Dynamic Street Light Management

Towards a citizen centred approach

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Abstract. This paper presents a novel approach towards dynamic street light control, which combines advanced Information and Communication Technologies (ICT) and citizens' involvement and engagement. Our proposal is based on the Citizens' involvement which would strongly increases the efficiency and performance of technological solutions in smart city context. We believe that Serious Games have the potential to strengthen people motivation in this context.

Keywords: Smart Cities; Serious Games (SGs), Dynamic street lighting (DLS); Internet of Things, Social behaviour

I. Introduction

On the one hand, street lightening is an essential tool for urban security of citizens and goods. On the other hand and despite the evolution of low consumption lighting technology like LED, the economy potential is still enormous. Indeed European municipalities are looking for innovative solutions to master the costs of their streetlights, which represent up to 60% of their electricity costs [1]. Dynamic street lighting (DSL), which allows the adjustment of the lighting intensity to the real needs is one possible solution. Research papers on DSL have been published [2, 3, 4]. The main concepts behind this literature is to rely on a sensor network to measure certain environmental indicators like luminosity, visibility in order estimate the need for lighting intensity. More specific works integrate presence detectors to include the pedestrian and road traffic activities as an additional information to estimate the lighting needs.

As for the control of light intensity, the LED technology has stimulated the development of a wide range of control and dimming possibilities. Nowadays a street lamp can be ordered directly equipped with one of the following dimmers: (1) DALI, (*i.e. Digital Addressable Lighting Interface*) a protocol that permits an intelligent control of lighting equipment including control gear, control devices and bus power supplies. (2) "0-10V" which is an electronic lighting control signalling system where the control signal is a DC voltage that varies between zero and ten volts. Our project takes advantage of these evolutions.

Serious Games (SGs) are games that use their ludic properties to serve any kind of "serious" aspects in any kind of domain. Our R&D team have recently used them in the health domain resulting in surprisingly good results to strengthen people motivation [11]. The use of SGs to stimulate citizen engagement and participation in the public space has been extensively studied [5, 6]. Known as Serious Urban Games (SUGs), this kind of SGs aims at providing, in most cases, mobile-based games to citizens to facilitate and thus catalyse their effective contribution to the improvement of their urban environment. Reporting of infrastructure defects is an example of contribution with a high potential. Our project is using a SUGs to involve citizens to increase the efficiency of public street lighting.

Here is the structure of the paper: Chapter II presents the technology that underlies the dynamic street light management platform. Chapter III exposes the SG "Sweet City" that allows the collection of citizen's feedback on street light quality and its alignment with their real needs. Chapter IV shows the integration of the feedback of citizens into the light management platform. Conclusive remarks and future work will be presented in the last chapter.

II. Internet of Things Architecture for DSL

A. *System Overview*

The system of dynamic street light management is illustrated on Fig. 1. The solution is made of the following parts:

- Central platform: analyses the data pushed by the sensors to characterize the context and to determine the needs on illuminating power, *i.e.* intense/low activity, good/bad visibility, etc.;
- Sensors which deliver:
  - Environmental indicators, *e.g.* luminosity, weather forecast;
  - Activity indicators, *e.g.* pedestrian, traffic;

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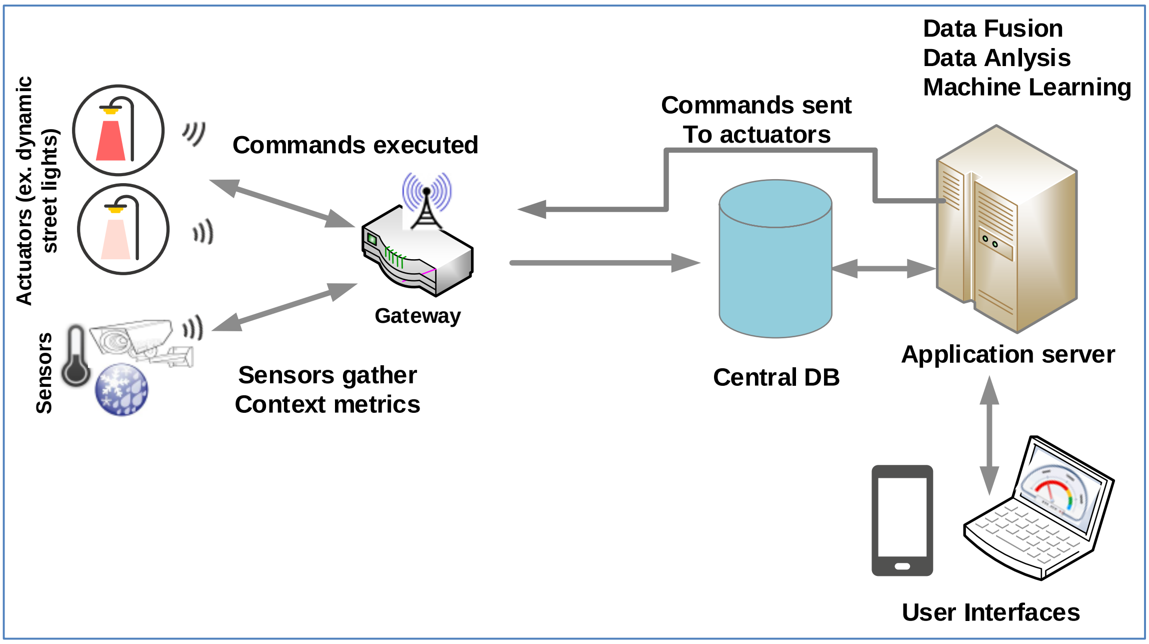

Fig. 1: Dynamic street lighting system overview

- Luminaires: receive the command to regulate the illuminating power according to the determined needs.

The different parts will be presented in details below.

B. IoT-based central platform

The proposed solution relies on a technological stack inspired from the Internet of Things paradigm [7]. A set of sensors are deployed in the field to measure street light relevant indicators which are processed and analyzed with the objective to accurately estimate the real need related to light intensity for a given context. Finally, a command is sent to individual or a group of luminaires for dynamically setting the needed light intensity. The

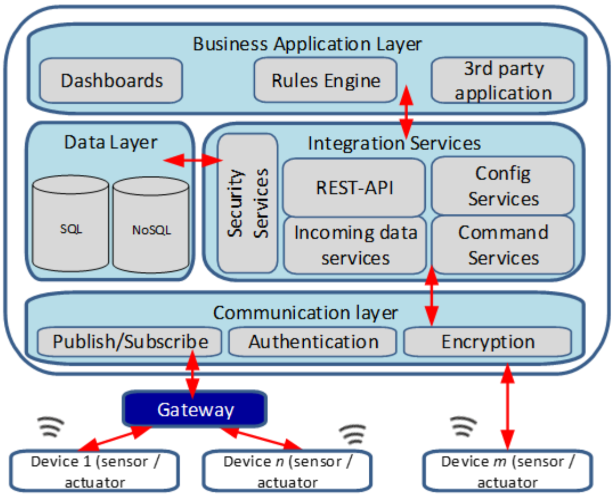

Fig. 2: Stemys.io detailed architecture

IoT platform *Stemys.io* (www.stemys.io) built around a set of building blocks for each layer of the IoT technological stack is used to integrate the DSL solution. Fig. 2 shows the different components of the platform, from the sensors/actuators layer to the application layer.

The platform is conceived and built to flexibly and seamlessly integrate new communicating objects with minimal effort. Largely addressing the IoT fragmentation challenge, the platform is implemented around the following modules.

1) Communicating Devices

The sensors and actuators are integrated on a single embedded device able to forward the measured values and to receive the commands.

2) Gateway

A ubiquitous processing unit capable of communicating with the end devices and to push the measured values to the central platform. Further, the gateway is able to pull the commands to the end devices. A new concept of gateway has been introduced which is based on the so-called communication agents. These communication agents allow the seamless integration of communicating devices. On top of the Java VM, the framework *Open Services Gateway initiative* (OSGi) [8] has been installed. OSGI is about a modular –built up of bundles–and *Service Oriented Architecture* (SOA) for deploying and executing Java services on top of a resources-constrained embedded system. Further, the basic IoT services proposed by Kura [9] have been integrated into the implemented architecture on top of the OSGi framework. Here are examples of the IoT services provided by Kura:

- Device Abstraction: Serial, USB, Bluetooth;
- Gateway Basic Services: Watchdog, Embedded DB, Clock Services;
- Network Management: Ethernet, WiFi;
- Connectivity and Delivery: Cloud Service, Data Service, MQTT (Paho);
- Field Protocols: ModBUS, CanBUS, ProfiBUS;
- Operation & Management: Remote configuration, remote update, log service.

Thanks to modularity offered by the framework OSGi, three bundles have been developed which make up the pursued communication agent. Each of the three independent bundles of the OSGi-based agent handles one specific task. 1) Recognize and connect to the end device registered by the IoT application. 2) Obtain/send the target data from/to the end device. 3) Publish/subscribe the target data through the MQTT broker to/from the central platform

3) Broker

It is message broker capable of forwarding the data between the gateway and the central platform based on the «publish/subscribe» principle. The underlying asynchronous communication mechanism assure a high performance of the data transfer.

4) Central Platform

Group of services executed either on the Cloud or on a dedicated server and capable of processing and exploiting the acquired data. The domain specific applications are integrated at this level.

Regarding the DSL application, the integration is realized using the built-in rules engine, which is based on DROOLS. As shown on Fig. 3, rules combining various indicators are implemented to control the light intensity.

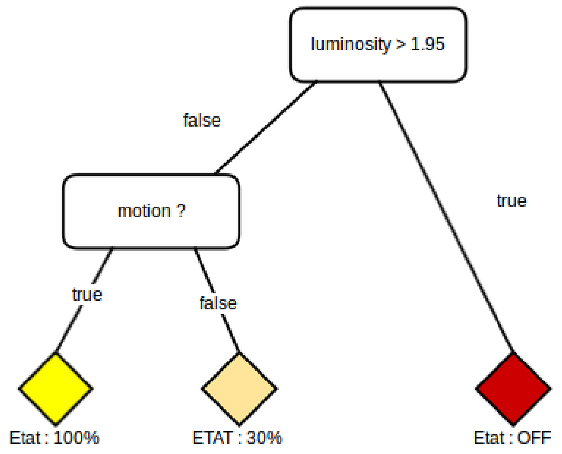

Fig. 3: Decision tree implemented in DROOLS

C. Sensors

The sensors used in our work to quantify the need for light intensity are of two types: (1) Environmental sensors which allow to measure, ambient luminosity; as well as meteorological visibility which refers to air transparency and c) pluviometry. (2) Traffic sensors which permit the estimation of road and pedestrian traffic densities. To estimate these indicators, our choice was oriented towards optical sensor and image processing techniques. These sensors are wirelessly connected to a gateway that communicates the measurements to a central platform presented above.

D. Luminaires

Experimentations were drilled using two types of LED-based luminaires: DALI dimmable luminaire and "0-10V" dimmable.

III. Urban Serious Game

SweetCity is a mobile-based urban SG that has been developed to stimulate the participation of people in the management of their cities. In particular, *SweetCity* facilitates the reporting of public infrastructure anomalies as shown on Fig. 4. The anomalies range from overfilled garbage cans to inappropriate lighting level on streets and degraded roads. For our project we rely on the street lighting anomalies which are: (1) excessive lighting intensity, (2) too low light intensity, and (3) defected luminaire.

By hypothesis, a major aspect of SG concerns the scoring, root of the player involvement. A scoring concept as well as ranking parameterisation have been implemented to integrate a challenge and fun dimensions to the game. The scoring is based on the number of submitted reports and their relevance. The relevance of the reports relies on votes or likes of other gamers and confirmations from the community authorities.

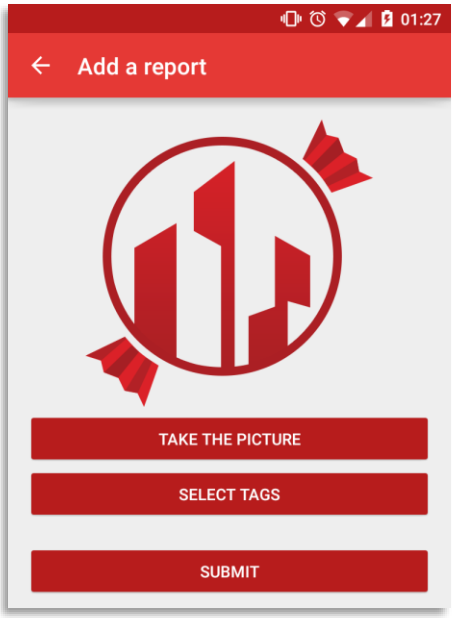

Fig. 4: SweetCity main mobile screen

IV. Future Work – Using the SG to Improve the DSL Efficiency

Currently the control of the luminaire light intensity is based on rules that combine various indicators like luminosity, visibility and presence detection. These rules have been elaborated by street lighting experts. However, these rules are fixed for all streets and situation and do

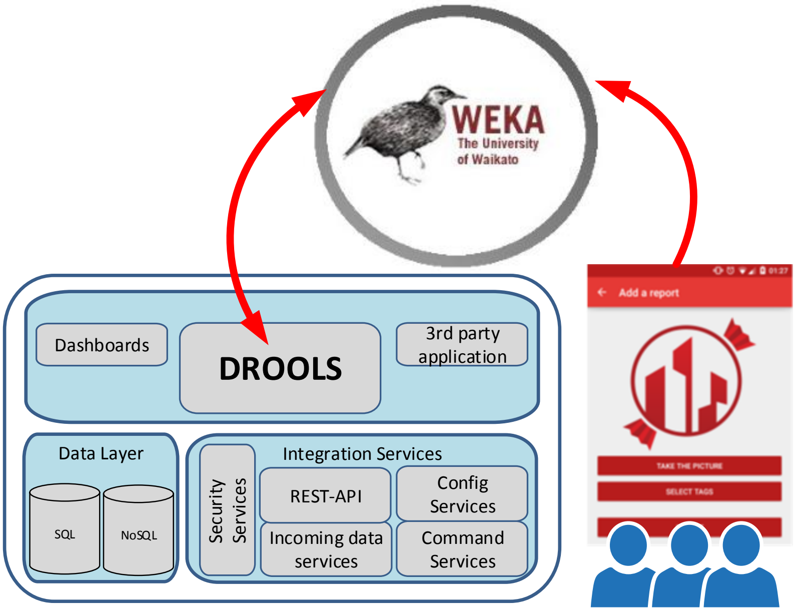

Figure 5: Integration of citizen's feedbacks

note cope with specific needs of local inhabitants. We can imagine that small rural villages have different lighting needs from crowded urban districts. The next step in our research projects is to use urban SGs like SweetCity to capture the feedbacks of citizens and to integrate these feedbacks into the light intensity control rules.

Technically, the integration of the citizen's feedback will be realized by *Machine Learning algorithms* [10]. Specifically, the open source data mining software WEKA (http://www.cs.waikato.ac.nz/ml/weka/) will be integrated with DROOLS in order to continuously adjust the indicators hierarchy and the weights of the decision tree presented above (Fig. 3). The J48 algorithm implemented in WEKA will be used for this end. A conceptual view of the future set up is illustrated on Fig. 5. At this stage of the work and given the nature of this paper (*i.e.* such short paper focusing on prospect work), we expect more detailed results to be published in the short time future.

V. CONCLUSIONS

The paper presented a functioning dynamic street light management system based on an Internet of Things architecture. The current system relies mainly on environmental and traffic indicators to estimate the needs for street light intensity. It then control the luminaires accordingly. We believe that the adoption of such solutions can be facilitated and catalysed through the involvement of citizens. Future work will explore the use of urban SGs to capture the citizen's feedbacks on lighting quality and integrate them into the existing DSL system.

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REFERENCES

[1] European Commission, Lighting the Cities: Accelerating the Deployment of Innovative Lighting in European Cities, June 2013.

[2] ROHAIDA HUSIN et al, "Automatic Street Lighting System for Energy Efficiency based on Low Cost Microcontroller", International Journal of Simulation Systems, Science & Technology, Vol. 13, No. 1, 1473-8031, 2012.

[3] Wen-Tsai Sung * and Jia-Syun Lin, "Design and Implementation of a Smart LED Lighting System Using a Self-Adaptive Weighted Data Fusion Algorithm", Sensors, Vol.13, pp. 16915-16939, 2013.

[4] Deepak Kapgate, "Wireless Streetlight Control System", International Journal of Computer Applications (0975 – 8887), Volume 41– No.2, March 2012.

[5] Adriana de Souza e Silva, Larissa Hjorth, Playful Urban Spaces - A Historical Approach to Mobile Games, Journal of Simulation and Gaming, Volume 40 Issue 5, pp 602-625, October 2009.

[6] Gabriele Ferri, Patrick Coppock, Serious Urban Games. From play in the city to play for the city, Media & the City Workshop 2012.

[7] Internet of Things Architecture: Final architectural reference model for the IoT v3.0, European project (FP7), 2013.

[8] OSGi Alliance. Available online at http://www.osgi.org.

[9] Kura. Available online at https://eclipse.org/kura/

[10] C. M. Bishop, Pattern Recognition and Machine Learning. Springer. ISBN 0-387-31073-8, 200

[11] S. Gobron *et al.* "SGs for rehabilitation using head-mounted display and haptic devices", AVR 2015, Salento, Lecce, Italy, 31st Aug ~ 3rd Sep., *in press*, 2015.