evaluation of products

To find the best fitting set of products, a list of requirements was created and research was conducted on available alternatives. The evaluation process and its results are presented in this section.

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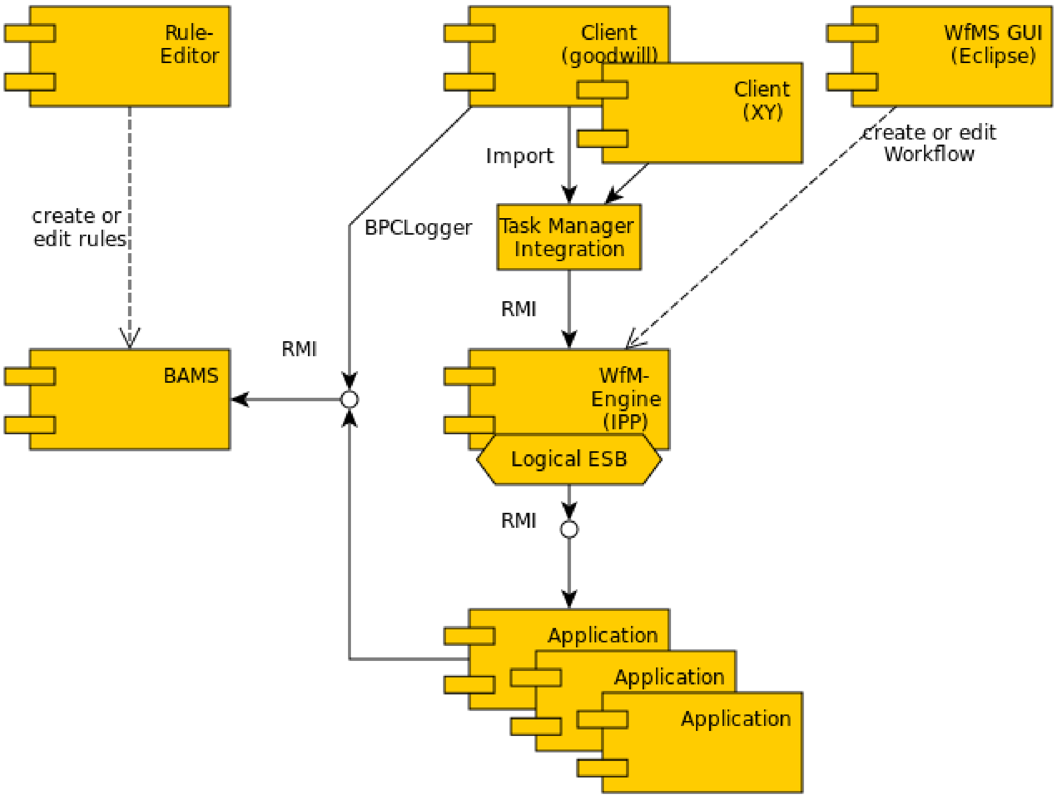

Figure 2. Initial architecture of the CC_ITM project.

TABLE I. ADVANTAGES AND DISADVANTAGES OF A LOGICAL AND PHYSICAL ESB FOR THE ARCHITECTURE.

	Advantages	Disadvantages
Logical	Already provided by the WfM-Engine	Dependence on the IPP WfM-Engine
	Responsibility for availability, security and reliability of the ESB outsourced to a third party company	Not expandable/modable for security, transport protocols and new interfaces
Physical	Lose coupling from IPP	More implementation work
	Less dependence on proprietary software components	Integration difficult or impossible due to the lack of knowledge
	More control and knowledge in self-programmed software components	
	More flexible software for security mechanisms, transport mechanisms and more interfaces	
	Future replacement of WfM-Engine easier (for example Stardust)	

A. ESB products

There are a lot of ESB solutions available today, analyzed in different publications. In this project, a long-list of possible ESB solutions (see Table II) was derived based on the publications [26][30][8][29][21][19].

Because of some sources not being up-to-date, an additional study had to be undertaken by the project team in order to map the long list to the current situation on the market. It was discovered that some of the ESBs are included in different solutions now, because the manufacturers were acquired by other companies. For example, Fuse ESB currently belongs to JBoss Solutions from Red Hat Inc. [31].

TABLE II. THE LONG LIST OF ESB SOLUTIONS

Apache Server Mix
Mule ESB
BEA System Aqualogic Service Bus
IBM WebSphere
Cape Clear
Oracle ESB
Fuse ESB
OpenESB
Talend Open Studio for ESB

In the next step, the long list was transformed into a short list. The conclusions drawn in [26][30][8][29][21][19] account for the choices made at this stage. Furthermore, special project requirements were used to extend the short list, such as the solution must:

- be open source and state-of-the-art
- work with both Windows and Linux operating systems respectively
- have an active support community

 ISBN: 978-1-61208-459-6

TABLE III. SHORT LIST OF ESB SOLUTIONS & EVALUATION (MAX. 100%)

Red Hat JBoss ESB	83.99%
Mule ESB	75.29%
OpenESB	83.98%
Talend ESB	89.87%

- provide an Enterprise JavaBeans connector for integration with existing components

The final short list is presented in Table III. A full installation of each of the ESBs in the short list was not undertaken. Instead, the results of the comparative analysis in [3] were used, which describe detailed testing of solutions on different platforms, amongst which are Mule ESB, JBoss ESB and OpenESB. Talend ESB was evaluated in an interview [17] with an employee of Talend, using the criteria from [3]. These criteria belong to three categories, such as ergonomics, processing and environment. The combined results from both sources are also depicted in Table III. However, these numbers alone do not constitute the best solution, since possible problems of this result must be considered. Talend ESB was evaluated in 2013. The others were compared six years in before, so additional features might have been added in this period of time. Thus, despite it not having the best score, JBoss ESB was chosen by the team, because of its good documentation, wide usage and ability to run on JBoss Application Server 5.1, which was successfully used in the project before.

The compatibility of the ESB to the existing application server led to a low-effort integration into the architecture. After the ESB had been deployed on the server, it was necessary to ensure that the applications are not called by the logical ESB of the workflow engine directly any longer. Instead, the logical ESB will access the JBoss ESB which will call the applications. Referring to this, the JBoss ESB must provide an Enterprise JavaBeans service for the workflow engine. Therefore, the `FacadeBean` was created and the definition of the business process was altered, so that this Bean is accessed by the workflow engine when needed. These changes to the architecture are depicted in the final architecture diagram in Figure 4.

B. Business rule execution approaches (BREA)

In order to choose a business rules execution approach, a requirements analysis was undertaken, both for general business rules execution approach requirements and special requirements determined by the project. The former are defined in the Business Rules Manifesto from the Business Rules Group [4] and includes portability and user friendliness of the rule editor. The project requires the business rules execution approach to be:

- open source
- compatible with Linux and Windows operating systems respectively
- integrable with the existing JBoss ESB
- capable of processing complex business rules
- well documented, supported and constantly updated

In 2012, the team conducted a research on BRMS available on the market and created a list of suitable solutions. In order to assess the features of systems, an evaluation of BRMS was undertaken based on a criteria catalog developed by the project team based on a `"Basel III"` scenario [32], [33]. The evaluation resulted in the BRMS short list in Table IV.

The `"Basel III"` scenario asks for two typical indicators used by the underlying insurance business:

- liquidity coverage factor (LCR)
- net stable funding ration (NSFR)

In [15], the criteria are divided into nine groups: Usability, ease of learning, run-time environment, performance, compatibility, functionality, safety and security, development and debugging, documentation. For each criteria, a score from one (worst case) to four (best case) was assigned to each product. The weighting of criteria was customized with respect to the specifics of the project. The evaluation results [14] are also presented in Table IV, although, those results cannot be used for judging about absolute quality of products. Nevertheless, due to restrictions of the project, an open source solution had to be chosen and therefore, JBoss Drools has been used in the prototype architecture.

JBoss Drools provides a complete system for business rules management, including a rule repository and a web server with a special site for rule management in Drools Guvnor. The BRMS architecture in the project is depicted in Figure 3.

TABLE IV. LIST OF BRMS SOLUTIONS& BRMS EVALUATION RESULTS (MAX. 100%)

Visual Rules	85.07%
JBoss Drools	61.09%
WebSphere ILOG JRules	77.19%

With this quantitative evaluation, we are able to identify the best fitting set of products to fulfill the requirements. The final system architecture build with those products is described next.

VII. TARGET ARCHITECTURE OF THE SYSTEM

There are several changes and optimizations between the basic and the target architecture of the system. Certain parts of the initial architecture have not been changed: Goodwill client, the connection between the client, the WfM-Engine and the BAMS are still as in the initial architecture. The original and modified parts are shown in Figure 4.

The first change of the initial architecture was the replacement of the logical ESB. For this purpose, JBoss ESB as a physical ESB was chosen as described before. Different applications will be called from the physical ESB instead of the logical one. Nevertheless, the logical ESB cannot be replaced completely, because it is an integrated part of the

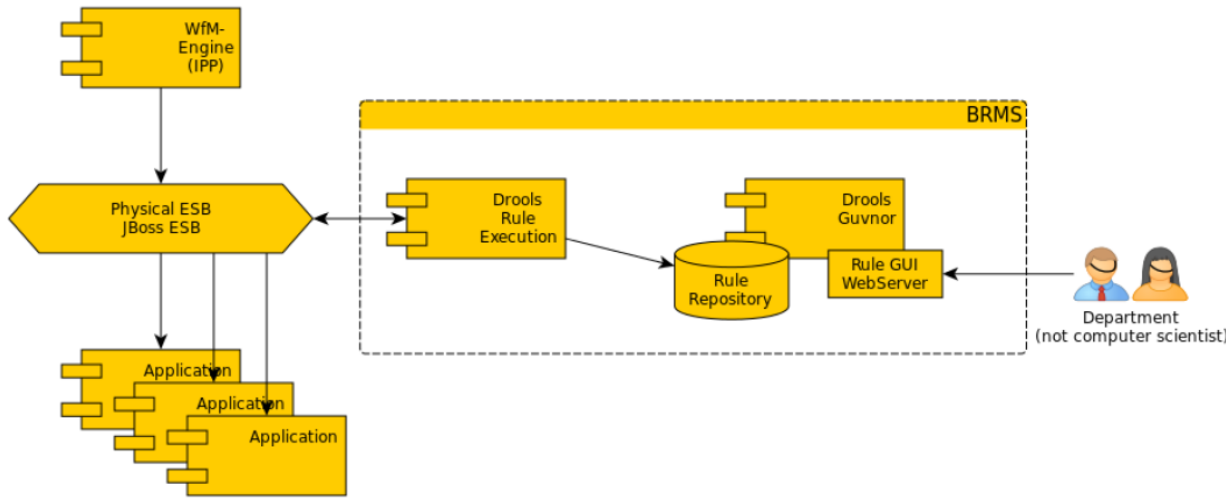

Figure 3. BRMS architecture with JBoss Drools and Guvnor

WfM-Engine. Also, it supports only EJBs and Web services connectors. Therefore, a connection between the logical ESB and physical ESB was developed. A simple `Facade Bean` represents this connection. It is called as an EJB from the logical enterprise service bus. All WfM-Engine calls will be channeled through the `Facade Bean` to different applications. Furthermore, the application calls in the process definition (XPDL file) were changed to leverage the physical ESB. To connect the applications to the JBoss ESB so called Services need to be described. The translation between the logical ESB and the Services is done by the `Facade Bean`. Moreover, the monitoring of these application calls is now handled by the JBoss ESB, for this purpose a connection between the JBoss ESB and the BAM-System was introduced.

The second change to the initial architecture was the integration of the BRMS. As stated before, the chosen BRMS is JBoss Drools. It's integration was realized through the connection between JBoss Drools and JBoss ESB. Furthermore, the BRMS was integrated into the process definition. Easily enough, a definition of a rule call is similar to an application call.

Management of the rule base is implemented by JBoss Drools Guvnor. Rules can be created or edited via a rule management website. Moreover, a rule storage (rule repository) is part of Guvnor.

The actual architecture is supported by decisions based on quantitative evaluation methods as well as on the expertise within the CC_ITM team. We assume, a combination of quantitative methods and qualitative experience should offer an architectural design, able to challenge and be challenged by future demands.

VIII. Conclusion and Future Work

To manage the application landscape of businesses, for example, companies operating in the insurance services industries, the combination of technologies such as SOA, business process management and business rules management is a promising approach.

In order to ensure the optimum of agility and flexibility, the decision logic should be shifted to a separate SOA service. In our previous work, we presented a decision framework, which recommends an approach to realize such a ”rule service”. As a key contribution of this article our decision framework is applied to a standardized insurance business process, namely ”Handle a Goodwill Request”. Starting from the initial design, in making design and infrastructure decisions, we obtain an enhanced service-oriented target architecture with technical components such as ESB, BPM system, BAM, and BRM system.

Based on these intermediate results, our subsequent research activities will focus on a detailed performance evaluation which may require a redesign of the target architecture. The evaluation is part of the current research project ”QoS measurements for combined BRM, BPM and SOA environments in the insurance domain”. As the insurance industry is receptive to cloud computing concepts and technologies - for example, product design and risk assessment heavily make use of SAAS - moving components of the target architecture towards the cloud might be a promising approach. Therefore, the investigation of cloud computing solutions is another main activity of our research group.

Actually, the enhanced architecture contains some proprietary components, such as the BAM system. As businesses prefer to use standard infrastructure components, we intend to replace all proprietary components. For this purpose we (also)

 ISBN: 978-1-61208-459-6

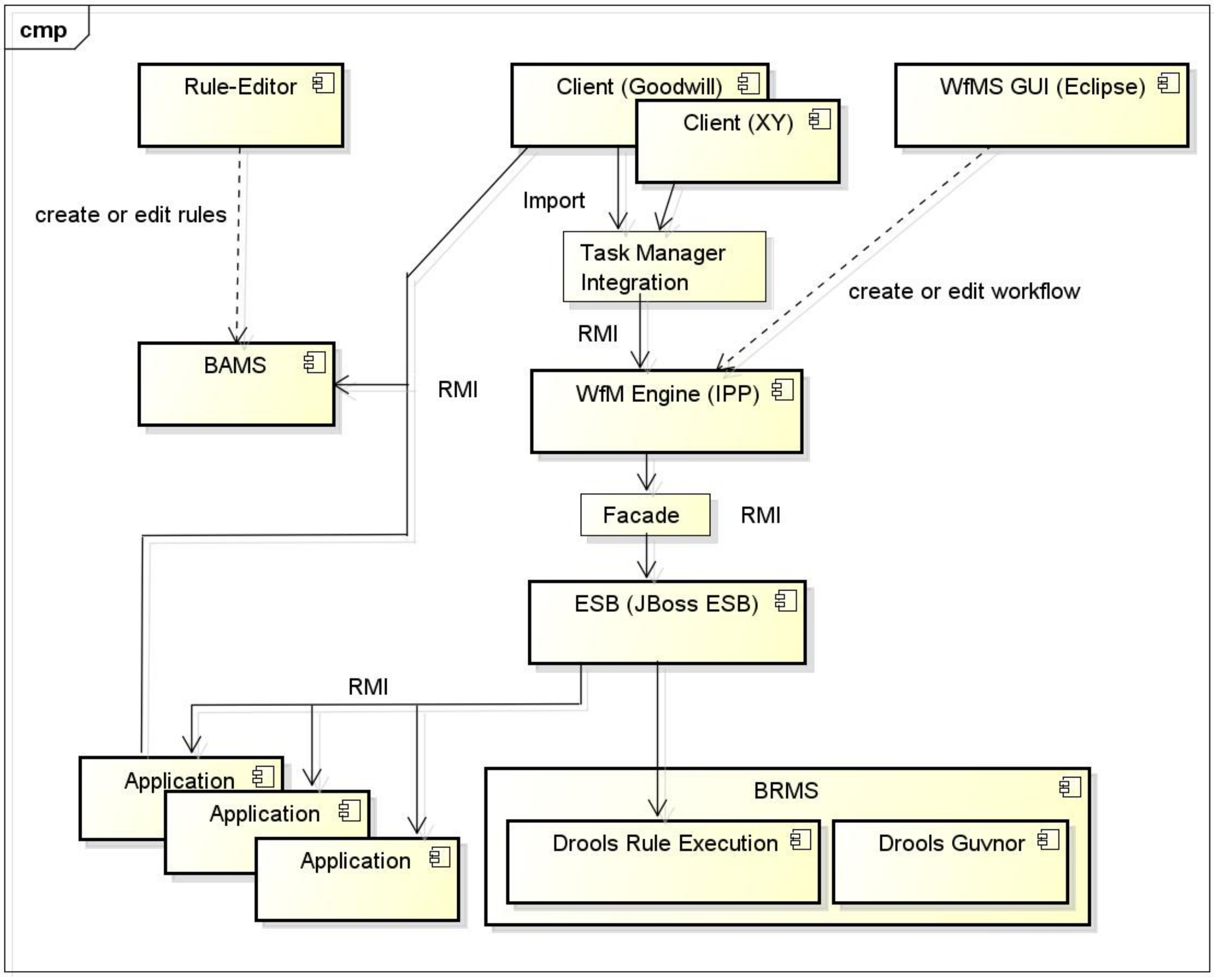

Figure 4. Final architecture of the overall system.

look at open source CEP tools. Another, but marginal issue is the optimization of the usability of the rule editor.

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SocialGlue: a Pluggable, Scalable, and Multi-Platform Service for Data Analysis

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***Abstract*—The growing use of Social Network Sites (SNS) and the exponential growth of social data is opening new research challenges in several scientific domains, such as: Recommender Systems, Data Mining, Sentiment Analysis, and Human-Computer Interaction, just to name a few. In this scenario, researchers from different fields are facing several obstacles given the lack of highly customizable frameworks able to let them perform a large number of ad hoc studies of big data flows coming from SNSs. Trying to overcome these challenges, this paper sets out *Social Glue (SG)*, a pluggable, scalable, and multi-platform social analysis service. SG is designed to easily enable the connection to potentially any SNS allowing scientists to plug and manage the execution of their algorithms against connected SNSs seamlessly from SG with the minimum effort. In this way, researchers can focus more on the design of algorithms rather than in the software infrastructure needed to set up their experiments.**

Keywords–Social Web; Computational Services; Framework Architecture.

I. INTRODUCTION

Being able to collect and process data is essential in all the fields of science and engineering [1]. Moreover, most fields nowadays are interdisciplinary and collaborative [2]. This means that in the so-called Social Web (also known as Web 2.0), *web communities* can generate and share large amounts of data. However, due to privacy and commercial reasons, the data generated on one environment (e.g., the e-commerce transactions) is not passed to other environments. Therefore, to generate services to a web community by analyzing and filtering the data generated by the users, each environment and system has to collect its own data. However, if a single environment to run multiple services without disclosing of sensible data to the service providers existed, the problem would be overcome and each service could run on much more data, improving its effectiveness.

As Koch and Lacher highlight [3], computer-based systems should support knowledge transfer and the exchange of information generated by the community, in order to integrate different services provided to the community. In this matter, they propose a set of guidelines to create a common infrastructure that enables this knowledge transfer. Karacapilidis et al. [4] proposed a web-based collaboration support platform for the biomedical domain, to strengthen collaborative data analysis and decision making in web communities.

As both the research works mentioned above clearly point out, web communities tend to generate large amounts of data that are recognized as a valuable source, and *the development of a flexible and domain-independent framework that allows researchers and developers to exploit and analyze these data and provide services to the users represents an open issue in the current literature*.

To overcome the aforementioned issues, in this paper we present *Social Glue (SG)*, a pluggable, scalable, and multi-platform framework, that enables the providing of any service to a web community. Indeed, our proposal allows researchers and developers to plug, run, and use their algorithms on a connected Social Network, with the minimum programming effort. Therefore, the data integration highlighted in the literature as a requirement for a system that provides services to a web community is made possible by *Social Glue*, since the system is able to process the plugged algorithms on the data generated by the web community. In other words, the data generated in one environment, can be exploited in many different contexts. The proposed framework has been designed to exploit modularity and employ state-of-the-art technologies.

The main scientific contributions coming from this paper are the following:

- the experimentation of a novel domain-independent framework to provide services in Social Web environments is proposed in the literature; each algorithm can run on our framework, by employing different types of data generated by the web community while using a social network;
- thanks to *Social Glue*, researchers and developers themselves are provided with services offered by the framework, i.e., algorithms upload, data and user base availability, back-end interfaces to plug the algorithms, and so on.

The rest of the paper is organized as follows: Section II provides an overview of the state of the art in the field of computational services for web communities, Section III provides a high level description of the architecture of *Social Glue*, while Section IV sets out a detailed description of each layer composing the system architecture; Section V contains conclusions and future work.

II. RELATED WORK

This section presents related work on platforms that support web communities to provide services to them.

In [4], the authors present Dicode, a framework to support a biomedical research community at collaborative analyzing data and enable decision making processes. The platform is flexible, in the sense that heterogeneous workloads can be processed by the framework. However, no layer that enables external contributions to process data in different ways is presented, so the system can only be employed by the community to run a fixed set of services.

 ISBN: 978-1-61208-459-6

Tiwana and Bush [5] presented an architecture to enable social exchange in distributed web communities. Again, with social exchange the authors intend the transfer of information among the users, but differently from SG, the possibility to employ the social data to run different types of services on a flexible architecture is not available.

Koch [6] presented an approach to support interoperable community platforms in the university domain, by also allowing the members of the community to manage their identity. The approach, however, assumes that different platforms for different services and communities exist, while in our approach we aim at developing a unique framework and environment to provide different types of services and exploiting all the data generated by the web community. In [7], the author considers also aspects such as the modularization of the provided services and the use of ubiquitous user interfaces.

The capability to provide different types of services has been developed in several systems as a form of context-awareness (i.e., to provide services according to the context in which the system operates). Zafar et al. [8] present an architecture of these types of systems. This type of frameworks provide ad-hoc services, like location aware tour-guides [9], [10]. Therefore, a system is devoted at providing a single service, and there is no chance to integrate other types of algorithms to run on these frameworks.

As this analysis shows, our proposal has some peculiarities that set us apart from other similar frameworks proposed in the literature. Our solution provides a way to integrate different types of services in a flexible framework to provide the knowledge transfer and data integration highlighted in the Introduction.

III. High Level Architecture

This section introduces the architecture of the proposed framework, by giving an overview of the layers that compose it.

The *Social Glue* framework is characterized by a multi-layered architecture composed of three macro-layers: the *Clients* layer, the *Back-end* layer, and the *Modules* layer. Each layer is in turn composed of sub-modules called *Plugins* in the Clients layer, *Adapters* in the Back-end layer, and *Modules* in the Modules layer. As can be seen in Figure 1, at the top of the architecture sits the *Clients* layer which exploits low level layers to give users the possibility to extend the framework by adding customized elements called plugins. Plugins are the tools users have to develop in order to interconnect with real-world social networks, to create custom web communities and, more important, to manage the execution of their algorithms against available communities. As an example use case, Social Glue natively implements two plugins built exploiting a famous social network engine called *Elgg* [11]: the *Simulator Movie* and the *Social Monitor* plugin. The former implements the functionalities needed for the creation and the management of a web community of movie lovers, the set up of algorithms to be executed against the community, and the management of the output of executed algorithms. The latter, instead, is in charge of implementing an administration interface to allow users to control the lifecycle of all available algorithms.

All the functionalities offered by a plugin are supported by the *Back-end* layer. This layer exposes a set of REpresentational State Transfer (REST) Application Programming

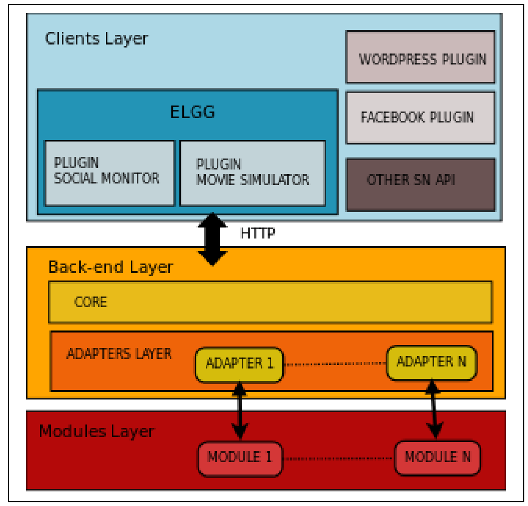

Figure 1. Social Glue Framework

Interfaces (APIs) that are responsible for the management of the algorithms. The Back-end layer is composed of a variable number of “Adapter” classes that manage the loading of the algorithms plugged in the system through the lower level of the architecture. In general, there must be an adapter for every available algorithm. The functionalities of the adapters are exposed to the higher level by means of a standard API in order to give clients full control on the execution of algorithms.

Finally, the *Module* layer actually contains the source code of the algorithms researchers plugged in the system. Every algorithm inserted constitutes a module that has to expose a standard interface to let the corresponding adapter in the Back-end layer expose all the functionalities the plugins in the Clients layer need to control the execution of the algorithms.

The low level layers have been designed to allow users to deploy system configurations able to scale horizontally in cases where multiple and potentially resource-intensive computations have to be performed in parallel. In fact, the the web service is able to correctly handle multiple databases sources and multiple modules/adapters provided that the logic flow of the program is designed to work in a stateless way and a web proxy is properly configured to route the HTTP traffic.

IV. Architecture Layers

The following section provides a detailed description of the previously presented layers composing Social Glue.

A. Clients Layer

As highlighted in Section III, at the top of the architecture sits the *Clients* layer. The entire system has been designed keeping in mind the modularity it has to offer to the final users and this layer is no exception. Indeed, a user can develop and plug into this layer her/his social plugins implementations to exploit public APIs to interact, for example, with a real world social network or even with a user-created social network.

In general, in addition to the implementation of the plugin that handles the communication with the social network, it is possible to implement also a custom administration plugin in order to provide a user-friendly web area where administrators can manage the APIs exposed by the Back-end layer (see

Subsection IV-B). By default, the framework provides an administration area to let users manage the lifecycle of the loaded algorithms. In cases where it is needed a finer control over the management of the algorithms, it is possible to implement custom administration functionalities by exploiting the APIs exposed by the lower level.

In the following, we will provide a more detailed description of the use case previously introduced (see Section III). This use case has been developed to set up a series of preliminary tests to investigate how the entire system behaves in terms both of reliability and performance during the execution of popular recommendation algorithms against a social community. As mentioned before, for our use case we decided to opt for a well-known and open source framework called Elgg that offers the possibility to build web communities with the minimum development effort. The framework is very powerful and in its base configuration is able to support blogging and microblogging functionalities, groups management, and several common social actions such as: comments on posts, tags, likes, and so on.

Elgg's architecture is highly modular and extensible. Its plugin system allows the user to easily develop and integrate new plugins inside the framework in order to provide her/his customized functionalities. As previously mentioned, for our use case we exploit Elgg's flexibility to create a social network for movie lovers that we populated using a well-known dataset called Movielens [12]. The community is managed by means of a custom plugin called *Simulator Movie*. This plugin supports the insertion of new users and movies, the population of the community by means of a dataset and so on. In addition to the community-related features, the plugin gives administrators the possibility to load algorithms to be executed against the community by exploiting the lower layers of the architecture. In our case, we loaded a recommendation algorithm to build tailored movies recommendations by exploiting users' preferences contained in the dataset we used to populate the community. In this way, we were able to provide users with tailored movies recommendation directly inside the social network (see Section IV-C).

The execution and management of the algorithms is demanded to another custom Elgg plugin called *Social Monitor*. Social Monitor implements all the functionalities related to the management of the algorithms the administrators intend to execute against a certain community. Figure 2 shows a screenshot of the Social Monitor. Starting from the top of the screen, the user has an overview of all the algorithms she/he can launch. In particular, it is indicated the name of the algorithm, whether or not some form of input data is required, and the possibility to launch the execution by means of the "Execute" button. Just below the "Algorithms" menu is shown the "Thread Pool" view that reports the current state of the low level threads that are in charge of executing the algorithms. In this particular case, it reports that there are two threads currently in execution and both of them are waiting for their inputs (see the "Waitdata Instances" label). The "Thread Pool Information" shows low level details about the current state of the Thread Pool. In particular, starting from the top of the view, the following information is shown: the current number of busy threads, the total capacity of the queue (i.e., the maximum number of algorithms that can be enqueued for execution), and the maximum number of threads the pool can contain. Finally, at the bottom of the screen, is shown the "Running Algorithm Status" that reports general information about the algorithms currently in execution. In this particular case, there are two running algorithms both waiting for their input data.

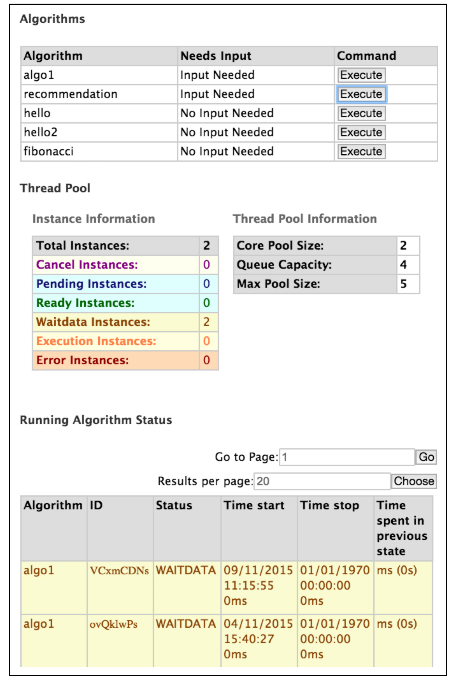

Figure 2. Social Monitor plugin

B. Back-End Layer

The Back-end layer is in charge of providing the core services to the higher layer. From a technological point of view, we decided to adopt a well-known and widely used software stack. The core of the Back-end is written in Java and implemented by exploiting the Spring framework [13] and the MySQL [14] database to manage the persistence of the data. The entire application runs on the Apache Tomcat [15] web application server. Thanks to this high flexible software architecture we implemented both the core logic and the set of RESTFull APIs invoked by the higher layer. This layer is responsible of managing the run-time load and unload of the user/researcher provided algorithms and, most important, it implements the control logic that handles the entire lifecycle of the algorithms plugged in the system by means of the lower layer (see Section IV-C).

The control logic is instructed on how to execute a certain algorithm by means of a simple configuration file that the user/researcher is requested to provide for every algorithm she/he intends to load. The following string represents an example of an entry of the configuration file:

{*"name":recommendation,"class":RecAlgoAdapter,"needInputs":true*}

The first attribute, called "name", indicates the name of the algorithm, "class" reports the actual Java class (Adapter) in charge of handling the execution of the algorithm loaded from the lower layer, and "needInputs" is a boolean value that specifies whether or not it is necessary to manually upload the input for the algorithm.

The most important component of the Back-end, in charge of handling all the steps needed to execute the algorithms, has been implemented by means of a finite state automata (see Figure 3). We opted for this tool because we needed a relatively simple and, at the same time, robust mechanism able to handle the concurrent execution of potentially very heterogeneous algorithms. Indeed, the entire system must be able to correctly execute algorithms that can differ a lot in terms of computational complexity, input/output dimension, memory consumption, and so on.

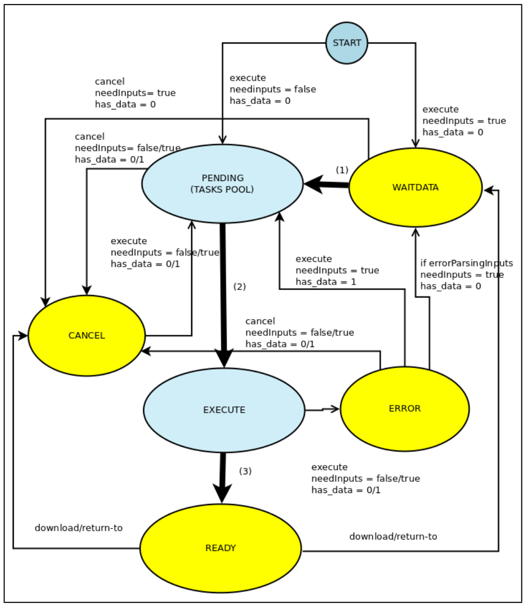

Figure 3. Back-end finite state automata

Let us now describe in detail the automata and, in particular, its states and the possible transitions between states that can take place during the execution of an algorithm. A client, through an ad hoc graphic control panel that in turn invokes the Back-end APIs, can issue the commands for a particular algorithm in order to trigger the transitions between states. As can been seen in Figure 3, the initial state is called "START" and this is the state that is associated to the invocation of the "execute" command. According to the type of algorithm being executed (i.e., according to the configuration provided by the user by means of the configuration file), the automata can transit to two different states. In particular, the state changes to "WAITDATA" if the current algorithm needs to be provided of input data (i.e., the label "needInputs" is equal to true). When an input is provided (i.e., the label "hasData" is set to 1), the current active state becomes "PENDING". The same state is reached directly when the algorithm being executed does not need input data (i.e.,"needInputs" is equal to false). At this point, the algorithm is ready to be executed and the control passes to the execution logic that has been implemented using a common thread pool. When one of the threads in the pool becomes idle (i.e., it can execute the current algorithm), the active state becomes "EXECUTE" (i.e., the system starts the execution of the algorithm). Eventually, the system reaches the "READY" state when the execution of the algorithm finishes correctly. On the contrary, a transition to the "ERROR" state signals that the execution has been terminated because of an unexpected error. In this case, the execution of the algorithm gets stopped and the system waits for the intervention of the user. From "READY", the automata can pass to "CANCEL" when the user downloads the results and then again to the "PENDING" state if the user triggers another "execute" action. From the "READY" state the control can pass to the "WAITDATA" state in cases when the user, after downloading the results, chooses to provide new input data for the current instance of the algorithm in order to wait for a new execution by following the same state transitions described above.

Let us now describe in more detail the "CANCEL" state previously introduced. An algorithm can be in this state when:

- the user has executed the "download and cancel" command after a correct execution of the algorithm;
- the user can decide to cancel the execution because she/he deems that the current algorithm is waiting in the "PENDING" state for a too long time (i.e., the entire system could be busy).

It is important to note that the system, when the current state is "CANCEL", is able to save the provided input and configurations in order for the user to restart the execution at a later time. Finally, as we saw before, the "ERROR" state is reached when the execution of an algorithm terminates abnormally. From this state, there are three possible transitions towards the following states:

- "CANCEL": the user decides to cancel the execution of the current algorithm;
- "PENDING": the user decides to reschedule the execution of the algorithm using the same configurations;
- "WAITDATA": the user decides to relaunch the execution by providing different inputs to the algorithm.

C. Modules Layer

The *Modules Layer* is designed to provide researchers and developers the opportunity to integrate their algorithms on the framework. Each algorithm can be seen as a module that runs on the framework and is a service provided to the researcher/developer. The integration of the source code of each module (that can also be in a different programming language, like C or C++), is made possible by the Java Native Interface (JNI), which enables Java to use the native code of the operating system.

We will now provide an example of a module integrated in our framework, which is a *user-based Collaborative Filtering recommendation algorithm*. The choice to integrate this type of module in our framework was made because it lends itself well to a web community domain, characterized by social interactions. Indeed, the algorithm is able to analyze the different items a user had an experience with, and provide recommendations for items she/he has not considered yet, but that might interest her/him. In general, with the term *item* we refer to something generic, which in a social domain might be anything, from a Youtube video a user has posted, to a restaurant she/he visited and evaluated on Facebook.

In order to provide the recommendations, a *user model* like the one in Table I is considered. A model contains for each *item* i_n that the user u evaluated, a *rating* r_{un} that expresses with

 ISBN: 978-1-61208-459-6

TABLE I. EXAMPLE OF *USER MODEL*

	i_1	i_2	i_3	i_4	i_5	i_6	i_7	i_8
u	r_{u1}		r_{u3}				r_{u7}	r_{u8}

TABLE II. EXAMPLE OF *RATINGS MATRIX*

	i_1	i_2	i_3	i_4	i_5	i_6	i_7	i_8
u_1	r_{11}		r_{13}	r_{14}			r_{17}	r_{18}
u_2	r_{21}	r_{22}		r_{24}	r_{25}		r_{27}	
u_3		r_{22}	r_{33}	r_{34}		r_{36}		
				...				
u_n	r_{n1}	r_{n2}	r_{n3}		r_{n5}	r_{n6}		r_{n8}

a numerical value how much the user likes the corresponding item.

All the user models, like the one previously described take the form of a matrix, usually called *rating matrix*, like the one in Table II.

The missing ratings for each user are predicted with a widely-used User-Based Nearest Neighbor Collaborative Filtering algorithm, presented in [16]. The algorithm predicts a rating p_{ui} for each item i that was not evaluated by a user u, by considering the rating r_{ni} of each similar user n for the item i. A user n similar to u is called a *neighbor* of u. To indicate that we are dealing with a user-based approach, the set of neighbors of this algorithm will be indicated as $neighbors^{uu}$. Equation 1 gives the formula used to predict the ratings:

$$p_{ui} = \overline{r}_u + \frac{\sum_{n \subset neighbors^{uu}(u)} userSim(u,n) \cdot (r_{ni} - \overline{r}_n)}{\sum_{n \subset neighbors^{uu}(u)} userSim(u,n)} \quad (1)$$

Values $\overline{r}_u$ and $\overline{r}_n$ represent, respectively, the mean of the ratings expressed by user u and user n. Similarity $userSim()$ between two users is calculated using the Pearson's correlation [17], a coefficient that compares the ratings of all the items rated by both the target user and the neighbor. Pearson's correlation between a user u and a neighbor n is given in (2). I_{un} is the set of items rated by both user u and user n.

$$userSim(u,n) = \frac{\sum_{i \subset I_{un}} (r_{ui} - \overline{r}_u)(r_{ni} - \overline{r}_n)}{\sqrt{\sum_{i \subset I_{un}} (r_{ui} - \overline{r}_u)^2} \sqrt{\sum_{i \subset I_{un}} (r_{ni} - \overline{r}_n)^2}} \quad (2)$$

The values of the metric range from 1.0 (complete similarity) to -1.0 (complete dissimilarity). Negative correlations do not increase the prediction accuracy [18], so they are discarded.

The output of the algorithm is a ranked list of top-n items with the highest predicted rating, which is recommended to each user of the community.

In order to evaluate the recommendation algorithm's accuracy, we need to choose the number of neighbors for each user (parameter $neighbors_{uu}$). The experiments that run the algorithm with different values of the parameter are now presented. Figure 4 shows the RMSE of the prediction algorithm for increasing values of $neighbors^{uu}$; this is the common way to choose the value [19]. Our results reflect the trend described by the authors, i.e., for low values of the parameter, great improvements can be noticed. As expected, RMSE takes the form of a convex function (Figure 5 shows a detail of Figure 4), which indicates that after a certain value improvement stops. In the experiment that value is 100.

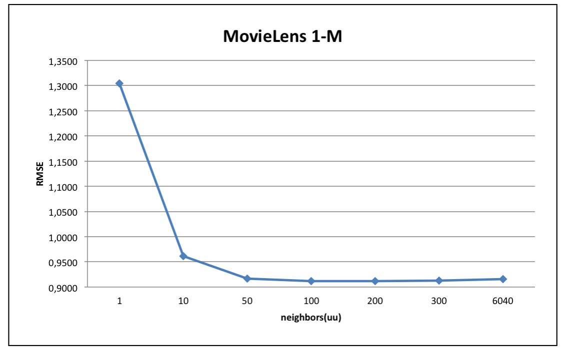

Figure 4. RMSE values for increasing number of $neighbors^{uu}$ in the MovieLens-1M dataset

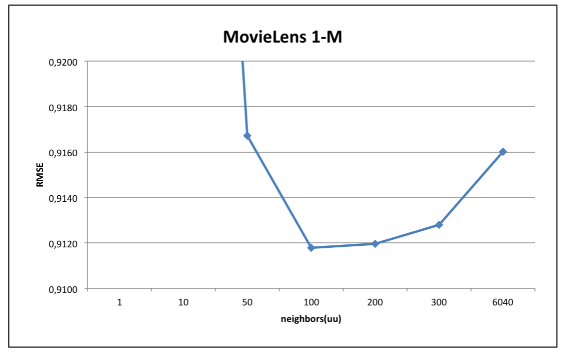

Figure 5. RMSE takes the form of a convex function in the MovieLens-1M dataset

Independent-samples t-tests to evaluate the difference between the results obtained between 100 and the other numbers of neighbors, are presented in Table III. Results show that there is no difference between choosing 100 and 200 neighbors. Since it is faster to compute predictions considering 100 neighbors instead of 200, $neighbors^{uu} = 100$ is the value chosen for the algorithm.

V. CONCLUSION AND FUTURE WORK

In this work, we presented Social Glue which is a scalable, pluggable, and multi-platform social analysis service designed to overcome many of the obstacles researchers face during the analysis of huge amounts of data coming for example from social networks sites. Social Glue is able to easily integrate with any kind of social network site allowing scientists to execute any kind of algorithm by means of its advanced plugin mechanism. In this way, researchers can both launch

TABLE III. STUDENT'S T-TESTS - VALUES OF THE $NEIGHBORS^{UU}$ PARAMETER.

MovieLens-1M	p
$RMSE_1$ vs. $RMSE_{100}$	0.00
$RMSE_{10}$ vs. $RMSE_{100}$	0.00
$RMSE_{50}$ vs. $RMSE_{100}$	0.00
$RMSE_{100}$ vs. $RMSE_{200}$	0.82
$RMSE_{100}$ vs. $RMSE_{300}$	0.33
$RMSE_{100}$ vs. $RMSE_{6040}$	0.24

 ISBN: 978-1-61208-459-6

and monitor their algorithms focusing on the experiments rather than wasting a considerable effort on the software infrastructure needed merely to set up the experimentations.

The usage scenario we described clearly shows the potential benefits the platform can provide. As a future work, we are planning a large scale experimentation based on data collected from multiple real big data providers in order to evaluate how the service performs with different and well-known analysis algorithms.

ACKNOWLEDGMENT

This work is partially funded by Regione Sardegna under project SocialGlue, through PIA - Pacchetti Integrati di Agevolazione "Industria Artigianato e Servizi" (annualità 2010).

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Home Lighting System Managed by Practical Reasoning Agents Society

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***Abstract*—The Agent-based Home Lighting Systems have shown good results decreasing electricity consumption and enhancing user comfort. However, there are certain characteristics of agent theory that have not been implemented, or even so, they are done in an inappropriate way. The main goal is to embed intelligent agents on this systems, so that they are capable of automatically decide over household resources use. The collaborative and cooperative decision-making behaviors are aspects of agent theory that may deal with the system management. Unlike regular lighting control systems, agents go beyond inputs refinement and output procurement. Agents have autonomous behavior, which, in the near future, will bring about what is called a Home Automation System as a Multi-Agent System. Previous approaches have designed solutions that divide the control of a lighting system into functional stages and thus assign specialized agents to perform each of them. These approaches distribute the solution but does not apply agent's society approach. This paper describes the functionality and composition of a Home Lighting System Managed by Practical Reasoning Agents and how it improves the weaknesses of other approaches. It does not present implementation results as it is just the architecture, and the implementation is let as future work phase.**

Keywords–agent; decision-making; energy use rate; home lighting system; user preferences.

I. INTRODUCTION

Nowadays, an inefficient use of resources in a house is typical. Electricity, water, LP gas and more, are used in an inappropriate way by home appliances, equipment, infrastructure and residents themselves. Some examples include usage of home appliances and entertainment systems for long periods of time, excessive use of water by garden irrigation systems, and improper use of air conditioning systems, among others. Home lighting is not the exception for this kind of waste, as an inappropriate distribution and selection of lighting sources (bulbs, lamps, luminaries, etc.), as well as, the misuse of them can be found.

In the recent years, agent-based home lighting systems have been developed with the purpose to optimize energy usage. The intelligent agents in those approaches, monitor, control and take decisions upon the system's state, mostly based in user preferences [1]–[5]. Also, these approaches distribute the management of the home lighting system into functional stages. Through this, they assign specialized agents to perform over each one of the stages. In general, those stages can be categorized mainly in perception, action and decision layers. The perception layer provides the current state of the system by means of agents administration of different sensors types. Actuation layer is quite similar to perception, but the intelligent agents control actuators to change the system state. Finally, in the last layer, decisions are performed through the implementation of algorithms or control mechanisms in agents, using the system's state obtained from perception layer as input and sending an action to action layer as output.

The scope of this document is to detail the proposal of a new agent-based home lighting system architecture, in which state-of-the-art implementations advantages, disadvantages, and main characteristics were taken into account for its design. The proposed model is based on the interaction of an agent society directly with the environment, something that other architectures do not have. Also, the agent society is in charge of managing the state of the system according to user preferences, plus energy consumption. Therefore, the environment is used to provide a representation of the physical world to the agents.

This document is structured as follows. In Section II, a comparison between agent-based home lighting systems is presented in terms of how perceptions and actions are performed, what decision-making algorithms have been used, and how these approaches manage user preferences and energy consumption rate. In Section III, the proposed architecture is described in terms of how the system's state is represented, shared and changed, the organization of the agent society, the process to reach a decision and how it performs an action plan. Section IV discusses how the weaknesses of previous designs can be improved by the proposal here presented, as well as, it describes the differences between approaches. Finally, the conclusions of the proposal and future work are discussed in Section V.

II. INCLUSION OF AGENTS IN HOME LIGHTING SYSTEMS: A COMPARISON BETWEEN APPROACHES

Because of the agent's paradigm nature, many of the systems that implement these approaches for lighting management can be described, in general, in a three-layer basis: perception, action and decision [1]–[6]. Some of these approaches are clearly divided in three layers [5]. In others, these layers can be merged in different combinations [1]–[4]. The purpose of the following comparison between approaches is to identify their main characteristics, and take them as a basis to develop a potentially improved architecture. Such comparison is summarized in Table I, and is described in following paragraphs.

 ISBN: 978-1-61208-459-6

TABLE I. AGENT-BASED HOME LIGHTING SYSTEMS FUNCTIONALITY DISTRIBUTION.

Author	**Sandhu, et al. [1]**	**Bielskis, et al. [3]**	**Mady, et al. [2]**	**Wang, et al. [4]**	**Paulauskaite-Taraseviciene, et al. [5]**	**Damián A. González N., et al.**
			Perception layer			
What does the system sense?	-Light -Occupancy -User preferences	-Temperature (indoor/outdoor) -Carbon dioxide -Light level -Users' ElectroDermal Activity (EDA) -User's electrocardiogram (ECG) -User's skin temperature signals	-Luminance -Occupancy -Light intensity -User luminance preferences	-Light intensity -Solar radiation -Infrared camera data -PIR data -User preferences -Energy data	-Luminance -Occupancy -Light intensity -User luminance preferences	-Residents occupancy -Residents preferences -Energy consumption -Light intensity -Light ignition
Who is/are in charge of system perception?	-Supervised learner agent -Reinforcement learner agent	-Thermo_measurer agent -CO2_measurer agent -Light_measurer agent -AV_FIA agent	-Person Movements agent -Daylight Intensity agent -Window Blinding Occlusion agent	Sensor agent	-Lighting Sensor agent -Resident Location Sensor agent	Environment
How do sensations are gotten?	-Occupancy sensor -Photosensor	Embedded system administrators of digital thermometers, carbon dioxide sensors, light level sensor and instrumentation amplifiers	-RFID detector -Light sensor	Multi-sensors	-Lighting Sensor -Hybrid Ultrasound and Radio Frequency (RF) technology	-Occupancy sensor -Light intensity sensor -Power meter -User Interface
What does/do it/they do to achieve system perception?	NIA	Analysis, storage and propagation of sensor measurements	Analysis and propagation of sensor measurements	Analysis and propagation of sensor measurements	Analysis, interpretation and propagation of sensor measurements	Analysis, storage and propagation of sensor measurements
			Decision layer			
Who is/are in charge of system decision?	-Supervised learner agent -Reinforcement learner agent	Radial Basis Neural Network component	Control agents	Local Lighting Agent via a Data Fusion Center	Decision agent	Agent society
How does/do it/they do to achieve system decision?	Via supervised and/or reinforcement learning	Radial Basis Neural Network	PI-Controllers	ANFIS	ANN, Fuzzy Logic and Bayesian approaches	Worth-Oriented Negotiation process
How does the system obtain decision data?	Sensors	-Thermo_measurer agent -CO2_measurer agent -Light_measurer agent -AV_FIA agent	-Person Movements agent -Daylight Intensity agent -Window Blinding Occlusion agent	Sensor agent	-Lighting Sensor agent -Resident Location Sensor agent	Perceiving environment
Who performs decision deliberation?	-Supervised learner agent -Reinforcement learner agent	EnvironmentCon-troller agent	-Daylight Intensity agent -Window Blinding Occlusion agent	Local Lighting agent	Control agents	Agent society via Environment
			Actuation layer			
What does the system actuate?	Lighting ballasts	-Fans -Lamps -Air-conditioners	-Sunblinds -Bulbs	-Lamp -Sunblind	Bulbs	-Dimmer -Switches
Who is/are in charge of system actuation?	-Supervised learner agent -Reinforcement learner agent	EnvironmentCon-troller agent	-Daylight Intensity agent -Window Blinding Occlusion agent	Local Lighting agent	Control agents	Environment
Where do actions are gotten from?	-Supervised learner agent -Reinforcement learner agent	AmbiantComfort agent	Control gents	Local Lighting Agent via a Data Fusion Center	Decision agent	Agent society

A. Perception Layer

The perception layer, as its name indicates, is where the state of the system is sensed, and is made up of a set of descriptive parameters. From "Perception layer" column in Table I, it can be observed that all the approaches differ in the type of measurement units in which the system state is sensed. These measurements are obtained by different types of sensors, from physical states to user physiological sensations. For readings of physical states, lighting and occupancy sensors are mainly used. In the case of user sensations, instrumentation amplifiers are used to obtain occupant's bio-signals in order to compute them. The installation of all these sensors in the house infrastructure brings minor inconveniences, because there exist diverse network protocols to interconnect several types of devices [7]–[9]. However, when users are required to wear sensors, it may become an issue, because of inherent human behavior misconception or fear to changes. In particular, for an office area, described by Sandhu et al. [1], two approaches of sensors installation are suggested, the workspace-based and the user-based configurations. The first of them uses static occupancy sensors located at strategic places where users sit, and the second require that users wear badges in order to locate them and identify their preferences. Workspace-based approach is appropriate for spaces such as offices where employees have specific places to sit. Otherwise, for a house environment, the user-based approach is more feasible but limited by some considerations. Residents may tolerate to carry a wearable sensor or even its own smart device but always taking into account comfort and personal information security and privacy.

Actually, in all approaches, the perception functionality is accomplished by one or multiple agents that, by means of sensors measurement, analyze, interpret and propagate sensor's readings to those other agents who may require them. Authors such as Paulauskaite-Taraseviciene et al. [5] emphasize the fact that agents responsible of perception layer, must only share data when there exists a request or when a significant and useful change occurs.

B. Action Layer

This layer interacts with the environment in order to change the perceived state of it. As shown in Table I, actuators are the instruments used to change the quantity of light provided by natural or artificial light sources (sunblinds, bulbs, lamps, etc.). The tasks of agents in this layer are quite similar to those performed in perception layer, they include analysis, interpretation and propagation of actuators measurements. But, these agents are able to change the state of affairs on the environment. All actions made by agents in this layer come from the decision layer.

It is noteworthy that not only agents manipulate actuator devices, but also its occupants. Their actions are taken as a feedback to measure the performance of the system. Thus, they are used by the decision layer in order to improve system's response, either with an energy decrement or with the profiling of user preferences.

C. Decision Layer

The decision layer determines the actions to be performed, based on user preferences and/or energy consumption. Thus, if a change is required, an action is to be decided by this layer. For this, one or a variety of algorithms are performed by specialized intelligent agents.

Other approaches differ in the selection of algorithms used in the decision layer. The decision-making of Paulauskaite-Taraseviciene et al. [5] has a "Decision Agent", that is capable to operate in two modalities: decision-making and learning or re-learning. In the first, a ”Decision Agent” executes an algorithm based on Artificial Neural Networks, Fuzzy Logic and Bayesian approaches to make a decision. It uses data received by sensor agents, establishing actions to be sent to ”Control Agents”. The learning or relearning takes place when a resident adjusts an already computed solution, in order to set up the next status of the actuator. This adjustment is taken as user's feedback for later learning purposes.

Sandhu et al. [1] describe two approaches when the system needs to execute an action: supervised and reinforced learning. In the first, training data are obtained from sensors and recorded actions, where sensor readings are the inputs and user actions are the target values. Then, a mapping between sensor and target values is made, in order to perform an appropriate control of lights. Thus, the task of a supervised learner is to minimize the difference between its action and user's action.

A reinforced learner merges user location and lighting reading to represent the environment's state, in order to generate actions that lead to an appropriate illumination setting. Reinforcement is based on how agent's actions approximate to those of the user. The absolute value of the difference between the illumination reading after an agent's action, and the illumination reading after the user action in the same state, is used as negative reinforcement, or punishment. In contrast, when an action performed by the agent and the user does not change anything (i.e., user is pleased with illumination setting), the agent receives a positive reinforcement, or reward.

The system developed by Bielskis et al. [3] is based on a index called Ambient Lighting Affect Reward (ALAR), which expresses human comfort. The system predicts the indoor RGB LED illumination conditions by measuring the ALAR index that reflects the sense of comfort of the resident.

Mady et al. [2] describe a ”Control Model” that is comprised by a ”Centralized Controller” that takes as inputs the user's illumination preferences, user's location and light intensity readings. The outputs are the illumination level and blinding position. The ”Centralized Controller” is integrated of an ”Optimization Engine” and a ”Refinement Controller”; PI-Controllers sub-compose the ”Refinement Controller”. For the representation of the ”Control Model”, two types of agents were used: control and environment agents.

The proposal of Wang et al. [4] is a multi-agent system applied to the control of household illumination. The system focuses on the user and communicates to him/her through a wireless network and a system terminal, that can be a personal computer, smarthphone, wearable device, etcetera. The system takes into consideration different variables, such as ambient illumination, occupancy, energy limitations, user preferences among other information, in order make a decision. By using an Adaptive Neuro Fuzzy Inference System (ANFIS), they estimate environment's visualization and occupancy of users, which are used by the control host in conjuction with user preferences and energy data for the decision-making process. The multi-agent system consists of three types of agents: central agent, local light agent, sensor agent and person agent.

From above implementations, common patterns of agent societies can be detected and described as follows. Agents have specific tasks that contribute to the main goal of the whole system. A communication is established to exchange information and/or goals. The decision-making task takes place in a dedicated part of the system. Algorithms used to select actions can be seen as processes that ingest several inputs to accomplish a goal. Also, another point to note is the importance of home residents preferences and energy consumption. User preferences can be considered very important, almost as a "law" [1], for others they are only one parameter to make a decision [2] [4] [5] and even some others do not take them into account, they focus on user physiological senses [3]. In the case of energy consumption, implementations consider it as an important parameter without leaving aside user preferences [4].

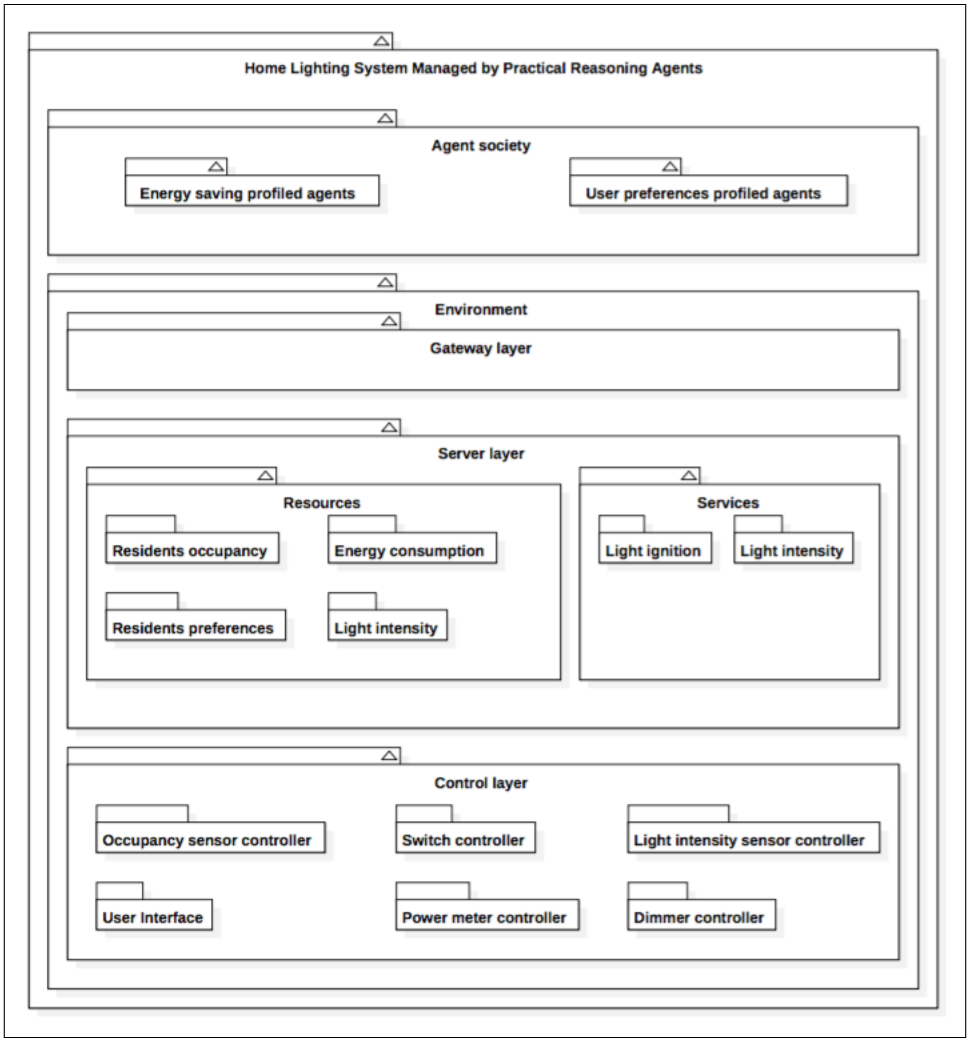

Figure 1. Home Lighting System Managed by Practical Reasoning Agents architecture.

III. Home Lighting System Managed by Practical Reasoning Agents

As mentioned above, the base of our model of a Home Lighting System (HLS) managed by Practical Reasoning (PR) agents is the interaction between the environment (an abstraction of the physical world) and a contoured society of agents (agents with guidance to energy saving and satisfaction of preferences). The structural distribution of the system consists of the environment, made of three layers, and the society of agents. Functionally, the environment is responsible for perception and action, and agents carry out the decision process. Overall system's architecture is shown in Figure 1.

A. *Physical representation*

In the proposed model, the administration of the entire system is divided into workspaces that correspond to every room of a house. Each workspace has an occupancy sensor, a light intensity sensor, a power meter, a switch and a dimmer. These are used to monitor the location of residents, measure the consumption of power, and to control the intensity of the light. Also, they are connected over a network. In the case of resident preferences, they are established by means of an User Interface (UI) and indicate the desired brightness in a particular workspace.

B. *Environment*

The environment is the component that abstracts the physical environment, allowing to obtain and modify the state of the system. This environment is made up of each workspace and controls all the sensors and actuators within the house.

1) Structure: The environment is composed of three layers: Control, Server and Gateway. The Control layer is responsible for the management of sensors and actuators and its divided into Control components. The Server layer has Resources and Services to consistently obtain the state of the environment and assign actions from and to Control layer. And, Gateway layer is the interface between the agent society and the environment itself (see Figure 1.)

2) Functionality: The Control layer of the environment manages different types of sensors and actuators. Control components assigned to sensors constantly monitor the state of power consumption, the location of the residents, the luminous intensity. Also, when required, the components share these signals to an specific resource belonging to the Server layer.

The Control components dedicated to handle actuators carry out almost the same tasks, but also they are capable of change the states of the switches and intensity regulators. States of actuators and sensors are updated on-demand by the Server layer or when a substantial change is detected.

The Server layer is divided into two types of components, Services and Resources. Resources aim to record the state of the environment through constant requests to the Control layer, and to translate it to perceptions for agents. Services component performs the same type of tasks, but its also capable to assign actions to modify the state of the environment to the Control layer. Figure 2 represents the interaction between Control and Server layer, when an update of the system's state happens.

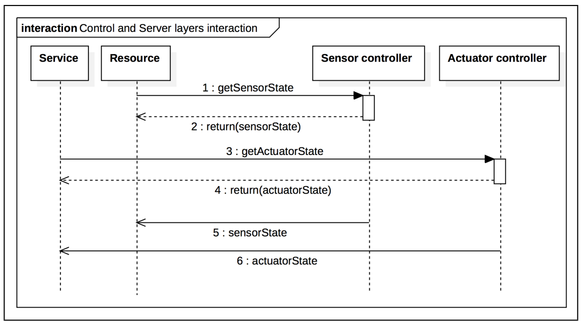

Figure 2. Control and Server layers interaction.

The Gateway layer is the interface between the agent society and the environment. The Gateway receives requests to get the status of the system and sends actions to modify it, both signals come from agent's society. Perceptions and actions are exchanged on-demand only. The message passing between Gateway layer, Server layer and a profiled agent is pictured in Figure 3.

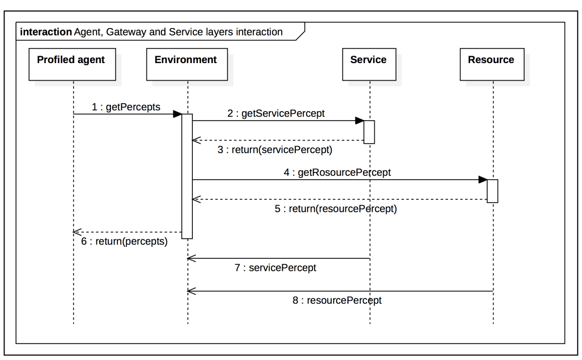

Figure 3. Agent, Gateway and Service layers interaction.

C. *Profiled agent society*

The approach allocates PR agents to the management of a HLS. The PR agent's *Beliefs*, *Desires* and *Intentions* determine the way it behaves [6].

- *Beliefs*, represent the current state of the environment.
- *Desires*, reflect an agent motivational state. They represent the objectives that an agent would like to accomplish or bring about.
- *Intentions*, are something that an agent wants to achieve or a state of affairs that the agent wants to maintain or avoid.

The society is composed of a number of agents with two types of tendencies: to save energy and to the fulfill the preferences of residents. These behaviors are observed in the *desires* of each type of agent, and they determine the way in which the management of the state of the environment is done. Agents which want to satisfy the user's preferences, tend to change the state of the environment according to the resident's desired light intensity. Similarly, agents devoted to the decrease of energy consumption prefer to modify the environment with the aim of reducing electricity consumption. Regarding to the distribution of the agents, in every workspace two agents are placed for the achievement of activities of decision, one of every category. For the stage of problem solving, the distribution in the workspaces is not a limitation, all the agents are capable of modify and of perceive the complete state of the environment.

1) Perception: Agents are able to perceive the current state of the system (a compilation of percepts) by means of the environment. Each type of percept corresponds to a property of the system: resident's occupancy, energy consumption rate, light intensity level, light ignition state and resident's preferences. The environment's state is only shared on-demand and can include one, many or all types of these percepts, depending on the request of a agent. Figure 3 shows the interaction between a profiled agent and the environment to share the system's state.

2) Reaching Agreement: The proposed approach for the decision mechanism is to have a Worth-Oriented Negotiation Domain (WOD) [6].

> *"...the goals of an agent are specified by defining a worth function for the possible states of the environment. The goal of the agent is thus implicitly to bring about the state of the environment with the greatest value. Reaching agreement involves the agents negotiating not over a distribution of tasks to agents, as in task-oriented domains, but over the collection of joint plans. It is in an agent's interest to reach agreement on the plan that brings about the environment state with the greatest worth."*

When a change in the state of the environment is detected by the agents belonging to a workspace, a process for construction of a *joint plan* begins. This type of plan is intended to change the environment to a better value and goes in accordance with the desires of the agents. *Joint plans* include from doing nothing (no plan change the environment to a better value), to a series of actions that require several agents. Once a *joint plan* is identified, a negotiation process begins. When two agents negotiate, they exchange proposals in series of rounds where the only way to continue is giving a *joint plan* that brings the environment to a higher value than received. Otherwise, negotiation stops and the latest proposal is accepted. Figure 4, shows an interaction diagram of the negotiation process.

3) Problem solving: The problem solving phase is conducted by a Cooperative Distributed Problem Solving (CDPS) process [6].

 ISBN: 978-1-61208-459-6

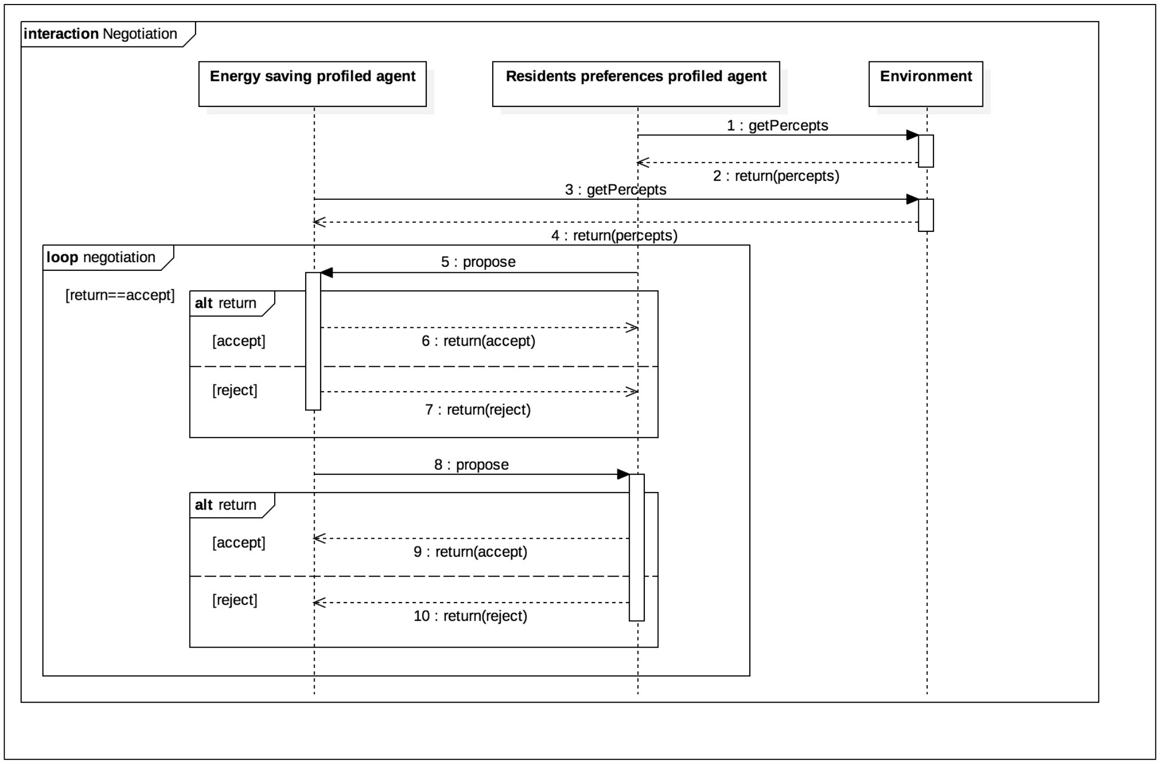

Figure 4. Worth-Oriented Negotiation process.

The CDPS process has three stages, which are summarized as follows.

1) Problem decomposition stage decomposes the overall problem into smaller sub-problems.
2) Sub-problem solution stage solves sub-problems individually.
3) Solutions to individual sub-problems are synthesized into an overall solution.

Specifically, ContracNet protocol was selected to perform CDPS process. This protocol requires an initiator and a sort of participants. In a first phase, the initiator requests agent's proposals by issuing a "call for proposals", where initiator specifies a task and conditions upon the execution of it. Subsequently, participants reply with a refusal or a proposal. Then, initiator selects the participants to perform the offered task and rejects the remaining agents. The selected participants acquire a commitment to perform the task. Once participants complete the task, they reply result to the initiator, this message can be a failure, task done or a result. ContractNet protocol is shown in Figure 5 [10]. In our approach, the initiator is an agent that previously have won a negotiation process in a workspace domain, and the participants are the rest of the agents in the system that are not performing any activity.

IV. Discussion

Section II described how different lighting systems treat the coming energy problem of improper use of lighting resource, guiding their behavior towards the preferences of users. Such description denoted the structure, operation and the role of agents in each of the systems. Section III described the

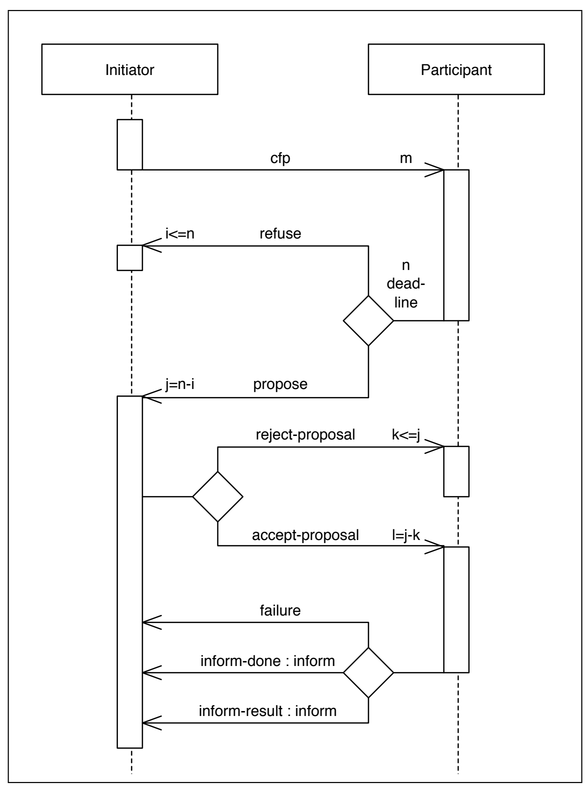

Figure 5. FIPA-ContractNet-Protocol. Adaptation of image found in FIPA Contract Net Interaction Protocol Specification [10]

 ISBN: 978-1-61208-459-6

proposal of this research work in terms of the structure and the interaction between components. Where the novel approach is the representation of the physical world's sensing and modification, by means of the environment. Also, it presents the way in which the agent society manage the condition of the system. By comparing the previous approaches, certain patterns were identified with respect to their operation and structure:

- Every agent fulfills, in a specialized manner, a specific function of the system.
- The communication that is established between agents is performed in order to exchange information and/or to assign tasks.
- The decision-making in order to change the state of the system is centralized.
- The design of the systems is very specific to the management of illumination.
- A major emphasis exists for the satisfaction of the preferences of the users, versus the decrease of electricity consumption.

The fact of splitting the functionality of the system into pieces is naturally more like a distributed system, than a MAS. As shown in Figure 6, an agent is abstractly modeled in two internal subsystems: perception and action. Where perception aims to provide the ability to observe its environment, and action, represents the decision process [6]. For the sake of the previous argument, the fact of to assign an specific task to an agent limits the essence of its definition, so the agents have specific capabilities, which cannot be to sense, decide and act, but only one of them. The agents who manage the sensors are just capable of perceiving a property of the environment, and to communicate such property. The agents dedicated to act, perceive and modify a property of the environment, nevertheless, they are not capable of determining the action that the actuator realizes. Finally, the decision-making agents, establish the actions to execute to modify the environment but, perceiving and acting are done by other agents.

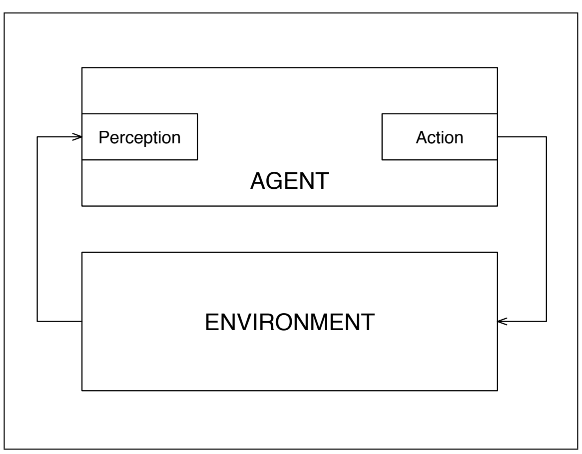

Figure 6. Perception and action subsystems. Adapted from [6]

In a MAS, the social ability goes beyond the binary exchange of information [6]. It involves the understanding and reasoning on the goals of others. Also, the accomplishment of actions to cooperate in order to reach own and other goals. For this, the agents must be capable of negotiate and cooperate. Nevertheless, in the discussed approaches this is not the case, the interaction between agents is merely to exchange perceptions and actions across a predefined protocolm and with a slightly clear sense of conscience of the goals of other agents. Likewise, the execution of an algorithm must be a part of the decision-making of the system, but not the whole process. In a MAS, the action must be agreed between the agents and established by means of a *joint plan* instead of the pure implementation of an algorithm.

Morganti et al. [11] say that a HAS is the collection of devices and appliances connected to a network, and its aim is to manage the resources in a house. The design of the previous approaches denote a high speciality in the management of home illumination. The agents are dedicated to a specific task, so these systems expose little or few scalability in terms of different services. In other words, the management of other types of resources would need the implementation of another different system.

Most of the approaches are based on the preferences and actions of the residents for the learning process of the agents, relying that information coming from them is trustworthy. This behavior may be not the best for decision-making process.For example, the residents can change their preferences and actions depending on emotional states, which not always complies with energy saving, thus in consequence this may lead to system's "corruption."

The architecture was designed to solve the issues stated above. First, each type of agent in the system shares the same capabilities for perception and action. Thus, every agent perceives an abstraction of the physical world and performs actions to modify it by means of the environment layer. Also, the decision-making process is a worth-oriented negotiation between agents in the society. So, social ability of the profiled agents is observed when reaching-agreement and problem-solving processes are done by agents interaction. Also, simple negotiation for a *joint plan* demonstrates that agents believe in other's goals. Therefore, when a decision is made, the agreement of a general task for system's state improvement and the distribution of the problem solving process are achieved by cooperation.

On the other hand, the architecture was designed with the aim of allowing scalability, regarding the structure of the system. As other agent-based HLS, this proposal takes as a principal goal the management of illumination of the house, but unlike them, it has the ability to extend the number of properties to sense. Thus, the three-stages structure of the environment allows the increase of the number of resources that can be managed in the house. Which is done by the increase on Services and Resources in the Server layer, and the variety of devices controlled in the Control layer. Also, the agent's architecture must be modified just in the type of tendencies (*desires*) and perceptions (*beliefs*). Finally, Negotiation and ContractNet protocols would be kept in essence, they would only change in the type of *joint plans* and their execution.

Another thing to note is that the agent society manages illumination over two types of profiles. As explained before, the energy saving is favored in a great manner. It is noteworthy that agents are conscious of the preferences of the users and direct their actions to fulfill them, to a certain extent. But, as the appropriate administration of the energy is the main goal, it has more importance on the proposal presented here.

Finally, some considerations must be taken when trying to implement a HLS. For example, the electrical, electronic and mechanical aspects of this type of systems influence the compatibility with others that exist in a house. Leaving aside the administrative aspect of the system, the selection and placement of light sources and luminaries in a home is an important issue when it comes to energy savings. A large part of the electrical waste comes from an inadequate placement of light sources. In many cases, with only replacing the light sources with those that consume less energy and taking advantage of the natural light resolves the excessive use of electricity. Another thing to consider is the compatibility between the rest of an existing HAS in the house, because there are many communication protocols to interconnect devices, which ones differ in the manner they perform connections. Some examples include: X10 [7], ZigBee [8] and Z-Wave [9].

V. Conclusion

This paper presents how agent-based HLS energy waste is caused by inappropriate light management, by giving blind confidence over preferences of the user. Their design, strengths and weaknesses were exposed. As said before, previous approaches take advantage of some properties of agent paradigm, such as collaborative behavior and task distribution. However, not all agent's characteristics have been fully applied. The approach proposed in this paper attempts to implement the correct agent's society paradigm over HLS requeriments. Therefore, it gives all importance to energy saving, without neglecting on user preferences, which seems to be a difficult task.

As future work, two goals have been identified. In the short term, the proposal will be implemented in collaboration with the Department of Renewable Energies of the Autonomous University of Guadalajara. The prototype will include the deployment of the agent society, the abstraction of the physical environment, and the electrical and mechanical aspects of a HLS. This prototype will be subject to a set of use cases to demonstrate its functionality, which will include scenarios to observe its energy saving performance and its behavior towards the user. A fact that it is expected to see, is that even when the user preferences are not fulfilled, partially or completely, He/She will appreciate an increasing performance in energy saving. Finally in the medium term, the house resources that the system can manage will be scaled with the purpose to achieve a prototype of a HAS as a fully MAS, for the sake of energy saving.

Acknowledgment

The authors would like to thank to the National Council of Science and Technology (CONACyT), for the scholarship No. 362650 given to Damián, in order to obtain Master's degree.

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