A New Equipment Management Framework Based on Grid of Things

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Abstract: *This paper describes the core of an equipment management framework offering general functionality based on grid of things. The framework supports sensor, wireless network and intelligent control system based on services and service features. The framework is more generic than traditional hierarchical equipment management framework. It supports sensor, actuator and wireless networks. In the framework, techniques of spontaneous service provision, grid, scene-aware, semantic reasoning, and equipment service management are smoothly synthesized. It enables equipments in grid of things to interact automatically, provides semantic-integration equipment status awareness, and supports meta-service management based adaptability and scalability.*

Key words: equipment management; grid of things; semantic reasoning

1 Introduction

The Internet of Things has been proposed for many years. It was first introduced by the MIT Auto-ID Center which is the precursor to the current EPCglobal organization. And at that time, the researcher just gave a vision of a world where all things are tagged with a globally unique ID-the EPC (electronic product code), which serves as a link to data which can be queried over the Internet about each individual thing. From then on, the concept of the Internet of Things has been expanded continuously. With the technological advances in mobile computing, sensor network and wireless network, further information about the equipments and the environment that equipments are in, can be recorded as well. Software embedded in the equipments enables data processing directly on the item, and in combination with actuators, local control loops can be implemented. The Internet of Things is a key part of the Future Internet. And the equipments with networking and computing capability are important part of Internet of Things. From an enterprise and economic perspective, the future Internet is the basis for a web-based service economy. There will be service platforms and services provided by all kinds of equipments over the Internet. The granularity of these services will be very different, ranging from business services to function services provided by the Internet of Things. The role of the Internet of Things is to bridge the gap between the physical world and information systems [1]. In recent years, various appliances are interconnected, enabling the user to remotely monitor equipments and to control appliances [2,3]. The application in hospital is able to provide valuable information to clinician without any user interaction, when the patients are at recovery wards and clinician is in his office [4]. The application of Internet of Things in the shopping mall can help a disabled person with wheelchair to find something he need

Received 27 May 2012

This paper is supported by the Northwestern Polytechnical University Basic Research Funds Program under Grant No. JC201121

easily [5]. In this paper, we will introduce the spontaneous service management framework based on remote intelligent equipments in Internet of Things. And its objective is to address smart system can manage the function service of equipment and information service of Internet uniformly, and then provide a continuous service for user automatically.

The rest of the paper is structured as follows: section 2 introduces an application framework of equipment management with automatic service provision capability. Finally, we conclude the paper with a short summary and give an outlook towards future work.

2 Equipment service managment

In this section, we propose several notions that support equipment service management in Internet of Things firstly. Based on the above-mentioned notions, we describe an equipment service framework which enables the services provided by equipments in Internet of Things to be accessible to any smart terminal, according to individual user´s preference, situation and device capability.

2.1 Notions

Stephan Haller and his colleagues think that Internet of Things is a world where physical objects are seamlessly integrated into the information network, and where the physical objects can become active participants in business processes. Services are available to interact with these smart objects over the Internet, query their state and any information associated with them, taking into account security and privacy issues [1].

In this paper, we propose the concept of Domain of Things. In our opinion, the equipment over the internet can provide not only information service but also functional service. Some functional service just can be used by a user within a definite period of time. Hence, compared with information service, sharing of functional service is limited. And the position and functional scope of equipment is constrained. For these reasons, we divide different Domain of Things according to equipment´s physical environment and logical district. The management objects are in charge of managing the equipments in a Domain of Things.

In a Domain of Things, we divide equipments in Internet of Things into four classes according to intelligence level.

The first is low-level equipment, which just has the capability of identifying itself. The low-level equipment can only be recognized by middle-level equipment or high-level equipment, such as the equipment with RFID tag.

The second is middle-level equipment, which has the capability of not only identifying itself but also communication with other equipment.

The third is high-level equipment. In addition to having the same function with middle-level equipment, high-level equipment can play a significant role in managing the middle-level equipment and low-level equipment, and providing computing service, storage service and controlling service.

The fourth is smart-level equipment, which has the same function with high-level equipment. Meanwhile, it can manage all equipments in a Domain of Things and has sufficient flexibility, extendibility and intelligence in management. The smart-level equipment supports collaborative work and has capability of automatic management.

Scene is any information that can be used to characterize the status of an equipment [6]. Commonly used scenes consist of location, identity, time and activity.

We consider that the involved entities in environments are all scenes.

Ontology is an agreement about a shared conceptualization [7], which includes the conceptual frameworks for modeling application domain knowledge, content-specific protocols for communication among interacting agents, and agreements about the representation of specific domain theories. Ontology has characteristics such as definitions of representational vocabulary, a well-defined syntax, easily understood semantics, efficient reasoning supports, sufficient expressive capabilities, and convenience of expression.

2.2 Equipment management framework

The physical world and information spaces fuse naturally and spontaneously in Domain of Things. The equipments in different Domain of Things can work together according to the time sequence of meta-services attached to a combination service. In recent years, more and more smart embedded devices can be integrated in all kinds of equipments to improve convenience for the user. With the development of communication technology, the embedded devices in equipments can be a node providing service too. And the isolated equipments can be connected to each other. A combination service can employ various software and hardware resources in different equipments simultaneously.

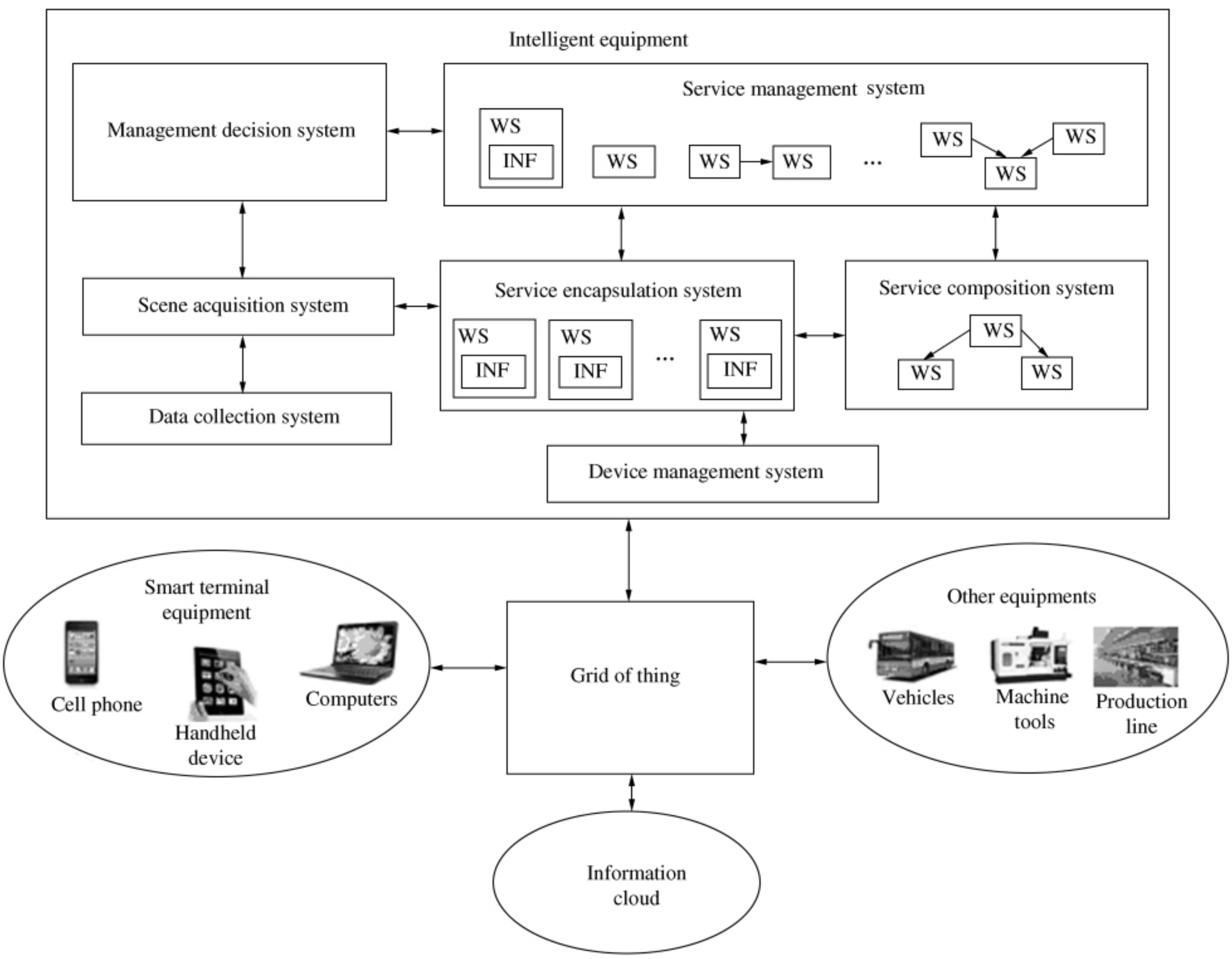

Figure 1 Equipment management framework

From the technical view, the spontaneous equipment management system in internet of things is illustrated in Figure 1, which is defined as SEMS = (DC,SA, MD,SCAP,SCOM,SM,GT,DM).

1) DC: The data collection system aim at sensing status changes of equipment and environments in domain of things, mainly gathers the outputs in raw format produced by sensors and other devices.

2) SA: The scene acquisition system can get the scene information (the processed data information) according to the scene representation set. The scene representation set is composed of a number of status thresholds. When the status changes and the values of status elements all equal to thresholds of scene representation set, the system will inform and start the management decision system.

3) MD: The management decision system uses the correlative status information, application domain ontologies and rules to make a decision. An application can be produced. And then the application can be decomposed into several tasks which generate a task graph identifying time sequence of tasks execution.

4) SCAP: The service encapsulation system is in charge of generating the meta-services. It can encapsulate not only software function but also hardware function on a meta-service.

5) SCOM: The main function of service composition system is constructing combination services. When existing meta-services can not satisfy the user task, the service composition system will automatically perform service discovery operation to find suitable services from another domain of things or information cloud. And then a combination service is constructed according to corresponding policy.

6) SM: The key feature of service management system is managing the services being deployed over the infrastructure that spans multiple domains and providing QoS support for the services. The services include web service, semantic service and meta-service etc. We define the service provided by the stand-alone functional unit of equipment as meta-service.

7) GT: The grid of things is the kernel of the Domain of Things, which makes different equipments work together effectively. It consists of the system messaging bus interface module, device management interface module, information cloud interface module, user interface module. Grid of things provides transparent adaptive communication environment for equipments in different Domain of Things. And at the same time supports all kinds of communication mode.

8) DM: The device management system is in charge of starting device, device scheduling, device running status management and stopping device etc. It can sent and receive message via its messaging bus interface module.

3 Conclusions and future work

In this paper, we present an equipment management framework. Simultaneously, we propose the architecture to support spontaneous service provision of equipment in Internet of Things. Further work includes

1) integration of the biological authentication and machine learning technologies to provide the natural services;

2) development of more applications based on our framework.

References

[1] Haller S, Karnouskos S, Schroth C, *The Internet of Things in an enterprise context.* FIS 2008: First Future Internet Symposium, FIS

2008 Vienna, Austria, September 29 ~ 30, 2008

[2] Brown A, Kolberg M, Bushmitch D, Lomako G, Ma M, *A SIP-based OSGi device communication service for mobile personal area networks*. 3rd IEEE Consumer Communications and Networking Conference (CCNC) 2006, Las Vegas, USA

[3] Kolberg M, Magill E H, *Programming a PVR with pen and paper*. Demo at 3rd IEEE Consumer Communications and Networking Conference (CCNC) 2006, Las Vegas, USA

[4] Miller B, Nixon T, Tai C, Wood M D, *Home networking with universal plug and play*. IEEE Communications Magazine, 39(12): 104 ~ 109, 2001

[5] Qin W J, Zhang D Q, Shi Y C, Du K J, *Combining user profiles and situation contexts for spontaneous service provision in smart assistive environments*. Proceedings of the 5th international conference on Ubiquitous Intelligence and Computing, Oslo, Norway, 2008

[6] Dey A K, *Providing architectural support for building context-Aware applications*. Ph. D. dissertation, Georgia Inst. Technol., Atlanta, GA, 2000

[7] Chandrasekaran B, Josephson J R, Benjamins R V, *What are ontologies, and why do we need them*? IEEE Intelligent System, 14(1): 20 ~ 26, Jan./Feb, 1999

Brief Biographies

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