SMART SOCIAL SPACES: OPPORTUNITIES AND CHALLENGES OF THE SOCIAL WEB OF THINGS

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1. THE SOCIAL WEB OF THINGS

The "Internet of Things" definition by Kevin Ashton in 1999 envisioned a scenario in which things communicating directly on the web would be able to "overtake" the limitation of data produced only by people, with "limited time, attention and accuracy". Still after fifteen years, the Internet of Things is lacking a killer application, defining a "de-facto" standard for making objects communicating over the web.

On the other hand, online social networks have been exploding over the last few years, attracting new users to the web who were not connected beforehand.

Hence, we started wondering if jumping on the fast-driving "social" car could be the final ace in the hole for the IoT to really get a common technology.

The relationship between Social Networks and IoT was introduced as "Social Web of Things" in 2009-2012[1]. This idea is a redefinition of the Internet of Things paradigm, in which things leverage social networks and specifically social standards to communicate, assigning a specific social identity to things at the same level than people. Until now, it was mainly studied by pioneering universities and only more recently showcased by some industry at CES 2014[2,3].

The IoT ecosystem is well covered by many initiatives and addresses low-level protocol specifications up to high-level APIs to access data, including "gatewaying" functionalities. Still, several topics limits its wide adoption, such as:

- User interaction/experience, currently verticalized via well-designed controlling applications dedicated to one or a few objects
- Object addressing and its relationship with user (administrator) identities, currently specific to each vendor
- Interconnection of (closed) IoT environments (e.g. home) with the outside world, e.g. to send notifications and receive remote requests/commands

[1] http://www.ericsson.com/uxblog/2012/04/a-social-web-of-things/

[2] http://ces.cnet.com/8301-35306_1-57616358/lg-homechat-lets-you-text-with-your-appliances/

[3] http://www.theverge.com/2014/1/8/5288748/a-look-at-samsungs-smart-home-a-central-app-for-your-social-appliances

Social Networks can help in that sense in "elevating" the semantics of IoT interactions to the user plane and thus foster the adoption of connected objects, acting as a generic high-level layer/bus to interconnect different domain-specific information & devices with users and being independent from low-level integration and/or standardization.

"Smart social objects" are considered to be an evolution of smart objects and consists in creating a network of "trusted" friends between humans and objects. Objects can post information to the social network, show their availability and discover new "friends", interacting with other objects or humans. In that sense the social component adds a user-friendly interaction (dialogue) paradigm for people to interact with their surrounding "Smart Social Space" environment.

Smart Social Spaces could be public, such as a local business or city square, or private, such as a smart office or home, in which appliance and sensors communicate together and post their behaviors on the social wall. Users could receive (multimedia) notifications or alerts about sensors and are able to send command remotely, for example to their home security cam or front door.

2. OUR APPROACH TO SWOT

We are currently experimenting the Social Web of Things in the context of a Smart Office environment trial of the BUTLER[4] project in Telecom Italia's S-Cube Joint Open Lab to control mainly lights, curtains and plugs. We envision it as a replicable proof-of-concept for other Smart Social Spaces. Our smart system is organized around Freedomotic[5], an open source middleware that allows interactions between the smart infrastructure and its users, and further provides a messaging bus coupled to an extensible plug-in architecture. Plug-ins can listen to events from the single infrastructure protocols, subscribe to sensor events through triggers, or send commands to actuators. Administrators can also define automations "à la If This Then That" that remain local to the system.

We continuously develop and integrate plug-ins into our own environment to incorporate off-the-shelf or do-it-yourself components and add automations, related for example to energy efficiency or light-based *infoviz*. Interestingly, we leverage the Freedomotic Android application for remote control, to which we're adding vocal commands support (through Android ASR and Freedomotic NLP) as well as Augmented Reality capabilities to control and monitor the environment.

Our approach to the Social Web of Things also leverages an internal social platform called "Teamlife", which runs locally in our office environment acting as a corporate social network portal for coworkers but also for *things*. Teamlife relies on Shindig[6], an open source project implementing the OpenSocial[7] API specifications to publish/retrieve social activities and media, and on an internal

[4] http://www.iot-butler.eu
[5] http://www.freedomotic.com

[6] http://shindig.apache.org

[7] http://www.opensocial.org

implementation of the OStatus[8] specification suite to achieve federation with other "Smart Social Spaces" and social networks.

We implemented a Freedomotic plug-in that acts as OpenSocial client and allows objects to post/comment on the Teamlife wall. Objects can actually post status updates in natural language (e.g. "kitchen lights turned on") or the result of a measure change (e.g. temperature or humidity in the environment) through a *superuser* account that manages all the objects that are not directly related to a specific user. The plug-in also allows to receive commands from users via social activities. First, it maintains a list of the "friends" of the *superuser* account so that (bidirectional) social relationships are used for access control. Then, it polls for new comments from those friends on its wall, before actuating the textual command (e.g. "turn on meeting room lights").

Yet in the standardization space, we are actively involved in a White Paper[9] activity within the Open Mobile Alliance to study the opportunities and challenges of the Social Web of Things, also in relation to the Social Network Web enabler specification[10] as reference protocol and data model to convey IoT-based interactions. The goal at this stage is mainly to identify the main issues to be solved prior to the wide deployment of such solutions as well as identify standardization gaps.

3. OPEN ISSUES

3.1. DIRECT VS GATEWAY INTERACTION AND THING'S SOCIAL IDENTITY

From an architectural point of view, a first question to be solved is whether objects should be "Smart Social Objects" and have their own account, or be exposed via a gateway? The answer relies in the things themselves.

A single object implementing a full "social" stack, able to connect directly to the Web via Wi-Fi and exploit social networking functionalities, could make that object more attractive, but limitations related to cost, environment, dimension, power consumption etc. should be taken into account. On the other hand, having things someway clustered into groups may limit the expressiveness of interactions in that a second level of addressing (within social network-based commands) should be implemented.

[8] http://www.w3.org/community/ostatus/

[9] http://member.openmobilealliance.org/ftp/Public_documents/CD/MobSocNet/Permanent_documents/OMA-WP-Social_Web_of_Things-20140305-D.zip

[10] http://technical.openmobilealliance.org/Technical/technical-information/release-program/current-releases/snew-v1-0

The assignment of social identities to things may also reflect the different existing relationships between users and objects in a smart space. Besides the Smart Social Object case with its own social identity, this mapping could be a 1-to-n[11] or a user-to-n mapping as follows:

- Co-functional object relationship: (1-to-n): established among homogeneous objects of the same type (e.g. all the lights of the lighting system, all the cameras of the surveillance system, etc…);
- Co-location object relationship (1-to-n): established among objects (either homogeneous or heterogeneous) located nearby (e.g. in the same room);
- Same I/O object relationship (1-to-n): established among heterogeneous objects which have the same input and/or output feature (e.g. a display capability).
- Ownership object relationship (user-to-n): established among heterogeneous objects which belong to the same user.

Yet in several situations these relationships may be temporary and/or shared, for example in case of movable objects or connected body scales used by several members of the family.

3.2. SOCIAL RELATIONSHIPS, ROLES, ACCESS CONTROL AND INFORMATION SHARING

The above classification clearly shows the need for a role-based system, which should go beyond a simple humans vs objects classification, further overtaking hard classifications of roles. Rather it should allow to define flexible user's roles and object clusters classifications on a per-system basis, in which each role is granted a set of actions on each defined cluster. Rules and guidelines for clustering should be searched over IoT standards to avoid over-specification.

A second aspect besides the role system lies in rules to control the frequency and granularity of information published by objects on the network, in order to avoid unnecessary information to be published and shared with users. For instance, some cluster of social objects could be allowed to post over the social wall only upon request or only at regular interval or based on some meaningful changes (no need to post indoor temperature every 10s).

3.3. AUTOMATIONS AND CONCURRENT ACCESS TO THINGS

Interactions with things are nowadays often simplified by tools "à la IFTTT" that provide simple automation rules to limit explicit interactions. However, such automations may become uncontrollable via unforeseen loops etc and often lead the user to feel unsafe and uncomfortable. In that perspective social network type of interactions could be leveraged to create true dialogues with the environment in which objects ask questions to users before taking action, even suggesting possible alternatives.

Another important issue of IoT in general and the Social Web of Things is the concurrent access to objects. In the case of SWoT, assuming that users can control objects only upon bidirectional friendship, still multiple users may try to access to the same object (nearly) at the

[11] Atzori, Luigi, et al. "The social internet of things (siot)–when social networks meet the internet of things: Concept, architecture and network characterization." *Computer Networks* 56.16 (2012): 3594-3608.

same time leading into loops or deadlocks, also considering possible mismatch with the actual state of the object. Solutions exist to only accept commands by referencing the latest state of the object (in a way similar to HTTP ETag[12]) or to time-limit access to object (e.g. no more than every minute) but still need to be investigated for their application in social network specifications.

4. CONCLUSIONS AND NEXT STEPS

In our vision the social web could become the main driver of adoption of the web of things into people everyday's life. As "social networks" attracted millions of new users to the web, they may interconnect things by leveraging their popular communication & relationships paradigm.

In this context we intend to promote the creation of means for gathering and growing the SWoT community through networking and joint research activities, with the objective of identifying and leading future standardization opportunities in that space.

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[12] http://www.w3.org/Protocols/rfc2616/rfc2616-sec14.html