Sharing User IoT Devices in the Cloud

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***Abstract*— Internet of Things (IoT) is the set of technologies that can interconnect anything, from daily life objects to more sophisticated networked devices. The IoT paradigm is constantly increasing the number of devices owned by end-users. Following the social networks paradigm, IoT-centric social networks would allow sharing of devices between users that would provide useful information captured by sensor devices or giving ways to make remote actions on user devices. This paper proposes an IoT centric social device network based on a Cloud computing model which provides a virtual execution environment thanks to its decentralized nature, high reliability and accessibility from anywhere and at any time. The paper describes an approach that allows easily reusing highly distributed IoT resources by building services on top of them. Applications are built by composing those services and deploying into service platforms distributed and hosted in the Cloud that grants secure access to the data shared by these devices in compliance.**

Keywords—Internet of things, Cloud computing, smart life, social device networks, sharing IoT resources

I. INTRODUCTION

With the evolution towards the web 2.0, the end-users have proved that when they have the necessary tools to create, collaborate and share contents (blogs, wikis, social networks, etc.), they get actively involved in the community building without any expectation (e.g., financial). We expect to see the same involvement of the users with the new generation of IoT devices (e.g., miniaturized sensors) that generate useful information for others (my friends, my family or anybody who is interested in that data) such as my temperature sensors in the garden, my security camera, my location, my health information, etc. Besides providing data, citizens can also provide ways to make actions on their device such as displaying important event information on my TV, turning off my special lamp when my mother goes to sleep at her home, receiving alarm messages if she falls down, receiving sound messages from my friends, etc.

Following the personal computers and smart phones era, the IoT paradigm is indeed constantly increasing the number of devices owned by end-users. These devices are becoming part of our daily life for the objective of improving our quality of life. The devices can be of different types such as sensor devices providing information on the physical environment (temperature, humidity, presence detectors, pollution and noise level meters, etc.) or information on the user (location, health, emotions, etc.); and actuator devices (light switches, displays, motor assisted shutters, or any other action that a device can do) that performs actions to change states of a physical (room, building, city, et.) or logical environments.

In this context, this paper proposes IoT centric social device network model that is being developed in the context of the ClouT project [1]. The concept is about sharing those devices with others: either with a restricted circle of the user (e.g., family, friends, and community) or publicly with anyone. This will lead for instance to collaborative applications that can see a highly distributed information source all over the city and build applications on top of that for the service of citizens. The applications are hosted by ClouT platform providers that grant secure access to the devices.

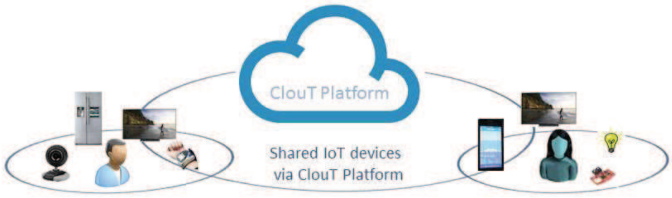

Fig. 1. Social convergence of the physical and the virtual world

This new approach of sharing devices raises many research problems at several levels of design: the integration of multiple heterogeneous devices using heterogeneous data and protocols, the management of the availability and distribution of a large number of devices, and secure access to all of these resources. In addition, sharing devices between multiple users and multiple applications is a very complex task that can lead to conflicting or undesirable behavior. The following section gives our overall approach for tackling these challenges.

II. THE SYSTEM ARCHITECTURE

The architecture is mainly composed of three layers:

- Heterogeneous IoT device layer
- Middleware layer providing homogeneous access to those devices in terms of services and
- Application layer that composes those services and provide high level applications to end-users.

The Figure 2 illustrates the general architecture.

At the southbound, several IoT protocols are supported (CoAP, ZigBee, UPnP, KNX, etc.) and integrated seamlessly in the platform. Similarly, at the northbound, several platform access protocols (REST, JSON-RPC, MQTT) have been implemented.

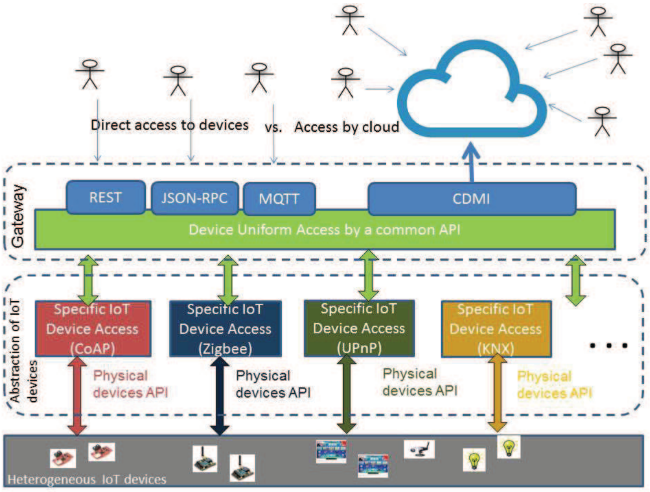

Fig. 2. General architecture

The platform is based on an IoT service/resource model that has been developed by the European project BUTLER [2]. In this model each IoT device is exposed *as a service* to access resources provided by devices (mainly data and actions). From a functional point of view, a resource is characterized by the following elements: an identifier, a resource type (Sensor data, Action, State variable, Property), a set of attributes and a set of access methods (see Figure 3).

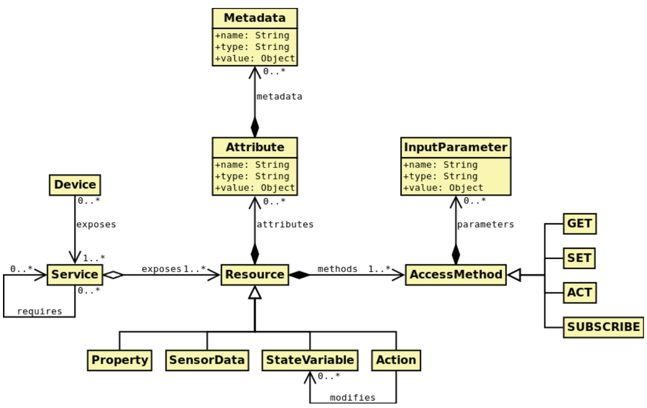

Fig. 3. BUTLER Service/Resource Model

Resources have a certain number of attributes that represent dynamic (sensor value, location) or static information (owner, model, vendor, firmware, description, etc.). Attributes have metadata that characterizes the attributes (unit, timestamp, etc.). A set of generic methods provide means to access to the exposed resources. The following table lists those methods.

Type	Description
GET	Gets the value attribute of the resource
SET	Sets a given new value as the data value of the resource
ACT	Invokes the action resources with a set of defined parameters
SUBSCRIBE	Subscribes to the resource with optional condition and periodicity
UNSUBSCRIBE	Remove an existing subscription

TABLE I. BUTLER RESSOURCE MODEL

The ClouT project adds new functionalities to the platform such as allowing access to resources in the Cloud. A CDMI (Cloud Data Management Interface) bridge has been added to the platform in order to allow storing IoT data in the cloud and providing access to the resources anywhere at any time. Typical user scenario for the ClouT platform starts with the user registration to the Cloud platform. Once he is authenticated he can start to share his devices with the others. He registers his device in the platform and defines who can access to that. He can visualize his data and use the data mashup tools to compose higher level data representation that is specific to his needs. On the other hand, the users who want to use shared devices also need to have an account on the platform. They can then discover all available devices that they can access. Once agreed by both the device sharer and the device user, the platform gives the access to the device and it notifies the sharer user. The device user then can start to use the device. Typical examples of usage can be given as follows:

- User installs his temperature sensor in his garden and shares the data with everyone.

- User's TV provides a pop-up window function to notify the users of important events. Access is given only a restricted number of people.

- User's lamp turns on and off to react to various events from other user's (when his/her mother goes to bed, when his/her wife/husband approaches home, etc.).

III. CONCLUSION

This paper presented a new approach on sharing IoT devices among end-users. Based on a service oriented approach, IoT devices expose data and action resources that are available within a cloud platform anytime from anywhere. This provides new business properties for application developers that can reuse information provided by the users and build applications on top. Furthermore, citizens could get involved in the revenue sharing for providing access to their devices, if only adequate business models can be built.

IV. ACKNOWLEDGEMENT

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