Experience and Challenges of Integrating Smart Devices with the Mobile Internet

Zhen Cao, Hui Deng
China Mobile Research Institute, Beijing 100053, China
{caozhen,denghui}@chinamobile.com

Abstract— This document introduces some experience from mobile operators and identifies several challenges of integrating the smart devices with the Mobile Internet. Only challenges that are related to the IETF audience are presented in this document.

I. INTRODUCTION

Smart objects network is the way people interact with the physical world, and Mobile Internet is the way to push the information to people wherever they move. Mobile Internet poses new opportunities for the Internet of Things. Anywhere available cellular networks and whenever necessary accessible mobile users are two important features that can be leveraged by the IoT architecture. Physical environmental information collected by the smart sensors can be reached via the mobile network and pushed to the mobile user directly and instantly. As a consequence, it is desirable to inter-connect the smart devices with the roaming mobile terminals. This paper introduces some existing experience from mobile operators on this integration, and identifies several challenges within this integration architecture. This document only presents the challenges that are related to the IETF scope and above the Media Access (MAC) and Physics Layer for more focused discussion.

II. EXPERIENCE FROM MOBILE OPERATORS

Years before the proliferation of the "Internet of Things" concept, cellular network operators have started cultivating the market. Many operators provide services such as mobile payment, e-healthcare, smart metering, device management, unattended area monitoring and etc. These services can be categorized into the following categories.

1. Dumb-pipe service, which provides basic communication ability to the enterprise users. Smart metering is such kind of service. The enterprise users deploy their own servers and clients utilities privately, and they use the communication channel as a dumb pipe. Any services that do not use any value-added features to operators flow into this category, e.g., smart metering, environment monitoring.
2. Smart-pipe service, which provides integrated and enhanced solution to the end users. Instead of using the communication capability as dumb pipe, these services use the common service platforms and/or device management capabilities provided by the pipe operator. In this case, there is a need of a communication protocol between the smart device and platform to convey management information [1]. Services that leverage integrated service from the operators are in this category, e.g., e-transportation with operating platform, transportation and logistics with locating management capability.
3. Vertical developed service. This category means the vertical service development within different applications areas, including transportation, electricity, finance, agriculture, government and etc. These services normally are independent and have their distinct requirements which do not flow into one common architecture, so it is unavoidable to develop those services independently. These services usually are summarized into templates to assist marketing prevalence.

One distinct example of the integration of Mobile Internet and these smart devices are depicted in Figure.1. The mobile/fixed gateway deployed at the home network edge is the bridge between the mobile network and the home sensor network. The communication flows are bi-directional. The smart sensor can report the sensed information to the mobile use via the home gateway (usually the fixed cellular device placed at home) to the

mobile terminal, e.g., sending the home/enterprise security alarming messages to host's mobile device. On the other direction, the mobile terminal can send commands from the service platforms to control those sensors, e.g., opening the air conditioners before going home, controlling temperature remotely. Enabled with the interface connecting with the smart devices, the mobile users are exposed to not only the Internet-wide information and resources, but also information scattered around the physical world.

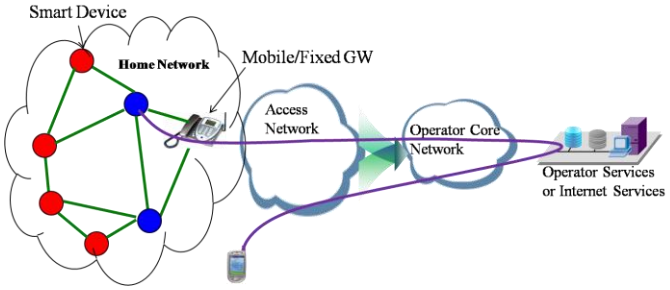

Figure 1. Integrating Smart Sensors with the Mobile Terminals

The scenario depicted in Figure.1 is actually one of the key scenarios are well accepted by the market. From users' point, they are reluctant to pay for brand new service with whatever fancy features, but they are willing and ready to try services coupled with their existing devices. That's why products integrating the internet-of-things features with the mobile terminals very welcome but purely sensor networks services not well accepted by customers. From this aspect, only through integrating with the existing Internet infrastructure will the IoT service be popular among a great many users.

III. Identified Challenges in the Mobile Internet Integration Architecture

A. *Challenge 1: Information Aggregation and Pass-Through Gateway*

In the service development, there are two choices on how to develop the fix/mobile gateway that integrates the smart objects network with the mobile Internet. The first one the information aggregation gateway, and second one is the pass-though gateway. In the case of information aggregation gateway (solid line in Figure.2), the gateway should take the responsibility of aggregating the information collected from the smart devices and send the aggregated message to the service platform. In this case, the information aggregation gateway should understand the application language, so the gateway should be tailored to each different application scenario. In the situation of a pass-through gateway (dotted line in Figure.2), the gateway only works at the network layer and does not need to understand the different application languages. In terms of scalability, the pass-through gateway is more favorable. But the information aggregation way is better at optimizing the service delivery for different application scenarios. So the challenge is to make an architecture choice about the gateway functionality and facilitate service deployment with each manner.

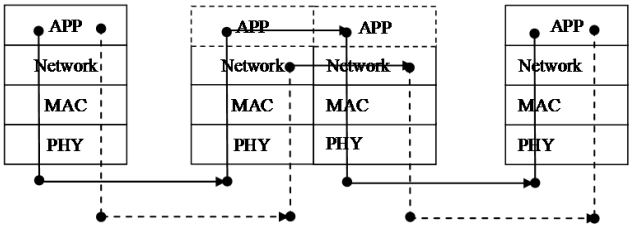

Figure 2. Information Aggregation and Pass-through Gateway

B. *Challenge 2: Always-on or Not: the Impact of Small Data Packets on the Mobile Network*

According to the current survey, the mobile broadband network especially the air interface suffers a lot from the impact of small data packets such as that generated by instant message applications. On the one hand, the mobile applications want to behave always online, but on the other hand, the wireless channels are scarce and enforce the mobile terminal to release the privilege to use the channel. The frequently generated small data packets always trigger the acquisition of the wireless channel which consumes a lot of wireless communication resources, degrading the normal voice communication experience.

The smart objects network will necessarily generate many small packets that result into the same problem as above. How to support the smart objects network communication and in the meantime maintain the operators' key voice services quality is a big challenge. From our experience, solutions to this question include tuning the wireless parameters, prolonging the state on NAT boxes, and data on-demand push services. But end-to-end and salient solutions are expected anyway.

C. *Challenge 3: Smart Device Management*

Manageability is a key requirement for the smart objects network, especially for smart pipe services as mentioned in Section.II. In many services, the customers have put much emphasis on the capability to manage the smart devices in order to know their behavior and schedule attendance. In many scenarios, this manageability capability is a key feature, e.g., tax monitoring devices on taxies and street business booth around. There is a centralized service operating platform that collects the real-time running information about the smart devices. The challenges of the smart device

management are several folded. First, small devices are mobile and their status information is difficult to collect. Secondly, separation of the service platform and management platform makes things complicated. It is desirable that the applications are developed via the Application Program Interfaces. And there is a need of a standard communication protocol between the smart device and the management platform.

D. Challenge 4: IPv6 Migration and IPv4 backward Compatibility

IETF is working actively towards enabling IPv6 on smart devices. The 6LOWPAN working group was chartered to develop a technology that can run IPv6 over the IEEE 802.15.4-2006 lower layer. The identified challenge is that some lower layer of smart devices has too small MTU size (127 for IEEE 802.15.4-2006) to accommodate full IPv6 packets, so 6LOWPAN develops a stateless IPv6 header compression standard [2] which can compress the minimal 40-byte IPv6 header into 1-2 bytes with link-local IPv6 addresses. The ROLL[3] and CORE[4] working groups were chartered to study light-weight routing and application protocols for smart devices respectively.

Even though the mechanisms to support IPv6 are well developed by IETF, the fact is the deployment of IPv6 in mobile network is much slower than what's expected. So even if the smart devices are enabled with IPv6 capability, the outside connection of the gateway is not IPv6 popular. If we still need the help of translating gateways between IPv6 and IPv4, the benefit of using IPv6 on the smart devices are not worthwhile. So the challenge here is we need a strategic IPv6 deployment scheme to overcome IPv6 latency development while maintaining IPv4 backward compatibility.

E. Challenge 5: Interoperable Implementation of Networking Stack

The smart devices are often resource constrained, with limited computing and communication capability. Even though the computing technologies will make these capabilities cheaply available as time evolves, engineers are indispensable faced with the problem of implementing their application in a light-weight manner, or as the saying goes, "dancing with shackles". While the engineers are on their way to make things simpler and smaller, the problem of interoperability arises. As a consequence, interoperable implementation of networking stack is a challenge to inter-connect products from different vendors. To address the question, the LWIG (Light-Weight Implementation Guidance) was proposed and being created since the BOF at IETF79.

IV. CONCLUSION

This paper shares some experience on inter-connecting smart devices with the Mobile Internet. Some challenges as are identified and are expected to be discussed further with the community.

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