SMART 2015

The Fourth International Conference on Smart Systems, Devices and Technologies

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URBAN COMPUTING 2015

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Foreword

The Fourth International Conference on Smart Systems, Devices and Technologies (SMART 2015), held between June 21-26, 2015, in Brussels, Belgium, continues a series of events covering tendencies towards future smart cities, specialized technologies and devices, environmental sensing, energy optimization, pollution control and socio-cultural aspects.

Digital societies take rapid developments toward smart environments. More and more social services are digitally available to citizens. The concept of ‘smart cities’ including all devices, services, technologies and applications associated with the concept sees a large adoption. Ubiquity and mobility added new dimensions to smart environments. Adoption of smartphones and digital finder maps, and increasing budgets for technical support of services to citizens settled a new behavioral paradigm of city inhabitants.

We take here the opportunity to warmly thank all the members of the SMART 2015 Technical Program Committee, as well as the numerous reviewers. The creation of such a broad and high quality conference program would not have been possible without their involvement. We also kindly thank all the authors who dedicated much of their time and efforts to contribute to SMART 2015. 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 are grateful to the members of the SMART 2015 organizing committee for their help in handling the logistics and for their work to make this professional meeting a success.

We hope that SMART 2015 was a successful international forum for the exchange of ideas and results between academia and industry and for the promotion of progress in the field of smart systems, devices and technologies.

We are convinced that the participants found the event useful and communications very open. We hope that Brussels, Belgium, provided a pleasant environment during the conference and everyone saved some time to enjoy the charm of the city.

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Table of Contents

Operational Evaluation of New Transportation Method for Smart City

Use of Personal Mobility Vehicles under Three Different Scenarios

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***Abstract*—One potential solution to traffic issues is to reduce traffic volumes in urban areas. A number of countries, particularly Japan, will face an unprecedented situation from an increasingly aging society. Thus, new eco-friendly universal mobility vehicles are expected to be developed. We proposed the use of personal mobility vehicles as a new type of transportation device. To evaluate the possibility of our proposed transportation device, it is necessary to conduct operational evaluations under real-world conditions by employing subjects in a pilot study. We used three experimental scenarios for an evaluation. The three scenarios used each different transportation route and subjects. Traveling data and questionnaire relating related to the velocity, stability, safety, and comfort of the proposed device were gathered. The results are valuable for evaluating the social receptivity, safety, and efficiency of a personal mobility device.**

Keywords- Personal Mobility Vehicle; ITS; New Transportation Device; Pilot Study.

I. INTRODUCTION

Many researchers have been seeking ways to solve traffic problems. The increase of urban traffic has led to increases in traffic jams, traffic accidents, and air pollution, all of which have resulted in serious damage [1][2]. One potential solution to these problems is to reduce the traffic volumes in urban areas. Modal shifts from conventional vehicles to public transportation and eco-vehicles, including personal vehicles, should also be considered to reduce urban traffic volumes. In this study, we focus on personal mobility to reduce traffic volumes in urban areas.

The rapid increase in the proportion of elderly people in the population has caused several issues in Japan [3]. Elderly people in Japan account for more road fatalities than any other age group [4]. Automobiles are an optimal means of transportation for the elderly because automobiles allow for door-to-door transportation. However, to address the traffic problems described above, we have to shift at least some movement of people from individual automobiles to public transportation, some aspects of which are less than ideal for the elderly. To resolve this conflict, useful and eco-friendly transportation must be provided for the elderly people. Although public transportation is useful and eco-friendly, the last-mile problem remains, particular for elderly users [5]-[7]. Personal mobility is considered the only option for solving this problem.

To address the aforementioned two challenges described above, we propose the use of personal vehicles as a means of future transportation. The main objective of this study is evaluating the feasibility of a new mobility device, i.e., a Winglet personal mobility vehicle, which is produced by the Toyota Motor Corporation of Japan. To obtain various types of related data, we prepared three different real-world scenarios under which we conducted an experiment using mobile sensors; in addition, we gathered questionnaire results regarding the subjects' overall experience with these scenarios.

Herein, in Section 2, the Tsukuba Designated Zone, where the real-world experiment was conducted, is described. In Section 3, we present the evaluation questionnaires provided. In Section 4, the results of the real-world experiment are all described.

II. TSUKUBA DESIGNATED ZONE FOR EXPERIMENTS

This section describes the Tsukuba Designated Zone, where the experiment was performed. This institution was formed to improve robotics technology (personal mobility is considered to be in the robotics category in Japan). It was officially approved as the Tsukuba Designated Zone by the Cabinet Office in Japan on January 29, 2010. The objective of this institution is described below.

It is impossible to do real-world personal mobility experiments in public areas because personal vehicles (including mobile robots) are prohibited from traveling in public areas under current law. Personal vehicles and robots are expected to contribute to the welfare of future generations through their low carbon emissions and high levels of safety and security. In addition, robotics technology is expected to contribute to the creation and development of new industries.

Since February 2012, Segway Japan, the Hitachi Corporation, and AIST have been engaged in conducting experiments in personal mobility, and more members, including private companies and universities, are planning to join them.

The Designated Zone has two areas for conducting experiments. One is the Tsukuba Center Station area, and the other is the Kenkyugakuen Station area, shown in Figure 1. The Tsukuba Center Station area consists mainly of a pedestrian road from the University of Tsukuba to Akatsuka Park, with a major focus on Tsukuba Central Station, where a large shopping center and a bus terminal are located. The

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width of this road is greater than 3 [m] and is sufficient to allow use by bicycles. For these reasons, this public area is appropriate for experimental studies. Even within the Tsukuba Designated Zone, there are some regulations that apply to conducting experiments.

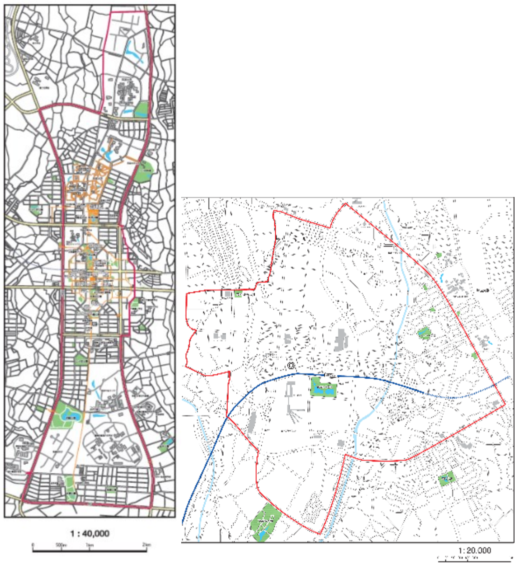

Figure 1. Tsukuba Designated Zone (Left: Tsukuba center area, Right: Kenkyugakuen area)

III. Operational Evaluations in Three Scenarios

We conducted an operational evaluation through real-world experiments. This section describes three scenarios employed in this study, the experimental conditions, the questionnaires provided, and the experimental results, as well as an overall discussion.

A. Personal Mobility Vehicle

The Winglet shown in Figure 2 was employed as the personal mobility vehicle in this study. The Winglet is an assistance-type mobility device that is ridden in a standing position and is designed to contribute to the realization of a world in which everyone can enjoy mobility freely and safely. The Winglet is more compact than a Segway personal mobility device [8]. We equipped each Winglet with several sensors to record data near incident scenes and record travel-related data (velocity, accretion, yaw rate, and location). We chose a Winglet because it is a two-wheeled, self-balancing vehicle, and riding a self-balancing vehicle poses different risks than riding a bicycle or walking.

Figure. 2 Winglets (equipped with mobile sensors)

B. Experimental Scenarios

All routes used in this study are located in the Tsukuba Designated Zone in Japan, which is described in section 2. We chose three scenarios, each of which has different features including a different route and subjects. Before conducting the experiments, we applied a risk assessment of riding a Winglet for every route. Each of the three scenarios is described in the following sub-sections.

1) AIST to Tsukuba St. (Scenario 1)

The route for scenario 1 runs between the AIST and Tsukuba Station in the Tsukuba center area. This route consisted of roads that are open to both pedestrians and cyclists. The route used for the experiment is shown in Figure 3 and Figure 4. The blue line shows the route itself, and the blue dots show the locations of the two stations in Figure 4. The route is mostly flat, but includes some slopes and pedestrian crossings. The surface of the route is asphalt and stone pavement. The distance of this route is about 3.6 km. The subjects participating in the experiment were AIST staff members and licensed drivers. The subjects ranged in age from 31 to 56, with an average age of 46.6. All subjects are engineering researchers. Most of the subjects typically use free AIST buses to or from Tsukuba station. For this scenario, the subjects used a Winglets as substitute for an AIST bus.

Figure 3. Experimental area for Scenario 1 (the blule line indicates the route for this scenario 1)

Figure 4. Photographs of the experimental route for scenario 1

2) Tsukuba City Government Office to Kenkyugakuen Station (Scenario 2)

The route for scenario 2 runs between the Tsukuba City Government Office and Kenkyugakuen St in the Kenkyugakuen area. This route consists of roads that are open to both pedestrians and cyclists. The area used for the experiment is shown in Figure 5 and Figure 6. In Figure 5, the green line shows the specific route used, which is mostly flat with pedestrian crossings. The surface of the route is asphalt and stone-paved. The distance of this route is about 0.7km. The subjects participating in this experiment were Tsukuba City staff members. All subjects were licensed drivers. The average age of the subjects was 36.6, with an overall range in age of 26 to 57. All subjects were office workers. In this scenario, we asked the subjects to use a Winglets as substitute for walking or using their own vehicle, and some of the subjects tried to modal shift from a vehicle to train and Winglet.

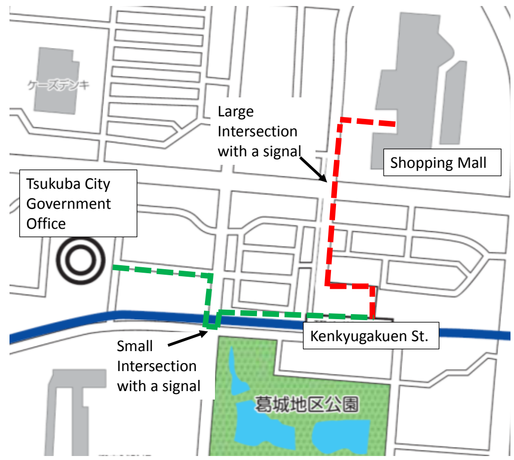

Figure 5. Experimental area for both scenario 2 and scenario 3 (the green lines indicates the route of scenario 2, and the red lines shows the route of scenario 3)

Figure 6. Photographs of the experimental course for scenario 2

3) Shopping Mall to Kenkyugakuen Station (Scenario 3)

The route for scenario 3 runs between the shopping mall and Kenkyugakuen St. tin he Kenkyugakuen area. This route consists of roads that are open to both pedestrians and cyclists. The route used for the experiment is shown in Figure 5 and Figure 7. The red line in Figure 5 shows the route used for scenario 3, which is also mostly flat with pedestrian crossings. The surface of the route is asphalt and stone pavement, and the distance is about 0.6 km. The subjects who participated in the experiment were staff members of the shopping mall. All subjects were licensed drivers. The average age of the subjects was about 47.5 with a margin of error of plus or minus 5 owing to an issue of privacy. Their ages ranged from 25 to 75, also with a margin of error of plus or minus 5. All subjects were office workers. For this scenario, we asked the subjects to use a Winglet on during their break period.

Figure 7. Photographs of the experimental route for scenario 3

C. Common Experimental Condition for the three Scenarios

All of the subjects participated in a seminar regarding the Winglet and received training on how to ride one. In addition, the seminar addressed the control mechanisms of the Winglet and the rules for operating a Winglet in an outdoor environment. The training included both physical skill and written tests, and every subject who participated in the experiment had to pass both tests. All testing was organized by staff members authorized by Toyota Motor Corporation. No testing was conducted under rainy or dark conditions. For safety reasons, one staff member follows behind the personal vehicle during travel.

Each subject drove his or her Winglet from the start point to the end point. There are two pedestrian crossings on each course. The use of public areas was thought to be important in obtaining experimental results that would more closely reflect reality than results that would otherwise be obtained in restricted areas or laboratories.

D. Questionnaire

Before participating in the experiment, each subject filled out a questionnaire to provide answers to the following questions.

- What are your relevant personal characteristics (gender, age)?
- Which transportation method do you usually use for this route?
- Have you ever used this type of personal mobility device before?
- Do you usually do some exercise?

Also, a conjoint analysis of the subjects' responses was conducted.

After the experiment, each subject filled out a questionnaire providing answers to the following questions.

(I) Would you use a Winglet again under the same conditions? (If no, please describe the reason why?)
(II) Do you think the distance of the course was too long? (If so, please state what you think an appropriate length would be.)
(III) Was riding a Winglet more comfortable than walking?
(IV) What was your opinion of the maximum velocity?
(V) What do you consider the advantages and disadvantages of using a Winglet?
(VI) Are there other conditions or locations under which you would like to use a Winglet again?
(VII) If you have any comments regarding this experiments, please let us know.

IV. RESULT AND DISCUSSION

The subjects covered a total distance of approximately 217 km. All of the experiments were conducted without the occurrence of any accidents or near-accident situations that could have led to serious injury. In comparison with the data available for other mobility devices such as bicycles, the amount of experimental data obtained in this study is insufficient to assess the safety of the device. Nevertheless, this mobility device is believed to provide a significant measure of safety. We will continue to conduct experiments to prove its safety statistically in future studies.

The results and an analysis of each question are described in the following.

Figure 8 shows the results for question I. We found that the subjects expressed favorable opinions regarding the Winglet, and many expressed a desire to use it again in the future. For those who answered "no" regarding their future use of a Winglet, their reasons are as follows:

- It took too long because of the low maximum velocity (6km/h).
- I want to use the Winglet without an accompanying staff member.
- The Winglet needs to be improved when traveling on uneven roads.
- I want to avoid muscle fatigue in my foot.

These comments indicate that we need to improve the riding capability of the Winglet. In addition, privacy was found to be an important factor on using this type of mobility device.

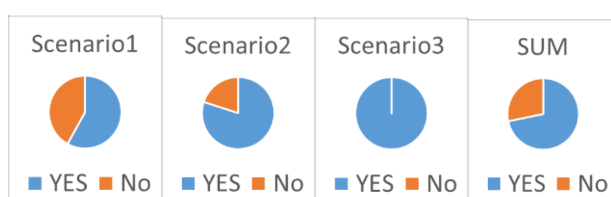

Figure 8. Results of wuestionnare I : Would you use a Winglet again under the same conditions

Figure 9 shows the results for question II. We found that the route distances of both scenarios 2 and 3 were appropriate.

Based on those subjects who answered "yes" to whether the distances were appropriate, it is assumed that the average appropriate distance for a Winglet is about 2.6 km.

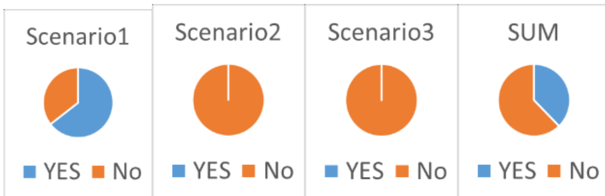

Figure 9. Results of questionnare II:Do you think the distance of the course was too long?

Figure 10 shows the results for question III. Most subjects answered that the Winglet is more comfortable than walking. It is assumed that a Winglet can contribute to a reduction in fatigue when traveling.

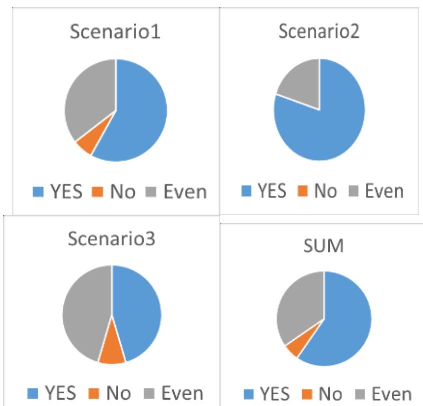

Figure 10. Results of questionnare III ("Even" indicates no difference between riding a Winglet and walking)

Figure 11 shows the results for question IV. None of the subjects answered that the maximum velocity (6km/h) was too fast. About 80% of the subjects who answered that it was too slow hoped for a maximum velocity of over 10 km/h, and the average maximum velocity desired was about 12 km/h. Depending on the user preference, it may be better for users to be able to change the maximum velocity.

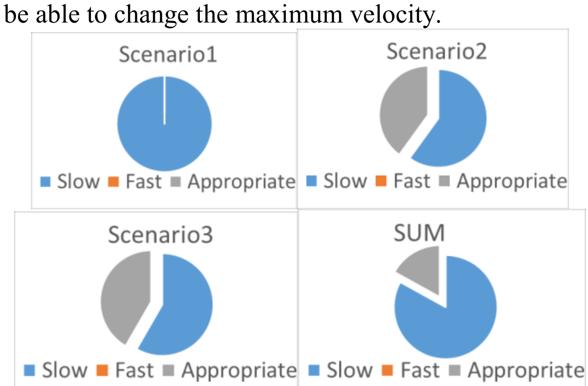

Figure 11. Results of questionnare IV: What was your opinion of the maximum velocity?

Positive comments in the result of question V are as follows:

- I was able to enjoy great view because of the higher vantage point when riding the Winglet than when walking.
- I could communicate well because I felt comfortable during the experiment.
- I can commute to my office without using my vehicle
- I can travel without sweating.
- I was comfortable without pitch movement compared to walking.
- I can avoid getting my shoes dirty.

Most of the subjects provided comments related to the better vantage point while riding the device, which was unexpected, but may be a significant motivation for people to utilize a personal vehicle such as a Winglet. There were no negative comments in the results for question V.

Other possible uses for a Winglet found from the result of question VI include the followings:

- On sloping roads
- In a shopping mall
- For sightseeing
- For poor physical condition
- To go to a restaurant during lunch break
- On patrol

The results of question VII indicate that the subjects found it easy to avoid pedestrians when riding the Winglet because the footprint of the Winglet is close to that of a pedestrian and the device is easy to turn. Although the maximum speed of a Winglet is 6 km/h, which is close to walking speed, the rider of a Winglet tends to maneuver to avoid pedestrians before the pedestrians maneuver to avoid the rider.

Based on the results of all of the question, we determined the following evaluations regarding the use of a Winglet.

- The device should be utilized for short transportation distances owing to its size and velocity.
- It is useful for multiple purposes including commuting and sightseeing.
- It can be a great private transportation device.
- It assists the rider, especially when traveling on sloping roads.

The results of this technological evaluation are similar to reports on experiments conducted using Segway [8]-[13]. In analyzing the questionnaire results, we found that those people who used this personal device expressed favorable opinions for all three different scenarios.

The results obtained show that a Winglet personal mobility vehicle offers good social receptivity and safety on pedestrian roads, regardless of the age or gender of the rider. Therefore, riding a Winglet is presumed to be a feasible activity for all types of people, regardless of their age, gender, exercise habits or other factors.

To examine the various factors that can affect the experience of a Winglet, the relationships among the various factors identified from both the questionnaire and data analysis results will be analyzed in a future study.

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In Japan, traffic regulations prohibit the use of standing-type vehicles, such as Winglets and Segways, on public roads, and hence, it is difficult to conduct experiments with these devices frequently, as mentioned previously in the section on the Tsukuba Designated Zone. Thus, the relaxation of these regulations is key to encouraging the use of the Winglet. If this issue is resolved, this system can be more widely used and would be particularly useful in a country such as Japan, given its traffic jams, expensive parking fees, and limited availability of parking lots. The findings obtained concerning efficiency, protection of the ecosystem and traveling data are not presented in this paper.

V. CONCLUSION

In this paper, we described an operational evaluation of a personal mobility vehicle as new type of transportation device. To evaluate the feasibility of the proposed transportation device, it was necessary to conduct an operational evaluation under real-world conditions by employing actual subjects in a pilot study. We used three experimental scenarios for our evaluation, each of which applied a different route and subjects. Travel data and questionnaire results related to the velocity, stability, safety, and comfort of the device were gathered. These results are valuable for evaluating the social receptivity, safety, and efficiency of a personal mobility device. In analyzing the questionnaire results, we found that the people who used this personal mobility expressed favorable opinions of the Winglet in three different scenarios. No accidents associated with the Winglet occurred during our experiments. Thus, the results of three experiment and questionnaire described in this paper show that Winglet personal mobility vehicle offers good social receptivity and safety on pedestrian roads for the multiple purposes. The Winglet riding assistance system for personal mobility are being developed [14][15]. A personal smartphone is used to determine percentage of closure of eyelid, eye blink time, eye-blinking rate, eye gaze, pupil movement, eyelid movement, postures, head pose using the front camera as well as Winglet speed and acceleration, vehicle headway (measurement of the distance or time between vehicles), lane position and road signs, Winglet turns using the back camera and other smartphone sensors. Rider Assistance Systems are the systems that assist the rider during the driving process. They are designed with a safe human-machine interface aiming to increase vehicle and road safety. It is common practice that such kind of systems are designed for car riders by the third party manufacturers that are specialized on them and can develop similar applications for the smartphones and tablets.

For future work, we will perform the experiments with the riding assistance system in the real world.

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Party4All: A Collaborative Digital Solution to Map Accessible Bars and Restaurants

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***Abstract*—This short paper presents results of a survey made with disabled people, to understand how they feel when visiting public locations with accessibility problems. It focuses especially on topics related to find the most suitable place, in terms of accessibility, in big cities. This version focus on bars and restaurants in Brazil. In addition, it presents existing applications that intend to assist disabled people to reach selected places. Finally, it elicits the opportunity to present a new digital solution, called Party4All, which presents opportunities to be more accessible and efficient than the depicted application.**

Keywords-eliciting; survey; accessibility; disabled; solution; restaurants.

I. INTRODUCTION

Universal Declaration of Human Rights states that human rights should be applied to everyone, but in practice, they are often denied to disabled people. Their interest a frequently ignored, either for political, economic or social motivations [1].

Around 15 percent of world's population, or estimated one billion people, live with disabilities. They are the world's largest minority. Eighty percent of people with disabilities live in developing countries, according to the UN Development Program [2].

Brazil - which will be used as representative of developing countries to investigations and solution proposed in this short paper - has about 45.6 million people with disabilities. They represent approximately 23.92% of the country population [3]. In Figure 1, is possible to see the percentage of people for each type of disability. According to Brazilian Institute of Geography and Statistics, 38.4 million of these people live in urban areas [4]. These areas come to be where most of the public services are located.

An appropriately designed environment may include enabling positive experiences of all users; yet public spaces are not always concerned about people with disability accessibility, in the universal sense. But manufacturers and builders who use the universal design concept, design their products and buildings to be as usable as possible by a larger population including children, older people, and people with disabilities. [5]. This universal approach to the designed environment allows the full social participation of everyone in the activities of public spaces regardless of age or ability. Everyone should have the right to choose and move around freely in any environment. No matter who, a person must have the chance to do what s/he wants and needs, including accessing houses, work, transportation, or social venues [6].

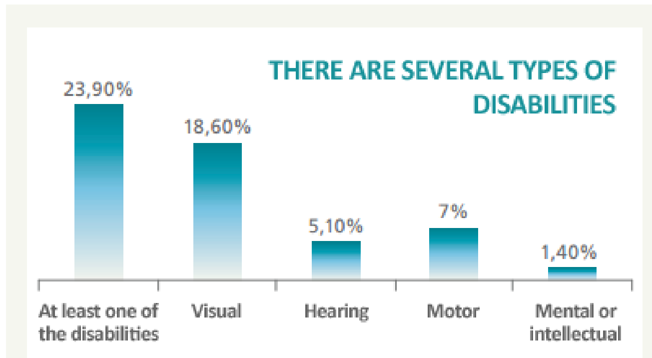

Figure 1. People percentage for disability type in Brazil in 2010

This short paper has as main goal to analyze disabled people accessibility experience when attending bars and restaurants in big cities of developing countries. It also investigates how these people feel about places that are not prepared to provide adequate services to them. Besides the bars and restaurants services, this paper also talks about a search over existing application that have the purpose to assist disabled people in finding accessible establishments. In addition, as result of this investigation, the paper presents a new digital solution proposal that aims to be more complete and efficient than other solutions found during the previous search.

Section II presents the background material. It also talks about accessibility concepts and challenges faced by people with limited mobility, when attending a place not adapted to receive them. In Section III, there is an analysis of three digital solutions that intend to help disabled people to find accessible places. The user survey results are also detailed. In Section IV, conclusion and next steps are described.

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II. BACKGROUND

A few years ago, it was rare to find a space with adapted toilets for people with disabilities or reduced mobility in bars or restaurants; today this is a trend. The Brazil national´s and regional´s laws state accessibility rules, and the increased importance of accessibility in the business marketing. Looking for a new audience and a consumer who values social commitment, the entrepreneurs begin to see the importance of adapting to accessibility rules, presenting opportunities in the field of adaptation. There are laws that require adequacy of tourist and leisure facilities to the requirements of ABNT 9050, making these spaces accessible to all people, including those with some type of special needs [7].

Although there are several studies on tourism and accessibility, there are few, or almost nonexistent, researchers focused on accessibility in gastronomical enterprises [8]. During an ethnographic digital research on specialized websites and social network communities, focused on disabled people – one of the first's steps of investigation to produce this paper - it was possible to see that this public wants to know more, enjoy and promote social inclusion initiatives. Anonymous statements on Brazilian Adapted Tourism blog attest that, when they go to accessible bars and restaurants, they recommend them. If not, they spread around the web their opinion about the bad services [9].

Focusing on this, an opportunity was perceived to work on an application to help them to map bars and restaurants, according to their suitability for accessibility, in large cities. The app should also help to find these sites easily, helping people with disabilities to get to the establishments, and entrepreneurs to propagate their services.

Accessibility is, according to Brazil´s Law No. 5,296 / 2004, a condition to use, with security and autonomy in whole or assisted spaces, furniture and urban equipment, buildings, transport services and devices, systems and means of communication and information for people with disabilities or reduced mobility. An accessible environment permits to be utilized and enjoyed by anyone, including those with disabilities [10].

Although people with disabilities are often seen with the stereotype of being unable to lead a normal life, they show up to be active and able to interact. They can participate in any activities as others, if provided adequate accessibility conditions [1]. During our ethnographic research, we found out how much people with disabilities were bothered about not having their rights respected, as much as any other citizen rights. Frustration and anger are feelings that appeared in their testimony. They state, "The world persists in believing that they would be locked in the house".

However, instead of complying with these preconceptions, they show disposition to fight to make everyone understand that they have a life, and they want to live it as any other [9].

III. SIMILAR APPLICATIONS

During investigative web researches and consultations with experts on disabilities – one professional and one director of a disability association - just a few mobile device applications showed to be available to assist people with limited mobility to name and locate properties that fall out the accessibility rules, particularly in Brazil. Three of them stood out and were chosen to an analysis, that took into account the following aspects: served platforms; general visual aspect; possibility to add new establishments; coverage of bars and restaurants in 5 biggest cities in Brazil; main features; possibility to share results and comments on social networks; feedback for establishment owners. Results of this research come next.

A. *Clapp-in*

Clapp-in is an application produced in Brazil with objective to allow users to applaud public or private establishments, according to their adaptation to accessibility [11]. With announced intention to promote social inclusion of people with disabilities in tourism and leisure, it allows people to map, evaluate and comment on application with notes and opinions about the visited establishments. In Figure 2, one can see app´s screenshots with a home screen, where user is introduced to application and its objective and also a main screen image, with a list of establishments, its addresses and evaluation results, represented by claps icons (from 0 to 5 claps).

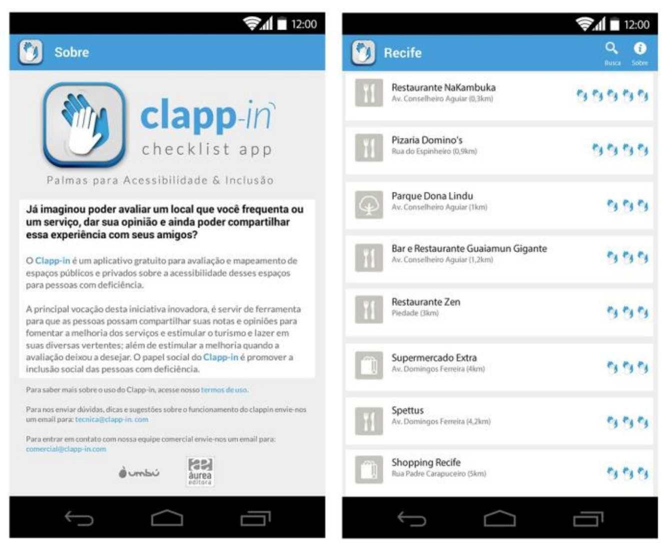

Figure 2. Clapp-in screenshots

Available for Android, it was possible to install it only on one of the four devices in which we performed tests – Samsung Grand Duo (Android 4.1.2), showing that it still does not seem adapted to the various versions of platform. The other phones were a Samsung SII TV (Android 4.2) and 2 Moto G (Android 5.0.2).

Clap-in has a simple design, but makes it clear to user its objective, and is not difficult to use. However, share comments on social networks or send feedback to establishment owners, are not possible with this application. Moreover, the numbers of establishments already registered at app are not significant, in comparison with the millions of public services offered in one of the 5 biggest cities in Brazil, which were taken into account during this analysis. That can make the app not very helpful for the user.

B. *Accessible Tourism*

Accessible Tourism is a Brazilian Ministry of Tourism program application and has the function of allowing collaborative construction of accessible establishment's data bank throughout the country [12]. Available in IOS and Android, it allows users to add new establishments in the system and information, such as city and type of service, covering not only bars and restaurants, but any public site. Users can also rate and seek for establishments according to type of disability. In Figure 3, one can see some of application´s screenshots: home screen with shortcuts to find accessible places according to disability type and a screen listing establishments prepared to receive people with physical disabilities.

With attractive design, large icons with clear metaphors and list items placed so user can select them and perform searches with ease, as well as an information hierarchy well planned, the application shows efficiency. This app has no integration with social networks and it has no possibility to locate establishments on a map for easy access. It was also noted that only 2 of the 5 biggest Brazilian cities have a significant number of feedbacks or information inputs.

Figure 3. Accessible Tourism screenshots

C. *Wheelmap*

Whellmap [13] is an online map to search, find and mark wheelchair accessible places around the world. It permits anyone to participate in this map, marking public places as restaurants, cinemas, bar or supermarkets. Wellmap is available for website, iPhone and Android. Easy to install, the app on iPhone 6 has an attractive and clear layout. Users can easily find establishments, evaluate them, comment and share by twitter, Facebook or email. They can also filter establishments on the map by categories, which is very useful. Although it was possible to see that are many places already mapped in Brazil, just a very few of them had their wheelchair accessibility marked. Figure 4 presents some app screenshots: a map with various establishments, identified according to their accessibility level. There is also a screen shot with more details of a restaurant, showing options for sharing, commenting and tracing the route to go there [13].

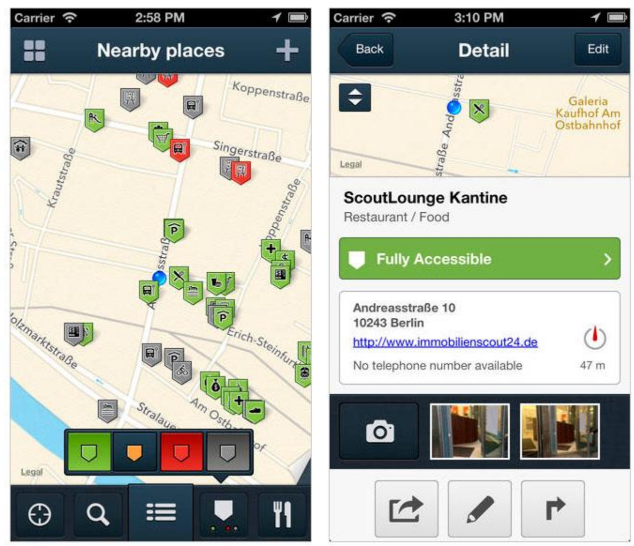

Figure 4. Whellmap screenshots

When conducting this research on Whellmap, we wonder why Brazilian government data is not part of this international effort to map accessible establishments, rather than having its own application for this. The answer could be in the new Law project 5.344 / 13, which establishes the regulatory framework of cloud computing and states that to acquire cloud computing services agencies of federal administration shall require that data center is located in Brazil. The measure intends to ensure that Brazilian law prevails, over any other, in case of contractual discussion and protects data, since contractor has to be subject to audit [15].

IV. USER SURVEY

By comparing the 3 applications, it was possible to find important inputs to determine what features presented at them could be interesting to add to a new solution proposal, and which ones are not relevant to this new app objectives. Adding a new establishment and evaluating a local business, is a common feature for all of them. They are also easy to

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use and seem to have enough tools to realize their main objective – allow users to evaluate a local business, according to its accessibility. However, some items, like lower coverage in Brazilian cities and giving no possibility to contact the local owners directly, or share opinions on social networks, are features that need to be considered in a new solution. The 3 apps are also very embracing in terms of public services types and what makes it difficult for a user to find a specific bar or restaurant nearby, for example.

After the ethnographic digital research and similar applications analysis, the next step was to make semi-structured interviews with disabled people. A total of 10 interviews were conducted, of which 5 people had physical disabilities, and 5 were blind. The intention was to understand who they are, what their recreational habits and interests are, how satisfied they are with restaurants and bars accessibility.

The research also intended to identify whether there was an opportunity to offer a digital service to help people with disabilities or limited mobility, on having the same rights when attending public institutions. In addition, if there was this need, which were their main interests as users of this service? We also tried to find out if they knew any application to help find and map accessible places in Brazil. We also wanted to know if they knew an app with this objective and their opinion about it.

The interviews resulted in rich testimonials and showed some of the problems faced by disabled people. In general, they stated that there were huge improvements in accessibility of bars and restaurants in recent years. They believe that Brazilian federal and state laws, which demand establishments to meet accessibility requirements to have operating license, caused it.

The interviewees display autonomy when the environment has ideal accessibility conditions. They are able to work, study, drive, practice sports, and socialize with friends. They rely on these friends to help them, when going to places that are not easily accessible for them, but prefer to go to the ones that give them freedom without any help. In Figure 5, some interviewees can be seen.

Figure 5. Some of the survey respondents

A few problems were recurrent in their answers. The sidewalks are not appropriate and make difficult accessing places. Sometimes stairs are the only access to establishments and others, the entrance to wheelchairs is through the service door. Even the bathrooms, which should comply with disabled people necessities, occasionally, have doors opening inside, what make impossible for wheelchair users to close them.

During the interviews, people said that they find out about accessible places through friends, social networks or websites. In spite of them being regular users of smartphones, they only heard about the digital applications found during mentioned research, having no opportunity to download it and use it. However, they showed interest in having an application that helps to choose a place, according to accessibility and share their impressions about it with friends. They declared to be available to collaborate with user tests, when the time comes.

Looking for services to facilitate their movements and ensure their rights, allowing life quality, is almost a consensus among them.

V. Conclusion and Next Steps

By reading through blogs and communities in social networks, in addition to interviews with disabled or with limited mobility people, was possible to observe that they are increasingly leaving their houses, looking for their rights, and using digital media to do so. They want a more active life and to be able to attend bars and restaurants that are prepared to receive them.

After the survey and conducted research, there was an indication that a collaborative application could be of a great help in promoting the social inclusion of people with special needs. This application should allow users to help build an information database, focused on mapping bars and restaurants, according to how accessible a place is. It also has to be possible to evaluate and find these places, besides enabling search for locations and trace route. They should also be able to share thoughts about these establishments on social networks, thus promoting greater awareness of services offered or problems faced.

The application proposed in this work - Party4all - intends to allow users to use their smartphones, find and map places, rate them by level of accessibility, check rates and comments created by other users. It is also possible to share all information and insights through social networks, allowing sharing good or bad initiatives. It also permits to communicate with bars and restaurants owners, to let them know their evaluation and give them the opportunity to communicate directly with their clients and give them feedbacks.

As represented in the application architecture, Figure 5, the sharing collaborative network cycle should go through the following steps: People, regardless of their disability status, should be able to add information to the tool and share on social networks. By doing this, it is expected that those places will have more clients improving their

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experience, changing the overall grade, and therefore spreading new information on social networks.

This should promote greater comfort and mobility in bars and restaurants for people with disabilities or with locomotion difficulties.

Figure 6. Party4all information architecture

The next step to accomplish this goal is related to publish studies and researches on, why people in Brazil appear not to have a significant participation in worldwide initiatives, like the Whellmap itself, or other international services that collaborate with social inclusion through technology;

Study the most suitable option to implement the solution itself and the possibility to take advantage of collaborative production is also a future step. This would bring new challenges to the project.

The development should start with an Android application, since this platform had been used by 91.6% of Brazilian smartphones in 2014 [16]. Nevertheless, more investigation will be made to decide, for example, what technology is going to be used to map places.

At the same time, the user experience solution will be built, through sketching and prototypes that can be tested with users. We also need to answer questions such as if the information is sufficient, or if more details are needed. Inputs as these and others will be primordial to have a solution. That will help achieve the goal to promote social inclusion in an engaged and efficient way.

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Example of a New Smart Kitchen Model for Energy Efficiency and Usability

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***Abstract* — The paper presents the design, the implementation and the evaluation of an innovative smart kitchen called E-Kitchen where the technology is intended to make everyday life easier increasing comfort, energy efficiency, usability and safety. E-Kitchen is a kitchen environment, completely redesigned according to User-Centered Design approach, which implements a home automation system based on ZigBee communication technology. It integrates several devices: smart household appliances, devices connected with smart plugs, sensors, lighting systems. A qualitative usability assessment, which involved final users, highlighted that adopted solution is able to enhance the accessibility and usability of the kitchen especially for the elderly. Moreover, it allows to increase the users' energy awareness and it contributes to increase energy saving.**

Keywords-Smart kitchen; user centered design; accessibility; context and energy awareness.

I. INTRODUCTION

Nowadays, the kitchen is the main room of the house, a multifunctional space where people spend a lot of time to prepare and cook meals, to eat them and store the supplies. Moreover a kitchen can be regarded as a space for the family members to meet together and pass time during lunch and dinner preparation.

In particular, it was estimated that the kitchen is the room where the family spends the majority of the time (35%) [1]. The kitchen is also the space more "dangerous": more than half of the domestic accidents happen in the kitchen (55%) [1]. No other room of the house is so dangerous, because in any other room the frequency of accidents is always less than 10% [2]. The main cause of trauma and incidents is due to the everyday use of devices and tools of kitchen, such as knives, oven, small appliances and cookware. Most of them occur for distraction and scarce prevention. The kitchen and in particular the worktop, have often insufficient lighting and this causes loss of visibility so increased risk of accident. Furthermore, the space above the worktop is often full of accessories and all kinds of objects, making everyday tasks more difficult and dangerous.

The kitchen is also the space with the higher number of "machine elements" and the room that consumes more energy in the house. It estimated that kitchen appliances, including refrigerators, freezers, oven, and dishwashers, account for nearly 27% of household electricity use [3]. Therefore, the necessity of reduce the energy consumption of a kitchen becomes a priority. In most home automation systems, control is given by user that establishes manually all parameters. In this way, the behaviors and actions become central for energy saving. For this reason, awareness and feedback about electricity consumption is a key aspect to save energy.

Our main focus has been to create a smart kitchen where user is central element of system design. In particular, it was attempted to make more comfortable and safe the kitchen environment through the inclusion of a series of technological interact smart and high usability solutions. Technology becomes a support and a tool by which to ensure a better livability of the kitchen in terms of safety, comfort and well-being. In particular, it has been developed a smart system that allows to coordinate the appliances and sub-systems in order to optimize energy consumption, increase energy efficiency, and improve the usability of the kitchen.

This system is managed through a web user interface, which gives information on the functioning and energy consumption of all devices in the kitchen, allows to set and control all household appliances in a simple and intuitive way and gives information and alerts in case of situations of warning.

The paper is organized as follows. Section 2 summarizes some of the approaches presented in literature about sensor in smart homes, smart appliances, energy management and intelligent control systems. Section 3 gives the description of system and highlights the innovations. Section 4 reports the results of the experimental assessment of e-kitchen environment. Finally, some final considerations are provided in Section 5.

II. RELATED WORK

Smart home can be defined as “a house which comprises a network communication between all devices of the house allowing the control, monitoring and remote access of all applications and services of the management system” [4]. There are a wide number of scientific works focused on smart home, but they investigate only one aspect such as smart object and sensors. Scientific research on kitchen environment is still at the beginning and it has often analyzed as part of the smart home [5].

Many studies of sensing systems have been developed for monitoring and controlling of environmental parameters of a house. Ding et al. [6] make a state of the art of sensor technology most commonly used in smart home. The work highlights the strengths and limitations of different sensor technologies and focuses on the opportunities from the

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perspective of technical, clinical and ethical. It emphasizes that there is not a generic perfect mix of sensors: each case must be evaluated independently and designed for the specific needs. Muñoz et al. [7] present a system that allows to control the house through simple and unobtrusive sensors, and a multi-agent architecture. This system gives the possibility to supervise the state of the house and occupants, and gives instructions and guidelines through an alert assistant. Similar work is that of Stander et al. [8] in which a sensor system provides an overview of the whole kitchen. The system, through a sensors infrastructure, monitors the status of the room and obtains information about the various devices.

On the other hand, many studies are focused only on smart appliances, in order to make them intelligent so as to make life more safety, convenient and comfortable. An example is the study on a smart fridge [9] which detects the amount of foods stored inside it (i.e., milk bottles, fruits, bread, drinks, water bottles, or the quantities of irregular shape, such as vegetables, meats, etc.). Moreover, if the amount of food is less than a set value, it can communicate automatically with the food supplier by web and order the needed food. In addition to detection capability, the refrigerator implements a control system of the gas oven installed in the kitchen. The system controls remotely the switching on and off of device.

In the recent years, this kind of development is being taken up by the major commercial players. For instance, at the last Consumer Electronic Show (CES 2015) Bosch [10] presented a refrigerator with built-in camera that allows to look inside when the user is not at home, making meal choices and grocery shopping easier. Even Whirlpool [11] and LG [12] have introduced on the market the first smart appliances such as refrigerators and ovens that communicate with the internet and could be controlled remotely by mobile phone.

The research focus is also on optimal energy load management strategy for household appliances. Arghira et al. [13] present a method that predicts the consumption of each appliance, to estimate how much energy can be saved. This research is based on dynamic demand-side management, and allows energy saving due to the different cost of energy and the maximization of renewable energy. Nistor et al. [14] propose a control system of household appliances to reduce energy loads. The system is made up of a central hub which communicates with the different devices and it is programmed according to user needs. The system can manage the functioning of the devices through various algorithms. According to user preferences, the shifting and interruption of appliance operation, permit save energy at the system level. Frederiks et al. [15] say that in order to save on domestic energy consumption, is necessary to act on user behavior. Only by understanding and managing the psychological motivations we can encourage a more responsible consumption of energy.

All of these studies focused on the technical aspects and marginally consider the end user preferences and characteristics. For this reason, the introduction of new appliances not always leads to an increase in usability. In fact, the user often uses only a minimum percentage of functions. However, it is possible to find several works focused on human-machine interaction but for only one aspect. An example is provided by the development of help and user guides in food preparation. Ficocelli and Nejat [16] have developed an assistance system in kitchen's daily activities as research of recipes, help during the preparation and guidelines to a healthier behavior. Chen et al. [17] presented a system that, once recognized the food, provides information about calories and nutritional values.

Almost all of the research is focused on one of the three aspects that characterize the smart kitchen: internal communication network, intelligent control systems, and home automation and do not consider the usability of the whole system. Our work has been focused in the development of a smart kitchen in terms of physical and cognitive ergonomics in which technology will be completely invisible to not limit the use of the environment. In this way, the kitchen itself will become an interface through which the system will communicate information and alerts (visual communication), and the user will be supported by an "artificial intelligence" in the management of household appliances.

III. SYSTEM'S GENERAL DESCRIPTION

E-Kitchen is a new concept of "innovative kitchen" (Figure 1) in which the technology is intended to make everyday life easier increasing comfort, efficiency, usability and safety.

Figure 1. E-Kitchen prototype.

The system was designed through the study of three main interactions (Figure 2): human-environment, human-machines and machines-environment. The study of these three aspects has allowed to obtain a kitchen usable and accessible highly, that implement a smart home automation system.

In particular, the work on machines-environment interaction permitted to achieve:

- the control of devices to ensure the safety of the environment,
- the control of operating parameters of devices,
- the possibility to manage the status and self-diagnosis and auto repair,
- the monitoring and optimization of energy consumption.

Figure 2. E-Kitchen structural represantion.

The second level of interaction (human-machines) is related to the usability of the "machines" and focused on the study of:

- an highly usable user interface to allow communication/visualization of information,
- system software based on User Centered Design.

Finally, the human-environment interaction has been analyzed to improve:

- the functionality and ergonomic layout,
- the system integration,
- the possibility to monitor user behavior and activate alerts in case of need or assistance.

In this way, it has been developed a kitchen environment in which there are multiple systems that contribute to transform a kitchen in “smart kitchen”. E-Kitchen is structured in three systems: kitchen system, the "smart" devices system and, finally, the home automation system.

A. Kitchen

An innovative kitchen layout has been developed to allow a perfect integration between technology, design and ergonomics. In accordance with ergonomic approach, an innovative layout has been designed, to prevent any risk to the user during daily operations. In particular, the depth of the working top has been increased according to the specification deduced from ergonomics (Figure 3) and the results of an ethnographic analysis, which involved 20 people aged between 50 and 85. In fact with the current base cabinets, deep 60 cm, the wall units are too close to the user's face causing the narrowing of the visual field and increasing the risk of collision. Moreover, the results of the behavior analysis showed that connections of water and sanitary system greatly influence the layout of the kitchen and often lead to bad design.

The worktop 80 cm deep has been then designed to obtain a more open space, a greater freedom of movement and a perfect view on the working plane. On the other hand, the additional space has been very useful to design the expansion of sanitary vacuum which can accommodate pipes. So, the layout of the kitchen can be separated from connections of water and sanitary system thanks to this added space.

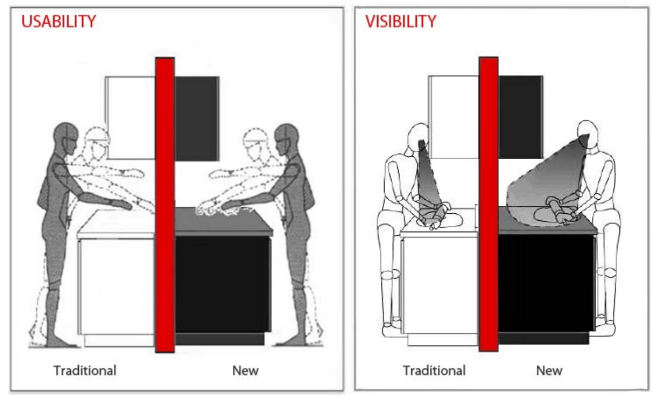

Figure 3. New worktop improve usability and visibility.

Ethnographic analysis also revealed many accessibility issues related to the interaction user-cabinets. To solve these problems the kitchen is also equipped with some electromechanical systems to improve its accessibility.

Devices have been inserted on the back of the wall cabinets to obtain an extra storage space. It makes accessible an additional space, always handy and useful for storing everyday items (e.g., dishes, utensils and small appliances such as coffee machine). Similarly, facilitator systems are included in the lower drawer of base cabinets, to facilitate easy access to users with limited mobility (Figure 4).

Figure 4. Electromechanical systems: the wall unit device (on the left), the system for base cabinet (on the right).

B. Smart devices system

The kitchen is equipped with a lot of devices. Figure 5 describes the architecture of E-Kitchen communication network and shows all the elements which constitute the intelligent system.

The network is realized through ZigBee technology. It provides communication from/to any appliance or device and from/to the Gateway. The Smart Gateway is able to communicate with the outside through connection to the Modem-Router. A Power Meter ZigBee (SmartPlug) installed downstream of the energy meter provide to measure the global consumption of the house and to send data to the Gateway.

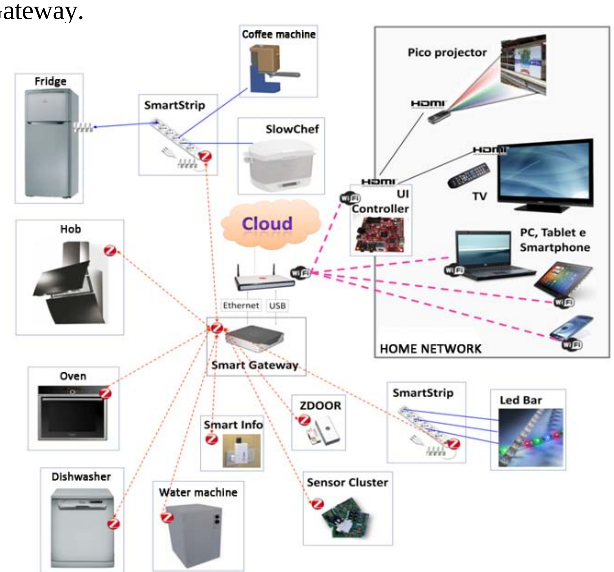

Figure 5. E-Kitchen communication network

Household appliances which provide smart service (i.e., oven, dishwasher and hood) are equipped with communication interfaces based on ZigBee standard. Other devices (i.e., the fridge) are connected through Power Line Communication (PLC) and ZigBee standard. For the conventional appliances (i.e., the coffee machine), which are not capable to communicate with system by themselves, ZigBee smart plug have been used in order to monitor energy consumption and to turn devices on/off remotely.

In the E-Kitchen system, standard sensors (i.e., temperature and humidity) and non-standard sensors (i.e., air quality) have been implemented to identify emergency situations: for example, light sensors are used to detect when room becomes too dark, and temperature sensors are used to control kitchen hob. All the sensors use the ZigBee and Bluetooth standards.

Led lights have been inserted under the wall cabinets and under the base cabinets of the kitchen. They permit to transform the kitchen into a real user interface able to communicate information and alerts. There are two kinds of led strips: white to illuminate the worktop and red for seeing information. The white lights can be automatically activated when the home automation system detects a low level of brightness in the environment. The red lights are exclusively remote controlled and are used to manage the information (e.g., warnings or alarms) that the system sends to the user.

C. *Home automation system*

The home automation system enhances the usability, intuitiveness and safety of the kitchen environment. The hub of such system is the Smart Gateway, which manages all the information. It connects smart devices of Home Area Network (HAN) to the modem/router Telecom Italia [18] to make them available outside the home automation network, through the internet (Figure 6).

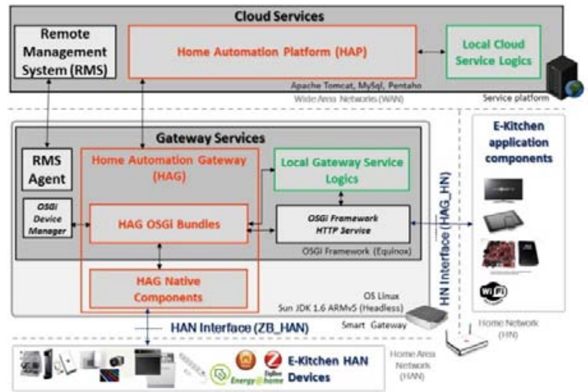

Figure 6. Hardware architecture.

The Smart Gateway is composed of Home Automation Gateway (HAG) and other local application bundles. HAG is constituted by a set of native components and some bundle included in OSGi framework (HAG OSGi Bundles). HAG permits local application bundles (Local Gateway Service Logics) and applications of devices of Home Network (E-Kitchen application components) to interact with HAN devices and access to storage data of Home Automation Platform (HAP). HAP is a platform in a cloud service that gives network storage service of data collected by the devices of the HAN. The stored data can be accessed from the HAG or other logic network application (i.e., Local Cloud Service Logics that can process the raw data sent by the gateway and store new data).

A web-based User Interface Controller has been developed that allows the user to manage and interact with the E-Kitchen environment. The controller software architecture is realized by two parts: Logic Unit (LU) and User Interface (UI) (Figure 7)

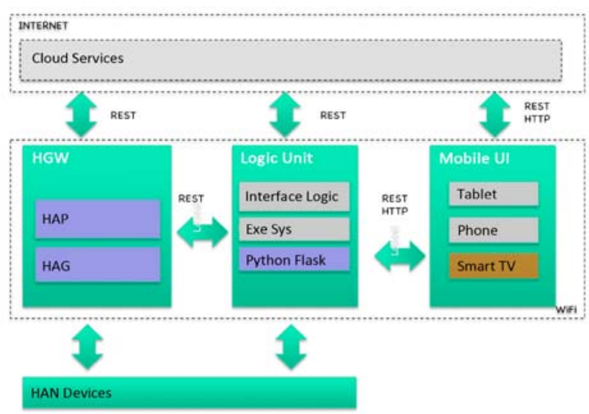

Figure 7. E-Kitchen software architecture.

The LU manages the communication to/from the home gateway and it is involved to execute logic management system based on events and store data. In particular, the LU processes all the information provided by system, it elaborates that information and operate events through a decision-making algorithm in order to support the user. It is also managed by the user through the UI.

Figure 8. E-Kitchen User Interface.

The UI is a web application developed in Cloud Services, which manages the interface visualization and user interaction with the system. The interface is visible and accessible at any time and can be displayed on PC, Smart-TV, Smartphone or Tablet (Figure 8).

The Graphical User Interface has been design according to User-Centered Approach. The design process consists of the following steps:

- collection of project requirements and user needs;
- definition of a concept design solution;
- construction of a paper-prototype;
- evaluation of the design solution with usability experts and identification of improvements;
- construction of full functional high fidelity prototype (figure 8);
- design evaluation with users, which is described in the following paragraph.

IV. EVALUATION SYSTEM

A preliminary usability evaluation have been carried out to assess E-Kitchen system in terms of usability and acceptability, with focus on the impact of additional features. It has been chosen to use the methodology well-known as thinking aloud [19] to understand in more detail the choices made by users during the course of the assessment.

In order to carry out a qualitative assessment focused on global characteristics rather than on individual aspects, usability tests have been based on tasks scenario. Each scenario has been designed in order to allow evaluation through the observation of interaction between the user and the whole system.

In the evaluation, there have been tested two different ways of interaction: direct (without the help of the user interface) and mediated by the user interface visualized through a tablet. At the end of the evaluations, user impressions were gathered through interviews conducted by evaluators and questionnaires.

The following objective parameters have been collected during the test by using the form reported in the figure 9:

- (C) Completion of the task (S / N);
- (E) Number of errors made by user during the interaction with household appliances;
- (I) Number of errors in the use of the interface;
- (O) Capacity error correction (S / N);
- (H) Reference to the instructions.

User recruitment is based on three main aspects: familiarity with the kitchen, age and ability with technology. The users have to be able with the kitchen: they have to be skilled in performing operational tasks (e.g., food preparation) inside the kitchen. The distinction based on the age has been defined according to the difference between adults and elders, where adults are intended between the ages of 30 and 50 years, and elders over 65 years. Intermediate characteristics (age between 51 and 64) were not considered because they are easily deducible from the behaviors detected in extreme groups. Users under the age of 30 were not considered in the test. According to the ability with technologies, the users are divided into two groups: high ability (HA) for users which use frequently computers, smartphones and tablets and scarce ability (SA) for who uses them less than once per week and with reduced functionality.

According to these definitions users were divided into three groups (Table 1) according to the following characteristics:

1. Adults (30 to 50 years) with HA;
2. Elders (over 65 years) with HA;
3. Elders (over 65 years) with SA.

To improve the assessment, users with minor limitations in vision, hearing and fine motor, have been involved, because such limitations are widespread in a large portion of elderly people.

Five subjects for each of the two categories of elders (with and without ability with technologies) and five users in the first group have been selected.

Tests have been conducted by two researchers. Performance data have been collected through diary study and Video Interaction Analysis (VIA).

TABLE I. USERS GROUPS

Groups	**Criteria**		**N°**
	Principal	*Limitations*	
G1	Adults (30 to 50 years) with HA	None	5
G2	Elders (over 65 years) with HA	View, Hearing, Fine motricity	5
G3	Elders (over 65 years) with SA	View, Hearing, Fine motricity	5
		Total	**15**

N°	Main Task	Object of verification	C	E	I	O	R	H
1	Search a recipe	Is the user able to perform the task? Does he/she need to consult the instructions?	Y N	☐ ☐	☐ ☐ ☐	Y N	☐	☐ ☐ ☐ ☐
Put ingredients out of the fridge								
2	Alert Fridge door open	Is the user able to understand the meaning of the alert?	Y N	☐ ☐	☐ ☐ ☐	Y N	☐	☐ ☐ ☐ ☐
3	Program the oven	Is the user able to perform the task? Does he/she need to consult the instructions?	Y N	☐ ☐	☐ ☐ ☐	Y N	☐	☐ ☐ ☐ ☐
4	Start the cooking	Is the user able to perform the task? Does he/she need to consult the instructions?	Y N	☐ ☐	☐ ☐ ☐	Y N	☐	☐ ☐ ☐ ☐
5	Alert term cooking and off oven	Is the user able to understand the meaning of the alert? Does he/she need to consult the instructions?	Y N	☐ ☐	☐ ☐ ☐	Y N	☐	☐ ☐ ☐ ☐
Serve the dish								
6	Program and start the dishwasher	Is the user able to perform the task? Does he/she need to consult the instructions?	Y N	☐ ☐	☐ ☐ ☐	Y N	☐	☐ ☐ ☐ ☐
7	Alert lack water dishwasher	Is the user able to understand the meaning of the alert? Does he/she need to consult the instructions?	Y N	☐ ☐	☐ ☐ ☐	Y N	☐	☐ ☐ ☐ ☐

Figure 9. Evaluation form.

Few examples of the scenarios used during testing are:

- Preparing a meal: the user must prepare a meal using a recipe. Tasks: selection and consultation of a recipe, finding the ingredients, start and setting the oven, check the status of cooking, preparation, programming and starting the dishwasher, management of any warning.
- Alarm management: the user manages unexpected alerts of system. Tasks: understanding the alarm, solve the problem.
- Power Management: The user manages the consumption after an overload warning and checks energy consumption in a given period. Tasks: programming one or more appliances, choice between automatic or manual management of overload, manage an overload alarm, and check the consumption in a given period.

A. Evaluation Discussion/Results

Users have positively assessed the layout of the kitchen and the additional space of the worktop. During the preparation of the meals they have expressed positive opinion about the use of the kitchen.

During the interaction with the User Interface through tablet positive impressions were collected from the users.

Instead during the direct interaction with the devices, by the majority of subjects, it was reported some difficulties to find right information for programming dishwasher and oven. In particular, 11 of 15 subjects have required the support of the researchers more than once and repeated the task once before do it correctly. In this case, the task has been evaluated by users as difficult. As regards the ability to program the oven, 7 of 15 users have utilized researcher instructions, and evaluation of task difficulty was better than dishwasher. This can be due to the characteristics of household appliances interfaces: instead of UI system, the dishwasher in particular presents a really poor button-interface, which is not able to suggest the correct sequence of action necessary to set up a program.

In the management of alarms (i.e., overload warning, ambient alarm, error or alerts of appliances) users have reacted to system alert without difficulty. All users have used the interface to get information and instructions to resolve the problem. Data collected during observation of user performances and answers given by users to questionnaires showed that light signals and user interface allow to identify the problem immediately and to react properly.

As regards the reading of energy consumption through the interface, users have completed the task without using the researchers' instructions or making mistakes and they have supplied very positive feedback in the activities. Through the questionnaire, users have highlighted the importance of knowing energy consumption in real time or and historical ones.

V. CONCLUSIONS

This paper presents the design of an innovative smart kitchen.

The results of a qualitative experimentation with final users has shown that it is accessible and highly usable for users with some limitations such the elderly. In general, it emerged that the new smart kitchen system is able to improve the usability of household appliances, such as oven and dishwasher, as regards the programming and controlling operations, compared with a "traditional" kitchen. At the same time, it shows how the introduction of smart technologies in the kitchen environment improves the usability also for users with scarce attitude to technology.

The main innovation of E-Kitchen is the ability to govern rationally and in an intuitive manner the functions of all the appliances that find place in the kitchen: it improves the use and the control of the devices, it reduces malfunctions and it makes them more easy to manage.

The work is not definitive: the smart kitchen will be evaluated with a greater number of users in order to verify this first qualitative evaluation. Moreover, a field study will be conducted to assess the ability of E-kitchen system to enhance the users' energy awareness and, in order to understand if it is able or not to contribute to increase energy saving and to demonstrate its benefits with respect to other proposals in the literature. Anyway, it is reasonable to assume that the system allows to save around 3% of money, in term of energy bill, because the system gives the possibility to shift the appliances program when the energy rate is low.

An additional effort will be focused on the development of E-Kitchen to make it commercialized at a sustainable cost.

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Online Barter
Trade of Goods in Digital Communities

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***Abstract*—This study aims to explore the terms of trade in a virtual environment to identify opportunities for the actors involved. The methodology used in this research was the development of mental maps by human and nonhuman entities. In order to understand this phenomenon, this study explored the current online barter scenarios, the collaborative consumption in Brazil and the analysis of the Facebook Barter Group, detailed here. In addition to this, it explores how social networks have been taking part in this initiative. Conclusions point to structural and behavioral aspects, identifying the need to build an application tool to provide a better consumer experience.**

Keywords-Smart Cities; Online Barter; Sustainability; Collaborative Consumption.

I. INTRODUCTION

Nowadays, the discussion about a society that provides sustainable solutions is growing due to the quick and easy access to information. This way, services of collaborative consumption have emerged with the goal to dematerialize products by proposing their uses beyond the consumption. The term "collaborative" means two or more people who collaborate on a product exchange system, such as sharing, trading, renting or lending objects [1].

> "*Consumption can be understood as a set of sociocultural processes that permeate the appropriation and the uses of goods beyond the likes of exercises, whims and thoughtless purchases, according to moral judgments or individual attitudes as often exploited by research market*"[2].

Services involved in a collaborative consumption system are divided into three systems: product service systems (paying to use the product without owning it), redistribution markets (goods are redistributed - modified) and collaborative lifestyles (people with similar interests gather together to share and exchange less tangible assets such as time, space, skills, etc.) [3].

In Brazil, some solutions promote collaborative consumption. Among the existing solutions, this paper will approach the online product exchange through Facebook. Product exchange is a trend of sustainable consumption, and social networks help spread this practice. Some Facebook groups stimulate the exchange and, without it, these people would probably not have the chance to meet each other. This project is the analysis of existent solutions, validating their impact and seeking to identify new opportunities that can improve the exchange of products in a practical and efficient way. Section 2 deals with the concepts of collaborative consumption and the problems that may occur during the exchange process of online products. Section 3 presents some existing solutions and a quick analysis of them. In Section 4, proposals are presented and then Section 5 concludes the paper and presents future research and its development.

II. COLLABORATIVE CONSUMPTION

Collaborative consumption as an exchange of products is a complex system influenced by several factors, such as economic, political, sustainable trends, human behavior, and the culture of a society.

> "*Collaborative consumption is a sustainable practice that requires a non-individual action, as in sustainability itself, but the cooperation between two or more consumers. Exchange of products and/or services between consumers who stop buying from a supplier and start to work together, feeding their consumption needs*" [4].

It was necessary to systematically analyze the factors involved in the service to study the online barter and then propose solutions. So, it was possible to "*have the micro view, but also the macro view of all processes involving a problem, see how they interrelate and what are the inputs and outputs of their subsystems and the system as a whole*"[1].

The Actor-Network Theory (ANT), also known as Sociology of Translation [5], is a contestation of traditional sociology, which does not consider the concept of society and understands the social dimension as a collection of human and non-human entities, such as people, animals, things and institutions, supported by an agency through the association in networks. It represents interconnections where actors are involved, and networks can take them to any side or direction and establish connections with actors who show some similarity or relationship [6].

First, linking humans and entities involved in the process, as shown in Figure 1, has created a mental map. After making all the connections between the actors, it was possible to ask questions and investigate the potential problems for the exchange of products in online services.

Figure 1. Mental map with human and non-human actors.

III. Analysis of Existing Solutions

In order to understand the online trading system, the websites ‘Permuta Digital’, ‘Zaznu’, ‘Impact Hub’, ‘Skoob’, ‘Caronetas’, ‘Tem Açúcar?’, ‘Troca Jogo’, ‘Joaninha’ and ‘Samba’ were visited, as well as Facebook groups. Those are websites used to share common goods, such as games, books, toys, bikes, and carpools. Most of the observed websites do not stimulate the sense of social interaction and the product exchange happens in a complex way. Some of them demand currency that users can buy, and with that, users can evaluate and offer to exchange for other products; that makes the system not fully based on trades. Some difficulties of communication between users were observed. Among this group of websites, the Facebook Group 'Escambo' was chosen for a detailed analysis, because other solutions still allow the exchange of goods using cache. The mentioned Facebook Group only allows users to exchange objects for another object them, it does not allow any kind of operation involving money.

In the Group, there is also a close review of the collaborative consumption concepts, something that was not observed in other tools that promote online barter. ‘Escambo’ has the main features of collaborative consumption, such as sharing an offer within a community, news, and recommendations of products widely transmitted by the social network [7].

A. *Analysis of the Facebook Group – ‘Escambo’*

The Group has over 20,000 registered users. There are constant exchanges of products among people and many of them believe in the exchange process as a way to practice a sustainable consumption. ‘Escambo’ has social guidelines that emphasize the exchange experiences, and forbids buying and selling products.

The dynamics of trades are simple: any user can post a picture of what they want to pass on, describing the object, and also they would like to receive for it, or if it is possible to simply leave it open [8]. Then, through the additional comments, people interested in the product start offering their own items in exchange for the announced good. The owner of the advertised object decides who will get the product through the exchange transaction. New exchange negotiations may appear from comments in any publication, since many people report what they have available so they can attract the interest of others.

Factors that boost the trade or not:

- From the moment that people start to exchange things, negotiations become more complex;
- Individualistic and critical sense among people;
- Many conflicts among participants, there is usually someone willing to take advantage of the transaction;
- Some participants do not have the collaborative spirit about the advantages of trading goods;
- No care about appearance, cleanliness, or organization of the offered product, based on the available pictures.

IV. Proposals

From the previous observations about the interactions in the Group, some proposals to solve the above-mentioned problems are listed below:

- Develop Facebook application tools to register people and organize product information as photos, reviews and negotiations;
- Create actions to inform and educate people about the principles of sharing and consumer awareness to demonstrate that the exchange experience is better than having a financial gain - It has been noticed that there are some people who are individualistic and more worried with financial benefits instead of thinking about the community and the goal of collaborative consumption;
- Stimulate the collective and social thinking inside the group, because it has been noticed that there are some conflicts and insults between the participants of the group.

V. Conclusion

In this paper, an alternative to improve collaborative consumption through exchange of products was proposed by using Facebook Groups tools. Encouraging interaction between different people and the exchange of common interests are part of this experience. The goal of being able to identify problems in the exchange of products on the Internet was also achieved. The analysis of the main difficulties of a collaborative service provided ideas and solutions that improve the relationship between individuals. As future works, the authors are prototyping the proposed solution in order to validate with users how the project will affect communities.

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Barrierfree Mobility for All by a Smart and Individual Travel Assistance

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***Abstract*—Public transport operators focus on a public transport system which is inclusive and fair to all groups of society. This requires a holistic approach, which considers the user and the service provider perspective. From the passengers' view, it becomes obvious that not only the accessibility of a single transportation system is relevant. The interchanges within the system as well as the change-over to other systems must be improved regarding the special requirements of people with reduced mobility and/or sensory restrictions. This article describes how this objective can be achieved in the project aim4it by an individual and smart solution, which is available and useable for every passenger-group. System components are presented and first results are pointed out.**

Keywords- cross-modal public transportation; barrierfree; smart solutions, customer-orientation.

I. INTRODUCTION

Every mobility chain is accompanied by an information chain, which has to be carried out at best parallel. Especially passengers with reduced mobility and/or sensory restrictions have to be informed in time about unexpected events and resulting changeover times. Also, for barrier-free information, the information has to be understandable, e.g., in sign language, as well [1].

Today, Intermodal Transport Information Systems (ITIS) manage the challenge to provide relevant pre-/on- and post-trip information to passengers [2]. But a barrier-free travel assistant includes information representation that is tailored to the specific requirements of passengers with sensory restrictions (e.g. information display in sign language). This increases perceived service quality and the usage of public transportation. With suitable evaluation algorithms, customer feedback can be systematically elicited, evaluated and interpreted. This is the basis for a continuous improvement of public transport operations. Timetables can be adjusted or available digital maps advanced, service personal can be used more appropriate [3]. Overall this will result in a better quality of services for passengers with reduced mobility and/or sensory restrictions.

II. HOLISTIC APPROACH FOR BARRIER-FREE PUBLIC TRANSPORTATION

The project aim4it incorporates the user's and service provider's point of view. When a trip is viewed from the perspective of the customer/user, it becomes clear that it is not enough to design individual transport modes and facilities for just one transport system. In order to be passenger-friendly and suitable for use by passengers with special mobility needs (i.e., visually impaired passengers and the deaf and hard of hearing) all transport modes and therefore all service providers have to be considered for barrier-freeness [4]. For a given destination to be reachable by everyone, barrier-free *mobility chains for all transport modes* should be set up. Therefore, passengers with reduced mobility have to get all relevant information about departure times, necessary transfer procedures and updates/changes due to breakdowns. This information must be up-to-date and understandable at important nodes before, along, as well as after the journey. Significant information needs to be conveyed in optical, acoustical and/or tactile form [3].

III. COMPONENTS OF THE AIM4IT SYSTEM ARCHITECTURE

The intended overall aim4it assistance system provides a benefit from the user's as well as the service provider's point of view. Thereby, the aim4it smartphone app is the key element.

A. aim4it smartphone app

With the aim4it smartphone app the passenger can start the planning of the trip by entering information about the start and the destination into the smartphone at home. Data entry and display for the aim4it user interface are designed in an innovative user-centered way: All information provided will be displayed as multi-sensual output to secure information for the different groups of passengers. Afterwards the aim4it smartphone app sends a request for a barrier free trip to the ITIS [2].

B. Link to Intermodal Transport Information (ITIS) and Transport Control Systems (ITCS)

Based on the start and endpoint of the requested trip the ITIS performs barrier-free routing. The following Use-Case is considered: The route reflects information from augmented digital maps (e.g., based on crowdsourcing projects such as wheelmap), error messages from the Intermodal Traffic Control System (ITCS) as well as events entered by local service staff at stations (e.g. malfunction of an escalator). The barrier-free route compiled by the ITIS is sent to the smartphone app. There it is displayed for barrier-free navigation along the planned trip chain. An additional feature is the request for bus driver assistance, e.g., to board the vehicle. This is entered and sent to the ITIS. By the ITIS this

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request is passed to the ITCS where the corresponding vehicle is identified. Via the existing data link between the ITCS and the vehicle the request for bus driver assistance is sent [2]. There it has to be displayed to the bus driver within the aim4it bus driver user interface when the vehicle approaches the proposed station.

IV. VALUE-ADDED SERVICES AND THEIR CONTINUOUS IMPROVEMENT

With the aim4it smartphone app passengers with reduced mobility and/or sensory restrictions get on-trip assistance. This includes several services, which are described further below:

A. Incident information in sign language

Whenever service irregularities (e.g., delays, cancellations, missed connections) are detected in the ITCS error information is forwarded to the passenger. The aim4it message generator automatically transforms the text message to a video stream, *displaying error information in sign language* for deaf and hard of hearing passengers.

B. (Re-)Routing

In addition to just following a static pre-planned route dynamic *re-routing* is an integral part of the system. Using available information in the ITIS each barrier-free route will be monitored. Whenever a deviation is detected re-routing will be automatically activated and the passenger will be informed about alternatives.

C. Request for mobility assistance

On trip the passenger can make stop requests along with requests for bus driver assistance. This information is send to the vehicle by an IP-based communication link. Also, it will be displayed at the aim4it bus driver interface.

D. Request for connection protection

The same mechanism is used for the passenger request of connection protection. In this case, the request is generated by the aim4it smartphone app and send from the passenger in the feeder bus via ITIS and ITCS to the bus driver of the corresponding distributor bus. Waiting time of the connecting distributor bus at the interchange station will be extended.

E. Feedback for continuous improvement

With the aim4it smartphone app passengers with reduced mobility and/or sensory restrictions can provide feedback to the public transport operator (post-trip perspective) for continuous improvement [5]. Therewith public transport operators can enhance their service, e.g., for barrier-free transport services. Further feedback can be entered to various quality aspects (e.g., vehicles conditions, service staff). This information will be sent to the aim4it evaluation and planning tool for reporting. Information can be used for schedule updates or service improvements. In case of schedule updates, these will become effective and be the basis for operations monitored in the ITCS. Then, trip requests sent to the ITIS. Based on available customer feedback, digital maps can be revised and additional features added. These additional features can be used for generating barrier-free trips in the ITIS.

V. CONCLUSIONS

A demonstrator of the aim4it architecture is currently been developed by the consortium members. Results of the project will be demonstrated in the city of Vienna (Austria) as well as the city of Karlsruhe (Germany). The value-added services for travel assistance based on the technical specifications that result from the previous standardization project for IP-based communication in public transport (IP-KOM-ÖV). The Association of German Transport Companies (VDV) will continuously update these technical specifications. They are open to future adaptations and amendments. As the value-added services developed in the aim4it project (connection protection and request for bus driver assistance) build on and further enhance this standard, the results will result in a new work item proposal in the standardization procedure managed by VDV. Following this procedure the changes and amendments to the technical specifications suggested by the aim4it project will be discussed in a forum of domain experts and incorporated into a revision of the Travellers‘ Real-time Information and Advisory Standard (TRIAS).

ACKNOWLEDGMENT

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Design and Simulation Evaluation of EcoSmart Driving Control for City Traffic

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***Abstract*— Many traffic signals, intersections, and road signs on city roads result in waves of traffic flow. Fewer waves of traffic flow result in less congestion and reduced fuel consumption of vehicles. In order to ensure that trade and commerce in future are rapid, clean, and comfortable, it is essential to make city traffic smooth by EcoSmart driving. However, it is difficult to accomplish EcoSmart driving "for the benefit of all traffic," even if drivers can use the me-first EcoSmart driving system. A control system that automatically performs EcoSmart driving for the benefit of all traffic was designed in this study. The proposed system overcomes the aforementioned obstacles by combining algorithms that consider traffic signals, preceding vehicles, and traffic flow, respectively. Herein, the details of the proposed control system are explained and simulation evaluations are reported.**

Keywords-text; EcoSmart driving; vehicle control; intelligent transportation system; energy saving; platooning; intelligent driver model.

I. INTRODUCTION

Cities with increasing or dense populations are faced with the problem of increasing travel time between cities and air pollution caused by exhaust gases. Increasing populations in cities should be welcomed because it results in more economic activity. However, this also results in heavier traffic in the city. Traffic speed is closely related to economic activities. Therefore, a method to ensure smooth traffic flow should encourage stability in order to advance economic activities in cities sustainably.

Conventionally, traffic flow can be made smoother by focusing on incidental equipment improvements. Currently, though, this solution does not fulfill the needs to expedite economic activities, because the population of cities is rapidly increasing. For instance, in an intersection with less traffic, traffic can be controlled using a stop line as a substitute for a traffic signal. On the other hand, intersections with heavier traffic often use traffic signals to control traffic. Control using traffic signals can impede traffic if the cycle time of the traffic signals is inappropriate. Traffic usually fluctuates depending on time zones and seasons. If only stop lines are used or if the run time of green signals is short when the traffic is heavier, more congestion would occur and the traffic speed would be lowered. Longer cycle times of red signals, in spite of less traffic, cause excessive idling and slow traffic speed.

Slower traffic speed not only disturbs the economic activities, but also causes air pollution in cities. Moreover, increasing fuel consumption is a direct out-of-pocket cost. The cities with lesser traffic speed than other cities would eventually be deserted by the inhabitants, i.e., there would be an outflow of the population of the cities, causing them to lose their economic competitiveness. In other words, smooth traffic flow is vital for future cities.

This study focuses on improvements in self-driving as a next generation method to enhance traffic flow. Improvements in self-driving can be accomplished by driver education. However, it is extremely difficult to guarantee smooth traffic flow through better individual driving techniques. Driving techniques, which create a smooth traffic flow, require the reduction of all unnecessary acceleration/deceleration. This requires that drivers have less influence from traffic signals and the preceding vehicles by maintaining long vehicle-to-vehicle (V2V) distances. On the other hand, when a driver tries to create a greater V2V distance, it may become difficult for other drivers to maintain their V2V distances, because the vehicle consumes more traffic capacity. In other words, to reduce unnecessary acceleration/deceleration, a "me-first" driving paradigm is required, not one that involves driving "for the benefit of all traffic."

This study focuses on a driving system for the benefit of all traffic by vehicle control. The vehicle control proposed in this study solves two issues: reduction of unnecessary acceleration/deceleration and saving traffic capacity. The proposed driving control for city traffic is called EcoSmart driving control, because it saves energy by reducing unnecessary acceleration/deceleration.

The EcoSmart driving control proposed in this study considers traffic conditions that reduce unnecessary acceleration/deceleration and traffic flow based on platooning control, which saves traffic capacity. Figure 1 is a representation of the concept of EcoSmart driving control.

Many studies in which energy was saved by reducing unnecessary acceleration/deceleration were conducted [1-3]. A driving control system that saves energy by solving optimization problems using model predictive control was also produced [4]. In these studies, driving control was achieved by considering the preceding vehicles, traffic signals, and fuel consumption characteristics of the vehicle. The vehicle controls proposed in these studies use me-first EcoSmart driving. Hence, these systems are obviously different from that in this study in that they are not EcoSmart driving systems for the benefit of all traffic.

The EcoSmart driving control proposed in this study aims at EcoSmart driving for the benefit of all traffic by combining me-first EcoSmart driving and platooning control. The platooning control is used to clear congestion, reduce drivers' load, and save energy mainly for expressways. Various methods for platooning control have been proposed [5-9]. Generally, the shorter the maintained V2V distance, the greater the efficiency, in terms of clearing congestion and saving energy. Thus, in recent years, control technologies to maintain a few meters of V2V distance even in driving at high velocity were developed, e.g., California Partners for Advanced Transportation Technology (PATH) in America, Safe Road Train for the Environment (SARTRE) in Europe, and Energy ITS in Japan.

The proposed EcoSmart driving control saves traffic capacity by following the nearest preceding vehicle with a short V2V distance using platooning control, assuming the driver of the nearest preceding vehicle is driving with consideration of the traffic signals and preceding vehicles. The proposed EcoSmart driving control can switch the consideration for traffic conditions and platooning control. Thus, the driving control accomplishes both a margin for V2V distance that is not influenced by the preceding vehicle, which unnecessarily accelerates/decelerates, and saves traffic capacity.

In this paper, details of the EcoSmart driving control are explained and simulation evaluations are reported.

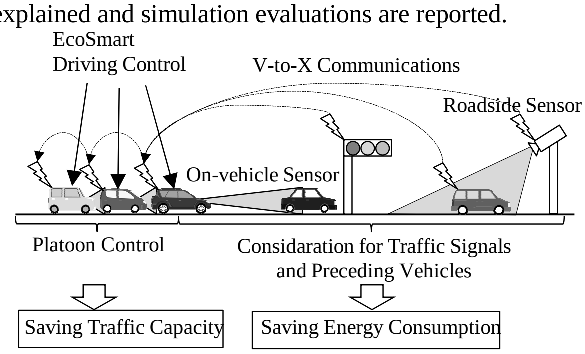

Figure 1. Concept of Proposed EcoSmart Driving Control.

II. ECOSMART DRIVING CONTROL FOR CITY TRAFFIC

This section describes the details of the proposed EcoSmart driving control system. In addition, the design approach for the EcoSmart driving control and its formulation are explained. Herein, the EcoSmart driving control is formulated not as an actual driving control, but for simulation and evaluation of traffic flow. EcoSmart driving control for actual driving requires several kinds of feedback controls in addition to the equations in this paper. The feedback controls are not explained in this paper, because their design is not within the focus of this study.

The EcoSmart driving control formulated in this study is based on an intelligent driver model (IDM). An IDM is simulates driving behaviors of an ordinary driver, considering the preceding vehicles and the traffic signals. An IDM is suitable for comparative evaluation with EcoSmart driving control.

EcoSmart driving control based on an IDM incorporates free road behavior, vehicle consideration behavior, traffic signal consideration behavior, and platooning behavior.

A. Free Road Behavior

The free road behavior simulates driving in a situation with no traffic signals and no preceding vehicles. The equation to calculate target acceleration for free road behavior is shown below:

$$\dot{v}_{t\_b} = \frac{dv_{t\_b}}{dt} = a\left[1-\left(\frac{v}{v_d}\right)^{\delta}\right], \tag{1}$$

where $\dot{v}_{t\_b}$ is the target acceleration for free road behavior, v is velocity of the vehicle, v_d represents the fixed target velocity of the driver, a is a model parameter of acceleration with efficient fuel consumption, and δ is a model parameter of acceleration exponent.

In a general approach, fuel consumption characteristics of the vehicle are considered in order to accomplish EcoSmart driving control, where no signals and other vehicles are on the road. This study does not consider the fuel consumption characteristics of the vehicle for two reasons: one is that it would result in me-first EcoSmart driving, and the other is that the optimization problem of consideration of fuel consumption characteristics of the vehicle explosively increases calculation costs of the traffic flow simulator.

If no traffic signals and other vehicles are on the road, a driving style that minimizes fuel consumption of the vehicle will also minimize fuel consumption of all the traffic. However, if there are vehicles following the controlled vehicle, and if the fuel consumption characteristics of these vehicles are largely different from those of the controlled vehicle, their fuel consumption would increase. Hence, on city roads where several vehicles are operating, the driving style that considers the fuel consumption characteristics of the vehicle is the me-first EcoSmart driving style.

For the benefit of all the traffic, the average fuel consumption characteristics of the vehicles on the road should be primarily considered, rather than those of the vehicle itself. It is desirable that the average fuel consumption characteristics be calculated using V2V communication. However, on normal city streets, consideration of the preceding vehicles and traffic signals reduces fuel consumption far more than focusing on fuel consumption characteristics of the engine. Thus in this study, each model parameter of the free road behavior is set to the average value of the fuel consumption of the engines of ordinary vehicles, and online changes of the characteristics are not made.

B. Vehicle Consideration Behavior

The vehicle consideration behavior simulates driving in a situation with preceding vehicles. Equations to calculate the target acceleration for the vehicle consideration behavior are shown in (2) and (3):

$$\dot{v}_{t\_f} = \frac{dv_{t\_f}}{dt} = \begin{cases} a\left[1-\left(\frac{v}{v_{t\_f}}\right)^{\delta}\right] & (v \le v_{t\_f}) \\ -a\left(\frac{s_f^*(v,\ \ \Delta v_{f\_\min})}{s_l}\right)^2 & (v > v_{t\_f}) \end{cases} \quad (2)$$

$$s_f^*(v,\ \ \Delta v_{f\_\min}) = s_0 + \max\left[0,\ \ \left(vT + \frac{v\Delta v_{f\_\min}}{2\sqrt{ab}}\right)\right], \quad (3)$$

where s_0 is a model parameter, which determines the minimum desired gap. This behavior does not make the V2V distance shorter than s_0. s_l is the V2V distance between the vehicle and the nearest preceding vehicle in the same lane. T is a model parameter that determines the desired time headway. b is a model parameter that determines the comfortable braking deceleration. $v_{f\_\min}$ is the minimum velocity of the preceding vehicles in the same lane, which can be observed using the vehicle's sensor.

Figure 2 shows an example calculating $v_{f\_\min}$. Figure 2-A shows an example of a vehicle, whose speed is 30 km/h, but its driver's desired speed is 60 km/h. The vehicle observes vehicle A, which is driving at 50 km/h. It is not reasonable that the vehicle accelerates to more than 50 km/h. $v_{f\_\min}$ is thus set to 50 km/h.

Figure 2-B illustrates that the vehicle observed vehicle B in addition to the condition of Figure 2-A. Vehicle B is driving at 60 km/h. However, because vehicle A is driving at 50 km/h, it is not reasonable that the vehicle accelerates above 50 km/h. Then, $v_{f\_\min}$ is set to 50 km/h.

Figure 2-C shows that the vehicle observed vehicle C in addition to the condition of Figure 2-B. Since vehicle C is driving at 40 km/h, vehicle A and B are predicted to catch up to vehicle C, and decelerate to 40 km/h. In other words, it is not practical for the vehicle to accelerate to more than 40 km/h. Then, $v_{f\_\min}$ is set to 40 km/h.

The design approach of the EcoSmart driving, which considers the preceding vehicles, is that the vehicle drives at the minimum velocity of all the preceding vehicles in the same lane. A vehicle control that considers the preceding vehicles is generally a following control such as an adaptive cruise control (ACC). However, if the V2V distance increases, the following control ignores the ecological driving, in order to maintain its target V2V distance. Also, the following control is not directly EcoSmart driving, because the control transfers unnecessary acceleration/deceleration of the preceding vehicle to the vehicle. Especially, in the following control of ACC, of which the string stability is not fulfilled, unnecessary acceleration/deceleration of the preceding vehicle is transferred to the vehicle with amplification, thus the following control should not be applied for EcoSmart driving.

The proposed vehicle consideration behavior of EcoSmart driving control deals the V2V distance between the vehicle and the preceding vehicle as margin for ecological driving. This control never allows acceleration to higher velocity than that of the preceding vehicles in the same lane. Driving at a higher velocity than the preceding vehicle not only spoils the margin of V2V distance for ecological driving, but also yields unnecessary acceleration/deceleration. On the other hand, if a preceding vehicle driving at a lower speed than the vehicle emerges, the vehicle consumes its V2V distance for ecological driving, using most of its ecological means (e.g., reducing fuel consumption and using regenerative braking) according to the vehicle consideration behavior.

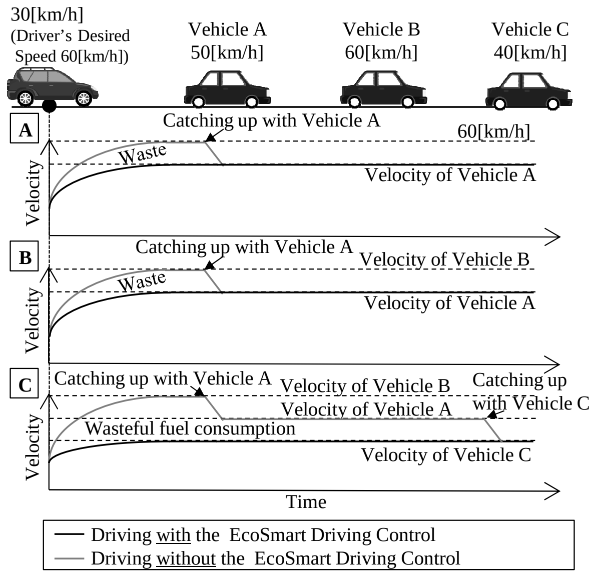

Figure 2. Consideration for Preceding Vehicles

C. Traffic Signal Consideration Behavior

The traffic signal consideration behavior simulates driving where traffic signals are on the road. Equations to calculate target accelerations of the traffic signal consideration behavior $\dot{v}_{t\_s}$ is as follows.

$$\dot{v}_{t\_s} = \frac{dv_{t\_s}}{dt} = \begin{cases} a\left[1-\left(\frac{v}{v_{t\_s}}\right)^{\delta}\right] & (v \le v_{t\_f}) \\ \min\left[-b\left[1-\left(\frac{v_{t\_s}}{v}\right)^{\delta}\right],\ \ \dot{v}_{s\_safe}\right] & (v > v_{t\_f}) \end{cases}, \quad (4)$$

$$\dot{v}_{s\_safe} = \frac{dv_{s\_safe}}{dt} = \begin{cases} \infty & (\text{signal is green}) \\ -a\left(\frac{s_s^*(v)}{s_s}\right) & (\text{signal is red}) \end{cases}, \quad (5)$$

$$s_s^*(v) = s_0 + \max\left[0,\ \left(vT + \frac{v^2}{2\sqrt{ab}}\right)\right], \qquad (6)$$

where $\dot{v}_{s\_safe}$ determines a limit acceleration in order to stop safely in case the preceding traffic signal is yellow or red. v_{t_s} is the target velocity to drive in accordance with the timing of green light of the traffic signals, with no unnecessary acceleration/deceleration. Here, the traffic signals are observed using sensors on the vehicle or via communication.

Figure 3 illustrates examples calculating v_{t_s}. Figure 3-A shows an example of the vehicle, which is driving at 30 km/h but the driver's desired speed is 60 km/h. The vehicle observes signal A. First, the vehicle estimates the arriving time at signal A. The vehicle has light timing data for signal A; it is not reasonable that the vehicle accelerates to higher speed allowing the vehicle to arrive at signal A before its timing of green light. Thus, the target arrival time at signal A is set to just after signal A turns to green. Then v_{t_s} is calculated from characteristics of the free road behavior and the vehicle consideration behavior.

Figure 3-B illustrates that the vehicle observed signal B in addition to the conditions of Figure 3-A. The vehicle estimates the arrival time at signal B. As the vehicle has the light timing data of signal B, it is not rational for the vehicle to accelerate to higher velocity making the vehicle arrives at signal A before its timing of green light. Thus, the targeted arrival time at signals A and B is set to just after signals A and B turn green, respectively. Then v_{t_s} is calculated from characteristics of both the free road behavior and the vehicle consideration behavior.

Figure 3-C shows that the vehicle observed signal C in addition to the conditions of Figure 3-B. The vehicle estimates the arrival time at signal C, from the target arrival time at signals A and B, calculated in Figure 3-B. As the vehicle has the light timing data of signal C, arriving at signals A and B at their target arrival times causes unnecessary acceleration/deceleration of the vehicle. Thus the target arrival times of signals A and B is set to any time in the green light period of each signal, and the target arrival time of signal C is set to just after it turns green. Then v_{t_s} is calculated from characteristics of the free road behavior and the vehicle consideration behavior.

Figure 3-D shows that the vehicle observed signal D in addition to the conditions of Figure 3-C. The vehicle estimates the arrival time at signal D, from the target arrival time at signal C, calculated in Figure 3-C. As the vehicle has the light timing data of signal D, arriving at signal C at its target arrival time causes unnecessary acceleration/deceleration of the vehicle. Also, if the target arrival time at signal C is set to just before it turns red, a deceleration is also needed in order to pass the signal D just after signal D turns green. Thus, the target arrival times of signals A and B are set to any time during green light phase of each signal, and the target arrival time of signal C is set to just before it turns yellow. Then v_{t_s} is calculated from characteristics of the free road behavior and the vehicle consideration behavior.

If the aforementioned process is calculated with updated information of the preceding vehicles and the traffic signals, the vehicle can drive reducing unnecessary acceleration/deceleration. As it would cause accidents to pass traffic signals during color transition, the target arriving time should consider of safety margin.

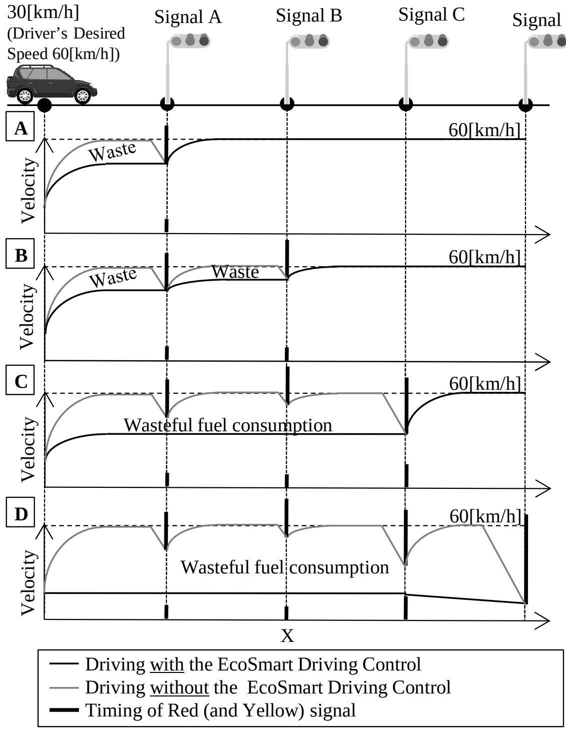

Figure 3. Consideration for Traffic Signals

D. Platooning Behavior

The platooning behavior simulates a driving condition where the preceding vehicles are driving under EcoSmart driving control. The equation to calculate target acceleration of the platooning behavior $\dot{v}_{t\_p}$ is shown below:

$$\dot{v}_{t\_p} = \frac{dv_{t\_p}}{dt} = \begin{cases} \infty & (\text{NOT EcoSmart}) \\ \dot{v}_l & (\text{Eco Smart} \ \&\ s_l \le s_{t\_p}) \end{cases}, \qquad (7)$$

where $\dot{v}_l$ is current target acceleration of the nearest preceding vehicle. s_{t_p} is the target V2V distance of the platooning control.

In addition to the equation, in case the nearest preceding vehicle is driving under EcoSmart driving control, a change is added to the vehicle consideration behavior. The equations to calculate $v_{f\_\min}$ of the vehicle consideration behavior are altered as shown below:

$$\dot{v}_{t\_f} = \frac{dv_{t\_f}}{dt} = \begin{cases} a\left[1-\left(\frac{v}{v_l}\right)^{\delta}\right] & (v \le v_l) \\ -a\left(\frac{s_f^{*}(v,\quad \Delta v_{f\_\min})}{s_l}\right)^2 & (v > v_l) \end{cases} \quad (2)'$$

$$s_f^{*}(v,\quad \Delta v_{f\_\min}) = s_{t\_p} + \max\left[0,\quad \left(\frac{v\Delta v_l}{2\sqrt{ab}}\right)\right] (3)'$$

These equations enable a narrow V2V distance necessary to execute the platoon behavior.

The platooning behavior simulates the platooning control, which maintains V2V distances at a constant value, by setting the acceleration of the vehicle to match that of the nearest preceding vehicle.

When a vehicle group is formed, with each vehicle under EcoSmart control, only the lead vehicle considers traffic conditions, and the following vehicles exhibit platooning behavior. In this way, the traffic capacity consumed by the lead vehicle can be compensated for. In addition, if the percentage of vehicles under EcoSmart driving control increases in a lane, the average traffic capacity consumption per vehicle decreases compared to the situation with no vehicles under EcoSmart control driving in the lane. Hence, EcoSmart driving control would clear traffic congestion. With the traffic congestion cleared, the efficiency of the traffic condition considerations, performed by the lead vehicle of the group under EcoSmart control, is enhanced. Thus, more ecological driving is achieved. In other words, EcoSmart Driving control proposed in this paper has a possibility to generate an ecological progression.

E. Integration of the Behaviors

A target acceleration is selected from the target accelerations calculated for the aforementioned behaviors. The equation to calculate the final target acceleration $\dot{v}_t$ is as follows:

$$\dot{v} = \min\left[\dot{v}_{t\_b} \quad \dot{v}_{t\_f} \quad \dot{v}_{t\_s}\right]. \quad (8)$$

The final target acceleration $\dot{v}_t$ is set to the minimum value of the target accelerations of all the behaviors.

In this study, the proposed EcoSmart driving control is evaluated using a traffic flow simulator. In the simulator, the statuses of all the simulated vehicles are determined according to the equations as follows.

$$v(t+\Delta t) = v(t) + \dot{v}\Delta t, \quad (9)$$

$$x(t+\Delta t) = x(t) + v(t)\Delta t + \frac{1}{2}\dot{v}(\Delta t)^2, \quad (10)$$

$$s_l(t+\Delta t) = x_l(t+\Delta t) - x(t+\Delta t) - L_l, \quad (11)$$

$$s_s(t+\Delta t) = x_s(t+\Delta t) - x(t+\Delta t), \quad (12)$$

where Δt is a calculation interval of vehicles modeled in the traffic flow simulation. s_l and s_s are V2V distances between the vehicle and the nearest preceding vehicle, and between the vehicle and the preceding traffic signal, respectively. x_l, x_s, and x represent the positions of the nearest preceding vehicle, the preceding signal, and the vehicle, respectively. L_l is the length of the nearest preceding vehicle.

III. Simulation Evaluation

In this study, the aforementioned EcoSmart driving control was evaluated using a traffic flow simulator. This paper reports the following four simulation condition evaluations and results: a) evaluation of the efficiency of the vehicle consideration, b) evaluation of the efficiency of the traffic signal consideration, c) evaluation of platooning behavior, and d) evaluation of the efficiency of the whole EcoSmart driving control.

Simulation conditions, except for evaluation on the efficiency of the whole EcoSmart driving control, are evaluated in the simulator, which simulates a straight road with an infinite length. Only the evaluation on the efficiency of the whole EcoSmart driving control is simulated in the ring road, which is 2 km per lap. These roads have one-way traffic, single-lane, and flat. There is no inflow/outflow of vehicles anywhere on the roads. The traffic signal position is stable.

The vehicle model in the traffic flow simulator has each vehicle under EcoSmart driving control or vehicle with an IDM. The model parameters of the EcoSmart driving control and IDM are set to the common values for the vehicles. All the vehicles have the same fuel consumption characteristics map, which simulates a D-segment car equipped with a 150 kW reciprocating engine. The fuel consumption per interval is calculated based on the map.

A. Evaluation of Efficiency of the Vehicles Consideration

In this evaluation, three vehicles drive in order of A, B, and C on the road. Vehicle A drives at 40 km/h of initial velocity, and at 40 km/h of target velocity, with an IDM. Vehicle B drives at 50 km/h of initial velocity, and at 50 km/h of target velocity, with an IDM. Vehicle C drives at 50 km/h of initial velocity, and at 60 km/h of target velocity. Vehicle C is driven with an IDM and, for comparative evaluation, under EcoSmart driving control. The initial position of the vehicles have vehicle B at 200 m preceding vehicle C, and vehicle A is 400 m ahead of vehicle C. There are no traffic signals are on the road.

Figure 4 shows the fuel consumption and velocity of vehicle C plotted against mileage. The result shows that the proposed EcoSmart control targets the velocity of vehicle A and starts to decelerate by running on inertia early on. In this way, vehicle C reduces unnecessary acceleration and results in improved overall fuel efficiency.

The results reveal that the vehicle consideration in EcoSmart driving control yields a reduction in unnecessary acceleration/deceleration and that leads to a reduction in fuel consumption.

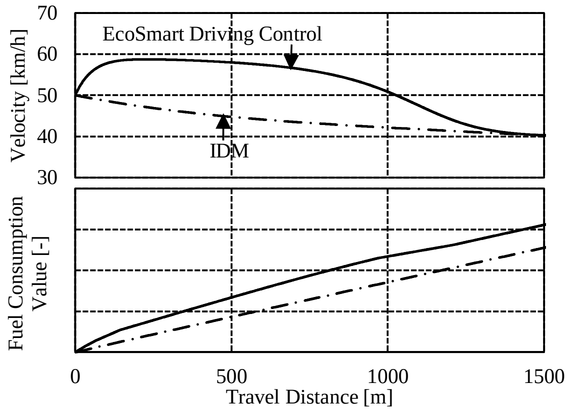

Figure 4. Simulation Result

B. *Evaluation of Efficiency of the Traffic Signal Consideration*

This evaluation consists of a vehicle and a traffic signal. The initial velocity of the vehicle is 30 km/h, and the target velocity is 60 km/h. For comparative evaluation, the vehicle drives with an IDM and under EcoSmart driving control. The signal is initially red, and it turns green after 35 s. The signal is 300 m ahead of the vehicle at the start time. EcoSmart driving control is shared the light timing of the traffic signal.

Figure 5 shows the resultant fuel consumption and velocity of vehicle C plotted against mileage. The results show that EcoSmart driving control considers the turning timing of the signal, and gently accelerates in order to not decelerate at a red light. In this way, the vehicle reduces unnecessary acceleration and results in improved overall fuel efficiency.

The results demonstrate that the traffic signal consideration in EcoSmart driving control yields a reduction of unnecessary acceleration/deceleration, which leads to a reduction in fuel consumption.

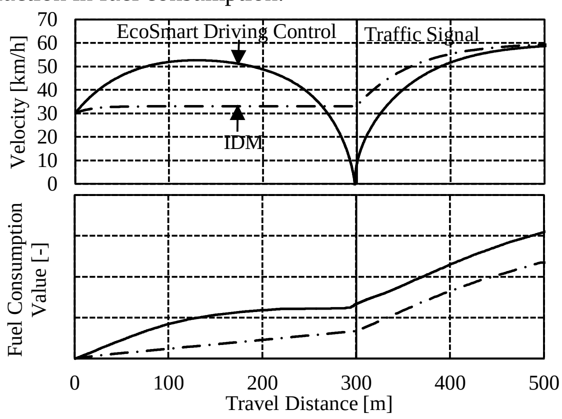

Figure 5. Simulation Result

C. *Evaluation of Platooning Behavior*

This evaluation consists of three vehicles driving in order of A, B, and C and a traffic signal. The initial velocity of vehicle A is 30 km/h, and the target velocity is 60 km/h, driving with an IDM. The initial velocities of vehicles B and C are 30 km/h, and the target velocities are 60 km/h, driving under EcoSmart driving control. The initial state of the signal is a red light, and it turns to green after 35 s. The initial position of the vehicles is as follows: vehicle B is 200 m ahead of vehicle C and vehicle A is 400 m ahead of vehicle C. The signal is 700 m ahead of vehicle C at the start time. EcoSmart driving control is shared the light timing of the traffic signal.

Figure 6 shows a graph of the velocities and control states of vehicles B and C plotted against mileage. The result shows that vehicle A decelerates and stops because of the red light, and then vehicle B decelerates. Also, vehicle C approaches vehicle B in accordance with the timing of vehicle B's deceleration, and then the platooning control is enabled. In addition, when vehicle B accelerates, vehicle C follows at the same velocity.

The result shows that platooning behavior in EcoSmart driving control precisely reproduces the platooning control.

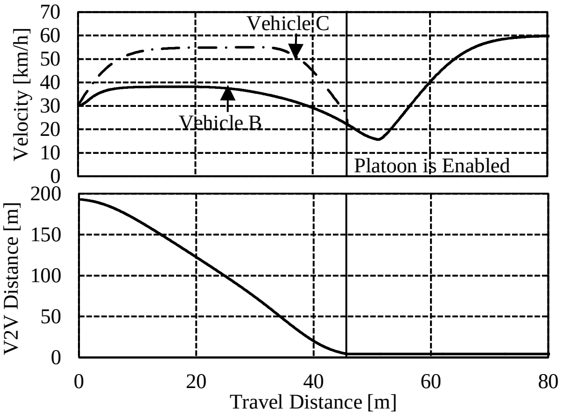

Figure 6. Simulation Result

D. *Evaluation of Efficiency of the Whole EcoSmart Driving Control*

This evaluation simulates a ring road, which is 2 km per lap. There are 50 vehicles every 100 m, and 10 traffic signals every 500 m on the road. The initial velocities of all the vehicles are 0 km/h, with target velocities of 60 km/h. 30% of the vehicles are under EcoSmart driving control, and the remaining 70% are driving with an IDM. The decision of which control is applied to each vehicle is determined randomly in each experimental run. The light timing of the traffic signals is set in normal random numbers in each experiment, based on statistical information of light timing of traffic signals on average city roads in Japan. An EcoSmart driving control system can obtain the velocity of preceding vehicles up to 400 m ahead and the light timing of the preceding three traffic signals. An experimental run is completed with all the vehicles covering 10 km, and the experiment is repeated 100 times. The average fuel consumptions and the average velocities are recorded in every test. For comparative evaluation, EcoSmart driving control can switch, i.e., enable/disable, the platooning behavior.

Figure 7 shows the fluctuation percentage of average velocity and fuel consumption for all traffic. The fluctuation percentage is calculated in as follows; the value of all the traffic, with no vehicles under EcoSmart driving control, is divided into that of the value where vehicles under EcoSmart driving control are driving on the road. The result shows that both EcoSmart driving control without platooning behavior and EcoSmart driving control with platooning behavior reduce fuel consumption for all the traffic. However, the platooning behavior also reduces the average traffic velocity of all the traffic. That is mainly because EcoSmart driving control without platooning behavior reduced fuel consumption by decreasing the traffic velocity. In other words, if the percentage of EcoSmart driving control without platooning behavior increases, traffic congestion would be generated, and that influences all traffic.

The results show that the EcoSmart driving control proposed in this study reduces fuel consumption of all the traffic, saving traffic capacity, and that the control performs with higher efficiency than other vehicle controls in related studies.

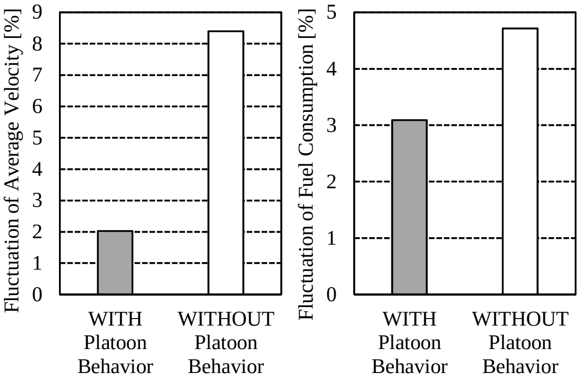

Figure 7. Simulation Result

IV. CONCLUSION AND FUTURE WORK

In this study, we developed EcoSmart driving control in order to enhance the efficiency of city traffic.

First, the importance of efficiency of city traffic in future cities is explained. Driving needs to be improved in order for the efficiency of city traffic in future cities to be enhanced. This requires a driving control system. The related studies would negatively influence traffic flow.

Then, the details of EcoSmart driving control proposed in this study are described. EcoSmart driving control consists of the free road behavior, vehicle consideration behavior, the traffic signal consideration behavior, and platooning behavior. Each behavior is formulated, and the objective is explained.

Next, a simulation evaluation of EcoSmart driving control is reported. Evaluations are conducted based on the following conditions: a) efficiency of vehicle consideration, b) efficiency of traffic signal consideration, c) platooning behavior, and d) efficiency of the whole EcoSmart driving control system. All the evaluation results show that EcoSmart driving control can reduce fuel consumption in traffic while saving traffic capacity.

Our future work is on system development for application to actual vehicles, and on driving evaluation.

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Towards Smart Traffic Lights Using big data to Improve Urban Traffic

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***Abstract*— The rise of urban population brings the need of effective ways to move around the city and strategies to improve the traffic flow. This study aims to observe the present context of the traffic lights, one of the solutions to traffic control most used in our time. This study will also look some solutions already implemented by the cities of Los Angeles and Recife using sensors and cameras at intersections, in order to optimize traffic control in real time. The proposal will be a system of intelligent traffic lights based on big data from navigation and traffic applications, which adapt the traffic lights depending on traffic, contributing to the improvement of systemically traffic control instruments, generating immediate gains in quality of life in cities.**

Keywords- Traffic Lights; Big Data; Social Network;

I. Introduction

Big cities have several challenges for us to tackle; one of them is the issue of urban mobility. "The United Nations projected that half of the world's population would live in urban areas at the end of 2008" [1]. Nowadays, predictions say that by 2050 about 64% of the developing world and 86% of the developed world will be urbanized [2].

By analyzing these predictions, it becomes clear that it is necessary to think about problems in the urban environment. Among urban problems, urban mobility and the massive use of cars is one of the most significant.

Dealing with such problems is not simple since cars have become one vital part of urban environments; the majority of the cities are living in car paradigm, as Recife city, which has the biggest flux of car in Brazil. This paradigm deals with the notion that we have to improve mobility but mobility is nor improving [3].

This paper proposes a discussion about how the traffic lights, one of the major instruments in traffic control of big cities, can be smarter by relying on data collected by the drivers using apps like Waze and Google Maps. The paper is divided as follows: Section II focuses on discussions about urban mobility. Sections III and IV highlight some existing solutions in traffic light, and briefly analyze them. In Section V, some proposals are discussed and future researches are suggested.

II. Cities analysis

For the last few years, the number of people that live in the urban area has surpassed the amount living in rural areas [4]. Figure 1 shows in 2050 the urban population will account for 6 billion people out of a total 9 billion.

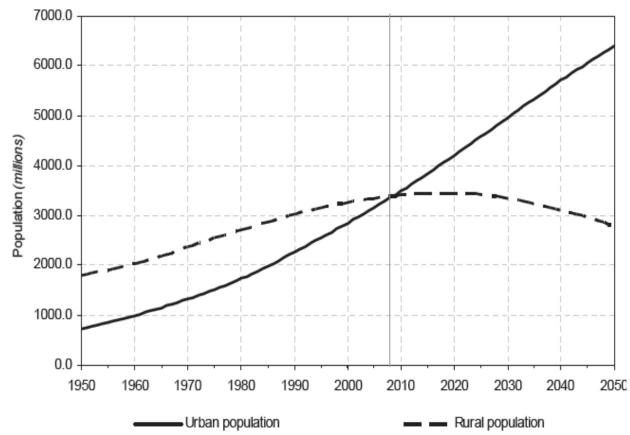

Figure 1. Urban and rural areas of the world, 1950 – 2050 [5].

Population growth in urban centers and the lack of infrastructure are the main factors to affect urban mobility, causing traffic problems and jams [5].

Recent politics of income redistribution in Brazil had increased the car sales for the past ten years.

> "*Brazil is the world's fourth-biggest auto market and a major base of operations for Italy's Fiat SpA, Germany's Volkswagen AG and U.S.-based General Motors Co and Ford Motor Co."* [6].

Even with the decrease in sales over the past years, big urban centers in Brazil are filled with cars. Recife is one big city with traffic problem, and one of the biggest cities in the northwest of Brazil. A research published in a local newspaper shows that Recife is the city that has a largest number of streets with traffic jam during rush hours in Brazil [7].

The increase in numbers of cars on streets is not the only reason for the traffic problems to appear; there is a lack of planning to deal with this amount of cars. For example, it is very common for someone to wait a traffic light to become green even if there is no car in the street. This might intensify the traffic jams instead of work as a traffic controller [8].

The problem of traffic jams in cities is not an easy problem to address. It is necessary to improve public

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transportation system and provide people with means to be less dependent on their cars.

In addition, it is also necessary to stimulate other possibilities of transportation, to improve safety on the streets, to increase people security feelings and walkability through the streets. Among the options to address such scenario, big data appears as a possible solution to improve traffic systems and solutions.

III. EXISTING SOLUTIONS

This section depicts some solutions in big cities around the globe.

A. *Los Angeles city*

The city of Los Angeles is a city with one among the worst traffic jams in the USA. It has a system that uses big data to control the traffic lights. The New York Times gives a breakdown of how it all works:

> "*Magnetic sensors in the road at every intersection send real-time updates about the traffic flow through fiber-optic cables to a bunker beneath downtown Los Angeles, where Edward Yu runs the network. The computer system, which runs software the city itself developed, analyzes the data and automatically makes second-by-second adjustments, adapting to changing conditions and using a trove of past data to predict where traffic could snarl, all without human involvement*" [9].

Further information about the smart grid system, used in Los Angeles, and how it works, could see below:

> *"The system is intelligent in that it can automatically adjust the time delay between light changes whenever issues arise. So, for example, if there is an accident that causes one or more lanes to be closed on any highway in the city (thus causing a bottleneck), it can adjust the lights and give more time to let cars caught up in it all pass through. Alternatively, it can also be used to help keep public transport running on time – if the buses are late, the system can help them to pass through the lights faster and get back on schedule"*[10].

This system slightly improved the traffic in the city. According to officials, the average time to drive 5 miles in the city before was 20 minutes. These smart traffic lights have reduced the time to just 17.2 minutes.

B. *Recife city*

Some actions have already been tested to improve the traffic control in Recife: some traffic lights use cameras to make the time that they stay green or red more effective, according to the traffic on the streets without the need of a pre-programed pattern.

With smart traffic lights, the control of the traffic flow is conducted in real time [11]. This means that a command and control service is responsible to change traffic lights through an adaptive control. Figure 2 shows how the adaptive urban traffic control system works.

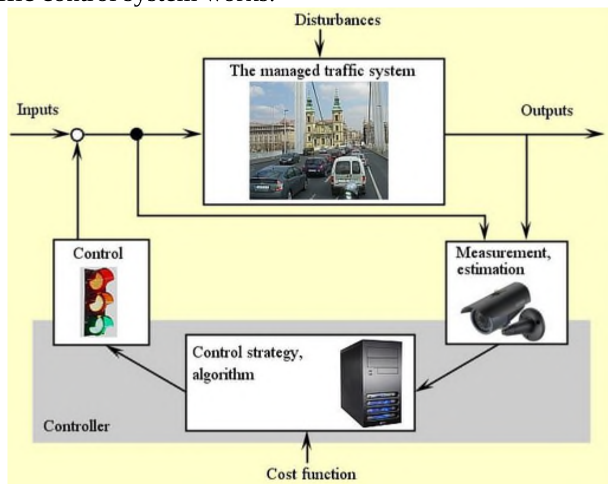

Figure 2. The adaptive urban traffic control system works.

IV. DISCUSSIONS

Looking at Los Angeles and Recife solutions it is possible to observe the need of the installation and maintenance of a great number of sensors around the city. This will possibly lead to a high cost for the execution of these services. There is also the need of the development of a system that controls and updates the data of the traffic lights. Besides that, these sensors just work for the nearby traffic and cannot understand what is happening with the traffic around the city as a whole.

Another aspect of this idea is the possibility of using the sensors that are already on the streets and do not depend on government agencies to work; they just need smart citizens feeding data for their own good. This approach can possibly lead to a lower cost of implementation and maintenance compared to the Los Angeles and Recife solutions that need the implementation and maintenance of sensors around the city.

V. PROPOSAL

The proposal, looking at these examples, is a new approach for these big data traffic lights. Instead of using a lot of time and money building an infrastructure of magnetic sensors in every road intersection, use data gathered by the drivers and shared trough the web using apps like Waze or Google maps. The drivers rely on this information for their daily commutes. We could use the data gathered by the drivers to help us improve the time and flux of the traffic lights.

Some actions are performed to enable the traffic light system of Smart Cities to control the traffic light based on the current traffic situation. Some traffic lights have camera assistance to help decide the length of the green and the red in order to smooth the traffic flow. In other words, with the

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help of the smart traffic lights, the control of the traffic is done in real time.

VI. Final Discussions

Our proposal in this paper shows the potential of using mobile sensors available in smartphones and other smart objects to solve problems in cities, in this case, urban mobility. These sensors have already improved the traffic for many people, especially for those who want to see the traffic flow, and take an alternative route, for example. It is time to use this data in a different way, creating a greater good for the city. The use of the big data information generated by these sensors connected to social networks and connected with the traffic lights, can create new possibilities for better optimized traffic flow and can generate algorithms that may help government agencies to create further solutions that could improve urban mobility.

Our proposal is an initial effort to study the possibilities of big data to improve the traffic flow in big cities and with further research can lead to the creation of a “smart traffic light.” The smart traffic lights are expected to access the huge amount of information generated by the users and shared through social networks.

Future studies will focus on user research, data mining techniques, and solutions that use big data for urban mobility.

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A Vision of Traffic Lights for Color-Blind People

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***Abstract* - This paper presents a work in progress and an analysis about the difficulties for color-blind people to recognize traffic lights. Colorblindness (dyschromatopsia or discromatopsia) is a disease characterized by an abnormality in the photosensor pigment cells of the eye, resulting in the malfunction of color detection, most frequently in red and green shades. With this work, we want to understand the main concern about how smart cities will provide an accessible environment for colorblind drivers.**

Keywords - smart city; accessibility; color blindness.

I. INTRODUCTION

Worldwide, hundreds of millions of people have vision problems and color blindness is one of them. In Brazil, 14.5% of the population have some vision disability and 10% have some kind of color blindness [1]. It is a genetic disorder that affects the X chromosome, causing inability to distinguish any primary colors. A color-blind person has deficient cells, resulting in a distorted perception of colors. The most common color confusion is between green and red shades [2].

The lack of standardization of traffic lights generates some difficulties for color-blind people, such as walking and driving or to identifying traffic lights. So, it is possible to identify opportunities for learning and for better management of special needs to accessible and smart cities [3].

Due to fast urban growth, cities now face many risks and an urgent need to find smarter ways to manage challenges such as adopting solutions and including disabled people [4][5]. The study contained here is an effort to identify and analyze traffic lights problems and how it could be used to create better solution to color-blind drivers.

The paper is structured as follows: Section I is the introduction of this study. Sections II and III are a review of the literature about color blindness. Section IV is research description and methodology and section V the research results. Finally, in Section VI there are conclusions and proposals for future works.

II. COLOR PERCEPTION AND BLINDNESS

Retinal cells, called cones, are responsible for the perception of colors. There are three kinds of cones and each one is responsible for the colors red, green and blue, known as basic colors and the other colors are a combination of those three colors. Color perception is a sensorial process that gives meaning to objects and environment lights through the use of memory to convert colors into sensations [1][2]. Therefore, for the colors to exist, we need two main elements: eye and light. An important factor to decode colors through the eye is the wavelength, since human visual perception is a sensation [6][7][8] and the white color is not considered a color, just a sum of all colors. The maximum spectrum of light sensitivity to give wave range are the colors yellow, green and blue [6][7][9]. The most common symptoms of color blindness are the problems to identify color brilliance and nearby colors [10][11]. Color is a fundamental part of visual communication. The meaning of colors can be covered in many aspects in society - it is common to use color as a direct reference to qualify objects, based on the guidelines of traffic lights, the red light means the driver needs to stop and green light means to go.

Color blindness is a cone cell deficiency that changes color perception; it is a problem that affects about 10% of the world population. Color blindness is a genetic problem with the X chromosome and it is more frequent among men with only one X chromosome, while females have two X chromosomes.

The degrees of dyschromatopsia are variable and they are classified into four categories: Protanopia, the most common, which is the inability to distinguish between red and green shades, deuteranopia, a confusion of red and green shades, tritanopia, a conflict between blue and yellow shades, and achromatopsia, a total blindness to other colors, providing a black and white vision.

One of the most common ways to discover color blindness ID is applying the Ishihara test [5]. This test consists of 32 colorful cards with various circles with a different hue, saturation and brightness in the same board [2]. Unfortunately, there is no solution to correct color blindness and people usually learn how to live with the problem.

III. COLOR BLINDNESS AND TRAFFIC LIGHTS

Driving may not be the most difficult activity for color-blind people. Nowadays, there is no evidence of traffic infractions by color-blind people. This particular situation demands a reflection about the relationship with traffic signs and lights for colorblind people. A colorblind person has the ability from visual perception about shapes and textures; so, no matter what traffic sign colors shown, a colorblind person will have no difficulty to understand color meaning.

Many types of colors and cards do not represent an obstacle to understand the messages as long as it follows a previously known pattern.

However, traffic lights must be considered a problem because they do not have an established standard. Many traffic lights do not have colors vertically distributed using the red light on top, yellow in the middle and green at the bottom. This lack of standardization contributes with the inability of color-blind people to understand traffic lights. Perception of green and red colors is the biggest problem for people with this disability. Some cities have already adapted accessible traffic lights. Most of the adapted traffic lights have a white band by the side of the yellow light, allowing the color-blind to distinguish a color signal by the illumination and position of the light. Some cities use horizontal traffic lights with the red light on the left and the green light on the right. If a color-blind guides himself by which side each color is, he will probably mix them all.

IV. METHODOLOGY

Based on a research with young color-blind drivers, data production was carried out between December 2014 and February 2015. The population of the study was composed by 14 male participants, from 18 to 40 years old, recruited and invited to participate in the study. They answered questions about driving in attention to mobility and accessibility in streets and avenues.

The objective of the survey was to identify problems with disordered and chaotic traffic signs and possibilities to solve urban problems. Questions were developed to help in the comprehension of the problem:

a) What mean of transportation do they use?

b) Do they feel any difficulty to identify traffic lights while driving?

c) How often do they drive?

d) How do they understand traffic lights?

e) What do they think about the traffic lights of the city?

Through survey, we first obtained information about how often the volunteers drive, which routes they take and their perception about traffic lights. Then, in order to identify color blindness, all volunteers were submitted to the Ishihara test, the most effective tool for color blindness detection in red and green shades, the most common kind [11]. For this study, we used a version with 24 plates to distinguish defects in the red-green axis. To confirm color blindness, volunteers must at least, fail in eight of the 24 plates. All the recruited failed in the test, confirming the presence of the disability. Through data collection, a semi-structured interview allowed a deep knowledge of users personal meanings about traffic lights.

To build the set of common data, all responses were transcript to use in future works. Analysis of content from interviews and data interpretation and convergent aspects of responses had a thematic categorization.

V. RESULTS

The research revealed that 70% of the volunteers have problems with the lack of standardization in traffic lights. Data showed that in order to improve contrast, it is essential to increase traffic light visibility. For 15% of the respondents, LED (light emitter diode) traffic lights create more difficulty to identify colors because of their excessive luminosity; focusing on LED lights is more difficult, especially at night. The radiation of bright lights might confuse users. When a color-blind person drives at night there is a risk of not identifying which shining light is up or down. In developing countries as Brazil, the biggest limitation for color-blind people is a prohibition to drive. According to the Brazilian law, Resolution No. 80 on 11/19/98 of the National Traffic Council, an ophthalmological evaluation is required (art. 1, Annex I, item 2.1, a) and it demands full color vision (item 3.3.4). Brazilian Traffic Council statement says: "the candidate must be able to identify the colors red, yellow and green" (item 3.8.1). In developed countries, it is quite different. Some European cities have adopted the first color letter matching its correspondent light. It is possible to match each color with different geometric shapes.

The most frequent answer to the survey was that 87% of the volunteers did different moves when they had doubts related to the color light. In some cases, the driver follows other drivers nearby when they do not know which color the traffic light is. We also found that when the carrier of the disability cannot identify the color of the traffic lights, there is a reduction of the speed until he reaches the semaphore. When meeting an intersection, color-blind people tend to stop and wait for another car to cross the roads. In critical cases, color-blind people do not feel safe driving alone; in this case, they always go with friends or family, so that they can assist them in the traffic.

VI. CONCLUSION AND FUTURE WORK

This research sought to understand difficulties of color-blind people and their relation to traffic signals. Distinct solutions were identified and each possible potential benefit will be shown in a future work. Even defining research questions and protocol beforehand, strict validation, especially related to the solution of problems, will benefit future research efforts. The lack of standardization of traffic lights must be an urgent subject to propose to governmental institutions.

However, it is important and relevant for this work to continue this research and propose relevant alternatives to improve accessibility for color-blind people - using technology to provide smart solutions such as identifying traffic signals and others, not only based on colors but on more accessible and adaptive ways for people with vision problems.

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Beyond Efficiency: How to Use Geolocation Applications to Improve Citizens Well-being

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***Abstract* - This paper presents a work in progress that exposes how the growing problem of urban mobility in large cities has contributed to the level of unhappiness of its inhabitants and tries to examine if the hypothesis of using geolocation applications to increase the well-being of the citizens might be a starting point for future works. A previous research concluded that people with the longest commutes are the least satisfied with life. Although some technological initiatives, such as Waze and Google Maps, tries to reduce the time wasted in traffic, the information here demonstrates that such efforts are not enough to reverse this everyday negative experience. Exploring theoretical concepts of emotional design and an experiment of Yahoo Labs, this paper argues that it is possible to work with the emotional responses of geolocation application users. Based on what was observed and collected, we argue that the use of these applications can create opportunities for positive emotions and encourage a change of attitude towards traffic problems, enabling more significant and delightful moments that potentially contribute to an increase in the feeling of well-being. We present the need of this new approach as it goes beyond current methods in its potential to make citizens smart when the city environment cannot be modified.**

Keywords-urban mobility; navigation applications; emotional design.

I. INTRODUCTION

The concept of smart cities is usually linked to efficiency in the use of natural resources. Discussions about this concept have been happening between citizens and experts. The use of the latest technology is promoted to transform large urban centers into a less aggressive place to live in, yet some problems faced by citizens come from government policies and economy. Urban mobility is one of the most impacted issues.

In Brazil, a survey conducted by the National Association of Public Transportation [1] found that the vehicle fleet in major cities in the country grew more than the road structure in recent years. From 2003 to 2012, while the fleet increased 92%, the street extension grew 16%. The study compared data from 438 cities with over 60,000 inhabitants.

The Brazilian case illustrates a current scenario in large urban centers. These survey data illustrate the significant increase of the fleet, being 70% for cars and 209% for motorcycles. An increase of 5% of the fleet does not have an impact on the course of time in the same proportion, but larger, as the relationship between flow and travel time is not linear.

A contributing factor in this scenario is the facility to buy vehicles and, in some cases, the cost is equivalent to public transportation. It is a scenario where political leaders encourage the production and car sales in the country and the institutions need a large volume of government funds to accompany the changes.

Another scenario that exacerbates those problems is the concentration of the population in large cities and in metropolitan surroundings, creating the need for daily mobility to places where there is a concentration of jobs and facilities through some means of transportation, whether public or private.

The vehicles in cities are a troubling issue in the short term. Usually, they are the result of structural problems of the cities and the necessary public policies for the alleviation of these problems compete with tax benefits granted to the establishment of the major automakers to generate direct and indirect jobs.

The experience of other countries shows that building more streets and avenues, which will inevitably be congested, is not a good solution. One example is the city of Los Angeles, in the US, where there are lots of freeways and still has slow traffic [1], leaving the discussion open on how to minimize the inconvenience caused to daily lives of citizens.

Citizens have to seek their own alternatives to live with problems derived from urban mobility caused by the economic situation and governmental choices.

In this scenario, this article begins the exploration of the subject in Section I, about the emotional consequence suffered by the people due to the excessive time wasted in traffic. Then, in Section II, we expose the rise and popularization of geolocation mobile applications, with the direct goal of reducing time wasted in traffic. In Section III, the concepts of Donald Norman about Emotional Design are introduced to allow the analysis of Waze, one of the geolocation applications analyzed in Section IV. Finally, Section V presents the case of Happy Maps by Yahoo Labs, which tested the implementation of features that aim to generate positive and emotional responses in users, such as the app to guide people displacement.

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II. TIME WASTED IN TRAFFIC VERSUS HUMAN EMOTIONS

Brazilian Demographic Census of 2010 presents on the traffic travel time that only 14.8% of workers in urban areas of the country spend up to five minutes to go to work. It means 6.6 million of the 55.1 million citizens working out of home. Furthermore, 28.5 million people spend from six to thirty minutes in the displacement and more than 1 million people spend over two hours.

A survey pointed out that people living in São Paulo, the largest city of Brazil, waste about one month per year in traffic jams, with an average time of 2.4 hour/trip per day.

Another striking statistic is the number of people studying or working in different cities from the ones that they live in. From 2000 to 2010, this number grew 93.9%. The explanations for the increase are related to population growth, increase in the number of formal jobs, acceleration of the metropolization and urban development process of inner cities as well.

In a study conducted in Canada [2], it has been discovered that traffic jams are in the top of the list of reasons why commuters experience increased stress. People who spend most of their time on the road experience higher levels of stress because they constantly feel hurried. The study discovered a direct link between commute team and welfare [3]. The findings concluded that people with the longest commutes have the lowest overall satisfaction with life. The commute lengths are usually linked to a sense of time pressure, people experience higher levels of stress because they constantly feel hurried and worried about all the activities they are missing.

Although there are a lot of evidences linking commutes to negative feelings, some researchers found out that a longer commute may benefit people. Reports of studies [3] found out that the key to an enjoyable commute is using the time as an opportunity to create a mental shift between home and work. If the time is used as a break from other appointments and responsibilities, the driver may become more relaxed. When reducing the driving time is not an option, some activities as using the journey to listen to music, enjoy the landscape, or simply being alone with the thoughts can change the commute to leisure time.

III. RISE OF NAVIGATION APPLICATIONS

Focusing on reducing time in the traffic, navigation applications are increasing their participation on the daily life of citizens in large urban centers. As a way to help reducing the inconvenience caused by urban mobility problems, mobile applications, such as Waze and Google Maps, intend to help people avoid the frustration of being stuck in traffic jams by offering alternative routes to their destination and much more information. Some of those are warnings about accidents, hazards, roadblocks, police and other events.

Even though a few minutes could be saved in some cases, such efforts are not enough to sufficiently improve this mobility experience in large cities. Many times it is simply impossible to avoid the traffic jam and information that would help drivers like ETA (Estimated Time of Arrival) ends up working backwards, increasing their levels of stress.

Currently, these applications do not propose motion to its users [8]. Routes are created to show only shorter or faster paths, but it does not provide and stimulate emotional pleasure to users. However, the application based on geolocation can use the data generated to propose a more randomly improvement in the relationship between individuals and cities, without a formal request [7].

A Canadian study reported that [2] commute lengths are linked to a sense of time pressure. Many people spend much of their time on the road worrying about all the activities they are missing, further enhancing the feeling of unhappiness.

IV. EMOTIONAL DESIGN

According to Norman [4], humans are the most complex of all animals; he suggests that emotions are related to three levels of brain processing: first, the "automatic layer", as a visceral level of call; second, the part that contains the brain processes that control everyday behavior, called behavioral level; and third, the contemplative part of the brain, the reflective level.

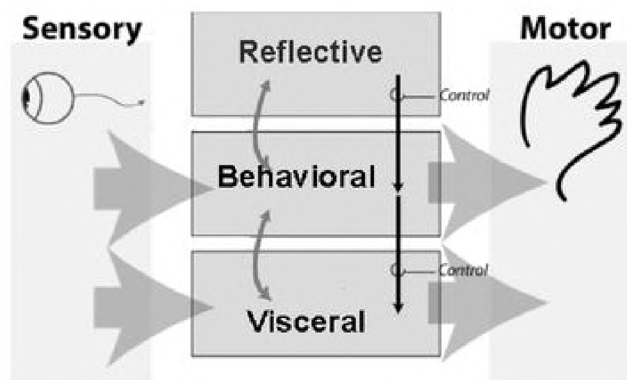

Figure 1. Three levels of processing: Visceral, Behavioral and Reflective [4].

Each level has a different role in the functioning of people and requires different design strategies. An explanatory figure about the three levels is shown in Figure 1. Each of the three processing levels will be discussed separately, with their respective design strategy.

A. Visceral

The strategy to design at this level is the appearance. Although this level corresponds to the earliest part of the human brain, it is sensitive to a variety of conditions.

People are programmed to react positively, for example, to the smell of flowers and fruits, as they represent food. In most cases, the cultural differences are important because conventions about what is desired are usually defined by society.

Working with visceral design is to understand the automatic emotional responses like shape, feeling and texture.

B. *Behavioral*

The design is totally linked to the use itself. Appearance and rationality are not important in this case, only performance. Perhaps this is the most widespread approach in the current mobile applications.

Professionals who focus on usability are used to this kind of reasoning. While making the product work may seem obvious, the needs of people are not as obvious as they may seem.

Norman [4] points out that many products fail because designers and engineers are often self-centered and believe to dominate the answers to usage issues. The behavioral design, on the other hand, should be people-centered, i.e., on users, when designing a project.

C. *Reflective*

It is a quite broad design; it covers message, culture and meaning. It works primarily with self-image and memory [4], which is why the task of designing must be based on the understanding that users have over all elements related to the artifact. There is nothing practical, biological or automatic in buying, for example, an expensive car or a famous brand; answers to these questions would be cultural.

Usually, the results of blind tests show much "confusion" among consumers who cannot distinguish, when blindfolded, between products of common brands and their "famous" preferred.

V. EVALUATING WAZE THROUGH EMOTIONAL DESIGN

The functionality and appearance of navigation applications are very similar and are usually composed by the map of the area where the user will travel, a suggested main route, and alternative routes to the destination point of the user. Currently, Waze app includes all the standard features of navigation that most of the popular applications contains, and it provides additional functionality as well; therefore, it will be used such in a way that the features can be analyzed at the behavioral level of the theory of Norman [4] about Emotional Design.

There are some features available for the user associated to the display or control of the distance to be traveled and time efficiency, and for each of them we can analyze the possible emotional stimulus.

The first feature is the set up of the route; it is possible to view the estimated time of arrival at the final destination. During the trip the user receives updates of the prediction that shows the worsening or improvement of the traffic. We can deduce some of the emotions or feelings that can be stimulated by this information:

- Security, which is a positive feeling, for being able to view the amplitude of information that would not be available without the application aid;
- Integration with the community, due to its characteristics of a social network, Waze can stimulate the culture of sharing and a sense of belonging through the exchange of information between users;
- Anxiety, a negative reflection of anticipating information about events along the way that cannot be avoided and may cause delay on the journey;
- Insecurity, in cases where the fastest route contemplates a deviation through a dangerous area.

Throughout this paper, it could be perceived that each feature can generate a number of both positive and negative emotional stimuli, although there is no data survey to consider whether there is a greater tendency for people to have (or not) feelings that favor their well-being while using the application functionalities. Still, it was not possible to consistently realize the existence of a strategy to reach the reflective level of emotional design and intentionally generate positive emotions.

Taking studies about emotions generated by problematic situations of urban mobility as a database, we can only infer that these applications are not reducing or acting to sufficiently reduce feelings of discomfort, as mentioned above, caused by the traffic context.

VI. THE DRIFT THEORY AND THE HAPPY ROUTES EXPERIMENT

Psychogeography is the science that analyzes and deciphers the relationship between humans and environmental contexts and evaluates the effects of the environment on the affective behavior of individuals [8].

Through the relations of the inhabitants with the place and elimination of the censorship imposed by conditioning, proposed by the optimization of time, the cognitive system and the appropriation of urban spaces are analyzed.

Based on the knowledge of individuals about cities, psychogeography and the theory of drift proposes that the individual should walk without a set destination letting the urban environment create the suggested path and then for each path created, the motivation needs to be pointed out. [7].

Using this theory as one of the working basis, in August, 2014 researchers from Yahoo Labs developed a GPS algorithm that allowed users to choose a route between two points based on beauty, for example, rather than time or distance [5].

The Shortest Path to Happiness [6] sought to offer "emotionally pleasant" routes using data from a crowdsourcing platform. The goal is a mapping application that presents the most enjoyable routes, taking into account not only what looks appealing, but also what sounds, or smells appealing and even the memories people attach to a place.

Researchers used a website that asks users to choose between photos of areas in London and Boston they found to be most aesthetically pleasing in order to determine the most "beautiful, quiet, and happy" journeys.

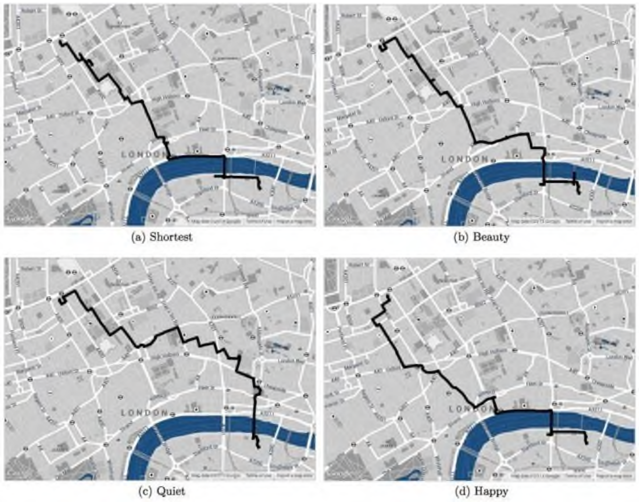

Figure 2. Route suggestions based on the "Shortest Path to Happiness" study [5].

"Based on a quantitative validation, we find that, compared to the shortest routes, the recommended ones add just a few extra walking minutes and are indeed perceived to be more beautiful, quiet, and happy," the study reads. "Web and mobile mapping services currently fail to offer that experience as they are able to recommend only shortest routes." Yahoo researchers hope to apply this feature to other cities without crowdsourced ratings by using Flickr metadata [5].

It may seem controversial that applications typically focused on the efficiency of time and distance can be used to generate emotional experiences as happiness. Considering all negative experiences reported previously, caused usually by daily commutes, the Happy Maps experiment serves as a counterpoint to open a new range of features that can enhance the experience with the traffic. The beginning of the discussion of how the location-based applications, that are so present in the lives of citizens nowadays, can be a powerful tool to enhance well-being.

VII. CONCLUSION AND FUTURE WORK

The goal of this initial investigation was to identify the potential of navigation applications to improve the well-being of people when commuting, especially in situations where there is no way to reduce their time of driving in the traffic jam, and use it as a valid starting point for further work.

In situations like this, the key to effectively improve well-being is not by changing the environment, such as increasing the number of large roads, but in the attitude of the citizens. It is directly related to the way they perceive and experience the moment, so it is necessary to create opportunities for a change of attitude towards the traffic problems. The citizen can use this shift range as a break from other commitments and responsibilities, engaging in pleasurable activities such as enjoying the cityscape. According to the Canadian study [2], enjoying the cityscape, listening to music or just staying with your own thoughts is the most suitable way to experience time in traffic as something beneficial.

Given the popularity of geolocation applications in commuting between home-work-home, a especially critical moment of the day, they can be used nt only as important tools to reduce the time in the traffic, but also as channels to stimulate positive emotional responses associated to the displacement experience, creating opportunities for this new perception.

By questioning current approaches and studying new ones for the situation, such as Happy Maps - the experiment developed by Yahoo Labs, we confirmed that it is possible to offer features via a GPS application with the clear intention of generating a change of perception, promoting positive emotional responses. This new approach also shows that there are many hidden opportunities to offer pleasurable activities through these applications, stimulating emotional responses through leisure and sense of productivity. The case of Happy Maps is a clear use of the reflective level of emotional design, which results directly in the improvement of the well-being of citizens and their relationship with the city.

Since our focus is to help citizens change their attitude and transform the city environment into a less aggressive place to live, we intend to develop a long-term research project by expanding the use of emotional design in the development process of geolocation applications. The key to the next stage is the identification of other activities that can be done in commutes in order to develop some further features. We also intend to use the results to enable the use of technology to help people with their personal attitude and, consequently, the meaning of moments.

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Analysis and Proposed Improvements in the Support for the Visually Impaired in the Use of Public Transportation

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***Abstract* - This paper proposes an improvement in an already existing service in Recife, Brazil that notifies the visually impaired of the time a bus arrives at a bus stop and the time they should get off a bus. Statistics on the number of visually impaired people around the world as well as some information about the main challenges they face in urban areas will be presented. This paper will also present the concept of SmartCity and some solutions designed around it. Finally, a solution is proposed in order to mitigate problems visually impaired people face when using public transportation. It is expected that this application will benefit not only blind people, but also any person who has a mobility impairment.**

Keywords-Blind person; visual impairment; physical disabilities; cittamobi; smart city; smartphone.

I. INTRODUCTION

Nowadays, moving around in Brazilian big city is not a smooth task. The streets are always overcrowded by cars and pedestrians are rarely prioritized. Sidewalks are commonly broken, and lack both good places to sit and shelter from the weather. Given the fact that the obstacles are big for common people, it is not difficult to understand how these problems may affect a person with a mobility impairment.

Among the various physical disabilities, blindness or visual impairment is the concern of this paper. It is estimated that an amount of 285 million people worldwide are visually impaired: 39 million are blind and 246 million have low vision [1]. In Brazil, more than 35 million (18.8% of the population) claims to have visual impairment. Part of this total, 29 million have some permanent difficulty, more than 6 million have great permanent difficulty for seeing and 528,624 are unable to see, according to an IBGE research [2].

According to Castro [3], one of the great difficulties for the visually impaired is moving around urban areas, from walking to a particular bus stop to knowing the right place to get off a bus when reaching the final destination. In recent years, accessibility has improved, but it is still hard for many people with disabilities to use public transportation. In many situations, passengers need to ask people for help at bus stops to know what bus is passing by. When there is no one else at the bus stop, a passenger needs to stop all buses in order to be able to identify which one they need to take.

The development of new technologies has increased the accessibility on smartphones. Both iOS (iPhone Operating System) and Android have features focused specifically for the visually impaired.

As a result, it is believed that smartphones have a big potential to help people with several kinds of impairment and can make this group more confident and independent in their daily activities. This paper proposes an improvement for an already existing application which help visually impaired to take buses.

This paper is presented as follows: Introduction, describes the problem; Section II depicts about smart cities, their concepts and visually impaired people; Section III is presenting the methodology of the our work; Section IV describes two good existing solutions; Section V explains the proposed solution; Section VI provides a conclusion and next steps.

II. ABOUT SMART CITIES AND VISUALLY IMPAIRED PEOPLE

This section presents a study about smart cities and people with visual impairment.

A. Smart Cities

The interest in Smart Cities is motivated by great challenges, such as climate change, economy, mobility, among other problems. The European Union (EU) has committed to constantly developing strategies that enable the "smart" urban growth in their cities. Arup (Arup Group Limited) estimates that the global market for smart urban services will be 400 million dollars a year by 2020. According to Su *et al.* [7], the concept of Smart City is defined as the use of communication and information technology to measure, analyze and integrate key data from small systems to a centralized system. Thereby, smart cities bring intelligent responses to different types of needs, including everyday needs, environmental concerns, public safety, trade activities and city services. In smart cities, buildings and smart buildings are highlighted with sensors, actuators, controllers, central programming units, several kinds of interfaces, communication networks and smart meters are installed to ensure better energy performance of the building [8].

Smart Cities tend to evolve, creating an integration of the "intelligences" within a city. Some of these intelligences stand out like Baloon *et al.* [4] and Deakin [5] defines:

- Creativity and inventiveness some citizens from a certain practice, such as scientists, artists, and entrepreneurs, which impact greatly on how work is organized;
- The collective intelligence of a population, which results in the human capacity to evolve based on the institutions of the city related to cooperation, integration and collaboration;

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- Artificial intelligence that is integrated into the physical environment and is available to the public, such as communication infrastructure, digital spaces or online problem solving tools.

The intelligent cities can create more efficient urban systems and are able to face contemporary challenges and urban problems. More innovative and competitive cities are created where mobility is improved, public spaces are more secure, and there is a better management of environmental resources.

B. Visually Impaired People

Blindness is understood as the lack of visual perception.

The International Council of Ophthalmology [9] describes total blindness as the complete lack of visual perception of light and form. The World Health Organization [10] defines blindness and visual acuity to 20/400 less than (6/120) or a visual field loss to less than 10 degrees.

According to the World Blind Union (WBU) [11], the lack in proper training in mobility and the lack of access to public transportation are some of the major obstacles for the blind or partially sighted when they need access to education, employment, services in general, and full participation in their communities. Transportation itself presents different challenges within the local, regional, national and international levels.

A survey conducted by a group of students from Paraíba Valley University points out the main problems of the visually impaired in urban mobility [6]:

- Obstacles on sidewalks
- Few or non-existent proper signaling
- Very short time for the sound signal of traffic light
- Absence of technology in the public transportation
- Lack of maintenance and standardization of sidewalks
- Large flow of people in public places

According to this survey done by Fornaziero and Zulian [6], most visually impaired memorize the paths, either by walking or by bus. The survey also found out that one of the major difficulties this group has is to know the right time to get off a bus. Some have set up "checkpoints" to know the right time to leave it. Examples of "checkpoints" cited by respondents were amount of "sharp curves" and "speed bumps".

III. METHODOLOGY

First of all, we discussed some of the problems that the people with disabilities experience in the context of public transport. In some bus stations, more than one bus line can stop at the same time, forming a big queue of buses and making it difficult to get on the bus, if this one has stopped far away. We observed a few problems at the bus stop. For example, some buses stops far away from where people are, and for blind people this is a serious problem. Finally, the data were analyzed with focus on people with visual impairments.

Once the problem was identified, bibliographic research was performed in order to find previous works related to the issue.

A benchmarking was performed and it was aimed at finding other existing applications that help the visually impaired to move around cities with public transportation.

Finally, brainstorming sessions and user research showed that the best solution is to improve an already existing application, *CittaMobi* [13]. It already benefits users and they are happy with it.

IV. EXISTING SOLUTIONS

Two good solutions will be presented in this paper. The first one is from the UK, and the latter is from Brazil:

A. GeorgiePhone (UK)

"Much more than phoning, texting and keeping in touch, *GeorgiePhone* is like a friend who helps with everyday tasks and takes the stress out of travelling alone. *GeorgiePhone* confirms where you are and what is around, bus journey information, your ability to keep up with the web and YouTube, reading print and diary dates."[12]

According to its site, *GeorgiePhone* is a family of apps designed mainly for blind or low vision people and it has a variety of functions like camera, color detection, user finder, bus track, among other very useful options.

The most interesting function for this paper is the bus tracking system. It locates the nearest bus stop for the user and tells how to get there. Once the user is on the bus, the app says the names of the bus stops. This way, a user knows when they need to drop, reducing the stress of a bus journey. Internet connection and GPS (Global Positioning Satellite) are needed, and it works only on the Android platform.

B. CittaMobi Accessibility (Brazil)

The *CittaMobi* accessibility is an app designer specifically for users with visual impairment and provides a bus arrival schedule. The interaction design is simpler and all queries are made by VoiceOver, with the application automatically notifying the user of the desired bus proximity.

A user does not need to be at the bus stop to know what time the bus will pass by, and it is possible to verify in real time the bus RTA. In addition, it also presents the closest bus stops of the current user location. This app is only available for iOS.

V. PROPOSAL

The *CittaMobi* already has some features which improve the user experience of bus users. The main feature is the estimated time left for buses to arrive at a particular bus stop. Before and after taking the bus, a user can look bus routes up. Users can also mark on the map where they want to get off a bus. It is possible to bookmark bus lines and bus stops.

As noted by Fornaziero and Zulian [6], one of the greatest difficulties the visually impaired face is knowing whether their bus arrived. In Recife, there are stops for multiple bus

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lines, making it even harder for these users. *CittaMobi's* current service is presented in Figure 1.

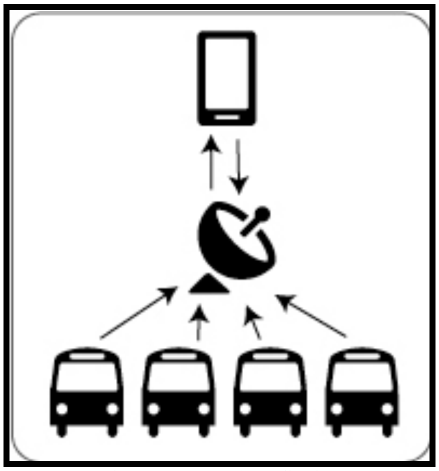

Figure 1. *CittaMobi* application

CittaMobi's current service uses a Web Service module to get information about the buses and also to provide the information to application's users. Figure 2 presents the adjustments proposed for the *CittaMobi* application service.

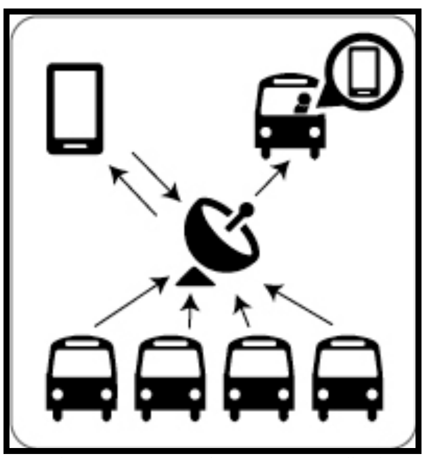

Figure 2. Enhancement proposed to *CittaMobi* application service

The enhancement proposed will be composed by Web Services to feed the mobile and web platforms. Based on *CittaMobi*, this paper proposes an enhancement to current service that includes an additional module to notify the presence of someone with mobility impairment at a bus stop. This module will provide to buses important information about passengers and other feedback like accidents, delays, etc. This will be useful to inform bus drivers of people with special needs at bus stops.

Currently the buses do not have a channel of communication with their passengers, especially those that require more attention, such as the visually impaired. The new proposal presented in Figure 3 presents the enhancement proposed to service, which comprises the interaction between users, services and applications. The new *CittaMobi* version will advise the bus driver that there is someone who needs special attention to get on the bus. The user that has a smartphone Android or iOS will select the bus line and then will press a button to send a message to the bus that has a smartphone fixed on the panel, connected to the service through the Internet aiming to show to bus driver that has someone at the specific bus stop who needs more attention to get on the bus.

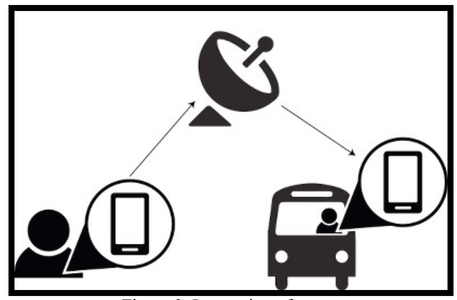

Figure 3. Interaction of actors

VI. CONCLUSION AND FUTURE WORK

The new service module will be useful for many people who have certain disabilities. Users will be able to choose bus lines through the mobile service and inform bus drivers when they need special attention when using public transportation services.

Many blind people live normal lives in their cities, but many cities do not invest the financial resources needed to make improve the well-being and quality of life of this group, especially in developing countries. Taking a bus should a simple routine task for everyone, not a challenging task. Thus, it is expected that the visually impaired have no great difficulty to take buses.

To the future work, we will create the actors map of the service to understand the actors involved in the whole process of mobility, from the application user to the other passengers of the bus.

Digital ethnography to finding out how the visually impaired people use smartphones.

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Empowering Public Education Students to Report Infrastructure Problems and Exercise Civic Engagement

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***Abstract*—Studies conducted around the world show that school infrastructure impacts the academic performance of students. The participation of students in the identification of school infrastructure problems is an exercise of citizenship. Taking the opportunity provided by the increasing popularity of smartphone use, this paper, as a work in progress, is aimed at assessing whether there is room for the design and development of a platform which would use smartphones as a crowdsourcing tool in order to allow students to report infrastructure problems in public schools from Recife, Brazil, so those issues would be easier to prioritize. The interviews performed with students showed a high level of engagement to solve problems they find at school, which points to a positive answer to the question above.**

Keywords-Smart Cities; Education; Citzenship; Infrastructure.

I. Introduction

Smart cities are based on efficient management of infrastructure and urban services, the democratization of access to information for citizens, and the improvement of conditions for decision making in the private and public spheres [1].

A smart city should be seen as an organic whole, as a network. In a smart city, attention is given to connections and not only to the parties. The open model of the Internet has contributed to the consolidation of a new type of social worker, immersed in the emerging social networks, that is both consumer and producer of information and knowledge, the *prosumer* (producer+consumer) [1].

Civic improvement stems from improvement between the interfaces and integrations. That means a smart city believes that the most important connectors between the various subsystems are people turning it from a set of mechanistic infrastructure elements into a set of vibrant and interconnected human communities [1].

Brazil is ranked as the 6th country in smartphone use, with 38.8 million users. It is estimated that this number will increase to 71.9 million by 2018 [2].

It is important to notice that most of the new smartphone users in Brazil are young people. In 2011, 48% of children and teenagers with ages ranging from 10 to 14 had smartphones, an increase of 12.6 percentage points since 2009. Between the ages of 15 and 17, 67.5% of teenagers had smartphones in 2011, which corresponds to an increase of 15.7 pp during the same period [3].

Also, there has been an increase in smartphone use by people with low income [4]. This part of the population makes up 80% of the public education students who took ENEM (the Brazilian national high school education assessment, often used as the admission test for public universities) in 2011 [5].

The increase in smartphone use has affected a great many sectors of our society, and education isn't an exception. The debate around the actual use of smart devices as a technological learning tool has been in vogue lately. While some would see smart devices in class as an obstacle for education (as demonstrated by the hereinafter research), institutions such as UNESCO reinforce mobile learning as a viable and encouraged use of smartphones [6].

Ironically, despite the technological aspect smartphones may bring to a student's life, infrastructure in schools is still a major education issue [7]. In Brazil, less than 1% of schools have the ideal infrastructure [8]. In fact, infrastructure impacts the well-being of students and their satisfaction levels while attending classes and, consequently, their average scores [9]. It is important to point out, though, that basic infrastructure standards, when not met, take their toll on other infrastructure areas.

While learning support facilities (such as libraries and computer labs) often provide a higher impact on test results [4], lack of water and sanitation facilities, for instance, affects not only students' enrollment and completion rates, but also teacher absenteeism [10].

Considering that students are the most affected party from infrastructure problems, this paper is aimed at assessing the usefulness for a platform where they would be able to report these issues themselves. Such a solution would inevitably rely on civic engagement.

Civic engagement or civic participation is the involvement of citizens in the political process and issues that affect their lives. It is aimed at ensuring the rights of citizens to participate and contribute to the development of their communities, cities, and country. It determines the policies by which well-being will be seeked collectively by the members of a community [11].

A school is a place where students spend much of their time and, besides providing academic education, it also has the purpose of contributing to the development of new citizens, as it is a great place to exercise civic engagement and develop values and motivation.

In fact, youth civic engagement in the school community is not unheard of. It is possible to point out examples of initiatives both to help improve other students' skills [12] and report school infrastructure problems [13].

This paper is presented as follows: Introduction describes the problem and the context of Brazil. Section II describes the methodology. Section III describes related works. Section IV presents the interviews with potential users. Section V displays the results of the interviews conducted. Section VI describes the proposed solution. Conclusion discusses the findings and suggest next steps.

II. Methodology

This paper started with a research on information about the context of education problems in Brazil. As infrastructure problems proved to be shockingly present in schools in this country, this kind of issue was selected to be addressed by a solution which has yet to be designed, but whose embryonic concept would take form in this paper.

As reference, some solutions which help solve infrastructure issues were examined. It was noted, then, that all those similar solutions which achieved some degree of success relied on crowdsourced problem reporting to feed their platform with data. Also, two of those solutions were smartphone applications, which demanded some research on smartphone popularity among the youth, especially those from families with low income.

Crowdsourced data depends on community engagement and easy access to the platform. In order to assess whether these requirements would be met, interview guidelines were prepared with two main goals: understanding the actions taken by students when they found or faced problems at school, and understanding students' relationship with their smart handheld devices.

Some interviews with students were conducted, then, and the results led to a rough sketch of an architecture to the solution this study aims at. The solution still needs input both from a larger number of students and from the other end of the information flow (i.e.: *desirability* from those in charge of the strategic decisions which define the course education in Brazil will take).

III. Describing related works

It is possible to list several solutions regarding civic engagement in both community problem solving and infrastructure problem reporting. Those listed below use crowdsourcing as a means to advise the relevant authorities of issues the communities cannot normally solve by themselves.

A. **Chinese Sidewalk Repair and Improvement Crowdsourcing Website** - Developed by the Beijing Transport Research Center, a crowdsourcing website asks pedestrians to identify areas in need of repair or improvement in Beijing. The system aims to help transportation planners to know how roads and sidewalks are being used by the public [14].

B. **Colab** - A social network for citizenship that helps citizens communicate with government. Their goal is to promote civic engagement and create better cities through citizen-govenment collaboration [15]. Colab won 2013 AppMyCity! Prize for world's best urban app [16].

C. **SITA (School Infrastructure Tracking Application) -** A mobile-based application that will allow stakeholders (SMC members, NGO staff, Government officials) to track the status of infrastructure facilities in schools, such as toilets, drinking water, barrier-free access etc. and provide feedback on their maintenance [17].

D. **UnB Infrastructure Mapping Platform** - The Central Students Directorate (DCE) of University of Brasilia (UnB) released the university's infrastructure and salubrity map. The problems reported are taken to the university mayor every other week. By the end of Janurary 2013, more than 70 complaints had been made, and they ranged from lack of toilet paper to classrom floods. The DCE asks students to take photos of the problems and report issues "pinning" them to a digital map of the campus [18].

IV. Interviews with Potential Users

Based on the studies referenced in this paper, interviews were conducted in order to understand students' relationship with their schools and the way they used smartphones. The interviews also included general questions, such as age, gender, schooling, and graduation year.

The questions were divided into two groups: 4 questions concerning smartphone use, and 4 other about their relationship with their school. Two of them were multiple-choice questions (device brand and operating system).

The survey respondents consisted of 13 people from Recife, Brazil, with ages ranging from 18 to 20. All of the participants had graduated from high school between the years of 2011 and 2013. The collected data analysis is presented below.

First, the participants were asked about their age and grade, for what they used their smartphones the most, how often they used their handheld devices, and how they accessed the internet at school while using their handsets (e.g., Wi-Fi, 3g).

After the first part of the interview, they were also asked how long they studied at their current school, what they liked the most about their school, what they disliked the most about it, and how they proceeded when they found or faced a problem at school.

V. RESULTS

The interviews found that all respondents own smartphones of various models and from various manufacturers. During their schools years, even though the use of handheld devices was banned in school, 7 of the respondents claimed to have used cell phones in the school dependencies. Moreover, 12 of the 13 participants said they used smartphones several times a day.

The research revealed that the respondents used their smartphones mainly for instant communication (such as instant messaging apps and phone calls), asynchronous communication (such as emailing) and social networking (e.g., Facebook).

Among the instant messaging applications used by the participants, WhatsApp [19] was the most popular one despite its need of internet access. Only two respondents claimed to not use the app.

SMS, on the other hand, was the least popular means for instant communication. According to the participants, texting is still relatively expensive when compared to WhatsApp messaging.

Using smartphones to make actual phone calls is common, but it is important to point out, though, that, by the time the interviews were conducted, WhatsApp had not allowed users to make voice calls [20], a fact that might impact future user research.

Facebook was mentioned by the respondents as the only real popular social networking application, as they did not see WhatsApp as such. The use of other social networking apps (e.g., Twitter and Instagram) was minimal.

On students' relationship with their schools, the interviews highlighted that the main problems reported by students revolved around relationship issues, whether they were among peers or between students and the school staff (i.e., teachers and the principal's office).

When asked about how they normally proceeded when they found or faced problems at school, the participants displayed a high level of engagement and participation, as most of them would either try to solve problems by themselves or discuss the issue with friends and teachers.

VI. THE PROPOSED SOLUTION

Despite the active behavior the students would normally present while trying to solve problems at school, infrastructure issues cannot be resolved directly by them. They can still be part of the problem solving process, though, and the architecture below addresses their proactive attitude.

The proposed solution is a platform aimed at informing the government authorities of infrastructure issues in schools in order to achieve better resource distribution. The data fed to the platform would be crowdsourced from students.

Taking into consideration the increasing popularity of smartphones, especially among the youth, these devices can be seen as a viable technical requirement for a crowdsourcing solution, so the data would be entered through a smartphone app.

Features present on most smart handheld devices nowadays, such as GPS tracking and digital camera, can provide invaluable precise data about infrastructure issues the students may find.

This way, a student would be able to photograph the problem and describe it textually. Through GPS, the location for the problem would be sent without the need of entering the information manually (i.e, address, name of the school etc). The app, then, would either upload the report to a cloud server or save it to be synchronized later, depending on internet connection availability (e.g, 3g, 4g, or wi-fi).

The data the students would provide would then be stored to a database so it would later be accessed by the relevant authorities through a web application which would present the data in the form of graphs, charts, heat maps etc. The problems would, then, be prioritized so the available resources could be better managed.

The proposed solution architecture can be better visualized on Figure 1.

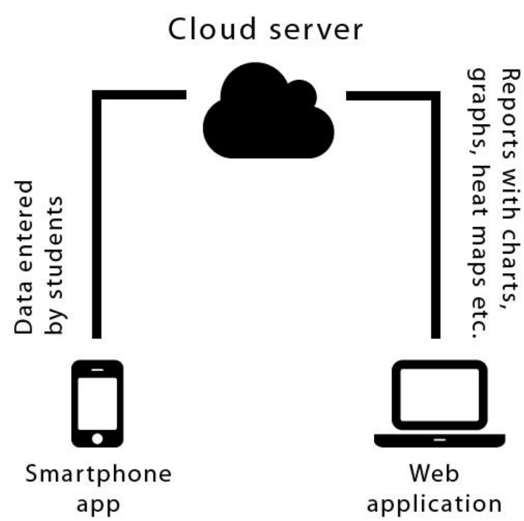

Figure 1. The proposed solution architecture.

VII. CONCLUSION AND NEXT STEPS

The results presented herein reveal that there is room for the development of a technological solution which can be used by students as a crowdsourcing tool. Such solutions would work not only to improve the school environment, but also to help develop civic engagement in students.

On the other hand, smartphone use restriction may be a challenging issue. It is a matter that needs further investigation, as smartphone use policies vary among public schools and may render the significant use of any handheld device based solution unattainable.

The existing tension between students and faculty is another obstacle to be surpassed. It creates an environment that may be unfavorable for a solution that requires unobstructed communication channels among those involved.

As following steps, it is important that the user research be expanded to a larger number of respondents from a wider variety of schools. Moreover, teachers, principals, school staff, and government authorities should also be interviewed. As mentioned above, it is needed to investigate the policy on smatphone use in public schools from Recife, Brazil.

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Telco Role and Assets for the Internet of Things (IoT) Infrastructure

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***Abstract*— The paper presents an analysis of what, an application provider willing to launch an IoT service, needs in terms of physical infrastructure in the urban scenario and how, a Telco (Telecommunications Company), can support such a scenario. The paper shows the different characteristics that the different Telco assets have and how they can be used to deploy IoT services, giving some practical real cases.**

***Keywords*— gateways; radio coverage; urban infrastructure; short range; site.**

I. Introduction

When we deal with Internet Of Things (IoT) we might think about a scenario where not only humans but also machines and objects ("things") will be connected to the big internet. Nowadays only part of the IoT applications use a full Internet Protocol, since for many applications, IP gateways are used to interconnect short range devices to IP networks. Even if everybody is looking forward to a full IP IoT scenario, it is likely that for a long time we will still have to deal with nodes of the network that will be connected to internet through gateways. One of the consequences is that we will also deal in the next near future with "infrastructure" devices whose role will be to bridge and to route objects connected to Short Range Device (SRD) networks (e.g. ZigBee). Such devices will be more complex in terms of processing and storage capabilities compared to end nodes. In many cases such gateways could not be operated by batteries and hence one of the problem to solve, for those willing to deploy IoT applications, will be to find adequate sites to host the gateways ensuring power source and, in case of wireless applications, guaranteeing adequate radio coverage and level of capillarity. Such sites are hard to find and costly to manage and it is unrealistic to follow the approach that was taken for the radio mobile networks, since in that case, very expensive rental of building roofs for hosting mobile base stations (in Italy in some cases, rental went up to 80k euros per year for the most precious cities) was sustainable considering the interesting ARPU (Average Revenue Per Unit) for mobile terminals. In case of IoT, almost negligible ARPU of "things" lead to look for very cheap solutions for sites hosting the gateways and to share this infrastructure to reduce costs.

II. Telcos Assets characteristics

Telecom operators can support this scenario and fulfill those needs since they own both physical assets and sites to host the gateway and the appropriate skill to plan, deploy and operate those additional networks. Specific sites for hosting devices should have some specific characteristics such as:

- Availability of power source (or possibility to install a solar panel, or remote power feeding)
- Possibility to install antennas
- Protection against vandalism
- Enabling good radio coverage (in case of wireless devices)
- Adequate level of capillarity with respect to the service to be provided
- Controlled access
- Non-intrusive integration with the environment
- Low rental costs
- Low authorization costs
- Low installation and maintenance costs
- Regional/National presence for specific services
- Preferably taking in advantage pre-existing infrastructure

Many different types of urban infrastructure are available in particular in the cities (e.g. street lighting, broadcasters, energy utilities) but very few of them manage to find a suitable tradeoff among all the mentioned requirements that is also suitable for a plurality of services. Telco operators managing fixed and mobile services have plenty of communication network infrastructure devices and related sites that according to specific needs for the IoT service to be deployed, can be used. Nevertheless not all Telco assets can host devices for capillary network infrastructure. For different locations it must be evaluated how these, fit the characteristics of the devices and how these are useful for the capillary network deployment (Table 1).

III. Case Studies

The plethora of possible assets that a Telco can provide to host gateways (and repeaters) can simplify the difficult job of a service provider willing to deploy a wireless network for a specific smart city application. As an example in Figure 1 the set of mobile base stations (red pinpoints) and of street cabinets (green pinpoints) of a small town in the north of Italy is shown. It is clear how the two sets of assets already provide a good level of capillarity in the most "dense" areas of the city; if all the many available assets were shown (such as distribution network boxes or phone booths), the map would become unreadable. In Figure 2 the radio coverage that could be provided for that city is shown, such a radio coverage is provided using some of the mobile base stations of the Telco to host the data concentrators (gateways) of a Wireless MBus 169MHz [1] network (this communication protocol is used in

TABLE I. Characteristics of the different assets

Telco Asset	Characteristics	Capillarity	Coverage	Suitable for
Switching Plant	Inside big cities Power source available No size constraints of devices	Poor	Good (limitatins only in historical city centers)	Both gateway and repeaters/ bridge
Distribution network street cabinets	Along the streets Remote power source available Easy to access Size constraints	Good	Poor	Repeaters / Bridge
Distribution network street boxes	Either along the streets or in building basements or building facade Limited remote power source available Easy to access Size constraints	Excellent	Poor / Good (in case of building façade)	Repeaters / Bridge
Distribution network street poles	Mainly in rural areas Limited remote power source available Difficult to access Size constraints	Poor	Good	Repeaters / Bridge
Mobile Base Stations	Power source available Difficult to access Sites may be shared among operators	Good	Excellent	Gateways / Data Concentrators
Phone boxes and booths	Power source available (only in cas of phone booth) Dismission plan running	Poor	Fair	Repeaters / Bridge

Europe for smart gas metering). In Figure 3 a radio coverage of a ZigBee network (2.4GHz) is shown; in this case only the street cabinets were used to host either ZigBee gateways or routers; since both devices (routers and gateways) could not be battery-operated, remote power feeding can be provided at the street cabinet using the copper pairs not only for transmitting data but also for transmitting energy remotely.
In this case a service provider interested in deploying a ZigBee network in that city for outdoor applications (e.g. waste management, pollution monitoring), could take advantage of the Telco street cabinets to obtain a good level of radio coverage (if a full mesh architecture was chosen where also the end nodes could act as routers, the coverage would be even better). The example shows how independently from the chosen wireless technology and from the type of service, Telco assets can fulfill the infrastructural need for IoT applications; this added value can be accompanied with the skill of a Telco, to plan those networks (to define how many and where gateways should be places) and to operate and manage them efficiently, making Telcos significant stakeholders in the IoT development [3].

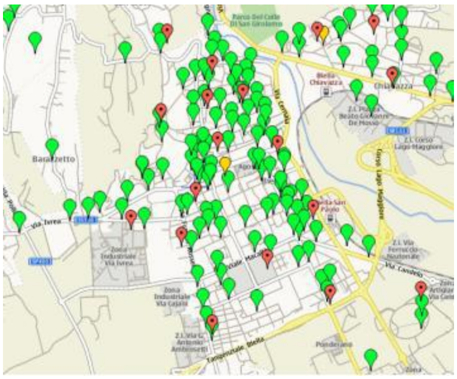

Fig. 1. Some of the available Telco assets in a small city

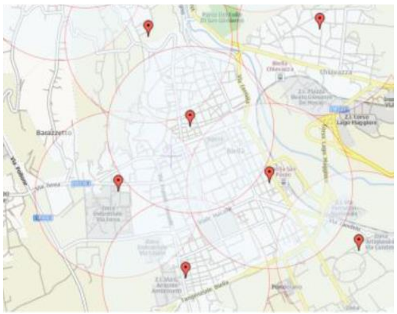

Fig. 2. WMBus 169MHz Radio Coverage achieved using Base Stations only

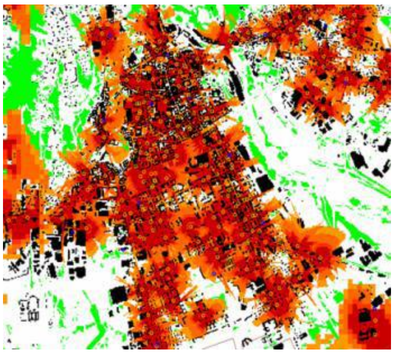

Fig. 3. ZigBee 2,4GHz Radio Coverage achieved using street cabinets

IV. CONCLUSION AND FUTURE WORK

For some time, some IoT devices will be too constrained in terms of size and processing capabilities to manage IP protocols; this means that such devices will be connected to internet through gateways. Adequate sites for installing and managing those gateways is and will be an issue; Telcos can play an important role in such a scenario enabling, with all their assets, the creation of a Smart Urban Infrastructure. Future work to demonstrate such an approach is the deployment of a multi-utility (gas and water) smart metering network (according to the requirements of the Italian Authority for Energy [2]) in 4 Italian cities where the data concentrators are installed only on the assets (mobile base stations and distribution network boxes) of Telecom Italia and they will collect meter readings from around 20000 gas and water meters.

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CITYOPT

Holistic simulation and optimisation of energy systems in smart cities

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***Abstract* — CITYOPT is a collaborative project supported by the European Commission through the Seventh Framework Programme (FP7). CITYOPT mission is to optimise energy systems in smart cities. The project will create a set of applications and related guidelines that support efficient planning, detailed design and operation of energy systems in urban districts.**

Keywords-energy efficiency; smart cities; urban planning; detailed design; demand-response; user awareness.

I. INTRODUCTION

68% of the European Union population lives in urban areas, this proportion is growing as the urbanization trend continues, raising the energy demand for private and public consumers and for economic activities with the subsequent increase in CO2 emissions [1].

Furthermore, urban areas have high levels of air pollution, primarily from the burning of fossil fuels in energy production and road transport, resulting in enormous economic and social costs [2][3]. Additionally, energy security is also becoming increasingly important with declining European natural gas and oil reserves together with the current geo-strategy situation [4][5]. This highlights the importance of the development of more sustainable urban areas which are more energy and resource efficient, the use of renewable energy sources, reduction of the carbon footprint, infrastructure development, engagement of the stakeholders and users, removing administrative and regulatory barriers and new business models [6].

The CITYOPT project addresses energy system optimization in different lifecycle phases, supported by a user-centred design approach. Stakeholders, including city decision makers, city planners, energy utilities, facility managers, and citizens, are involved in all project phases.

CITYOPT develops a set of applications and guidelines supporting efficient planning, detailed design and operation of energy systems in urban districts. Business models for the use cases have been developed and are shortly described in this paper. The project considers appropriate service business models, privacy and trust and involves users in all the project phases.

This paper presents the overall context in Section II and project objectives in Section III. It then introduces the 3 pilot case studies in Austria, Finland, and France in Section IV. Finally, preliminary results and expected results of the approach are presented in Section V.

II. URBAN ENERGY SYSTEMS

A holistic view considers integrating the design of the urban areas, the built environment, infrastructure and the energy system creating opportunities to explore the possibility to optimize the use of resources and synergies in an efficient way. However, existing cities are captive to their history which constrains the implementation of new measure without high economic investments. Nevertheless, relatively short turnover times for many technologies provide opportunities to improve the efficiency and develop integrated design [7]. The following aspect should be considered during the design and use of the urban energy systems:

- Energy efficiency of the built environment

The primary focus of energy-efficiency in most cities is on the built environment (i.e., dwellings and commercial properties) which should be designed to optimize their sustainability. This situation implies a strong argument for definition and regulation of building standards.

- Supply side

The supply side is having an important progress in innovation to design efficient energy networks which allows integration of energy resources, such as solar energy, heat pumps, fuel cells etc. or the use of energy storage systems, allowing shifting the production to match with the demand. This integrated thinking has been highlighted in the design of the new eco-cities, avoiding strong dependence to fix solution as big power plants and giving to the city an integrated growth based on a higher flexibility from the energy supply side.

- Holistic approach - Optimisation of the energy systems

Energy systems are traditionally designed separately looking at demand and production as separate issues. There has been some progress in linking demand and transmission with for example demanding low temperature heating systems in buildings to enable low temperature levels in district heating systems. To analyse the whole energy system from demand to production with one design tool is a new approach. Also to include both heating, cooling and electricity into one holistic approach is a new aspect in

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planning energy systems in districts. Systems and integration methods could have an important potential for reductions in direct primary-energy use, without other significant physical impacts, and significant advantages in terms of a reduction in externalities of energy use such as air pollution.

- Role of real-time monitoring and steering systems

For the new urban energy system design expertise should also focus on the operational phase. There are opportunities in the field of Information Control Technologies (ICT) applied to the urban energy sector which enables effective management of the real-time performances of the energy systems, allowing the interaction between them and citizens, which could be increased through real-time energy pricing, virtual energy markets, real-time displays for households, large building, neighbourhood, city resource-use profiles, and personalised decision-support services.

III. Objectives

CITYOPT addresses energy system optimisation in different lifecycle phases, considering potential and user & stakeholder involvement characteristics (Figure 1):

- **Planning tools** - support analysing, simulating, optimizing and communicating different alternatives in the city planning. A holistic approach integrates energy dynamics of local grids and buildings, consumption behaviours, energy storage, and local energy production units.
- **Design tools** - optimise design for energy efficiency of supplementary construction and renewable integration ensuring grid stability. Stakeholder and user research on design requirements specifies how new or retrofitted energy efficient buildings interact with nearby buildings through local energy networks, e.g., exchanging surplus renewable heating/cooling energy.
- **Operational tools** - increase optimization opportunities related to user behaviour, like residential demand response schemes for inhabitants to participate in online-optimization, and visualizations to engage users.

IV. Pilots

Three case studies in different climate zones will demonstrate the CITYOPT solutions:

A. Helsinki, Finland

The Helsinki case study evaluates electricity- and heat storage solutions and business models in the new residential districts of Kalasatama and Östersundom. In the planning phase of the new districts, CITYOPT applications will examine technologies, sizing, placement and steering of electric and heat storage solutions, to find the optimal storage solutions.

In both study cases of Helsinki, the optimisation task is divided into two connected parts:

- Design optimization (I)
- Operational optimization (II)

In part I, the optimisation will strive to choose the correct type and size of energy storage unit(s) and its connections to energy producers and consumers. This being done, the second part of the optimisation (II) will find the operational optimum. Thus the problem is a bi-level optimisation. The optimisation tasks are described below in terms of:

- Process description
- Performance metrics with constraints
- Degrees of freedom
- Scenarios

The bi-level optimisation means that the operational optimisation (II) runs inside the design optimisation (I). In other words, for each design candidate from part I, a new solution of the operational optimisation (II) will be solved. This enables a more holistic analysis of the situation and can provide some new insights in what is the best combination of solutions for both design and operation strategies.

B. Vienna, Austria

In Vienna, at the Austrian Institute of Technology (AIT) premises, CITYOPT investigates the optimal design and possible implementation (including cost assessment and business model development) of integrating the AIT buildings, their existing energy supply and storage systems, and the cooling system of RTA's climatic tunnel into a site-wide energy system that uses the waste heat to heat office buildings. The expected impact will be to maximize the utilisation of waste heat to increase the energy performance and reduce CO_2 emissions of the overall urban area modelled in the study case.

The optimization process in the Vienna study case is based on the integration of a thermal energy network of the office buildings, current supply systems, energy storages together with the use of the waste heat from the RTA´s climatic wind tunnel.

The performance metrics which will be taken into account in the objective function are:

- Energy consumption (kWh)
- CO_2 emissions (tons)
- Investment cost (€)
- Running cost (€)

Running cost makes reference to the operational and maintenance cost. The design optimisation should set the best option according to the objective function and constraints defined by the user. The objective function also will be able to combine all the listed metrics weighted properly by the user. There are two main goals; first, to optimize the design of this thermal energy network by a suitable design of the water tank which is used as thermal energy storage and the number of boreholes of the ground heat exchanger and second, the optimisation of the operation of system taking into account the temperature levels and the mass flows.

In this context, there are several type of constraints that should be considered to perform the optimization process: the maximum size of the water tank, the maximum area were the boreholes of the heat exchanger can be allocated, the maximum temperature of the ground which can produced by the rejected heat, the minimum and maximum temperature levels of the warm water needed to cover the heat demand of the office buildings, economical constraints based on the investment and operational cost of the system, oscillations on the production of the waste heat from RTA´s climatic tunnel due to its use and the influence of the weather conditions in the heat production from the solar thermal panels.

To produce usable information, the optimizations are performed in different scenarios which comprise different options in terms of the design of the water tank, ground heat exchanger, the district heating networks together with operation of the system according to the variation on the defined constraints. These scenarios could include the best design of the district heating network: to maximize the rejected heat to the ground to maximize the energy efficiency of the chillers of the RTA´s climatic tunnel, to minimize the CO2 emissions of the overall system according to the technical and economic constraints, to minimize the importation of the energy (gas and electricity) to the system, to minimize the energy bill of the of the office buildings, etc.

C. Nice Côte d'Azur, France

Provence Alpes Côte d'Azur (PACA) is one of France's most fragile regions for electricity supply. In Nice Côte d'Azur, CITYOPT will develop and demonstrate innovative demand-response services, to reinforce the continuity of service of the electricity supply network. 200 families will be recruited to participate in the experiment. CITYOPT will analyse the conditions for which the customers will agree to modify their behaviours, within a CITYOPT energy community.

The CITYOPT NCA case study takes place amid restrictions of energy use at certain times of the day due to dated electricity infrastructure. Nice depends on a single high voltage transport line which supplies electricity to the south east of France (around 5 Million inhabitants), covering in particular the densely urbanized coast from Marseille to Menton. Due to the tourism attractiveness of the region, the population can be doubled in certain towns during summer holidays. As an answer to the recurrent problem of higher peaks in load demand, the French electric energy supplier EDF is forced to use thermal power plants which generate CO2 emissions and have a high cost in terms of maintenance.

The Nice case study will develop and experiment an internet application called Community Network for Energy. Its objective is to encourage individual actions for promoting the reduction and/or shift of power consumption at homes during peaks of consumption in the PACA region. EDF consumers use electricity primarily for heating, cooking, dish and clothes washing, and consumables operation. As a reward, the dwellers earn bonuses that will be invested in useful projects in the community to which they belong to. Such projects are for example funding of new public buildings, such as schools, an academic project, cultural activities, or complimentary "Vélo Bleu" (electrical bicycles) memberships. Thus, instead of using additional and punctual energy production from thermal power plants, end-users of electricity will "learn" how to consume energy in a better, more optimized way and at the same time they will benefit from these economies of scale for their community. When joining the experiment, the 200 volunteers will have at their disposal a tablet pc to access the application.

The community Network for Energy developed and tested in CITYOPT is a new mean:

- to contribute to energy demand reduction of households through increased energy awareness;
- to contribute to time-shifted energy usage, through timely demand-response notifications;
- to enhance coherence between different energy projects/services and city planning alternatives.

The project will offer a new insight on how citizens react to the utility's request and how the community scale and crowd funding approach offered in the application act as incentives. A 12 months operational validation and test phase with the 200 volunteers will be conducted from October 2015 to September 2016.

V. RESULTS

The CITYOPT holistic solution is composed of two layers as represented in Figure 1: it includes both a planning application and an operational application.

A. CITYOPT planning application

The CITYOPT planning application is ready for demonstration use. The tool is designed to be used by city planners and energy systems planners in the early design phase of a district. The user first enters the basic information about the area. After this the user can create different scenarios regarding the energy solutions, the scenarios are then simulated by the CITYOPT Planning application using APROS simulation software. The next step is to choose the weighing factors for the optimisation. The user can choose for example that economic factors should be weighted with 80% emphasis and CO2 emissions with 20%.The tool gives as result which of the scenarios is the most optimal according to the chosen weighing factors.

A genetic algorithm based optimization can be performed where the application seeks the best solution by creating a number of scenarios by itself and seeking the most optimal scenario within the constraints set by the user, meaning that the optimal scenario can be different from one of the scenarios chosen by the user. If the genetic algorithm ends up with Pareto optimal scenarios, the user can then execute the weight based optimization to acquire the most optimal scenario.

B. CITYOPT operational application

The CITYOPT operational application is currently being implemented and will be tested in Nice Côte d'Azur. A typical user journey in the application is presented below in the following 6-steps tutorial:

1. Welcome to CITYOPT: a community committed to protect the environment, avoiding overconsumption and resources waste.
2. CITYOPT engages citizens through the support to local projects. Projects will address issues at the neighbourhood scale, lowering the impact on the environment.
3. Like in crowdsourcing, people can support their favourite projects. Support is given "investing" CITYOPT points in one project or more. CITYOPT points are the "currency" used to back projects up. Points are earned by CITYOPT members for their successful commitment during peak load alerts.
4. CITYOPT calls its participants to rally to avoid severe peak loads. The entire community has a common mission: reduce energy waste and respect the environment.
5. Participants set ready for an alert laying out a strategy. Choosing what will be off, decreased of shifted during an alert will allow people to gain points to be later invested in community projects.
6. CITYOPT will succeed if people will engage with each-other. Participants will receive after each peak the result on their energy savings (at the individual scale and at the community scale) based on the load curve analysis (statistical models are implemented). Moreover participants can tap into social networks to show their commitment and get others to join for a healthier environment.

Users will receive regular notifications and updates before and after every alert on their mobile phones and email.

VI. Conclusion

CITYOPT seeks to assist the challenges posed by ever increasing urbanization and the pressure placed on grid infrastructure in cities. It looks at how grid optimisation can help to improve the utilization of renewable energy generation and the impact on local energy markets. In addition to this, considerable user analysis is performed in an attempt to shed further light on the reactions and behaviour of people using the networks and the buildings involved and ensure solutions developed will be well received.

A comprehensive technical and socio-economic evaluation of the 3 CITYOPT pilots will be conducted and publicly documented by the end of 2016. It will include an analysis of the replication potential of CITYOPT solutions from one country to another.

Acknowledgment

CITYOPT is a collaborative project supported by the European Commission through the Seventh Framework Programme (FP7).

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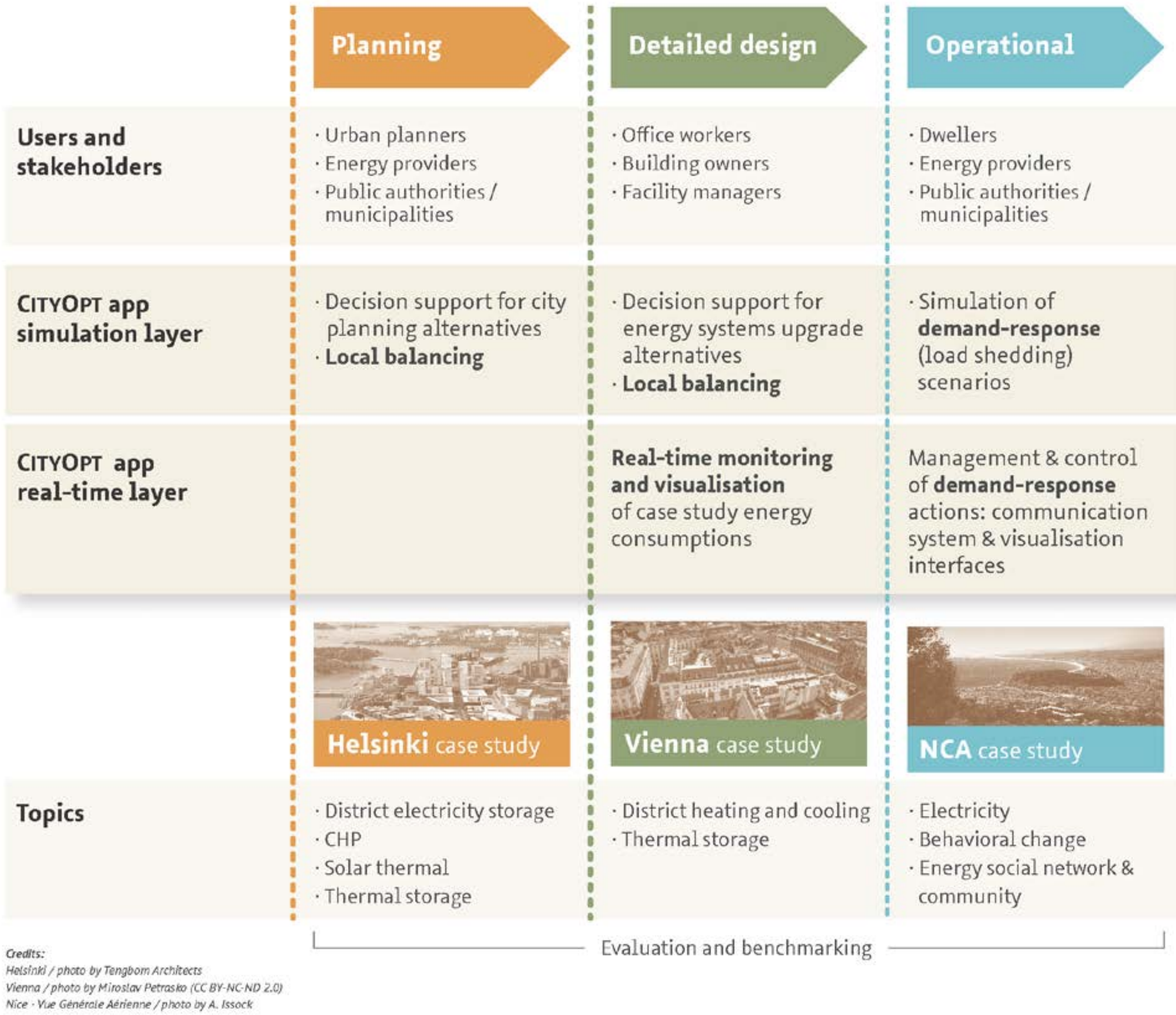

Figure 1. CITYOPT holistic approach of energy systems optimisation in smart cities

Secure Integration of DER into Smart Energy Grid and Smart Market

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Abstract—**The integration of decentralized energy resources and loads into the smart energy grid and into smart market is gaining more importance to cope with the increasing demand on energy while reducing load on the energy transmission network that is not affected by energy exchange between local generation and consumption. Characteristic for the involved control systems is the data exchange between intelligent electronic devices (IEDs), which are used to monitor and control the operation. For the integration Decentralized Energy Resources (DER), these IEDs provide the data for obtaining a system view of connected decentralized energy resources – DER. Based on this system view a set of DER, realizing a Virtual Power Plant (VPP), can be managed reliably. In substation automation, the standard IEC 61850 is used to enable communication between similar IEDs to control the central energy generation and distribution. This standard being enhanced with features and mappings to enable its application also for DER. One problem to be solved here is the integration of IEDs residing on a customer network, most likely to be operated behind Firewalls and Network Address Translation (NAT). The solution required must ensure end-to-end secured communication between DER and control center also over public networks. Here, adequate IT security measures are a necessary prerequisite to prevent intentional manipulations, affecting the reliable operation of the energy grid. This paper investigates into currently available security measures and utilizes them to propose a secure communication architecture for DER integration. The described solution is currently proposed within the International Electrotechnical Commission (IEC) for enhancements of the energy automation communication standard IEC 61850. Besides that, this paper also investigates into open issues related to the secure integration of DER.**

Keywords–security; device authentication; firewall; decentralized energy resource, substation automation; smart grid; smart Market, IEC 61850, IEC 60870-5, IEC 62351, XMPP

I. INTRODUCTION

DER, i.e., renewable energy sources like solar cells or wind power, are becoming increasingly important to generate environmentally sustainable energy and thus to reduce greenhouse gases leading to global warming. Integrating DER into the current energy distribution network poses great challenges for energy automation: DER need to be monitored and controlled to a similar level as centralized energy generation in power plants. Widely distributed communication networks are required for exchanging control communication. Multiple DER may also be aggregated on a higher architecture level to form a so-called virtual power plant. Such a virtual power plant can be viewed from the overall energy automation system in a similar way as a common centralized power plant with respect to energy generation capacity. But due to its decentralized nature, the demands on automation and communication necessary to control the virtual power plant are much more challenging.

Furthermore, the introduction of controllable loads on residential level requires enhancements to the energy automation communication infrastructure as used today. Clearly, secure communication between a control station and DER equipment or energy loads of users as well as with decentralized field equipment must be addressed. Standard communication technologies based on IEC 61850 [1], which are used today for substation automation, cannot directly be applied and need enhancements. An abstract view of the setup used as base for the security discussion is shown in Figure 1.

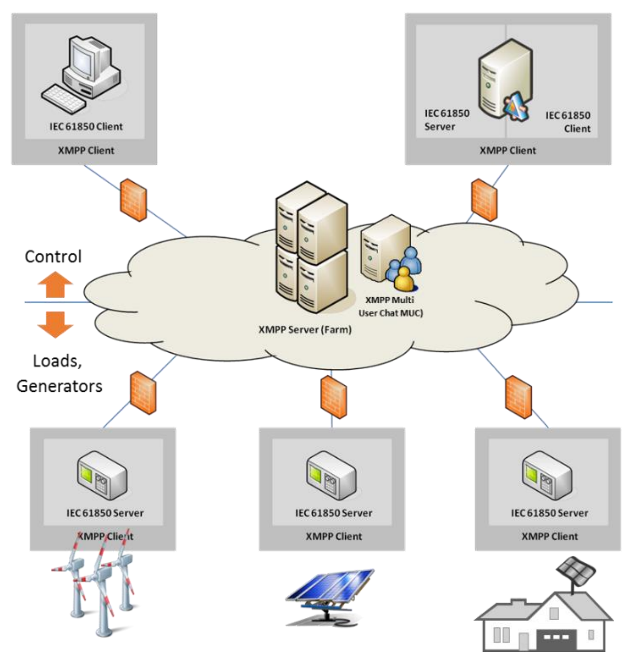

Figure 1. DER Integration based on IEC 61850 over XMPP

Figure 1 depicts the integration of DERs into the Smart Grid and Smart Market. The lower part of the figure shows the distributed generators and loads, which shall be managed by the control function shown in the upper part. The control function may be located at a Distribution Network Operator (DNO), a VPP operator, or a smart energy market operator. Also shown are typical security infrastructure elements – Firewalls – which shield the different sub-networks. Communication is realized by applying IEC 61850 transmitted over the eXtensible Message and Presence Protocol (XMPP) [1][2]. XMPP is a well-known protocol standardized in the Internet Engineering Task Force (IETF) as RFC 6120 and is used for instance in chat applications. It supports Firewall and NAT traversal and also device registration and discovery. As XMPP, IEC 61850 itself is a client-server protocol. In the scenario shown in Figure 1, the IEC 61850 server part resides at the DER sides. Thus, a direct connection to control the DER may not be possible due to blocked inbound connections at the Firewall of the network the DER is connected to. This is the part where XMPP is utilized, as the XMPP client resides on the DER and starts establishing a connection with the XMPP server, which can used to facilitate the IEC 61850 communication.

The remaining part of the paper is organized as following: Section II provides an introduction to IEC 61850 and also investigates into missing parts for the integration of DER into Smart Grids. Section III analysis the security requirements and also potential security measures, by applying existing technology as far as possible. Section IV discusses the resulting security approach, which is also proposed for standardization. Section V concludes the paper and provides an outlook for further work.

Note that this paper targets the identification of existing security means as well as existing gaps for the concept of secure DER integration. Implementations as proof of concept are not finished, yet.

II. IEC 61850 Overview

A. The IEC 61850 principles

While the first edition of the IEC 61850 series [1], published in 2003 focused on standardizing communication between applications within a Substation Automation Domain, the second edition published in 2010 extends its domain of application up to the Power Utility Automation System. The IEC 61850 series specifies:

- An Abstract Communication Service Interface (ACSI),
- A semantic model based on an object oriented architecture,
- Specific Communication Service Mappings (SCSM),
- A project engineering workflow including a configuration description language (SCL) based on the XML language.

Using the IEC 61850 philosophy, i.e., decoupling the IEC 61850 object model and associated services from the communication technologies allows the standard to be technology independent, that is, specifying new technologies when a set of new requirements is being processed by the standardization body without modifying the system architecture. Services in IEC 61850 include:

- Client and Server communication within the scope of a Two Party Application Association (or session), for discovering, controlling and monitoring objects implemented in the device model,
- Peer to peer communication within the scope of a Multicast Application Association, for providing a unidirectional information exchange from one source to one or many destination.

The IEC 61850-8-1 SCSM part has specified the mapping of IEC 61850 object model and associated services to MMS (ISO 9506 series [3]). While IEC 61850-8-1 SCSM has proven to be a very efficient communication technology within the substation, i.e., within a private network, new challenges appear with the integration of the DERs. A current effort in the standardization has gathered the requirements for an IEC 61850 SCSM to Web Protocols.

Public network/infrastructure are neither administered by the DER owners nor by the control function operator; the use of public network represents therefore a major change in comparison to the way IEC 61850 Systems and communication have been deployed within the substation.

The gathered requirements [4] show also that the response times are less critical than they are in the substation environment. Both the number of devices connected to the Smart Grid as well as the dynamic changes of the system (continuous integration of new resources) encourage the use of a technology that supports the volatility of the system.

The decision criteria used in the standardization committee lead to elect XMPP [5] technology as a network layer in the SCSM.

B. The XMPP principles

XMPP is a communication protocol enabling two entities (XMPP clients) to exchange pieces of XML data called stanzas. As shown in Fig.1, both the DERs (IEC 61850 servers) and the VPP or DNO control center (IEC 61850 client) are then exposed as XMPP clients. They are not directly connected together but can exchange XML messages over the XMPP server(s) they are connected to. Each XMPP client is responsible for initiating a TCP/IP connection to the XMPP server of the domain the XMPP client belongs to. The XMPP servers are located in the WAN and their location can either be statically configured in the DERs or can be discovered by the DERs via DNS-SRV records [6].

Since DERs will be located behind (most of the time unmanaged) firewalls, the XMPP servers cannot reach/connect to them (requirement – blocked inbound connection); nevertheless DERs can reach/connect to the XMPP server of their domain over the stateful firewall of their infrastructure.

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As soon as the TCP/IP connection to its XMPP server is established, each XMPP client starts a bi-directional XML stream with its XMPP server.

Each XMPP client has a unique system identifier, a so-called JIDs, whose format is quite similar to the well-known mail addresses format: entity@domain.tld.

Communication between XMPP clients occurs over the XML streams, each client has negotiated with their XMPP server, the server acting then as router forwarding the message exchange.

The XMPP series define three different XML message formats called stanza. Similar to the mail message, each stanza contains an attribute "from" (from="JID of the source of the message") and an attribute "to" (to="JID of the destination of the message"). The message formats are:

- of type <iq> (dedicated for request/response exchange - solicited service),
- of type <message> (dedicated for push-exchange - unsolicited communication),
- or of type <presence> (dedicated for presence announcement).

C. Mapping of IEC 61850 to XMPP

The current draft of IEC 61850-8-2 foresees XER encoding of MMS using following mapping of the services to the XMPP stanza:

- request/reponse services will be mapped to the <iq> stanza (e.g., initiate-RequestPDU, initiate-ResponsePDU, writeRequestPDU, …)
- reporting services will be mapped to the unsolicited <message> stanza (e.g., informationReportPDU, …).

Through the mapping of MMS to XMPP the MMS defined security measures are directly applicable as outlined in the next section.

The XMPP standard provides protocol extensions (so called XEPs [7]), i.e., optional technical specifications to solve additional communication requirements. The developments of the specifications are hosted and coordinated by the XMPP foundation [8]. For example, the XEP-0045 specifies the Multi-User Chat (MUC) environment, with which XMPP clients can exchange messages in the context of an administrated room. The IEC 61850 multicast application association defined the abstract model could easily be mapped to a moderated room, where the moderator is the publisher of the unidirectional information, and the subscribers are dynamically invited to join the room in which the information is being published.

III. Security Considerations

This section investigates into IT security requirements and maps them to existing security measures.

A. Security Requirements

Security requirements targeting the integration of DER into a power system architecture are typically derived from a given system architecture like the one shown in Figure 1 and use cases describing the interactions of the components. Hence, the main focus here is placed on the investigation of the communication relations and data assets exchanged between the components. Table I below provides the most relevant data assets.

TABLE I. Data Assets

Asset	Description, example content	Security relation
Customer related information	Customer name, identification number, schedule information, location data, electrical network topology data	Effects on customer privacy
Meter Data	Meter readings that allow calculation of the quantity of electricity consumed or supplied over a time period.	Effects on system control functions and billing (and thus also privacy)
Control Commands	Actions requested by one component. These may include Inquiries, Alarms, Events, and Notifications.	Effects on system stability and reliability and also safety
Tariff Data	Utilities or other energy providers may inform consumers of new or temporary tariffs as a basis for purchase decisions.	Effects on customer privacy and competition

Data exchange of this information can be performed using hop-to-hop, end-to-end, and multicast communication, depending on the context and the involved entities. Based on Figure 1 the following trust assumptions are assumed:

- DER resource (XMPP client on IEC 61850 server) belongs to DER owner
- DER control (XMPP client on IEC 61850 client/server) belongs to DNO or 3rd party grid service
- XMPP server may belong to DNO or 3rd party grid service provider
- Trust relation between DER resource owner and DNO (e.g., based on contract)
- XMPP server operator trusted regarding resource discovery and message transfer (not handling!)

These trust assumptions for the data exchange lead to base security requirements enumerated in Table II below:

TABLE II. SECURITY REQUIREMENTS

	Security requirements
R1	End-to-middle source authentication ensures peers are properly identification and authentication. It is required between XMPP client and XMPP server or between XMPP servers. Note that here it may target mainly component authentication.
R2	End-to-end source authentication ensures peers are properly identification and authentication. It is required between IEC 61850 client and server instances. This authentication goes across the XMPP server ("application layer") and may be bound to a dedicated instance running on the IEC 61850 host.

	Security requirements
R3	End-to-middle integrity protection to ensure that data in transit has not been tampered with (unauthorized modification) between the XMPP client and XMPP server.
R4	End-to-end integrity protection to ensure that data in transit has not been tampered with (unauthorized modification) between the IEC 61850 client and server instances. Based on the different communication relations, the protection needs to support a) unicast: peer-to-peer related communication b) multicast: group based communication (via the MUC)
R5	End-to-middle confidentiality protection to ensure that data in transit has not been accessed (read) in an unauthorized way between the XMPP client and XMPP server.
R6	End-to-end confidentiality protection to ensure that data in transit has not been accessed (read) in an unauthorized way between the IEC 61850 client and server instances. Based on the different communication relations, the protection needs to support a) unicast: peer-to-peer related communication b) multicast: group based communication (via the MUC)

Mapping the enumerated requirements to the base architecture from Figure 1 is depicted in Figure 2 below.

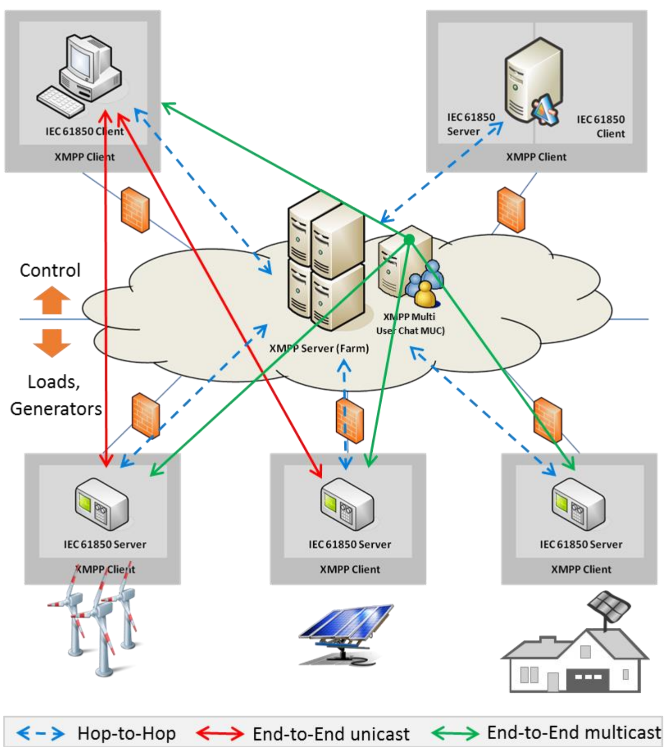

Figure 2. Security Relations for DER Integration

The consequent next step is the mapping of existing security measures to the base requirements to identify a target system architecture and also potential missing pieces.

B. Mapping of exisiting Security Measures

The following subsections map the security requirements to existing security measures, to discuss their applicability.

1) Security Options in XMPP

XMPP as defined in RFC 6120 and shown in Figure 3 already considers the following integrated security measures:

- Transport layer protection using Transport Layer Security(TLS, RFC 5246, ref. [9]), allows for
  - Mutual authentication of involved peers
  - Integrity protection of data transfer
  - Confidentiality protection of data transfer

  Depending on the chosen cipher suite, the application of this security mean addresses the security requirements R1, R3, and R5.
- XMPP peer authentication with two options
  - Rely on TLS authentication (addresses R1), or
  - Using the separate Simple Authentication and Security Layer (SASL) authentication (in XMPP [10], addresses R1) to authenticate users.

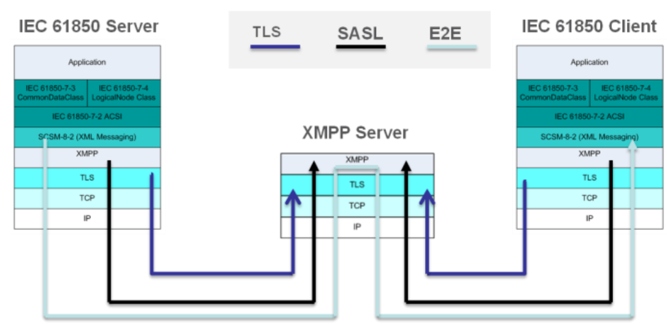

Figure 3. XMPP Security Options

Note that the XMPP security features target the communication between a XMPP client and XMPP server in the first place. Additional means to address end-to-end security support (between XMPP clients) on higher protocol layers are being available or discussed. Examples are:

- RFC 3923 [11] describes end-to-end signing and object encryption utilizing basically S/MIME. This approach addresses the security requirements R2, R4a, and R6a by applying asymmetric cryptography on a per message base. This may influence performance.
- The IETF draft draft-miller-xmpp-e2e [12] describes end-to-end object encryption and signatures between two entities with multiple devices. This addresses the situation, where some end points for a given recipient may share keys, some may use different keys, some may have no keys and some may not support encryption or signature verification at all. The draft defines a symmetric key table that is managed via three mechanisms that enable a key to be pushed to an end point, to be pulled from an originator or negotiated. If applicable it addresses R4a and R6a.

2) Security in IEC 61850

The working group IEC TC 57 WG15 is responsible for maintaining and evolving different security mechanisms applicable to the power systems domain. Here, IEC 62351 [13] has been defined, which is meanwhile split into 13 different parts with different level of completeness. Mainly

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four parts are within scope for the further discussion of security mechanisms, which help to protect XMPP communication. Note that three parts are already available as technical standard (TS), but are currently being revised and updated, while the fourth one is defined in edition 1.The parts referred to are:

- IEC 62351-3: Profiles including TCP/IP: This part basically profiles the use of TLS and is referenced from part 4, 6, and 9.
- IEC 62351-4: Profiles including MMS: This part is currently in revision. The current document defines protection of MMS messages on transport and application layer. The application layer provides only limited protection as it does only allow for an authentication during the initial MMS session handshake without a cryptographic binding to the remaining part of session. As new scenarios arise, involving intermediate devices, this protection is no longer sufficient. Hence, IEC 62351-4 is being revised to enhance the protection of MMS traffic with additional application layer security profiles. Now, MMS session integrity and confidentiality protection is provided as depicted in Figure 4:

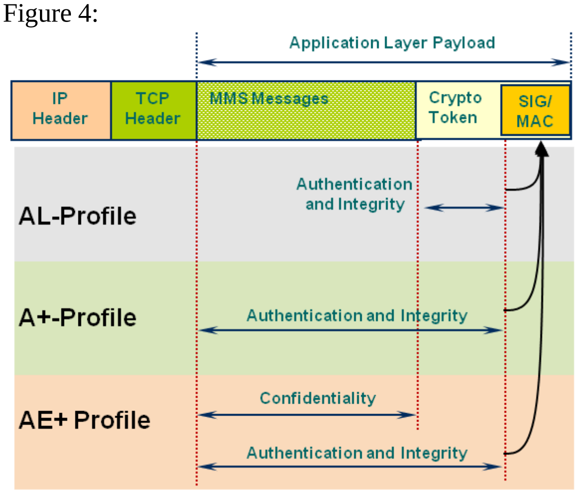

Figure 4. IEC 62351-4 A-Profile enhancements

This approach can be leveraged for the transport over XMPP to address R2, R4a and R6a.
- IEC 62351-6: Security for IEC 61850: This part targets the protection of Ethernet multicast communication exchanges in substations. The applied security measure bases on digital signatures and is currently being reworked to address performance shortcomings. It will be enhanced to allow for a group security approach utilizing symmetric cryptography. This approach can also be leveraged to realize for the secure integration of DER addressing R4b and R6b.
- Draft IEC/TS 62351-9: Cyber security key management for power system equipment: This part focuses on the base key management of asymmetric key material like X.509 certificates and corresponding private keys, but also symmetric keys applicable for group communication. For the latter, the IETF defined "Group Domain of Interpretation", RFC 6407 [14], is used to provide the key material for IEC 62351-6.

IV. PROPOSED COMMUNICATION SECURITY APPROACH

Based on the discussed trust assumptions, the security requirements and the security means in Section III, the following measures are proposed as base for a secure communication architecture to enable the secure integration of DER systems into the Smart Grid. The measures are distinguished into unicast and multicast communication. Also identified are open issues, which have to be addressed.

A. *Unicast security means*

For unicast communication, the security requirements can be fulfilled by the security means described in the sequel. Both hop-to-hop and end-to-end security are required to fulfill the security requirements.

Mutual authentication, session integrity and confidentiality of an XMPP-based client, -server, or server-server communication are protected (hop-to-hop security from IEC 61850 point of view). This fulfills the requirements R1, R3, and R5. The TLS security protocol as specified in RFC 6120 (XMPP Core) is applied, using the cipher suites and settings defined in IEC/IS 62351-3 defining a SSL/TLS profile for protecting TCP based IEC 61850 traffic. The credentials used for authentication are X.509 certificates of the involved peers. The verification of XMPP client or XMPP server certificates requires that the root certificate of the issuing certificate authority (CA) is available at the other peer. Most likely the CA has a relation to the DNO or another 3rd party grid service provider.

End-to-end authentication, integrity, and confidentiality can be achieved by applying the draft IEC/IS 62351-4 MMS secure session concept as stated in section 2) utilizing the AE+ profile to address R2, R4a, and R6a.

Open at this point in time is if there is a distinction between the transport layer authentication and the application layer authentication in terms of utilized credentials. Using the same credentials for both may require access lists of allowed XMPP clients (DER resources) for the XMPP server upfront provided by the DNO (as blacklist or white list).

B. *Multicast security means*

For multicast communication, the multicast distribution point is the MUC, residing at the XMPP server side. Multicast communication is protected only hop-to-hop between MUC and XMPP clients. Here, the solution defined in IEC 61351-6, i.e., the application of a group key for multicast communication, in conjunction with IEC 62351-9 defining the group key distribution, can be re-used directly to address security requirements R2, R4b and R6b.

The realization of the group key management is open, i.e., which entity generates the group key, and distributes it to the clients. Based on the given requirements, and the trust assumptions, the group key generation would be performed at the DNO side, while the group key distribution would be performed using the MUC of the XMPP architecture. This

 ISBN: 978-1-61208-414-5

distributed key management certainly requires a protected end-to-end transport of the group key to avoid that the XMPP server operator has access to this sensitive information. Further information about multicast authentication can also be found in [15].

V. IDENTIFIED OPEN ISSUES

As stated in the previous section, open issues have been identified regarding the credentials used for the peer authentication (hop-to-hop, and end-to-end) in unicast communication, and also regarding the mapping of certain multicast security related functions to the various involved entities. Another issue besides the selection of the authentication credential relates to the performance of peer authentication of XMPP clients towards the XMPP server. It has to be determined, which entity performs the authentication and access control. Different options have been identified:

- Option 1: The XMPP server performs the client authentication locally, using a locally available access control list. The access control list can be provided by the DNO, or by another 3rd party grid service provider over a secure configuration protocol.
- Option 2: The DNO, or another 3rd party grid service provider, performs the authentication, and access control check remotely, based on a redirection from the XMPP server. Frameworks like OAuth [16]could be involved here
- Option 3: While the authentication is performed locally by the XMPP server, the access control check is performed remotely.

These topics require further research, and will have to be included in future standardization work.

Based on a threat and risk analysis, the options for using single credential or different credentials for hop-to-hop, and end-to-end security, have to be compared in the specific application context. This is the basis to make a well-founded design decision. It has to be defined whether the choice can be left to the energy operator to provide flexibility for both options. If all peers authenticate using X.509 certificates, and corresponding private keys, the creation, and distribution of these operational certificates needs to be defined from a process, and also a technical point of view. The standard IEC 62351-9 (targeting key management) provides guidance here, but the involved peers need to be identified, and their responsibility needs to be described for all use cases at a fine granularity to assure interoperability.

Further issues requiring future research are the management of multicast membership: Which entity is determining which XMPP client is allowed to participate in which MUC multicast room. How is the multicast key distribution being performed? It could be performed independently from the MUC, or alternatively using the MUC for distribution of the (encrypted) multicast key.

VI. CONCLUSIONS AND OUTLOOK

This paper proposes security measures for the integration of DER systems into Smart Energy Grid and Smart Market, utilizing and combining mostly existing, or security means currently defined by different standardization organizations. The process for the definition of a standardized security solution is currently ongoing within the IEC.

Open issues requiring further research have been identified, and possible directions for defining a suitable solution have been outlined. While open issues lie in the technical domain, they have dependencies also in the operational domain as security management operations have to be aligned with general operational use cases. The means to address have not been decided yet and need further research.

It is envisioned to provide an implementation in the next step as proof of concept for the applicability of the proposed security approach.

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V2G-based Smart Autonomous Vehicle for Urban Mobility using Renewable Energy

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***Abstract*— IRSEEM is coordinator of a research program Savemore [19] aiming to develop and demonstrate the viability and effectiveness of systems for electrical transport and urban logistics based on autonomous robotic electric vehicles operating within a smart grid electrical power distribution framework. As a part of this project, our work focuses on the study of the coupling of electric vehicles with renewable energy. At the scale of a city, electric vehicles can be considered as a means of intermittent storage of electric power which can be distributed to the network when it is required (e.g., at times of the date when demand spikes). When these vehicles belong to a controlled and intelligent fleet, network organization is dynamic and leads to a smart grid. The widespread use of electric vehicles in cities coupled with renewable energy appears as a powerful tool to help local and regional authorities in the implementation of the European Agenda for low-carbon, reduced air pollution and encourage energy savings. In this paper, we present a Vehicle to Grid model which implements the interaction between an electric vehicle and a smart grid. The model takes into account several kinds of parameters related to the battery, the charging station, the size of the fleet and the power grid as the expansion coefficient. A statistical approach is adopted for the setting of these parameters to determine the significant parameters. Several simulations are performed to validate the model. In first step, we have studied the behavior of the model on a typical day of a person who has traveled from his home to work (in France). As a second step, and in order to study the power consumption behavior of the model, we have tested it during several seasons. The results show the effectiveness of the model developed.**

Keywords; V2G; smart grid, bidirectional charging station, design of experiment.

I. INTRODUCTION

In a context of the economics and development of renewable energy, the "Grenelle Environment" enables research and development of electric vehicles and infrastructure. The Electric Vehicle (EV) market although launched many years earlier does not have great success so far, mainly due to lack of sufficient infrastructure to reassure consumers about autonomy. The development of new batteries has given a new boost to the field of electric mobility. However, a problem has been identified: while for example, the French State has planned to put into circulation a number of electric vehicles in the year 2020, recharging all these batteries is a real problem since it will create additional demand in periods already known for very high energy demand. However, recent proposals for the creation of Smart Grids of Electricity Distribution are suggest the peak demand can be managed effectively by introducing intelligent management of power consumption and storage. Until now, we have always used electric vehicle batteries in unidirectional mode. That is to say that the use of the battery can be summarized in a load area and a discharge operation of the vehicle. The innovative idea in smart grids is to use the batteries in bidirectional mode this time, and to inject electricity back to the grid when needed. However, a question arises: will this bidirectional battery usage counter peak daily consumption?

At present, the countries of the world are confronted with serious issues and problems related to energy; whether for its production, operation, management or even transportation. It should be noted that the energy produced in the world comes, about 80% of fossil fuels [16][17]. The consumption of fossil fuels today poses a major environmental problem. Indeed, the production of energy from fossil fuels causes the release of greenhouse gases to the atmosphere, which results in global warming.

Today, and for the sake of sustainable development, some sectors such as the automotive and logistics industries have to address the problems and offer alternatives to the use of combustion engines (which consume major part of fossil fuels). One such alternative is the expansion of the use of electric motors. The introduction of electric vehicles fleets by 2020 is of increasing importance. This will lead to a significant change in the behavior of the electricity distribution grids. To

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anticipate this future behavior, the network must evolve to become "smart".

This paper is organized as follows: Section 1 introduces the motivation of the paper. Section 2 presents the state of the art on Vehicle to Grid (V2G) projects. Section 3 presents the V2G model we developed. Section 4 illustrates the impact of the V2G model parameters in the interaction between the EV and smart grid. An adjustment of the model parameters is presented in this section. Results are presented in Section 5. Section 6 concludes this paper.

II. V2G STATE OF THE ART

There are different ways to integrate a vehicle in the network: V0G: direct load on standard household outlet, V1G: the vehicle communicates in real time with the network and the network load when needed (outside peak), V2G: as V1G but bidirectionally, discharge to the networks when it is needed, V2H: as V2G but only with a specific building or building complex, and V2G NGU: a V2G project related to renewable energy production.

The University of Delaware has launched the V2G project in 2004. This project is led by Dr. Willett Kempton [1][5][6]. Electric-drive vehicles, whether powered by batteries, fuel cells, or gasoline hybrids, have energy and power electronics capable of producing the 60 Hz AC electricity that powers homes and offices. They call it V2G. As an example of power production, the project has experimented for one vehicle that it can put out over 10kW, which is the energy consumption of 10 houses [2][3].

The company AC Propulsion Inc. has developed the concept of Vehicle to Grid by designing the eBox car [7], with a V2G system for the transfer of electricity in both directions between the battery and the electric grid. This car is derived from the Toyota Scion Xb equipped with an electric motor and a V2G interface for the transfer of electricity.

Danish Edison project stands for "Electric vehicles in a Distributed and Integrated market using Sustainable energy and Open Networks" [8]. The Danish electricity production environment is conducive to the development of this project as 20% of its energy is wind. This represents a large share of intermittent and difficult to control energy. They use them for the eBox project developed by AC Propulsion Inc.

As part of a project on a larger scale in the city of Toyota, the manufacturer available to Toyota Prius Plug conducted 10 tests at houses. They were equipped with a V2H (Vehicle to Home) interface for storing in the car battery intermittent production from photovoltaic panels. The injection of energy to the battery or to the network is managed by a specific charging station equipped with an inverter to convert the current system and Home Energy Management System (HEMS) [9].

V2G technology developed by the U.S. Company Nuvve is based on the possibility of using electric vehicles as energy buffer reserves [10]. On the one hand, electric vehicles, used on average 5% of the time, representing energy capacity "dormant", *i.e.*, not used for 95% of the day [4]. On the other hand, energy production is not constant, particularly in cases such as Denmark, where the random nature of renewable energy needs to be considered.

Unveiled in August 2011, the Leaf-to-Home is a V2G device that reverses the energy flow of the Nissan Leaf to allow the vehicle to provide electric power to a private network [11]. Indeed, thanks to an integrated model that is 100% electric, Nissan offers the possibility to transform the electric charge stored in the battery into alternating current for the energy needs of a home. According to Nissan, this system would power a Japanese home for 48 hours and a more energy-consuming house, such as an American home, for a day. This is useful when system power fails (for the basic operation of lights, freezer, etc.), or to reduce demand on the national system during peak times.

The German E-Energy program aims to enable intelligent integration of electro-mobility in a global energy supply system. Electricity consumption is guided by the production and the vehicle battery is charged only before its next use, no matter what time of the day it will be connected to the mains for charging [12].

The GRIDbot Canadian Company is specializing in the design and installation of charging infrastructure for municipal, commercial and multi-residential electric vehicles. It offers a global solution for the EVs' networking. It is one of the largest manufacturers across public, commercial and residential sectors in Canada for recharging devices. The project aims to make possible bidirectional electricity flows for the introduction of V2G in Quebec [13].

French Police Power Regulation assumptions are based on V2G, for a fleet of one million electric vehicles connected (the French government will provide a total of 2 million EVs by 2020). Their storage capacity could reach 10 GWh [14]. This storage capacity could be valuable during peak periods.

In [18], the author proposes a photovoltaic synthetic generator. The system developed show a stochastic model for solar energy based on Markov chain approach and uses real data to generate the solar states for different times of the day. The system can be applied to design the appropriate size of energy storage devices or to determine the charging rate of photovoltaic powered EV charging station [18].

III. V2G MODEL: EV & SMART GRID INTERACTION

A. *V2G Model Parameters*

In order to study the V2G model, it is necessary to identify the parameters constituting the model. In TABLE I, we summarize the whole of these parameters:

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TABLE I. V2G MODEL PARAMTERS.

N°	Description
1	Battery Capacity
2	Real Battery Capacity
3	Battery Voltage
4	Battery Intensity
5	Max Battery Power
6	Minimum Time of Charge/Discharge
7	Recharge Power Terminal
8	Transformation Efficiency DC/AC
9	Vehicles Number
10	Behavior Losses Coefficient
11	Theoretical Vehicle Autonomy
12	Real Autonomy Estimation
13	Conducted Middle Journey
14	Expansion Coefficient

B. V2G Model Calculation

In order to give a clear description for the model to be used, we consider the following parameters:

- Real Energy Injectable from the battery to the grid : $REIBG$
- Real Battery Capacity: RBC
- Transformation Efficiency: $\frac{DC}{AC}$: R
- Number of Vehicles: N
- Average Journey carried out: P
- Manufacture Battery Capacity: MBC
- Real Autonomy Estimate: RAE
- Maximum Energy Injectable from the Grid to the Battery during Time $Tmin$: $MEIGB$
- Charging Station Power: CSP
- Charging Time in Hours: T
- Real Energy Injectable on the Batteries: $REIB$

The Eq. (6) shows the resulting model. For obtaining $REIBG$, we have to do the following calculations:
Firstly, we calculate the energy consumption for 1 km as shown in Eq. 1:

$$EG1 = \frac{MBC}{RAE} \quad (1)$$

Secondly, we calculate the energy consumption per day for one EV as shown in Eq. 2:

$$ECD1 = EG1 * P \quad (2)$$

Thirdly, we calculate the total energy (Eq. 3) expended per day:

$$TEED = ECD1 * N \quad (3)$$

Fourthly, we calculate the remaining energy in the batteries which corresponds to the real available energy (Eq. 4):

$$RAE = RBC * N - TEED \quad (4)$$

And finally, for obtaining the real energy injectable from the battery to the grid, Eq. 5 is presented as follows:

$$REIBG = RAE * R \quad (5)$$

And now in using the different parameters, we have (Eq. 6):

$$REIBG = R * \left(RBC * N - \left(N * P * \frac{MBC}{RAE}\right)\right) \quad (6)$$

The maximum energy injectable from the grid to the battery during time T is presented in Eq. 7:

$$MEIGB = CSP * N * T \quad (7)$$

The Energy which really injectable on the battery is shown in Eq. 8:

$$REIB = RBC * N \quad (8)$$

C. Significant Parameters

Significant parameters were selected initially based on an analysis of the impact of each parameter on the output of the system. In order to validate our choice, significant parameters determining strategy based on the Design of Experiments (DOE) [15] was adopted.

The resulting significant parameters which are taken into account in the simulation are: 1. Power charging station, 2. Time of charge/discharge, 3. Battery autonomy, 4. Reinjection capacity in the network, 5. Fleet size : vehicle number, 6. Fleet type and 7. Expansion coefficient.

IV. V2G IMPACT SIMULATION

Several scenarios were simulated to validate the V2G approach presented in this paper. As an illustration, we present two of them:

A. 1st Scenario

1) Significant Parameters

The significant parameters which are taken into account in the simulation are: Battery Initial Level, Battery Target Level, Reinjection Capacity in the Network, Fleet Size: vehicle number, Expansion Coefficient.

2) Selected Scenarios

The scenario chosen is based on a significant study of the RTE Company for the EV fleet at 2020: Lithium-ion battery capacity of 22 kWh, 2 Millions of vehicles (Special fleet: 1 200 000 vehicles, Captive fleet: 800 000 vehicles), Recharge exclusively off-peak: 00h00 - 5h00, summer and winter day consideration. The captive fleet behavior was simulated as follows (Figure 1):

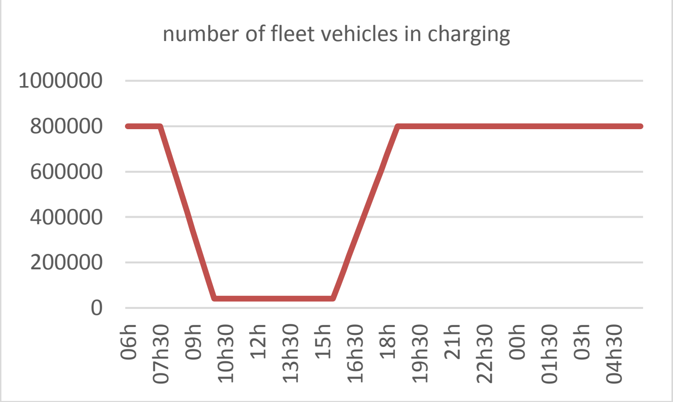

Figure 1. Captive Fleet Vehicle Behavior (X Axis in hours and Y Axis in number of vehicles).

The particular fleet behavior was simulated as follows (Figure 2):

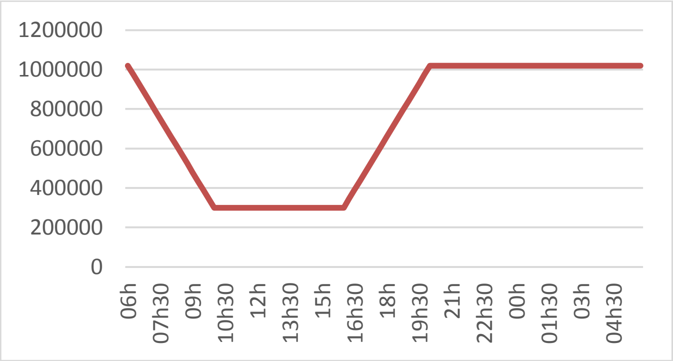

Figure 2. Particular Fleet Vehicle Behavior (X Axis in hours and Y Axis in number of vehicles).

3) Results Obtained

The simulation results were obtained following the choice of the following parameters: Initial Level of the Battery (Particular Fleet: between 70% and 80%, Professional Fleet: 25%), Battery Chargers Capacity (Particular Fleet: 3 kW, Professional Fleet: 43 kW), Security Level: threshold at 25% to avoid premature battery depletion, Users behavior, Charging has been restrained from 7h00 PM. The batteries must be recharged from 05h00 AM. We present in Figure 3 the case of a classic day in which we make comparison between classical consumption and V2G consumption:

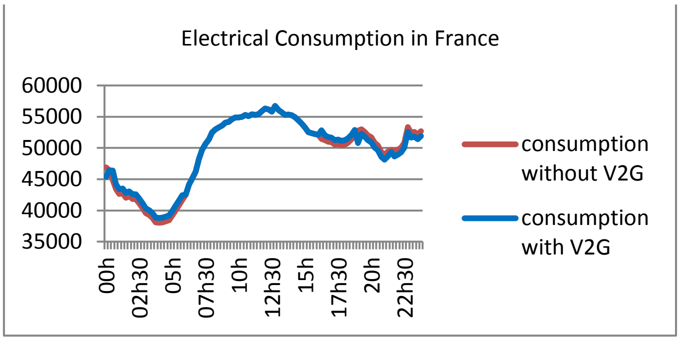

Figure 3. Case of Classic Day (X Axis in hours and Y Axis in MWh).

The case of a winter day is shown in Figure 4:

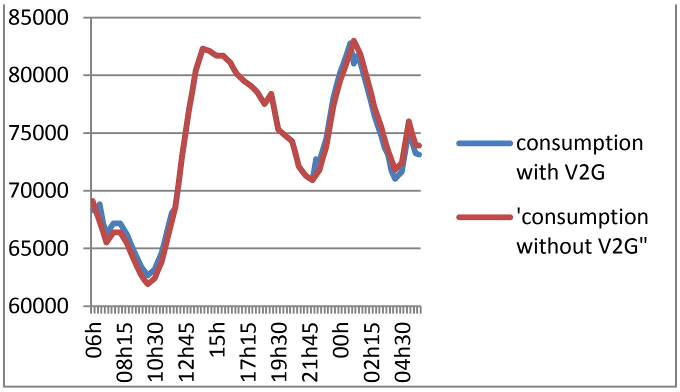

Figure 4. Case of Winter Day (X Axis in hours and Y Axis in number of vehicles).

The summer day is shown in the Figure 5:

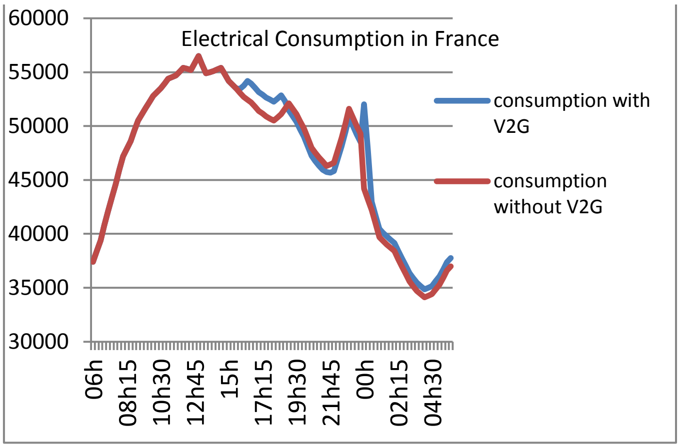

Figure 5. Case of Summer Day (X Axis in hours and Y Axis in MWh).

B. 2nd Scenario

1) Significant Parameters

The significant parameters were taken into account in this simulation are: Fleet Size, Fleet Type, Power Charging Terminal, Expansion Coefficient, Charge/discharge Times.

2) Selected Scenarios

For each simulation, we varied only one parameter of the model at a time. This amounts to 5 different simulations.

3) Results Obtained

The results obtained by varying the parameter “fleet type: particular/captive” are shown in Figure 6:

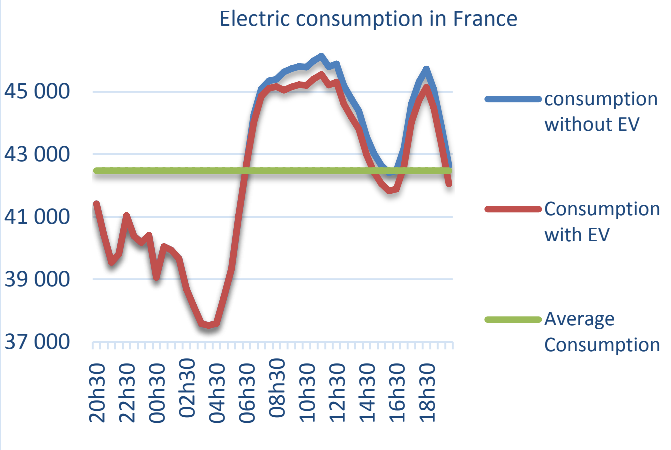

Figure 6. Power Consumption by Fleet Type (X Axis in hours and Y Axis in MWh).

The results obtained by varying the parameter fleet size are presented in Figure 7:

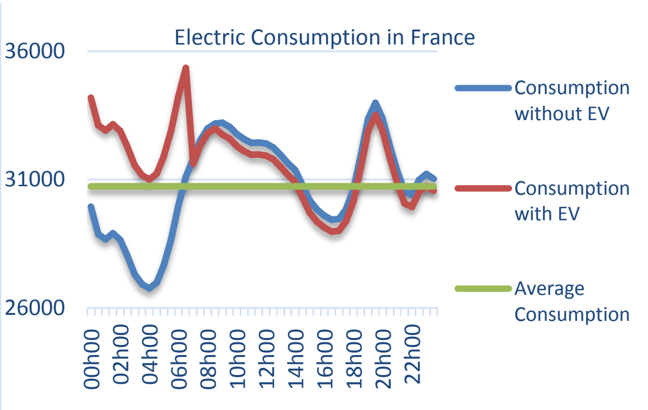

Figure 7. Power Consumption by Fleet Size (X Axis in hours and Y Axis in MWh).

The results obtained by varying the parameter expansion coefficient are shown in Figure 8:

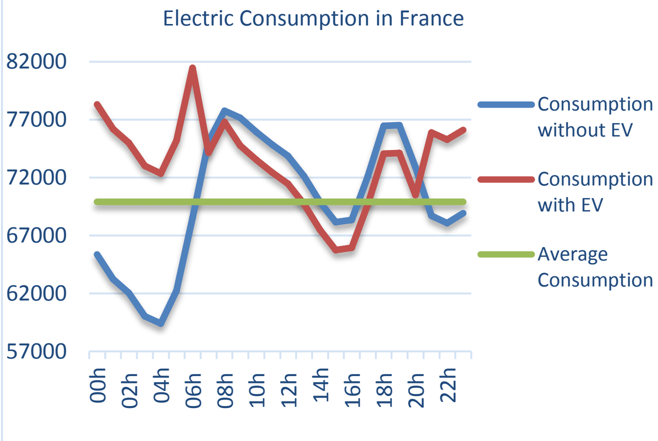

Figure 8. Power Consumption by Expansion Coefficient (X Axis in hours and Y Axis in MWh).

The results obtained by varying the parameter Times of Charge/Discharge are shown in Figure 9:

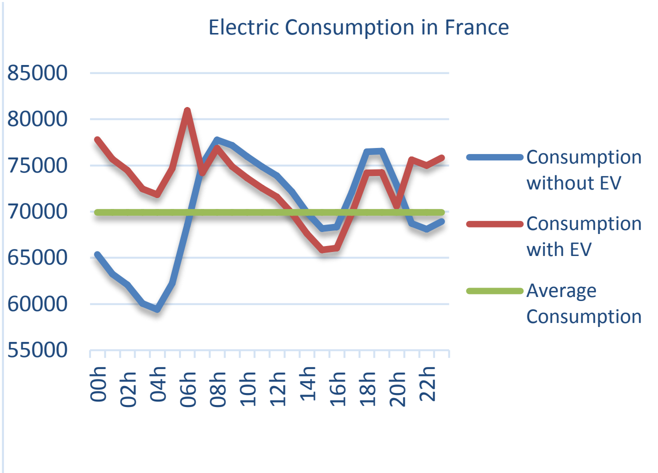

Figure 9. Power Consumption by Charge/Discharge Times Batteries (X Axis in hours and Y Axis in MWh).

C. V2G Model Significant Parameters

In order to refine the study on the significant parameters selection from the set of V2G model parameters, 4 scenario simulations were performed to test the V2G model for the following configurations, namely: summer, spring, autumn, and winter:

1) V2G 4 Seasons Simulations

The whole configurations for the simulations of the V2G for the 4 seasons are summarized in TABLE II:

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TABLE II. V2G 4-SEASONS SIMULATIONS.

	spring	summer	autumn	winter
Real Battery Capacity (kwh)	15	15	15	15
Battery Voltage (v)	400	400	400	400
Minimum Time of Charge/Discharge (h)	5.5	5.5	1	5.5
Recharge Power Terminal (kw)	4	4	22	4
Transformation Efficiency DC/AC (%)	90	95	90	90
Vehicles Number (million)	1	0.5	1	1
Behavior Losses Coefficient (%)	85	85	85	85
Theoretical Vehicle Autonomy (km)	210	210	210	210
Real Autonomy Estimation (km)	179	179	179	179

The variation related to the expansion coefficient is shown in TABLE III.

TABLE III. EXPANSION COEFFICIENT VALUES.

	7h-12h	12h-14h	14h-18h	18h-7h
Spring (%)	70	60	40	100
Summer (%)	60	70	60	50
Autumn (%)	70	60	60	100
Winter (%)	50	60	40	80

2) Results Obtained

The results obtained for the energy interaction are shown in TABLE IV.

TABLE IV. ENERGY INTERACTION BETWEEN THE EV ANS THE SMART GRID.

Maximum Energy	spring	summer	autumn	winter
Power back into the smart grid (MWh)	6430	3218	6874	5321
Injected from the network to the EV (MWh)	2000	1000	11000	2000
Injected from the EV to the network (MWh)	9978	5265	9978	9978
Consumption increase in EVs (%)	0.66	0.26	1	0.64

3) Significant Parameter-based Design of Experiment

The setting of parameters based on methodology from the Design of Experiments (DOE) filed is used to identify the most significant parameters of our V2G model (by significant parameters we define those for which changes of values directly impacts the model output). The use of DOE has reduced the model parameters from 14 to 4 significant parameters. This significantly reduces the number of experimental simulations required and causes rapid converge towards an optimal parameter sets. The significant parameters obtained are shown in TABLE V.

TABLE V. V2G MODEL SIGNIFICANT PARAMETERS.

	Description	Unit
1	Battery Capacity	kW.h or Ah
2	Recharge Power Terminal	kW
3	Vehicles Number	Vehicles
4	Expansion Coefficient	%

V. Results Analysis & Discussion

As a synthesis of the whole set of simulations, we present the following conclusions concerning the impact of EVs on the power grid: Despite 2 million vehicles added to the classic park, the consumption profile has not changed “very significantly”. In other words, the general behavior of the smart grid is the same but with a higher level of consumption. These two million EVs replace probably at least their thermal equivalent. This causes more power consumption, which requires more energy production. This in turn provides the benefit of reducing fossil fuel fleet and thus reduces the carbon footprint.

The energy feedback network does not affect the life of lithium-ion batteries; this is due to the fact that the discharge threshold setting of 25% was observed. Electric vehicles have an impact on electricity consumption although this impact remains "relatively modest" compared to the large size of the fleet of EV (2 million). Except for the private fleet (with 10000 VE), and during the charging period, we found an increase in electricity consumption. However, as the fleet in question is a V2G fleet, EVs outside charging periods inject energy into the network to reduce consumption during peak hours. The average consumption clearly shows a slight increase in the daily electricity consumption, which supports our first observation above about the non-significant impact of EVs on the overall energy consumption. In addition to the V2G, the introduction of future wind farms and hydro plants could reduce the load on the grid absorbed by the EVs during the daily power consumption. This is also aided by the contribution of Vehicle to Home (V2H), hence the strong interaction between the V2G and V2H.

VI. Conclusion

We have presented in this paper an extensive experimental study on V2G and its impact in the production of renewable energy and its interaction with the conventional smart grid. This study included an overview of V2G projects. Subsequently, we presented our V2G model including several significant parameters. This model has been the subject of several simulations to demonstrate its feasibility.

Subsequently, a synthesis has been prepared to present the impact of EVs on the smart grid. We found during our various simulations that despite the 2 million EVs added to the fleet on the horizon of 2020, and despite additional consumption of energy caused by the large number of EVs, the general behavior of smart grid has not changed “very significantly”. The EV power returned to the network is important and could, eventually, relieve the smart grid. The regenerative feedback into the smart grid does not affect the life of lithium-ion batteries. The scenarios provide a minimum charge level for users. Designs of Experiments methodology have reduced the V2G model parameters from 14 to 4. As an example, our V2G model shows that for a fleet of 3 Million EVs, we can inject into the grid at about 31.6 GWh per day, representing energy production of two nuclear reactors (900 MW from each one and 32 GWh both of them) and a wind farm of 645 wind turbines (2 MW from each one and 31 GWh both of them). This illustrates the value of our V2G model and the benefits of using EVs within a Smart Grid environment.

ACKNOWLEDGMENT

This research is supported by the Franco-British project Smart Autonomous Vehicle for Urban Mobility using Renewable energy (SAVEMORE with the website: http://savemore-project.eu/) that has been selected in the context of the INTERREG IVA France (Channel) England European cross-border co-operation program. The authors wish to thank the students of ESIGELEC Engineer Project for their contribution in the development of the results presented in this paper.

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Home Appliance Load Scheduling with SEMIAH

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***Abstract*—The European research project SEMIAH aims at designing a scalable infrastructure for residential demand response. This paper presents the progress towards a centralized load scheduling algorithm for controlling home appliances taking power grid constraints and satisfaction of consumers into account.**

***Keywords*–Smart grids, demand response, load scheduling**

I. INTRODUCTION

Demand Response (DR) is in its nascent stage in Europe. DR programs allow Distribution System Operators (DSOs) to reduce electricity peak demand by incentivizing consumers to adapt their usage to variations in the electricity generation [1]. Existing DR programs aim at large industrial consumers, who can be managed as one large client, representing an aggregated demand of hundreds of residential households. Despite the fact that households constitute 27% of the total energy consumption in Europe and are responsible for 10% of the CO_2 emissions, no automated DR programs have been implemented for European households. The European FP7 research project *SEMIAH* (Scalable Energy Management Infrastructure for Aggregation of Households) strives for developing an Information Communication Technology (ICT) infrastructure for DR [2]. SEMIAH enables shifting of energy consumption to periods with high electricity generation from Renewable Energy Sources (RESs) which helps DSOs to flatten the peak electricity demand.

SEMIAH undertakes three different approaches to address the home appliance load scheduling optimization problem as follows: 1) scheduling of non-critical power-intensive loads using a residential Home Energy Controlling Hub (HECH) system, 2) two-stage linear stochastic programming for scheduling of domestic loads, and 3) load scheduling with multi-objective optimization techniques. This paper introduces a single-objective load scheduling optimization as a precursor for the latter multi-objective optimization approach.

II. THE SEMIAH SYSTEM

The SEMIAH system employs a centralized approach for aggregation and scheduling of load demands of appliances. It relies on the flexibilities provided by households who decide to join a DR program. The *flexibility* concept of SEMIAH aligns with the European mandate M/490 [3]: "The flexibility [offering] concept assumes that parties connected to the grid produce offerings of flexibility in load and (distributed) generation. Thereby, so-called flex-offers are issued indicating these power profile flexibilities, e.g., shifting in time or changing the energy amount. In the flex-offer approach, consumers and producers directly specify their demand and supply power profile flexibility in a fine-grained manner (household and SME level)." In SEMIAH, flexibility from home appliances are aggregated in a coherent way to produce flex-offers that can be traded in the electricity markets.

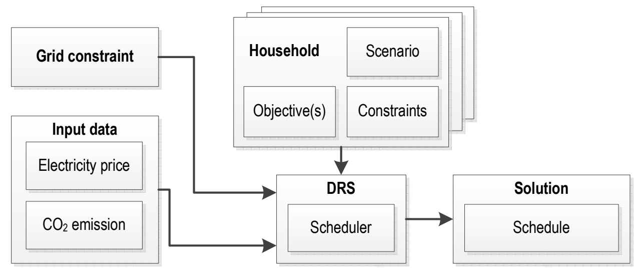

Figure 1. Conceptual diagram of the demand response serving subsystem.

Load demands of appliances can be categorized based on the *shiftability* feature [4]. Shiftability means to authorize a DR System (DRS) to shift load requests of *shiftable* appliances to a future time interval. Some appliances cannot be shifted, for instance the refrigerator. Hence, these become members of the category of *non-shiftable* appliances. Shiftable appliances can be further divided into groups based on the *interruptibility* feature. As an example, the DRS can both shift and interrupt the charging cycle of an electric vehicle. However, it should continue operation of the *uninterruptible* appliances until completion when these are started, e.g., a washing machine. Each household presents a scenario including the usage schedule of appliances. The household applies a *deadline flexibility* constraint, which sets a contract when a given appliance must complete its operation at latest. Subsequently, the DRS produces a schedule for the aggregated set of appliances, i.e., a solution. The deadline constraint imposes a non-trivial optimization problem for the scheduling of electricity loads.

Fig. 1 illustrates a conceptual diagram of the load scheduling subsystem. The DRS applies input data from the electricity market and the bulk generation side to establish an objective function used by the scheduling algorithm. In the household, a HECH is installed to manage loads of appliances. The HECH connects to sensors and actuators of the household by using ZigBee communication. It receives control information from the DRS and runs the scheduled appliances accordingly.

III. LOAD SCHEDULING

The DRS schedules and manages appliances based on desired scenarios of households. When consumers provide their appliances in the "DR Ready" mode to the DRS, they authorize the DRS to schedule appliances in a 24-hour period. The DRS receives load requests from all presented scenarios in each time interval of 5 minutes. Consecutively, it runs the scheduling algorithm on load requests taking the shiftability and interruptibility features of appliances into account. Three constraints are assumed by the scheduler: 1) keeping the total

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power consumption below a specific *Electricity Consumption Threshold (ECT)*, 2) satisfying the deadline flexibility of appliances, and 3) satisfying the *dependencies* between appliances, e.g., the laundry washing is completed before drying can start. The first constraint relates to the grid stability. The second and third constraints impact on satisfaction of consumers.

The scheduling algorithm allows non-shiftable loads to start or to continue their operation. If there are uninterruptible loads running in the previous time interval, they are permitted to continue. When there are loads which cannot be shifted without violating the deadline constraint, they must start or continue. Afterwards, the algorithm utilizes a Knapsack approach [5] on the remaining load requests to calculate the fitness of subsets. It returns a subset of remaining load requests to start or to continue in the current time interval. Loads, which cannot be started, are shifted to the next time interval.

IV. Preliminary Results

Table I offers an example of a scenario from a household with a consumer returning home at 18:00 and commencing to operate his appliances. The corresponding scheduled load demands of the household is demonstrated in Fig. 2 using two different *ECTs*. The maximum demand occurs at 18:25 and equals to 8,940 W. It comprises the electric vehicle, lighting, washing machine, oven, and stove. The day-ahead market is utilized for electricity price data (www.nordpoolspot.com). The CO_2 emission rate is derived from the electricity generation mix (www.energinet.dk) using the Danish power grid as the case study. To arrive at a *cost metric*, combining electricity price and CO_2 emission cost, an average cost of CO_2 emission of 171.78 DKK/1,000 kg is used. No shifting occurs when *ECT* is 9 kW which is higher that the peak demand of the household. When the threshold is lowered to 3 kW, load shifting takes place. The DRS decides to shift the charging of the electric

TABLE I. An example of a household scenario.

Start	End	Activity description	DF	P_p [W]
18:00	23:00	Turning the **lights** on.	23:00	100
18:00	20:00	Plugging the **electric vehicle** in its station.	23:00	3,600
18:05	19:50	Running the **washing machine**.	23:00	2,000
18:10	18:50	Preparing food and turning the **oven** on.	22:15	2,350
18:20	18:50	Starting and using the **stove**.	22:15	840
19:00	19:45	Eating the food while watching **TV**.	23:00	55
21:30	23:00	Preparing the **laundry dryer**.	23:00	2,000

DF and P_p are the the deadline flexibility and the peak power consumption of appliances (marked with **bold** type face) , respectively.

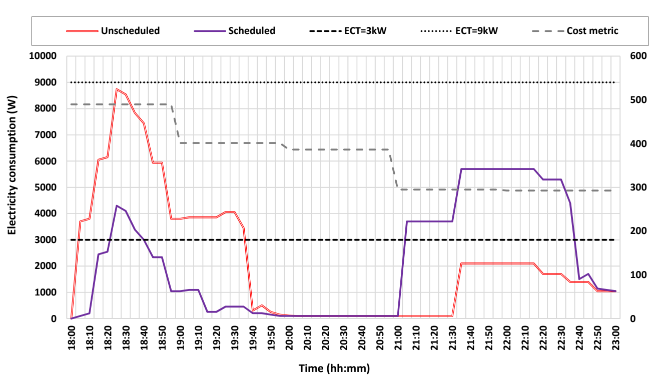

Figure 2. Peak demand shifting of home appliances due to *ECT* constraint. The cost metric (from 4 Nov. 2014 data) indicates a decreasing trend.

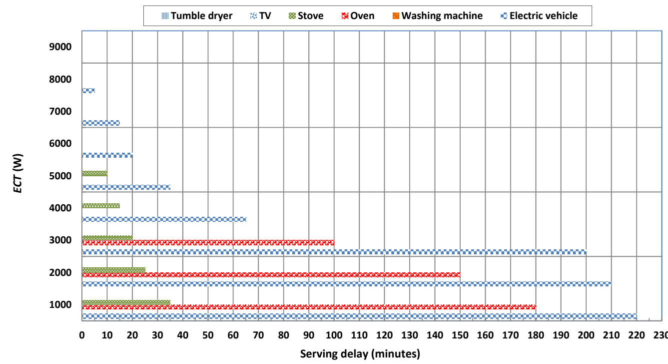

Figure 3. As *ECT* decreases, the serving delay of appliances increases.

vehicle by 200 minutes, and operations of the stove and oven by 100 and 20 minutes, respectively. It is beneficial to note that the threshold cannot be fully satisfied due to non-shiftable appliances that must run. This implies a “softness” of *ECT*.

To study consumer satisfaction, Fig. 3 examines the deviation between the starting and the serving times of appliances. Obviously, consumers prefer minimal deviation between the provided scenario and the offered schedule. As *ECT* increases, the consumer gets closer to the desired scenario. In the example, the electric vehicle is the best candidate to be shifted to later time intervals due to its higher peak power consumption.

V. Conclusions and Future Work

The SEMIAH project aims at developing an infrastructure for DR enabling aggregation and scheduling of electricity loads of home appliances. A scheduling algorithm based on a single-objective optimization approach has been developed. It allows the shifting of loads according to flexibilities provided by consumers. As future work, the scheduling algorithm will support multi-objective optimization techniques coupling with the divergent priorities of consumers and the DSO. SEMIAH targets a solution that scales to 200,000 households to produce aggregated flex-offers tradable in the electricity markets.

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A Framework for Detecting and Translating User Behavior from Smart Meter Data

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***Abstract*—The European adoption of smart electricity meters triggers the developments of new value-added service for smart energy and optimal consumption. Recently, several algorithms and tools have been built to analyze smart meter's data. This paper introduces an open framework and prototypes for detecting and presenting user behavior from its smart meter power consumption data. The framework aims at presenting the detected user behavior in natural language reports. In order to validate the proposed framework, an experiment has been performed and the results have been presented.**

Keywords–Nonintrusive Appliance Load Monitoring; Machine Learning; Smart Meters; UML.

I. Introduction

In a recent report, i.e., "Benchmarking smart metering deployment in the EU-27 with a focus on electricity", the Commission has accelerated smart meter deployment in European households. A roll-out target of 80% market penetration of smart electricity meters by 2020 has been required by Member States given that a long-term cost-benefit analysis proves to be positive. Besides being essential for electricity billing, smart meters have been used as a vehicle for delivering value-added services such as providing Distributed System Operators (DSOs) with diagnostic information about the distribution grid [1] or by permitting third party application providers to deliver grid-related information services to residential homes [2]. Furthermore, the higher temporal resolution of consumption data, offered by smart meters, allows physical events resulting from user behavior to be detected and analyzed by using a Nonintrusive Appliance Load Monitoring (NALM) system [3].

This paper rests on recent advancements in NALM based on smart meter data readings with high temporal resolution. A conceptual framework (shown in Figure 1) for detecting user behavior from the electricity usage fingerprints, resulting from activities in the residential home, is proposed. The key novelty of the research comes from a combination of simple machine-learning techniques for event recognition with a subsequent analysis and translation of information into natural language. After an initial training period, the responses to the actual user behavior can be delivered in near real-time. The immediate benefit of the proposed framework stems from the fact that an observer no longer needs to be a skilled technician but instead can rely on comprehensible reports on user behavior.

A domain where the framework can be applied is elderly care, where a report in natural language will enable care takers to take the role of the observer. By cutting away transportation overhead, this has the potential to allow care takers to spend more time paying attention to indicators of discomfort or worse. The paper is structured as follows; Section II gives a brief overview of the related work. Section III shows the techniques and modeling languages used in this work. Section IV presents the proposed framework and Section V demonstrates the applicability of the framework via a test case. Section VI draws the conclusion and outlines future work.

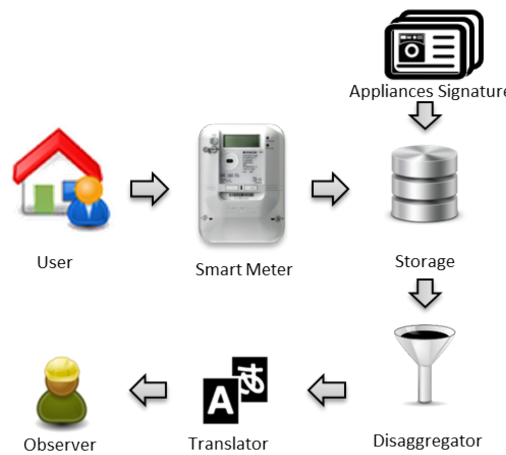

Figure 1. Overview of the data flow architecture

II. State of the Art

While frameworks for NALM by smart meter power consumption data forms a relatively new research field, diverse algorithms and tools have been presented to implement these frameworks. In [3], authors present an infrastructure and a specialized algorithm that provide users with real-time feedback on their electricity consumption. They achieve 86.8% accuracy in detecting ON/OFF switching events. In [4], Ruzzelli et al. present a smart system for recognition of electrical appliance activities in real-time. Their system provides 84.6% accuracy in determining the set of appliances being used.

In the same context, the work reported in [5] defines a service-oriented architecture for collection of electricity data from resource constrained devices in residential homes. In the same work, the REpresentational State Transfer (REST) principle is applied when designing the application layer protocols and a database cloud service, providing storage for other elements in the architecture.

Beside the simplicity stemming from only using smart

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meter data, research has also focused on the use of data with low time resolution. The works of [4] and [6] both rely on data collected at $\frac{1}{60}$ Hz, where the latter achieve a precision of 76.1% in detecting switching events.

Regarding the representation of the analyzed smart meter data results; generation of natural language from software models is considered as a key target in this point. Burden et al. in [7], investigate the possibilities to generate natural language text from Unified Modeling Language (UML) diagrams. They use a static diagram (i.e., class diagram) transformed into an intermediate linguistic model to demonstrate their approach. They show that the generated texts are grammatically correct. In this work, we have followed the same approach to generate natural language reports from high-level models.

III. Background

This section gives a brief overview of appliances detecting algorithms, natural language generator and interfaces that are used to exchange data between the framework elements.

A. Load Disaggregation Algorithm

Defined as an algorithm that takes data on aggregated electricity loads from multiple appliances, as input, and outputs disaggregated loads for individual appliances [8]. Combined with a non-intrusive approach to obtain the data, it forms a method for NALM. Assuming that labels with information about appliance load is available for some of the load data, the problem of disaggregation is similar to a supervised learning problem known from Machine Learning (ML) or a problem of statistical regression [8]. Another problem, related to load disaggregation, is that of detecting event states, typically "ON" or "OFF".

B. Model-to-Text

An Eclipse project is concerned with the generation of textual artifacts from high-level models. Object Management Group (OMG) specifies a correlated language named Mode-to-Text Language (MTL) to express its transformation. Acceleo [9], an Eclipse plugin tool, is a pragmatic implementation of the MTL standard. It is widely used by software engineers to generate code from high-level models.

C. Interfaces

REST is a design style for designing application based on web services, calling for simple (client-server, stateless, self-documenting) interfaces building on Hyper Text Transfer Protocol (HTTP). The openness, modularity, interoperability and security provided by REST are beneficial when designing interfaces for an open framework such as the proposed. The Internet Protocol (IP) suite is a key building block for cloud services, due to its widespread use. As discussed in [5], the larger address range of IP version 6 (IPv6) is necessary to assign each device an address and thereby observe the End-to-End principle.

ZigBee is implemented on the top of IEEE 802.15.4 standard and widely used in home automation applications, offering low transmission rates over a low-power wireless radio links.

IV. Proposed Framework

In this section, the context of the framework is outlined and elements of the framework are defined.

The context is that of a *user* living in his/her home. In the home, some electrical *appliances* are installed and when a user makes use of an appliance it is referred to as a *usage*. The framework interfaces with user consumption data through a *smart meter* by receiving data on electrical power consumption. The framework is then responsible for establishing the user's usages of appliances and outputs the result as natural language report. An *observer* will receive this natural language and thereby obtain information about the user behavior without having to be physically present.

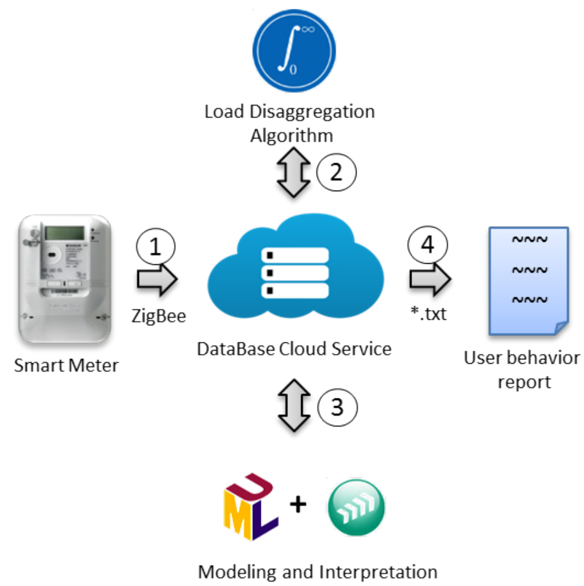

Figure 2. Tool-chain structure of the proposed framework

The framework is outlined in Figure 2 with its five components; numerical labels are used to denote the data flow directions. A *smart meter* will be responsible for collecting consumption data of the home. By using ZigBee communication data will be transferred to a DataBase Cloud Service (label 1) and a gateway has to be deployed in the home as discussed in [5]. The *DataBase Cloud Service* provides a data storage for the resource constrained smart meters. With RESTful web interface the service has potential for great scalability, like many other cloud services, while still offering constrained devices a simple interface. Beside providing a way to how to store potentially data, which is not discussed in other work on NALM, this framework describes a component which can be expected to scale well and has the benefits of consolidating storage. To make use of the collected data, it is proposed to deploy a *Load Disaggregation Algorithm (LDA)* [10] (label 2) as a cloud service. The LDA service takes measurement data from the DataBase Cloud Service as input and disaggregates the aggregated electricity consumption to produces data on appliance usage. Multiple implementations of LDAs exist as discussed in Section II and one of the key features of this framework is the capability to use various algorithms without rebuilding other components [2]. This is a benefit in both evaluation and deployment as it simplifies comparison and replacement of the LDA. As a novel idea in this context, Natural Language Processing (NLP) is applied to present information derived from electricity usage data to the receiver as natural language (label 3). Depending on the specific requirements this can be audio or text (label 4). An important feature is that the NLP components can be replaced without affecting other components in the framework. Figure 3 shows a part of a developed UML class diagram of the framework architecture. The class diagram depicts the main used classes with their attributes and relationships among each other's. In this way, objects of those classes can easily be instantiated and information related to each object can be tagged. Afterwards, such objects will be transformed into a natural language as it explained in details in [7].

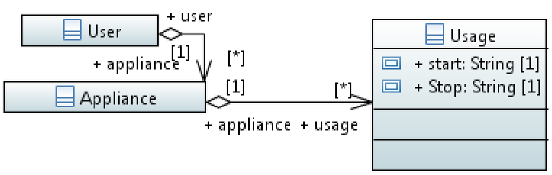

Figure 3. Part of the framework architecture that related to the natural language generation

V. EXPERIMENTAL RESULTS

This section demonstrates the applicability of the proposed framework via a test case.

A. Electricity Traces of Appliances

In place of a real smart meter and the data to be obtained from it, this work in its current state relies on the *Tracebase* data set provided by [11]. The data set contains 1836 traces of 24-hours duration, from 159 different appliances of 43 types, with average power consumption sampled at 1 Hz. For collecting, the authors of [11] used the smart plug product named Circle, by PlugWise [12]. While providing precise per-appliance measurements, the Circle is an intrusive device, that must be installed between power outlets and appliance power plugs.

To simulate a smart meter, two days of data from six appliances are considered — one for test and one for training. The test and training sets are constructed by summing across appliances for each time of day, resulting in two virtual days of smart meter measurements. Any correlation information between appliances, such as the *PC-Desktop* and *Monitor-TFT* tending to be ON at the same time, is lost in the described process. Loss of information is expected to make the task of the LDA harder, leading to worse performance in the evaluation and thereby erring on the side of caution. The labeling with usage of appliances is done manually by visually inspecting the data set, introducing a source of error. Both errors are to be eliminated in future work by using a smart meter to measure multiple devices and by recording the true appliance usage.

B. Storage Service

Without a deployed smart meter, there is no need for a storage service and it is not yet implemented directly in this project. However, in related research efforts, the authors have obtained experience with the development and implementation of the DataBase and Analytics (DBA) service of [5], and plan to use it in the near future.

C. Load Disaggregation Algorithm

To verify that the LDA component is feasible, two prototypes have been implemented using two different supervised ML techniques, namely Support Vector Machine (SVM) and Random Forest [8]. For each LDA, a classifier for a home is built on the training data, obtained as discussed in Section V-A. To evaluate, the classifier is applied to the test data set, resulting in predictions of which appliances are in use at each time interval. Usage patterns are obtained from sliding a time window and by observing changes in which appliances are in use. A change to ON signifies the starting time of a usage and the next change to OFF for the device signifies the stopping time of the same usage.

SVM results in an overall accuracy of 94.0% and F1-score of 77.3% with worst per appliance F1-score being 38.4%. Random Forrest on the other hand provides an overall accuracy of 94.3% and F1-score of 78.3%, with worst per appliance F1-score of 39.2%. The difference in performance between the two methods is too small to ascribe any significance. Therefore, the results for the worst performing SVM is considered in the following.

Table I shows that the LDA is good at determining when appliances are OFF, as the True Negative Rate (TNR) is high. It is also good at determining when appliances are ON, except for the Lamp and the TV-LCD, which shows a low True Positive Rate (TPR) and thereby a low F1-score. The counts of True Positive (TP), False Positive (FP), True Negative (TN) and False Negative (FN) are available in Table II.

TABLE I. LDA (SVM) TEST PERFORMANCE METRICS.

	Prec.	Acc.	TPR	TNR	F1
TV-CRT	0.998	0.976	0.855	1.000	0.921
PC-Desktop	0.820	0.934	0.975	0.919	0.890
Cooking-stove	0.932	0.997	0.997	0.997	0.964
Lamp	0.621	0.887	0.288	0.974	0.394
Monitor-TFT	0.613	0.930	0.988	0.923	0.757
TV-LCD	0.571	0.934	0.402	0.976	0.471
Overall	0.780	0.943	0.787	0.967	0.783

Prec.: $\frac{TP}{TP+FP}$. Acc.: $\frac{TP+TN}{TP+FP+FN+TN}$.
TPR.: $\frac{TP}{TP+FN}$. TNR: $\frac{TN}{TN+FP}$.
F1: $\frac{2TP}{2TP+FP+FN}$.

TABLE II. LDA (SVM) TEST ERROR COUNTS.

	TP	FP	TN	FN
TV-CRT	12048	21	72280	2049
PC-Desktop	23159	5099	57538	602
Cooking-stove	3107	226	83057	8
Lamp	3177	1935	73428	7858
Monitor-TFT	9336	5890	71056	116
TV-LCD	2541	1912	78159	3786
Overall	53368	15083	435518	14419

TP: True Positives. FP: False Positives.
TN: True Negatives. FN: False Negative.

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D. Natural Language Processing

Figure 4 shows a part of the generated object diagram of the previously explained class diagram (Figure 3). The diagram is automatically built from the output of the LDA, by mapping it directly into class instances. A Python module outputting XML conforming to the format used by Eclipse MTL has been implemented specifically for this purpose. The tool generates *.uml* files which are visualized using Papyrus UML editor tool as shown in Figure 4.

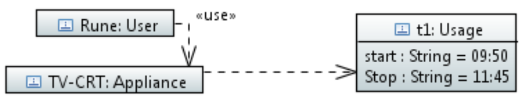

Figure 4. Part of the UML model of the case study

E. Model-to-Text

The last step in the synthesis, is to transform UML object diagram into a natural language. This step has been done by developing an Acceleo model-to-text generator to parse and convert the model into a natural language. A part of the generator is shown in Figure 5.

```
[let I: Sequence(InstanceSpecification) =
    model.eAllContents(InstanceSpecification)]
[if (I.classifier->at(i).name = 'User')]
[I->at(i).name/]
[let iUser : Integer = i]
    [for (it : NamedElement | I->at(iUser).
        clientDependency.supplier)]
     was using the [it.name/]
     [it.clientDependency.supplier.
         eAllContents(LiteralString).value->sep
         ('from ',' to ','.')/]
...
```

Figure 5. A part of the developed Acceleo natural language generator tool

The automatically generated natural language report from the parsed UML object diagram (Figure 4) is:

```
Rune was using the TV-CRT from
09:50 to 11:45.
```

VI. Conclusion and Future Work

A framework for deducing user behavior from smart meter data has been presented. Tool-chain structure and prototypes have been described and evaluated for the key components, specifically the Load Disaggregation Algorithm, the Modeling and the Natural Language Processing. The prototypes have been developed to validate the feasibility of the framework.

Future work includes modeling of the entire framework in details, formalizing interfaces between components and validating them. In particular, the issue of multiple users is a topic that has not been discussed in related work. Smart meters will be introduced and utilized for acquisition of real and complex electricity consumption data. The database cloud service will need to be implemented to support data acquisition, and potentials for sharing data or appliance profiles can be investigated. LDA performance might be improved through use of other algorithms or by tuning parameters. Establishing the statistical significance will be an important part of the evaluation.

Acknowledgment

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Energy Consumer Knowledge Through Eco-visualization Evolution

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***Abstract*—This paper present energy consumer knowledge, through eco-visualization evolution in an attempt to identify how solutions, and their related technologies are evolving and what the perspectives for the future of the field are. Consumer awareness of energy use showed to be one of the roots to energy conservation. Technology, through digital artifacts, appears as an important factor to provide better feedbacks and, among with this, eco-visualization appears as one key enabler. The analysis was conducted by an ontological design and sustainable interaction perspective. This short paper presents this analysis and how eco-visualization solutions evolved through time in complexity and interactivity with features including, among other things, motivational and persuasive aspects and a tendency to use ubiquitous technologies.**

Keywords-Energy consumption; interaction design; eco-visualization; sustainability, eco-feedback.

I. INTRODUCTION

There is a need for cities worldwide to become smarter in how they manage their infrastructure and resources to cater to the existing and future needs of their citizenry - economic growth, technological progress, and environmental sustainability are the drivers for this new found urgency [1]. Focusing on global energy challenges, one important way of achieving sustainable behavior change is to provide better feedback on energy consumption (eco-feedback) [2]. People are often unaware of the extent of theirs immediate consumption of energy [3]. According to Sun [4], consumer awareness of energy use and their act in energy conservation are inextricably linked because the former enables informed decision-making and motivates behavior change.

How this information should be presented is not yet well understood, but apparently the digital artifact ability to provide meaningful information and usability are very important factors to increase energy consumer knowledge through eco-visualization [5]. Based on the problem of providing effective energy feedback to changing consuming behaviors in positive ways, the objective of this paper is to show energy consumer knowledge through eco-visualization evolution in the last ten years in an attempt to identify: (i) how solutions and their related technologies are evolving, (ii) what are the perspectives for the future of the field and (iii) what is the impact of time in the design of eco-visualization applications. The term "solution" is used in this work to indicate digital artifacts (prototypes and products currently on the market or not) addressed to fix the problem.

This paper is organized as follows: theoretical background on eco-feedback and ontological design ways of sustainable interaction are presented in Section II. The methodology used in this work is presented in Section III. Related work in energy knowledge consumer field is presented in Section IV. Relevant solutions comparative analyses and finding results are presented in Section V. Some final considerations and next steps are presented in Section VI.

II. ABOUT ECO-FEEDBACK TECHNOLOGIES AND ONTOLOGICAL DESIGN WAYS

This section will depict some theoretical aspects of eco-feedback technologies (with focus in energy consumer knowledge) and a framework for ontological design sustainable intervention.

A. *Eco-feedback Technologies*

Eco-feedback technologies can be defined as: "technology that provides feedback on individual or group behaviors with a goal of reducing environmental impact" [2]. These are generic definitions that can be applied to many contexts (water, energy, and solid waste or carbon footprint, for example). In this work, the focus is energy, and the terms eco-feedback and eco-visualization are used most of the time as synonyms. Metrics, frequency, granularity and other factors play a role in the design of data feedback [6] and some possible ways to categorize these systems are by commitment (social or individual) [5], data visualization (pragmatic or artistic) type [7], or the support to the user behavior change (raise awareness, inform complex changes, and maintain sustainable routines) [8]. Few Human Computer Interaction (HCI) eco-feedback studies have attempted to measure behavior change [2]. In many cases, it is difficult to evaluate the efficiency of these artifacts in long-term usage because experiments reported in the literature were tested (validated) with a relatively small number of users, for a short period of time or both.

B. *Ontological Design Ways of Sustainable Intervention*

The solutions were analyzed grounded in the notion of an ontological design framework with the following aspects: Balancing (B), Prevention (Pv), Persuation (Ps), and self-Motivation (M) [9], as shown in Figure 1. Analyzing eco-feedback technologies through this view makes sense, since these solutions have the goal of reducing environmental impact. According to Kim [9]:

- Exploring design activity to synthesize technological effect, understanding users' practices and local environments as an ever-changing complex and applying appropriate technologies and services are some actions that can be performed to promote the balancing between now and the future (B);

- Prevention (Pv) of environmental problems involves, among other things, avoiding superfluous consumption and reducing the use of materials or energy;
- Understanding a digital artifact as a communicative possibility for transmitting sustainable meanings, indicating the efficiency of energy and materiality, and encouraging sustainable behaviors are some actions that can be performed to persuade (Ps) users to engage in sustainable practices;
- Self-motivation (M) involves, among other things, discovering how to empower and motivate users and groups or communities to organize their own thinking and act for ecological satisfaction.

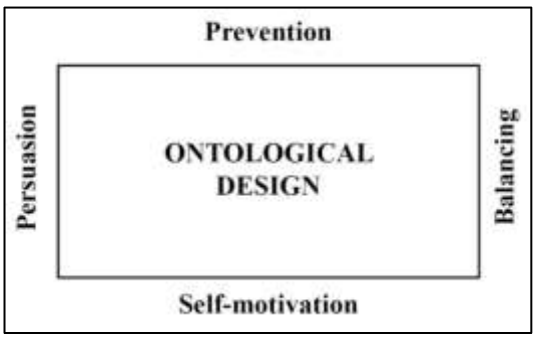

Figure 1. Ontological Design framework [9]

Originally, the framework presents a design perspective, but it can be applied during the entire process of new products creation.

III. Methodology

To achieve the objectives, a literature review to form a theoretical basis and a benchmark was conducted. The goal of this activity was to find previous works related to the issue of providing effective energy feedback. The intention was not to collect cases in terms of quantity, but to choose cases in a representative way according to their impact, creativity and diversity.

Following the criteria mentioned before, five solutions were selected - some of them are currently on the market (Cloogy [15] and Power2Switch [12]) and other represent early experimental functional prototypes (The Ténéré [11], Power-Aware Cord [10] and PowerViz [7]). They are presented in chronological order pointing in many aspects to an evolution along the years. After that, we analysed each one of those solutions, in order to validate and gather how they changed, or did not change, the way in which an energy assessment is done.

The findings from previous step were analyzed through the concept of an ontological design and a sustainable interaction framework [9] following these aspects: Balancing between now and the future (B), Prevention of environmental problems (Pv), technologies that Persuade users to engage in sustainable practices (Ps), and empowering self-Motivation (M). In order to perform the evaluation, these aspects were linked to some eco-feedback relevant characteristics that might be present or not in the selected solutions, such as: commitment, data visualization, support to user behavior change and the additional electric power consumption the solution could cause.

Finally, an analyses was conducted comparing one solution with another, to better understand how this field is evolving and how the next generation of eco-feedback digital artifacts is expected to be and cover.

The implementation and creation of a new approach to this matter was not part of this work.

IV. Existing Solutions

This section will depict the main features of existing solutions for analysis.

A. *Power-Aware Cord*

Power-Aware Cord is a re-design of a common electrical power strip that displays the amount of energy passing through it at any given moment. It uses dynamic glowing patterns produced by electroluminescent wires molded into the transparent electrical cord, as shown in Figure 2. By using this functional prototype, the authors of the project investigated how ambient displays could be used to increase the awareness about energy consumption [10].

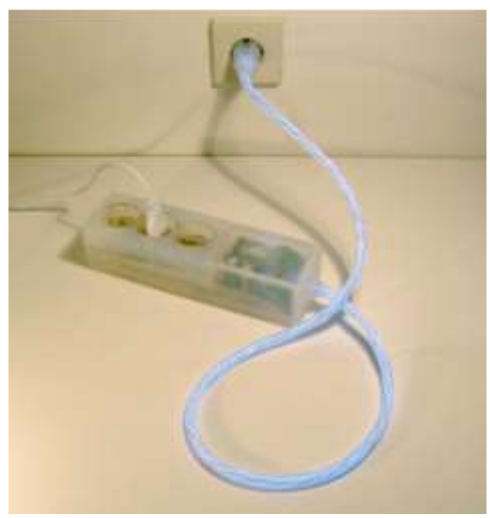

Figure 2. Power-Aware Cord prototype [10]

The system uses individual commitment, feedback and abstract data visualization to increase awareness. It causes additional electrical use and long-term use may reduce the effect of meaningful and emotional appeal. According to Gustafsson and Gyllenswärd [10], the prototype was validated by fifteen users in the original study.

B. *The Ténéré*

Ténéré is a power wall tap and power extension cord that connects end products to energy source to measure and

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indicate the power use, as shown in Figure 3. It was designed to support people's energy conservation behaviors, focusing on providing appropriate energy awareness information in meaningful and emotional ways while products are being used [11]. A narrative of tree (which names the project) was used to indicate energy use, symbolizing the environmental consequences of human activity.

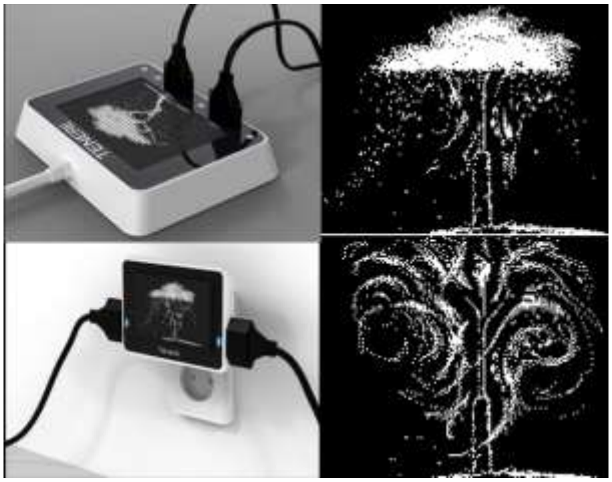

Figure 3. Ténére extension cord extension cord and wall tap type; Screen transitions that reflect current power usage [11]

The system uses individual commitment feedback and abstract data visualization to raise awareness. It causes additional electrical usage and long term usage may reduce the effect of meaningful and emotional appeal [11].

C. PowerViz

PowerViz is a prototype to an always-on eco-feedback display, which provides information about people's power usage in their homes at an appliance level [7]; as shown in Figure 4. The system draws its data from a smart home energy metering system, obtaining usage data from each outlet in the household. User interface consists of four individual screens: current usage (screen saver), usage history, appliance usage, and appliance history.

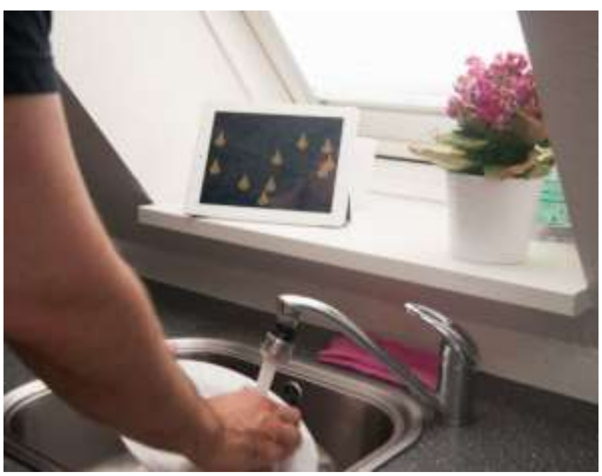

Figure 4. PowerViz usage [7]

The system uses individual and social commitment feedback and abstract and pragmatic data visualization to raise awareness. It causes additional electrical usage. According to Pierce et al [7], the prototype was validated with 3 end users (a very low number) in the original study.

D. Power2Switch

Power2Switch is an American startup that offers as service the account bill redesign and helps to find the best supplier (in many American cities consumers can choose the energy company) [12]. The redesign uses color, variation in font sizes and graphics that help to emphasize the most important information in the account and also to reduce noise and little relevance information [13]; as shown in Figure 5.

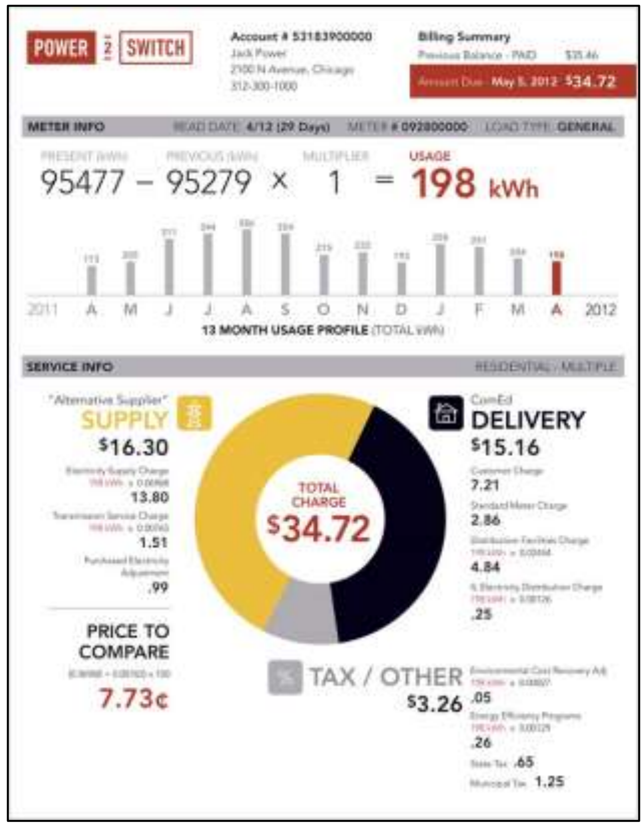

Figure 5. Account bill redesign sample [13]

It gives a better understanding of how much is paid by electricity (Supply), how much is paid to energy delivery and how much is paid in taxes [14].

E. Cloogy

Cloogy is an energy management solution that allows monitoring energy consumption. The device is Portuguese and was launched in late 2012. It promises savings of up to 25% on energy bill. Some system features are: simulate tariffs, set personal goals, create user profile, obtain forecasts of consumption and comparison between periods of times, control equipment remotely in real time and schedule the equipment operations [15]. The system uses individual commitment feedback and pragmatic data visualization to raise awareness, inform complex changes, and maintain sustainable routines.

V. Analysis

It would be difficult to provide an in-depth comparison between the commercial and prototype solutions presented. This is due to the fact that, despite having the same purpose they have distinct characteristics and use different technologies. But, using a framework, as described in Section II, could help in the analysis. The main characteristics considered in this evaluation were: commitment, data visualization, support to user behavior change and the additional electric power consumption the solution could cause.

Motivation can be interconnected with many elements. Although, for simplifying, commitment was related to Motivation in this analysis: social commitment was considered more motivating than individual commitment. Data visualization types were related to Persuasion: offering both pragmatic and abstract visualization modes or mixing up both was considered more persuasive than using just one kind. Support to user behavior change was related to Balancing and Prevention. If a solution uses a lot of electric power it can contribute negatively to Balancing and Prevention.

As shown in Table 1, the analysis of the selected solutions states a tendency to combine the multiple factors listed before in order to achieve greater effectiveness. The findings also state a tendency to eco-visualization solutions adoption in homes, along with the use of ubiquitous and pervasive technologies [7][12][15] to control and monitor power consumption remotely from devices with internet connection.

TABLE I. Sustainable Interaction

Year	Sustainable interaction				
	Solutions	***B***	***Pv***	***M***	***Ps***
2005	Power-Aware Cord	✖	✖	✔	✔
2009	Ténéré	✖	✖	✔	✔
2010	PowerViz	✖	✖	✔	✔
2010	Power2Switch	✔	✔	✔	✔
2012	Cloogy	✔	✔	✔	✔

The latest solutions presented, especially Power2Switch and Cloogy have several improvements in usability and show consistent Balancing (B), Prevention (Pr), Persuasion (Ps) and self-Motivation (M) by mixing forms of abstract and artistic visualization. They involve different types of commitment and can be more economic in power consumption compared to earliest artifacts that serve as the foundation for this evolution indicating somehow the impact of time in the design of eco-visualisation applications and the field development .

VI. Final Considerations

It is already known that meaningful information and usability are very important factors to increase energy consumer knowledge through eco-visualization [5]. Legibility of energy data in real time (or not) thought information systems with or without big data helps users to control, define goals and improve energy use contributing to sustainable behavior. In some cases, the available solutions analyzed expose to the user a consumer profile, turning power information more transparent and knowledgeable [12][15].

Energy consumer knowledge through eco-visualization evolved thought time in complexity and interactivity with features including, among other things, motivational and persuasive aspects. The related work analysis shows a great solutions range: pragmatic and abstract data visualization [7][10][11], narratives to meaningful and emotional ways [11], with social and individual commitment [7], energy management [15] and account bill redesign [12]. It is interesting to observe that the research field extrapolated to and generated new business and products with end users. It is possible to notice consistent and useful products currently on market.

As future works, it is intended to improve validation techniques from the framework factors of the conducted study and use it as metrics to better evaluate and design eco-feedback technologies. That may contribute to developing more sustainable digital artefacts and user experiences.

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eTelematik: ICT-System for Optimial Usage of Municipal Electric Vehicles

Outline of System Requirements, Implementation Design and Field Test Results

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***Abstract*—Electrical vehicles are not only passenger cars but also commercial vehicles and, in special, municipal vehicles. Their acceptance and usage depends primarily on everyday usability, aiming for a smart vehicle with intelligent energy and range supervision and driver support. In our funded research project eTelematik, we conceptualized, implemented and proved an Information and Communication Technology (ICT) System with directly connected vehicle components, driver interface and backend applications. In order to expand the usage of electric vehicles, we predict energy consumption of complex work task sets and guide vehicle drivers while driving.**

Keywords-Municipal vehicles; ICT-support for fully electric vehicles and electric vehicles with range extender; range prediction; mobile client; in-car module.

I. INTRODUCTION

Worldwide electrical vehicles are seen as mobility's future. Primary focus in this vision is mainly on private cars [1]. Commercially used vehicles however, have a much better starting point for electrification. Based on pre-scheduled tasks and daily high usage work the capability of commercial vehicles can be predicted. At the current state of development commercially used, fully electrical vehicles are not able to fulfill a full day's work without recharging. Therefore, hybrid vehicle concepts are developed and currently in advanced prototype state. A special class of commercial vehicles are municipal vehicles. These universal vehicles can be used with different setups and add-on structural parts in various scenarios.

In our research project eTelematik, we developed an Information and Communication Technologies (ICT) based system, which supports daily commercial usage of electrical municipal vehicles and enables new usage scenarios with hybrid vehicles.

The project eTelematik was a federal funded research project between 2012 and 2014. The consortium included four main partners [2]:

1. EPSa GmbH: industry, electronics and communication devices
2. Navimatix GmbH: mobile and server applications
3. Friedrich Schiller University Jena: research, distributed software systems, range estimation´
4. HAKO GmbH Werk Walterhausen: electrical municipal vehicles

The paper presented here focuses on the overall perspective on project results. While funding elapsed many questions are left open and are subject to further research and development work.

The remainder of the paper is organized as follows: In Section 2 we will provide an overview of the project´s overall ICT architecture including the main challenges of our distributed system. From there we will highlight the usage of collected data inside the vehicle and on backend systems. In section 3 we will present some information about our field test. We close with a short review of goal reaching in section 4.

II. THE ETELEMATIK PROJECT

Main focus of the project was the creation of a complete ICT infrastructure to enable an improved usage of electrical municipal vehicles.

Our main requirements to this system were

a) to gather data from mobile electrical vehicles and store them in a central universal database,
b) to interpret gathered data to evaluate the influence of various parameters on energy consumption during the fulfillment of certain work tasks with required work equipment,
c) to adjust the internal energy consumption and range prediction model with computed factors of influence and
d) to support the driver with information about estimated and real energy consumption of current and scheduled work tasks irrespective of the status of the connection to the central server.

Excluded from the project focus was the development of a new work force management or fleet management/ optimization system. Thus, all required business data had to be provided from an external fleet management system via designated service interfaces.

Basing on these requirements we developed our system as schematically shown in figure 1.

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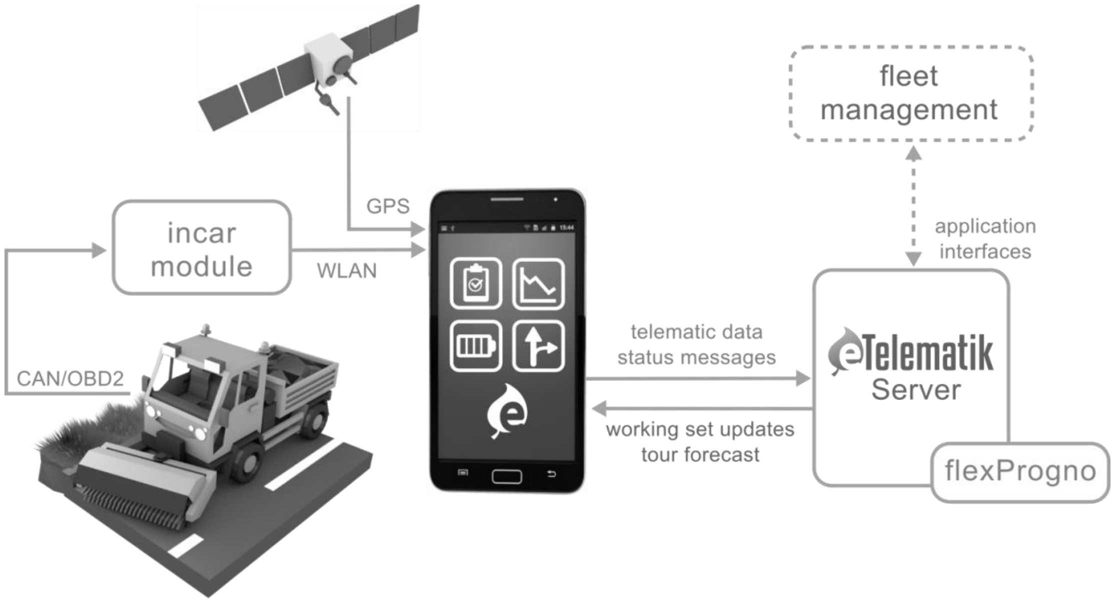

Figure 1. eTelematik system architectur overview (adapted figure, based on original by Johannes Kretzschmar, University Jena)

The eTelematik solution consists of a communication hardware (named “in-car module”), a mobile application (named “mobile client”) and a central server (named “central instance”) with a prediction model (named “flexProgno”).

Externally computed work task sets are evaluated concerning their practicability in our central instance *eTelematik Server*. We use our energy consumption and range prediction model *flexProgno* to estimate the power consumption for every single part of the given working set. While power consumption depends on various parameters like vehicle model, payload, environmental temperature as already shown in [3], we need to know more about the work task, required add-on structural parts and settings of them. Also we require knowledge about the concrete routing and whose elevation profile between different work task places. We use the commercial available route calculation service and map height services of project partner Navimatix GmbH to gather this data.

If a working set is estimated as accomplishable, the assigned driver gets this set shown on his mobile client.

Inside the vehicle the communication hardware, developed by EPSa GmbH, collects vehicle specific data in real-time, aggregates and sends them to the mobile client. Communication between the communication hardware and the vehicle is realized by Controller Area Network (CAN) connections. The mobile client, developed by Navimatix GmbH, is an android application running on established consumer devices. The mobile client informs the driver about the actual operating status of the vehicle, the current status prediction based on the assigned working task set and the probability of fulfillment of this set. All collected vehicle data combined with sensor data from the mobile phone are transferred to and stored at the central instance.

Figure 2 shows the internal conceptual system design of the mobile client application. The mobile client is subdivided into a user interface related part and some background services. While the data storing modules are responsible to realize business logic which is used by the UI module, the ICM Communicator Service takes care of establishing and keeping alive connection to the in-car module. We use plain TCP socket connections at this communication channel to minimize transport size and delay overhead. The eTele App Communicator Service realizes the reliable communication to the central instance. All other services, background as well as UI-related, use this service to communicate to and receive data from the central instance. At this channel, we use HTTP as transport layer. As our JBoss Application Server based central instance is realized using Java Servlets and Enterprise Java Beans, HTTP is a natural choice. As payload we used data objects with an own implemented key-value based object serialization which represents our business data.

To summarize our system has to handle following data from central instance to vehicle:

- master data of vehicles and drivers
- general and vehicle specific configuration setting for communication between in-car module and mobile client
- current work task sets depending on logged in driver

From vehicles to central instance we send:

- updates of work task status
- vehicle’s positions and velocity
- electrical vehicle specific measurements

The electrical vehicle specific measurements and especially their representation on in-car communication buses vary between vehicle manufacturers and even between vehicle types of one manufacturer. Within our project consortium we are able to gather and transfer following electrical vehicle specific measurements:

- state of charge
- primary battery voltage
- current in high voltage circuit
- connection state, settings and power of battery recharger
- state and settings of range extender (if applicable)

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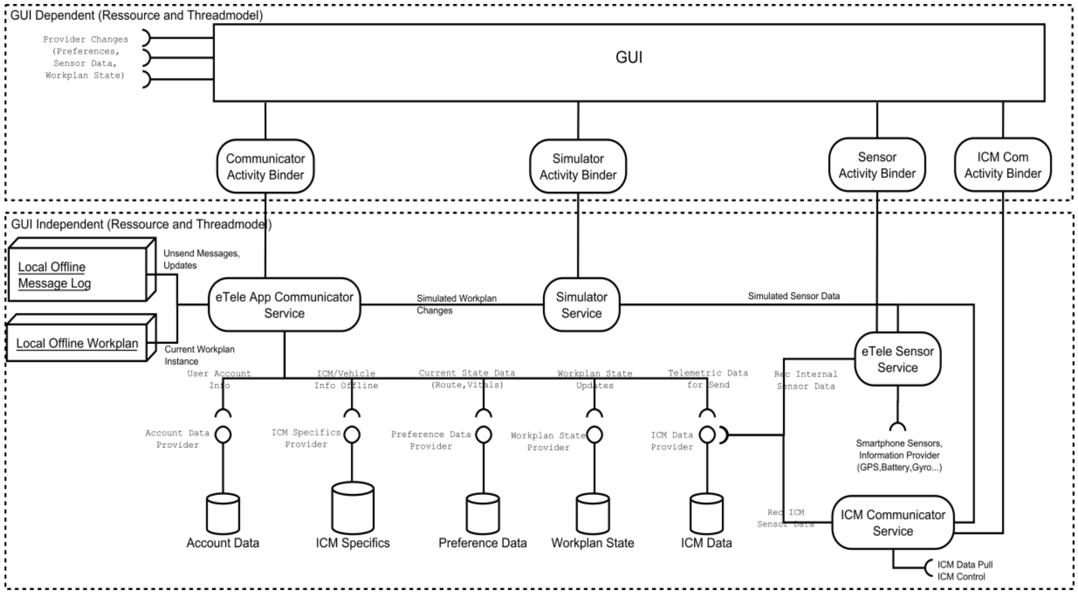

Figure 2. eTelematik mobile client´s internal module overview

These data are used in different situations. Inside the vehicle the data support the driver in driving between work task places of action and while task fulfillment. On server side, we use recorded data in different analyses.

Inside the vehicle we are able to realize “enhanced foresighted driving”. Because we know basing on the scheduled work task sets, which route has to be to driven and what kind of working task has to be accomplished, we are able to predict if this planning is still valid. Usually, only average statistics about energy consumption per kilometer are available to the vehicle and the driver. We know the concrete route to drive as well as the required settings of add-on components. Thus, we are able to predict the required energy consumption on a much more detailed basis. This advanced, detailed knowledge allows us to warn the driver that he will not reach his destination, even if the average statistics would tell him so. Alternatively, we can relax him in situations where average statistics would show a much to low range, for example when the planned route has many downhill sections. Furthermore, we can delay in hybrid cars the usage of the range extender when it would be triggered by the vehicle’s management system because we know when the user’s preferred charging stations are in reach.

By doing so, we are able to optimize the battery usage and to extend the usability of electrical vehicles.

In vehicles with range extender we can optimize the point in time for recharging. In certain situations, work tasks have to be fulfilled without any avoidable emission, e.g. noise or exhaust. If recharging is only controlled by battery state of charge it could happen, that the driving to the workplace is realized fully out of battery and that the recharging has to be started at working place. With our knowledge about the complete work task set and desired or required restrictions in work task fulfillment we can foresee and avoid such situations.

On server side, we use recorded data of the vehicle in different scenarios.

A long-term use case which is very important to vehicle manufactures as well as to the vehicle owner, is predictive maintenance. With data mining technics, we are able to detect deviations in characteristic gradients long before the vehicle breaks down. This is of particular interest to our project partners due to the lack of long-term experience with the completely new designed power train and the used battery system.

In addition, this process enables for the first time insight into exhaustive detailed real world usage records for these vehicles. This information is very helpful to vehicle manufactures for further improvements and new developments.

A short-term use case is monitoring of overall resource consumption for certain work tasks. To date the direct assignment of fuel consumption to single work tasks is not possible. Since we record work task state changes as well as energy consumption parameters continuously we are able to match them.

Inside our project’s system we also process recorded data for intrasystem usage. Main task is to adjust and improve our energy consumption and range prediction model flexProgno. Our model is based on assumptions like required energy stays equal if all influencing parameters do not change or stay very close to situations before. Initially we did not have many vehicle specific data. By processing recorded data the vehicle specific parameter set gets more accurate over time. The basic approach of our model is shown in [4].

Energy consumption does not only depend on vehicle or work task parameters, but also on driver characteristics. Hence, it is important to include the driver’s start-up and stop behavior in energy consumption prediction. Since these parameters cannot be measured beforehand they need to be determined from the recorded data.

As we developed our system from scratch we designed a long running field test. We built up a complete system installation to validate the system’s long term stability, data transfer reliability especially in areas with unreliable mobile network connection and to validate and harden our prediction model.

In our build up test, we installed our system components in five electrical vehicles. These vehicles were used on a regular daily basis.

The field test is a still ongoing process but we like to emphasize some preliminary results.

A) Our system setup is running very stable over all components. During the development there was some doubt about wireless local area network (WLAN) communication between in-car module and mobile client. However, we do not register any significant disturbance in this communication channel. All relevant data provided by the electrical vehicles in the field test were recorded by the in-car module and were transferred properly to mobile client.

B) We succeeded in establishing a robust communication between mobile client and central instance. Even in our test region where mobile network coverage is very patchy, we had no data loss.

C) Synchronization of master data as well as measurement data between mobile client and central instance is working very solid even if network connection gets lost while transfer. Thus, required offline capability of the mobile client is achieved.

Our field test is still in progress and we are still collecting data. The respective data evaluation with primary focus on our range prediction model will be published separately.

III. SUMMARY AND FUTURE WORK

Based on the evaluation of our long-term field test we can state that we achieved our primary goals. Quantity and quality of recorded and transferred data are satisfying, data transfer reliability is sufficient and offline capability for mobile client is achieved.

Therefore, we can determine that our selected system design and implementation are adequate to meet our overall requirements. Though, we have to rerate our selection of mobile phone as primary communication channel. We deployed mass market mobile phones in the field test. To date we did not have substantial failures. However, based on other tests we expect thermal problems in very cold and warm to hot situations. These problems will become more seriously when running more applications and parallel tasks on the mobile phone’s hardware.

Therefore the partitioning between in-car module and mobile client has to be reviewed very carefully. An alternative approach could be to transfer all permanent running processes of data collection and aggregation to the fixed-powered in-car module. This could as well include data transfer from and to the central instance. This process should be realized in a proxy-like way to keep this functionality transparent to the mobile client. The main function of the mobile phone still has to be the communication to the driver of the vehicle. This includes the exchange of information about working sets, as well as electrical vehicle state of charge, and driving instructions, to reach optimal range and energy usage.

A disadvantage within this alternative approach is the limited updatability and extensibility of the in-car module. The software for the in-car module has to be written system-specific and very closely fitted to the underlying hardware. One option to overcome this drawback would be to implement a scripting language like lua to encapsulate high level logic from lower hardware-near level.

Still many questions and tasks are left open. Our work will be continued, partly in cooperation with the federal funded project call “Smart City Logistik Erfurt” (SCL) [5].

In SCL, we address aspects of inner city freight logistic processes with full electric vehicles. The logistic partners of SCL intend to deploy available medium sized electrical vehicles into their business as freight transporters for the last mile, from the city’s perimeter to the final destination. The project’s focus is on ICT support to optimize vehicle’s utilization and integration in existing fleets and processes.

Therefore we have to adapt our in-car module to the selected vehicle models. The driver assistance mobile application needs adjustments to meet the specific needs in delivery logistic applications. Our range prediction has to be adjusted to the new domain as we have differing influence factors like weight or specific vehicles accessories. In SCL we will not only validate existing working sets. Implementation of route calculation and tour optimization with electrical vehicle´s additional restrictions will be an important task. Overall we have to improve usability and user experience in our driver assistance application as well as in backend systems user interface, which was not in focus of eTelematik but is undoubtedly important to bring our research and development into real world applications.

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