Smart City Services for Citizen-Centric Internet of Things

Nenad Gligoric*, Srdjan Krco*, Dejan Drajic*, Ignacio Elicegui**, Carmen López**, Luis Sánchez**, Michele Nati***, Jorge Bernal Bernabé****, José L. Hernández-Ramos****,Davide Carboni*****, Alberto Serra*****

*DunavNET, Research and Development, Antona Cehova 1, 21000 Novi Sad, Serbia

**University of Cantabria, 39005 Santander, Cantabria, Spain

***Centre for Communication Systems Research, University of Surrey, Guildford, GU2 7XH, Surrey, UK

****University of Murcia, Department of Information and Communications Engineering
Campus de Espinardo, 30100 Murcia, Spain

*****Information Society Area, CRS4
Piscina Manna, Edificio 1 - 09010 Pula (CA) – Italy

{nenad.gligoric, srdjan.krco, dejan.drajic}@dunavnet.eu, {iemaestro, clopez, lsanchez}@tlmat.unican.es, m.nati@surrey.ac.uk, {jorgebernal, jluis.hernandez}@um.es, {dcarboni,alserra}@crs4.it

***Abstract*— SocIoTal project addresses a crucial next step in the transformation of an emerging business driven Internet of Things (IoT) infrastructure into an all-inclusive one for the society by accelerating the creation of a socially aware citizen-centric IoT. In this paper are described the scenarios selected for the field trials and pilot deployment in this project, together with the evaluation methodology. The purpose of field trials and pilots is to test the developments over real environments, with real users, facing all the constraints and limitations that a complex society can pose in these kinds of trials. Within the pilot's evaluation process different methodologies and tools are considered: questionnaires and qualitative interviews from target groups collected during workshops where the services are presented to the end users, and real life testing.**

I. INTRODUCTION

SocIoTal project addresses a crucial next step in the transformation of an emerging business driven Internet of Things (IoT) infrastructure into an all-inclusive one for the society by accelerating the creation of a socially aware citizen-centric IoT. By providing adequate socially aware tools and mechanisms that simplify complexity and lower the barriers of entry it will encourage citizen participation in the IoT. In our previous work [1][2] we have highlighted the challenges that the creation of a privacy-aware framework needs to face for envisioning the social perspective of citizen-centric services based on the IoT paradigm. Later on, we have published [3] analysis and definition of use cases as a result of co-creation workshops and feedback received from the citizens. A logic step forward (which is also a main topic of this paper) is a definition of pilots and field trials going to be developed and evaluated.

In this paper we describe the services and pilots to be deployed during the last year of SocIoTal, as well as the evaluation process and the test defined for each one to evaluate its correct execution. The selected pilots come from the work done in previous phases of the project, evolved through the progress in the rest of the SocIoTal work packages and refined with several meetings and co-working sessions. As the result, but still having further to go, selected pilots will provide scenarios to play and test all the innovations introduced by SocIoTal, as well as the selected platforms to build its running instantiation. The purpose of field trials and pilots is to test the developments over real environments, with real users, facing all the constraints and limitations that a complex society can pose in these kinds of trials.

The paper is organized as follows. In Section II, SocIoTal platform is described, field trials are explained and evaluation methodology of trials is provided. Section III presents the selected SocIoTal service pilots. In Section IV KPIs and evaluation questionnaires are given. The paper is concluded with section V.

II. IoT PLATFORM

The SocIoTal platform uses the principles and the framework defined in the Internet of Things – Architecture (IoT-A) referent model [4]. This approach allows an existing well-showed module to be reused and extended with privacy-oriented features.

As one of the SocIoTal goals is to enable two main user groups (citizens and developers) to use its services, platform is composed of functional blocks enabling both to use the platform. Accordingly, an APIs (Application Programming Interfaces) that expose a set of the required functionalities of the SocIoTal platform to application developers are defined.

For citizens, the SocIoTal User Environment is envisioned as service composed of two applications: a mobile application, i.e. Mobile UserEnv; and a web based application, the Web User Environment. Both, the web application and the mobile application, are the front-end to an API-to-API broker that enables data and events to flow either from device-to-device or from device-to-service (e.g. from a sensor to a social network) having in

the user workspace the possibility to compose events and actions in a straightforward way (Figure 1).

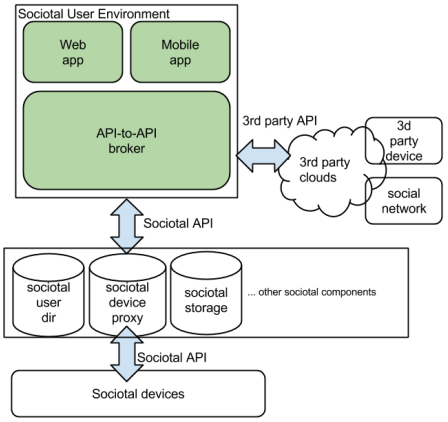

Figure 1. High level view of components and subcomponents of UserEnv in the context of SocIoTal and 3rd party systems

A. *Field Trials*

In this section evaluation methodology is described as well as field trials to be deployed within the project in order to test the different tools and enablers developed within SocIoTal.

1) *Registering people, devices and resources*

The objective of this tool is to provide a set of methods to register users, devices and resources in the simplest way possible. These methods, that conform an API, will be used by the final user to get registered through a specially designed user interface. Once the user is registered, the Registration tool will interact later with the corresponding platform resource directory to properly register devices and with the user's directory, assisted by the SocIoTal's Security Framework, to check the user credentials. Figure 2 presents the initial scheme for the Registration Tool.

2) *Discovering people, devices and resources*

To improve the sharing information process between users, different types of discovery will be developed. Through the SocIoTal Discovery Tool users will be able to discover other users by using different filters such as geolocation, community to which they belong, etc. In addition, the tool will allow the users to discover devices/resources filtering by different properties such as geolocation, entities, attributes, etc. An initial scheme for the Discovering Tool is depicted in Figure 3.

3) *Community Creation*

Based on the conducted comprehensive set of interviews, surveys and workshops, as one of the most important barriers in the IoT is recognized user's acceptance of the fear of loosing data control and personal privacy. Users want to share information without information leakage and having the control of their data in every moment.

In order to achieve that, the Community Creation Tool allows creating groups where the information is only shared among authorized members thanks to the SocIoTal Security framework. Functionalities such as owner assignation, add/remove user/resources/storage, modify security policies, etc. are provided by the tool. An initial scheme for the Community Creation Tool is presented in Figure 4.

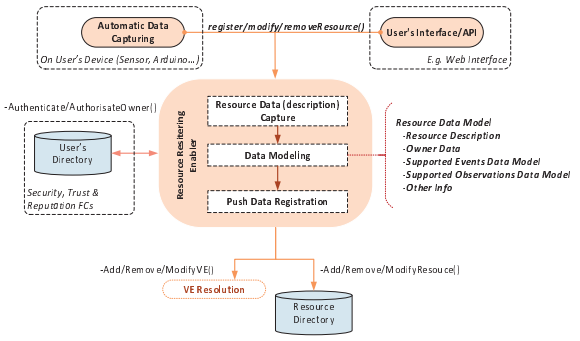

Figure 2. SocIoTal Registering Tool initial diagram

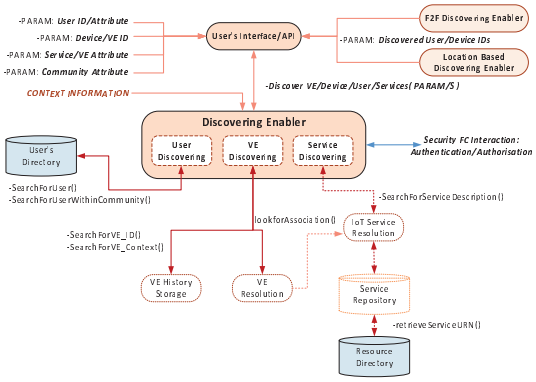

Figure 3. SocIoTal Discovery Tool initial diagram

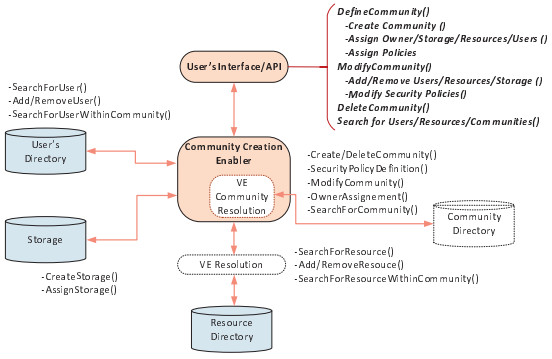

Figure 4. SocIoTal Community Creation Tool initial diagram

4) *Evaluating Mood of the city*

"Mood of the city" is a concept defined in SocIoTal project that offers citizens a method to assess their mood and share it with other citizens. There are previous methods for evaluating peoples' mood [5] and happiness [6], [7]. This use case tries to provide a joint metric that will help citizens to measure mood in the city by introducing contextually different parameters [8] to previous work.

This trial will allow the evaluation of the mood of the city enabler that offers to the users a method to assess their mood based on data entered (i.e. picture of their face and answers to the specific question) as well as based on current environmental data collected in the city using sensor devices

a) Collecting environmental data

Environmental data, i.e. humidity and temperature are summoned from Ekobus device [9], a shield sensor board attached to a rooftop of a public transportation vehicle in Novi Sad. These data are collecting and processing in the local database, on every few minutes. Also, users can access these data through an Android mobile application.

b) Collecting user's mood data

This main functionality of this use case is mood detection from the users' facial expression as well as collection of the users' happiness index by using happiness index questionnaire. Using mobile application's camera, user detects his mood and then populates questionnaire, with a set of questions commonly used in scientific community for evaluating peoples' happiness.

c) Computing mood of the city index

This use case is focusing on several functionalities offered to the user in order to compute the final mood which is going to be presented to the user. Data gathered from all users are then combined and used to compute mood of the city index. Inputs are scaled to a predefined maximum impact factor that each parameter has and then final value is given to the user as overall summation ratio of all inputs.

5) Evaluating Elevator Supervisor

One of the challenges tenants have from time to time in building maintenance, is elevator repairs. There is no efficient method to know which distance elevator reaches between scheduled inspections, thus this number can be significantly different in the same time intervals. To provide better insight into these numbers, as well as to provide automatic detection of elevator malfunction elevator supervisor use case is proposed.

This trial will evaluate elevator supervisor deployment that enables tenants to monitor history of repairs, elevator distance travelled between inspections and to signal when a new repair is required, as well as to detect malfunction. SocIoTal Web application portal can be used to add new users that can monitor elevator condition, schedule next inspection depending on number of travelled kilometers, put alarms for elevator jams and inspections.

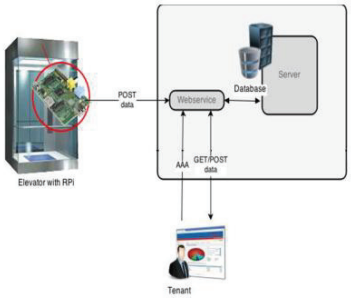

Figure 5. Elevator Supervisor field trial

In this scenario two use cases are identified:

a) Detecting elevator's travelled distance

This use case is based on a set of HW and SW tools that enable monitoring of elevator travelled distance. Raspberry Pi (RPi) device [10] with accelerometer is used to detect movements and after postposing of the signal using low pass filter a number of travelled meters is calculated and sent to the SocIoTal Web application. Users can track travelled distance of the elevator in order to schedule an elevator inspection.

b) Detecting elevator malfunction

This use case is used to automatically detect elevator malfunction by using accelerometers' and PIR sensor [11] data attached on the RPi board. If detected, details about malfunction are sent to the SocIoTal Web portal. User can create notifications in case of malfunction in order to be alerted in case of emergency.

B. Field Trial Evaluation Methodology

The main objective of this process is to gather, from every trial's set of final users, the results of testing each tool/s and/or enabler/s involved, using the mechanisms defined through this text. The target groups are attracted from local events and workshops, and through these activities the project interacts with them and gathers feedback regarding the potential usage of the project outputs as well as new requirements, potential additional functionalities, features that the SocIoTal solution should provide and also a rich evaluation in the different evaluation phases. The target groups considered at the moment are: end users as citizens not directly involved in technology; citizens with a higher level than "user-level" knowledge but without being experts; and service developers as a group involved in the creation of high value services for citizens. This last group is expected to provide more technical feedback which will help the project to capture new requirements, new possible features, technical bugs or malfunctions.

The enablers and tools to be developed during the project life will be evaluated in different phases and within each step a target group (or several) will be approached. Firstly, the first version of the enabler will be evaluated internally within the project partners with the purpose of fixing first bugs and malfunctions. End users will evaluate a following version of the enabler, those will be citizens and developers selected from workshops, and technology savy people interested in the project. In order to obtain a complete evaluation that aims to have a final and stable version of the tool, questionnaires will be distributed to the different target groups during and at the end of the experiment. Also, an email communication channel will be provided in order to report bugs, malfunctions, suggestions, etc.

During the evaluation a set of different KPIs (Key Performance Indicators) will be tested. These indicators involve different aspects such as number of evaluators, % of failures during the execution of the tools, process performance time, look and feel, usability, correct security processes executions, accuracy of data, user trust, energy and data spent, etc.

III. PILOTS

The selected SocIoTal service pilots fulfill two of the most important achievements of the project: to bring to the final users the platform, tools and the developed enablers together, including the mechanisms designed to engage and enrol them and, as a result, to collect the feedback related to their experience, together with performance and acceptance of the SocIoTal innovations. This way, a proper performance of the selected pilots will conform the best method to evaluate SocIoTal as a whole. In next paragraphs, the pilots to be deployed in Novi Sad and Santander will be described and then a summary of the evaluation process will be presented.

A. Novi Sad Pilots

Novi Sad pilot will implement two different pilot trials: Elevator Supervisor and Mood of the city. Elevator supervisor field trial is depicted in co-creation workshop with citizens held in Novi Sad, as one of the use cases that participants were showing the most interest for. Mood of the city is a novel concept calculated using a set of scalable inputs collected from the citizens, i.e. citizens' mood and environmental data collected from sensors.

1) Elevator Supervisor

This field trial is deployed in a resident building where sensor and application provide elevator malfunction detection, data access control and notification for multiple users as well as history track and information about previous repairs and inspections. The main goal of the application is to enable history track of previous repairs and to signalize when the elevator maintenance should be done after certain travelled distance. The pilot is deployed using Raspberry Pi [10] board with GPRS interface, 3-axis accelerometer to detect elevator movements and PIR sensor for presence detection. Movements' value are logged at the SD card and evaluated in a real-time in order to detect certain behaviour. Data is saved to a web application which limits access to authorized users only. Data access control and notifications for multiple users (e.g. tenants, company responsible for repair, etc.) enables history track, information about previous repairs and scheduling of future repairs.

2) Mood of the city

This pilot will enable computation of a Mood of the city defined herein as a scaled metric, derived from contextually different entities that influence people happiness and mood. Final Mood of the city value is computed using aggregated users' data, i.e. users' mood detected from an image, answers to a subjective happiness questionnaire [13], users' selections from a predefined mood list and environmental data.

It is worth noting that responses to the happiness measure cannot be attributed to respondents' current mood [13]. In addition, as final value will depend of a number of users posted their data, we have included well-known parameters that are proven to influence peoples' mood: environmental parameters, i.e. temperature and humidity [8]. Before detecting emotions using a camera, the face region is extracted from the image. From the face, mouth area is cropped and then classified using Fisherface algorithm [14] trained on a Yale dataset [15] increased with a series of custom labelled images. The algorithm is capable of detecting three types of emotions: happy, sad and normal. Implementation is done using OpenCV android library [16]. Temperature and humidity are summoned from EkoBus [9] devices; sensors attached to a moving public transportation vehicles. All these are used as an input to build the final mood of the city index.

B. Santander Pilots

In Santander Sharing Information and the Enabling Santander are two pilots extracted from ideas shared by citizens through the Santander City Brain platform [17]. In the case of the Enabling Santander, this idea was led by an external group of developers and, through the first Santander IoT Meetup [18] it was incorporated to SocIoTal as one of its scenarios with the objective of building the application over the tools provided by SocIoTal.

1) Sharing Information

Sharing Information pilot is shaped as a service that will provide citizens with a platform that will allow them sharing their own data (from their devices) only with people to whom they give permission, within a secured and trusted environment.

This pilot will use mainly the Registering users/devices, Community Creation and Discovery tools [19] but can be easily modified to include other tools developed within SocIoTal.

Users will firstly register themselves against the platform through the SocIoTal Registering Tool [19].

Once the user is registered they will be able to register their devices. All devices capable to send their measurements to a server are susceptible to be registered within the SocIoTal platform. Users can share information from different sources, for example, information gathered by the sensors included within their smartphones or tablets. In the case that they are more interested in technological DIY gadgets, they could build their own devices such as weather stations through Arduino or Raspberry Pi boards and different sensors and in an easy way program them to send their observations to the recipient platform. Once the Community has been created, members will be able to access information produced by the rest of members in the Community through the SocIoTal User Environment. To request information about users, devices or observations within the community the users will fill the needed information to describe what are they looking for, and the SocIoTal Discovery tool will be in charge of discover all data related to the request that users are allowed to access. In addition to this, citizens will be able to receive information following a pub/sub pattern, subscribing their profile to the different resources.

2) Enabling Santander

Enabling Santander pilot will provide disabled citizens with an application to go from one place to another in the city, avoiding barriers along their journey (works, road closed, narrow sidewalk, etc.). This application, proposed by a group of external developers in the city, will be built over some necessary SocIoTal tools.

The application will make use of the SocIoTal Registration enabler in order to register the users and give them the authorization to access the platform and use the services

Within the application, the route calculation service will make use of the SocIoTal Discovery Tool. When the user requests a route, the route calculation algorithm will need data about the barriers that can cause a problem for a disabled person. These events will be requested through the Discovery Enabler. Also, a user through the application could request data about the accessibility of a concrete area by only selecting the area they want to analyze.

C. *Evaluation Methodology*

It can be highlighted that the evaluation process has started from the beginning of the project when the use cases were selected since they were extracted from ideas gathered within workshops with citizens or from platforms where users can upload ideas and vote them. From that use cases a smaller group of ideas were selected and adapted to turn into pilots.

Within the pilot's evaluation process two main methodologies and tools are considered: questionnaires and qualitative interviews from target groups collected during workshops where the services are presented to the end users, and real life testing. The questionnaires are composed with the aim to collect useful information on improvements of the presented pilot as well as end users (i.e. citizens) satisfaction with the current implementation. The data is going to be collected during workshops where service is presented to the end users and their feedback collected for the further pilot improvement. In addition, the description of a set of different test cases are be provided to check the correct operation of the functionalities of the pilot. These test cases will be focused in different aspects such as API usability and performance, correct operation of the different tools forming the bases of the functionalities, security, look and feel, data accuracy, etc. Finally, all feedback collected will be used for driving corrective and improvements measures for the platform. Evaluation process is shown in Figure 6.

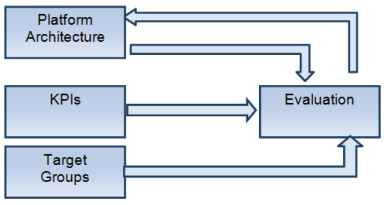

Figure 6. Evaluation process

IV. Key Performance Indicators and evaluation questionnaires

In this section KPIs and questionnaires for evaluating the field trials are presented. The data is going to be collected during workshops where service is presented to the end users and their feedback collected for the further pilot improvement.

TABLE I. Field trials' Key performance indicators

KPI Id:	KPI title:	Definition
SocIoTal Context Management Tools Key Performance Indicators (KPI)		
001	**Number of evaluators**	Number of people from the target groups that will evaluate the corresponding tool/API.
002	**Tools Usability**	Usability measures the grade of simplicity, adaptability and functionality perceived by users when they perform the corresponding tests through the provided tools
003	**General Tool crashes ratio**	Percentage of tool crashes during its usage, due to APIs malfunction coming from issues out of SocIoTal development (selected platform crashes, communication links failures, etc.).
004	**Process performance time**	Time the user takes to execute (prepare and send the request and receive the response) the corresponding procedure
005	**API Usability**	API usability measures the grade of simplicity, adaptability and functionality perceived by users (mainly developer – geek users) when they perform the corresponding tests through the provided APIs
006	**Failed process execution ratio**	Percentage of errors occurred during the execution of the analysed process
007	**Procedure (API) response time**	Related to the time the procedure API takes to retrieve Ok once it's been called
Community Creation tool Key Performance Indicators (KPI)		
008	**Usability**	Usability measures the grade of simplicity, adaptability and functionality perceived by users when they perform the corresponding tests
009	**CM Tool crashes ratio**	Percentage of tool crashes during its usage
010	**Process performance time (User Interface)**	Time the user takes to execute (prepare and send the request and receive the response) the corresponding procedure
011	**Process performance time (API response time)**	Time the user takes to execute (prepare and send the request and receive the corresponding procedure response)
Mood of the city Key Performance Indicators (KPI)		
001	**Number of evaluators**	Number of people from the target groups that will evaluate the Mood of the city enabler.
012	**Usability**	Usability measures the grade of simplicity perceived by the users when they use Mood of the city application.
013	**% Application crashes**	Percentage of application crashes during the usage of the Mood of the city enabler
014	**Process performance time**	Time the user takes to provide a data (current image of themselves and answers to the specific question)
015	**% Facial expression detection accuracy**	Percentage of success Facial expression detection accuracy
016	**% Environmental data accuracy**	Percentage of accuracy of environmental data
017	**Look and feel**	This KPI tries to measures the look and feel perceived by the users when they receive the results.
Elevator supervisor Key Performance Indicators (KPI)		
001	**Number of evaluators**	Number of people from the target groups that will evaluate the elevator supervisor enabler.
017	**Look and feel**	This KPI tries to measures the look and feel perceived by the users when they receive the results.
018	**Usability**	Usability measures the grade of

		simplicity perceived by users when they use elevator supervisor application.
019	**% Application crashes**	Percentage of application crashes during the usage of the elevator supervisor enabler
020	**% Malfunction detection accuracy**	Percentage of success of malfunction detection accuracy
021	**% Travelled distance calculation accuracy**	Percentage of success of travelled distance calculation accuracy

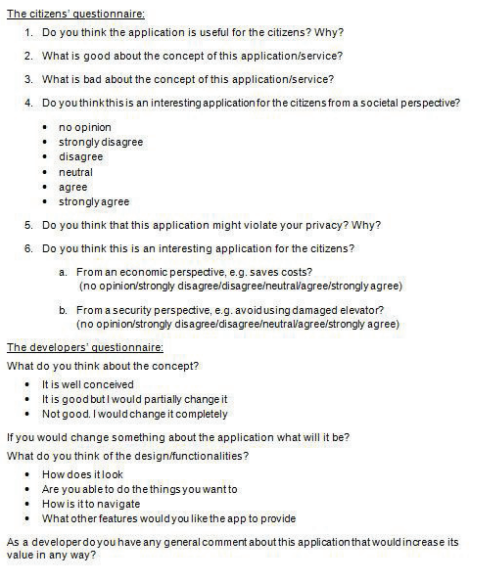

Figure 7. The evaluation questionnaire

Some of the KPIs are common (the same) for a few scenarios, but they are provided for all pilots for readability. Some KPIs have the same name (like KPIs 002 and 008: Tools Usability) and perform the same measures, but evaluate different tests (for example KPI 002 performs test: Create a new SocIoTal user/identity, while KPI 008 performs test: Using the community Management Tool to create/update/modify/delete community.

V. CONCLUSION

In this paper we have presented the scenarios selected for the field trials and pilot deployment, together with the evaluation methodology, including relevant KPIs. The trials are deployed within the project in order to test the different tools and enablers developed within SocIoTal. The purpose of field trials and pilots is to test the developments over real environments, with real users, facing all the constraints and limitations that a complex society can pose in these kinds of trials. Appropriate test cases and evaluation methodologies are described. Within the pilot's evaluation process different methodologies and tools are considered: questionnaires and qualitative interviews from target groups collected during workshops where the services are presented to the end users, and real life testing. A summary of the methodology followed in the project to evaluate the different pilots described above in terms of acceptance by the final users and correct operation of their functionalities is given.

ACKNOWLEDGMENT

This paper describes work undertaken in the context of the SocIoTal project (http://sociotal.eu/). The research leading to these results has received funding from the European Community's Seventh Framework Programme under grant agreement n° CNECT-ICT- 609112.

REFERENCES

[1] M. Victoria Moreno, José L. Hernández, Antonio F. Skarmeta, Michele Nati, Nick Palaghias, Alexander Gluhak, Rob van Kranenburg, "A Framework for Citizen Participation in the Internet of Things", Pervasive Internet of Things and Smart Cities (PitSac) whorkshop, 2014.

[2] Bernabe, J. B., Hernández, J. L., Moreno, M. V., & Gomez, A. F. S. (2014). Privacy-Preserving Security Framework for a Social-Aware Internet of Things. In Ubiquitous Computing and Ambient Intelligence. Personalisation and User Adapted Services (pp. 408-415). Springer International Publishing.

[3] Nenad Gligoric, Srdjan Krco, Ignacio Elicegui, Carmen López, Luis Sánchez, Michele Nati, Rob van Kranenburg, M. Victoria Moreno, Davide Carboni , "SocIoTal: Creating a Citizen-Centric Internet of Things", ICIST 2014, 4th International Conference on Information Society and Technology

[4] EU FP7 Internet of Things Architecture project, http://www.iot-a.eu/public, last accessed 28/11/2014

[5] Mit Mood Meter, [Online]. Available: http://moodmeter.media.mit.edu/, accessed 31.10.2014

[6] Anna Maffioletti,Agata Maida, Francesco Scacciati, "More Terminological and Methodological Problems in Measuring Happiness, Life Satisfaction and Well-Being: Some First Empirical Results", The Pursuit of Happiness and the Traditions of Wisdom SpringerBriefs in Well-Being and Quality of Life Research 2014, pp 13-21

[7] Peter Hills, Michael Argyle, The Oxford Happiness Questionnaire: a compact scale for the measurement of psychological well-being, Personality and Individual Differences Volume 33, Issue 7, November 2002, Pages 1073–1082

[8] Howarth, E., & Hoffman, M. S. (1984). A Multidimensional Approach to the Relationship between Mood Weather. British Journal of Psychology, 75 and (1), 15-23

[9] CITI-SENSE FP7 EU project. Official Deliverable D8.2., "Pilot studies platforms"

[10] Raspberry-Pi platform [Online]. Available: http://www.raspberrypi.org/ , Feb. 7,2014

[11] PIR motion sensor [Online]. Available https://learn.adafruit.com/pir-passive-infrared-proximity-motion-sensor

[12] SOCIOTAL FP7 STREP EU project. Official Deliverable D6.1, " D6.1 Report on first year community interactions and detailed dissemination strategy"

[13] Sonja Lyubomirsky, Heidi S. Lepper A Measure of Subjective Happiness: Preliminary Reliability and Construct Validation, Social Indicators Research, February 1999, Volume 46, Issue 2, pp 137-155

[14] PN Belhumeur, JP Hespanha, D Kriegman, Eigenfaces vs. fisherfaces: Recognition using class specific linear projection, Pattern Analysis and Machine Intelligence, IEEE Transactions on 19 (7), 711-720

[15] YALE Dataset Athinodoros Georghiades, Peter Belhumeur, and David Kriegman's paper, "From Few to Many: Illumination Cone Models for Face Recognition under Variable Lighting and Pose", PAMI, 2001

[16] OpenCV [Online], Available: http://docs.opencv.org/index.html

[17] Santander City Brain. [Online]. Available: http://www.santandercitybrain.com/ , [Nov. 13, 2014]

[18] IoT Santander Meetup. [Online]. Available: http://www.meetup.com/IoT-Santander/

[19] SOCIOTAL FP7 STREP EU project. Official Deliverable D5.1, " D5.1 Trial and pilot specifications" Report on first year community interactions and detailed dissemination strategy"