The Internet of Things – Challenge for a New Architecture from Problems

Gyu Myoung Lee[1], Noel Crespi
Department of Wireless Networks and Multimedia Services
Institut Telecom, Telecom SudParis, Evry, France
gm.lee@it-sudparis.eu[1]

Abstract—For the Internet of Things (IoT), this paper analyzes several required characteristics of the objects, investigates key technical considerations to solve problems and discusses a new architectural framework for IoT.

1. Introduction

The basic idea of the Internet of Things (IoT) is that Internet will connect objects around us to provide seamless communication and contextual services provided by them. There are so many applications to be supported because of IoT. Development of several technologies made it possible to achieve the vision of Internet of things.

This paper analyzes several required characteristics of the objects, investigates key technical considerations for the IoT to solve problems and emphasizes the necessity of a new architectural framework for IoT.

2. Required Characteristics of the Objects

Many studies are going on regarding IoT which is going to be an advanced network including normal physical objects together with computers and other advanced electronic appliances. Instead of forming ad hoc network, normal objects will be a part of whole network so that they can collaborate, understand real time environmental data and react accordingly in need. As shown in Table I, the objects are required the following characteristics depending on different purposes.

TABLE I. Required Characteristis of the Objects

Functions	Characteristics
Automation	Objects should be able to handle themselves automatically. Collecting contextual data, processing it, collaborating with other required objects and acting according to the condition should be at some level of automation.
Intelligence	Devices should be able to perform intelligently. Intelligence in devices give them power to act based on different situations.
Dynamicity	Dynamicity should be available to achieve the IoT concept. When one devices move from one place to another or one application domain to another, it should be dynamically recognized in new scenarios.
Zero configurations	Many users are not expert who uses the physical devices. So, users should be able to configure devices and develop services of devices without having much technical details.

3. Technical Considerations for IoT

There are many technical considerations for IoT as follows:

Scalability: The IoT has larger overall scope than communications with conventional hosts. There will be small scale (home environment) or large scale (factory, building environment) application area. Objects communicate with each other and/or with people seamlessly. Each constituent might be offering different services. Basic functionalities such as communication, service discovery need to be functioning efficiently in both environments. Scalability regarding addressing can be taken as an example.

Interoperability: Objects have different communication, information and processing capabilities. Each object would also be subjected to very different conditions such as power energy availability and communication bandwidth requirements. In order to facilitate communication and cooperation, common practices and standards are required. Interoperability solution should be maintained to provide seamless interaction among them. Service description, publishing, and discovery mechanisms should be interoperable. Otherwise the IoT will be converted into islands of heterogeneous object network.

Discovery: In dynamic environment of ubiquitous networking, suitable services for objects must be automatically identified. As users want to know product information and their availability all the time, it requires appropriate semantic means of describing their functionality.

Data volume: In case where there are large number of objects and interaction among very frequently, there are large amount of data. How to handle big volume of data is one of the important challenges of ubiquitous networking. Each object has augmented memory, storage and processing capability. If there are a large number of peer objects communicating with each other, these objects run out of processing, memory and storage. From network perspective it is also difficult to handle bulk amount of data if objects produce huge bytes of data regularly. Solution can be periodic communication between objects or some data compression and optimization techniques.

Power supply: Objects may move around and difficult to connect to power supply all the time. So they need to operate with self-sufficient energy source. Passive RFID does not contain power supply, which requires reader in order to get information from it. Not all objects can be connected to continuous power supply also, providing battery for each small object may not be feasible. Therefore, energy efficient communication mechanisms are essential.

Fault-tolerance: To maintain robust and trust worthy dynamic ubiquitous networking requires redundancy in several levels and ability to automatically adapt to changed conditions depending on the required quality of service.

Security and personal privacy: Confidentiality, authenticity and trustworthiness of communication partners need to be maintained. Users may want to give objects limited service access not allowing them to communicate in uncontrolled manner.

Device adaptation: There are heterogeneous devices, application scenarios, data format, and communication networks. Each connected objects should be able to adapt the situation where it is now. Adaption in many senses should be maintained.

Intelligence: The smart objects should be able to intelligently co-operate with the environment in which it will be introduced. The IoT makes possible for virtually any object around us to exchange information and work in synergy to increase quality of our life. Most of the devices act according to their predetermined set of actions or they will collaborate with each other based on current context and act accordingly.

For addressing above issues, there are technical problems in the following areas (see [1] for details):

- Identifier for objects and services (Identification (new naming space, globally unique ID))
- Object naming (object naming services)
- Security/privacy/authority (ID-management for things)
- Presence (of people; of devices)
- Geographic location (self-identification of location)
- Discovery/search
- Tracking and mobility support of mobile object
- Data processing /computing (information model for data store, retrieval and transfer)
- Heterogeneous networking interfaces (interworking model with proxy (gateway))
- Global connectivity (IPv6)
- Scalability in terms of routing (ID/LOC seperation feature)
- Global interoperability
- Autonomics (self-configuring, intelligence for control) for remote control and management/maintenance of objects
- Constraint objects
- Coordination among many objects
- Web Services

4. Architectural implications

For future work, we need to find possible solutions for each problem. It would be a good starting point to develop a new architectural framework in order to solve problems. Thus, various issues on the architecture for IoT are discussed.

Vertical vs. Horizontal

Based on technical problems for IoT, the current standards should require extension of the architectural principles of both vertical (from link/physical to service/application) and horizontal (one object(user) to other object(user) through local networks as well as global Internet infrastructure) perspectives.

In the vertical aspect, more studies should require in networking capabilities for control and operation of various services over complicated stacks of different layer technologies. In horizontal aspects, further enhancements of user-centric communication capabilities should take into account the complex user situations including various devices connected to home networks and various access technologies which support convergence. These capabilities are necessary to support the ubiquitous networking to provide seamlessly interconnection between humans and objects for Any Services, Any Time, Any Where, Any Devices and Any Networks.

Architectural considerations in the service perspective

In the service perspective, a target goal of architecture design is to support various applications using a common communication infrastructure. For this, service oriented architecture, open service platform and overly networks are considered.

Common infrastructure in the networking perspective

In the networking perspective, common infrastructure should provide scalable, interoperable solutions to support abundant of communicating nodes/objects. There are new concepts of networking such as user-centric, data-centric and content (information)-centric networking. We need to investigate feasibility of those technologies in the context of interoperable end-to-end model and integrating of smart objects.

5. Conclusion

In this paper, we have analyzed several required characteristics of the objects and investigated key technical considerations for the IoT. For further work, we need to develop technical solutions to solve various limitations in heterogeneous environments. Based on this, we should develop a consolidated layered architecture for IoT as a new architectural framework.

Reference

[1] Gyu Myoun Lee, et. al., "The Internet of Things - Concept and Problem Statement," <draft-lee-iot-problem-statement-01.txt>, *work on progress*, March 2011.