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Survey on IoT Services: Classifications and Applications

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Abstract: ***The Internet of Things (IoT) is an umbrella term which covering various distinctive base advances that went for connecting physical items and their virtual representation with the objective to use this connection for enhancing services and communication ideas. The IoT approach joins paradigms and ideas, educated by Ambient Intelligence, Sensor Networks, Ubiquitous Computing, and Grid Computing. The purpose of this paper is to abstract the services provided by the Internet of Things (IoT) and its application. Therefore, we present a definition of IoT services and classify them based on the relationship to their life cycle and a physical entity.***

Keywords: Internet of Thing, IoT, IoT Services, Grid Computing

1. Introduction

Modern communications are steadily evolving, and IoT is one of the milestones, which is going to determine the technological advance in the future. IoT is becoming very promising but having various challenging. The dynamic environment of IoT introduces unseen opportunities for communication, which are going to change our perception of computing and networking [1]. At the same time, the privacy and security implications of such an evolution should be carefully considered to prevent the promising technology from being transformed into a pervasive surveillance object [1].

Particularly, IoT services have divergences from other IT-related techniques in traditional or home office situations because of their ubiquitous and embedded characteristics that pervade everyday life. Thus, privacies are concerns due to unobtrusive data collection methods are more critical for this class of applications, and appropriate evaluation instruments are required [2].

2. Internet of Things (IoT) Services Definitions

IoT Services are a very suitable abstraction for building complex software systems and consider as the fundament of most of the today enterprise systems [2]. In the same way they play a crucial role in nowadays IT, it is suggested that they will also play a crucial role in the Internet-of-Things [3].

Nonetheless, service is a somewhat heavily overloaded term, which can have many meanings. What is surprising is that only few papers and projects dealing with IoT-services defined precisely what they consider an IoT service and what the differences to traditional services are, and how to deal with combining IoT and non-IoT services. The term "IoT-service" has different meanings among different projects. It is acknowledged that in a technical sense, there are differences between traditional services and IoT-services, like special QoS-parameters, and the fact that devices running these services are often resource-constrained with respect to computing, storage, and communication and energy capabilities.

Furthermore, IoT services might occasionally be connected only to a network such as in [4]. IoT service is an ambiguous term; *Thomas et al* [5] gave a definition that is not too limiting by defining a service as a software component only, but still restricting enough. Therefore, IoT-services can stand on a field of their own. Therefore, they used the term transaction as introduced in *Barros* and *Oberle* works, but does not limit ourselves to commercial transactions [6]: An IoT-Service is a transaction between two parties, the service provider and the service consumer. It causes a prescribed function enabling the interaction with the physical world by measuring the state of entities or by initiating actions, which will cause a change to the entities [5].

Some research projects differentiate between sensing and actuation services. Nonetheless, definitions of these two kinds of services, which are essential for the Internet of Things, are only implicitly given. The term IoT service is used for describing interfaces to devices, which perform the actual sensing or actuation task [7].

3. Internet of Things Services Classification

In the following, we present a simple but comprehensive classification of services along two dimensions: (1) Relationship with the Entity and (2) based on the life cycle. Thomas, et al. [5] defined IoT service as services enabling interactions with the real world, and thus as the superset of the more specifically defined services outlined in Table 1; Integrated services are conceptually used to bridge between IoT specific services and external services non IoT specific services.

Table 1: Classification based on Relationship with the Entity

Low level service	The low level services make the capabilities of the devices or the resources accessible to entity services or integrated services
Resource service	Resource Services provide the observations the Resource is capable to make or provide the actions a

	resource is capable to execute.
”Entity”-Service	Entity services are the heart of IoT systems. These are the services provided by the entities and are often, but not necessarily, compositions of low-level services.
Integrated service	Services that work with “Entities”, they usually work with Entity services and compose them with non-IoT services.

When we classify along the relationship with the Physical Entity (see Table 1), one of the key concepts, we explicitly introduce are the Entity service and integrated services as higher level of abstraction that utilizes simple resource/device and other (IoT-external) services as primitives, thereby hiding the complexity of dealing with them from modelling experts, developers and users. This is the most natural way to look at an IoT-thing entity, because it is more intuitive for domain experts as they do not work with some low-level sensor service interface. This has to be abstracted for being usable, for example, in Enterprise environments. Additionally this, of course, also reduces the complexity for development in general and allows the integration into SOA environments.

Another important classification is according to the service life cycle as shown in Table 2. Apart from the different quality of Information (QoI) and Quality of Service (QoS) constraints of IoT-services, the other very special thing is that they are bound to and running on a large variety of devices, thus complicating the service management a lot.

Table 2: Classification Based On the Service Life Cycle

Deployable	A service, which is not yet in the field, but is generally deployable. The according service description exists in a service repository, but an appropriate runtime environment is not yet assigned. Thus, a service locator is not available in the service registry.
Deployed	A deployed service is already in the field, but not yet ready to use. There are further steps necessary to make it operational. This further steps could be technical, as well as economical (like paying for the service)
Operational	An operational service is, as its name suggest, already deployed (if applicable) and ready to use. The service is associated to an Entity and the association is known to a resolution infrastructure.

In an Enterprise context, it is therefore, a necessity to have a closer look at the different states in the service life cycle. This is a necessary precondition for the service management and binding in Enterprise service orchestration and service choreography engines [8].

4. IoT Services Applications

There are many exceptional applications, which can make use of the Internet of Things, from home and office automation to production line and retail product tracking. The number of applications is endless. For each application, a particular IoT service can be applied in order to optimize application development and speed up application implementation. Note that the categorizations that follow come from [9].

4.1 Identity-Related Services

Identity-related services are the most simple, yet maybe one of the most important, services to be provided to an application of the Internet of Things. Applying an identity-related service to an application provides the developer with vital information about every device, or everything, in their application. The most prominent technology used in identity-related services is RFID. RFID is a technology that enables data to be transmitted by a tiny portable device, called a tag, which is read by an RFID reader and is processed according to the needs of that particular application. RFID provides an upgrade from the traditional form of device identification: barcode scanning. RFID is more versatile because it does not require line of sight transmission, and, in the case of active RFID tags, can transmit its data as opposed to simply just being read by a reader device.

Most IoT applications that are aimed at providing an identity-related service make use of RFID technology. As described in [13], the RFID tag stores an identification code unique to that device. The RFID reader reads that code, and looks up the device in the RFID server, which then returns the detail information require by the application. Production and shipping are two common applications that would benefit greatly from the use of an identity service. Another application that uses an identity-related asymmetry problem in supply chain management and supply chain information transmission [14]. Every IoT application will either be based on, or at least incorporate some instance of, an identity-related service. This is because for the IoT to incorporate every-thing in the physical world to the digital world, the application will need to be able to identify all of the devices that are connected.

4.2 Information Aggregation Services

Information aggregation services in corporate identity related services, along with other components such as wireless sensor networks (WSNs), and access gateways to collect information and forward it to the application for processing. The information aggregation service is just responsible for providing the application with all of the information that is collected, and potentially processed along the way, from the terminals of the system (sensors, RFID tags, etc.). In this regard, the WSN can be a powerful tool for collecting and communicating data between terminals and the platform (host of application), as long as the platform is within range of the WSN. However, this would not be an IoT application on its own; an IoT application would consist of multiple WSNs all configured to work together to provide information about the world around them. The link between these networks is an access gateway. Each access gateway in the IoT network will have access to the database server, thus every device would be connected and information from the entire network aggregated at the database server.

There are a number of applications out there that make use of information aggregation services and access gateways. In Shen [11] research, the importance of extending the information aggregation service to beyond the WSN is proposed by using a cellular network (CN) to extend the range of the WSN. The idea is that if a terminal is outside of the WSN of interest, it uses CN resources to access that information with an "IoT gateway," which essentially implements both WSN and CN resources.

Information aggregation services are useful in monitoring situations, such as energy monitoring in the house and in the enterprise, or, if the Internet of Things has been realized, monitoring of anything, anywhere. For example, Shen et al. [11] introduces a monitoring and control system for use in an agriculture greenhouse production environment. The system measures and records critical temperature, humidity and soil signals which is then transmitted through the network to the platform for processing. Another application; Zhao et al. [12] uses a ZigBee WSN to monitor physiological data of patients that automatically generates electronic medical records.

4.3 Collaborative-Aware Services

The key difference between information aggregation services and collaborative-aware services are the use of the data collected to make decisions and perform actions. As mentioned before, the keys to creating a collaborative-aware service are network security, speed, and terminal processing power. Terminals can no longer be just simple sensors that collect information, or if there are simple sensors in the network, there must be separate embedded devices within the network that can make use of the data. There are fewer applications published in terms of IoT and collaborative-aware services. We can, however, attempt to apply new technologies to a collaborative-aware service. An example of a new technology that will help shape the way the Internet of Things grows is IPv6. IPv6 is a new version of the Internet Protocol (IP) that allows for a significantly greater number of addressable devices to be connected to the Internet. Although the use of IPv6 has had a slow start, it is definitely the Internet protocol of the future due to the lack of available IP addresses. Moving forward, one of the most important factors in IoT becoming reality is being able to address each of the embedded devices in the world, which converting to IPv6 would allow.

Referring to Luo [10], offers a number of applications for IoT, many of which could be considered collaborative-aware services, or which could at least provide a baseline for such a service. They propose integrating every object into the IP infrastructure using both IPv6 and 6LoWPAN, which is the use of IPv6 over low power wireless personal area networks. They propose a network with three types of nodes, all of which can be reprogrammed to function as any of the three types. The three types essentially are a base station node (IPv6 router), a mobile node (wireless dongle that allows WSN connectivity to a standard laptop) and specialized nodes, which are used for specialized tasks. This becomes a collaborative-aware service because it incorporates terminal-terminal and terminal-person communication, which is accomplished due to the use of the IPv6 protocol [9, 10].

4.4 Ubiquitous Services

Ubiquitous services are the ultimate goal of the Internet of Things, taking collaborative-aware services to the next level by providing complete access and control of every-thing around us, whether it is through a computer or a mobile phone or something else. Ubiquitous services have yet to be realized in the world today, but most research in IoT is ultimately aimed at providing some piece to the puzzle that will ultimately be ubiquitous services. Guinard [3] in his reference, firstly, talks about why the Internet of Things is so difficult to realize. One of the biggest hurdles for IoT is having a single architecture that allows the many different application layer standards to communicate and inter operate. Guinard [3] proposes an architecture, based on Restful services, in which a universal API would be created so that everyone who creates devices to be used in the Internet of Things has an architecture to adopt in order to be interoperable with the rest of the world's devices.

5. Conclusion

This paper plots the four fundamental service's classes of the Internet of Things and endeavored to give a few illustrations of each to give the designer of an IoT application a beginning stage for his application. Generally speaking, there is still much work to be carried out in IoT, particularly in figuring out how to consolidate the majority of the service into an omnipresent, all-powerful service went for conveying communication whenever, anyplace, for anyone, and for everything.

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