An SDN_based Management Framework for IoT Devices

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Abstract— **The ever evolving technology of the Internet of Things(IoT) requires ubiquitous connectivity to billions of heterogeneous devices such as sensors, cameras, RFID devices, etc. However, due to the heterogeneity of devices and access protocols, IoT networks are becoming enormous and complex, which makes the management extremely difficult. Based on Machine-to-Machine(M2M) technics and the programmability feature of the network, brought by the Software Defined Network(SDN), devices in a network can be treated as objects, thus decoupling the control plane from the data plane. In this paper, we proposed a framework for managing the devices and configuring the network dynamically based on SDN. Finally, we apply the framework in our project and get a successful result.**

Keywords **– Software Defined Network (SDN); Internet of things (IoT); Programmable; Devices and Network Management**

I INTRODUCTION

In 1992，the Auto-ID center was established by MIT, and the idea that “everything can be interconnected by network” was first proposed which clarifies the basis of the Internet of Thing (IoT) [1]. Since then, the application of IoT has been increasing sharply. With the development of technology and applications, major changes in the field of IoT occurred. “ITU Internet Report 2005: Internet of Thing”, released by the International Telecommunication Union cited the concept of IoT. The definition and scope of IoT has changed, the coverage has been greatly expanded, IoT is no longer only based on RFID technology. The concept has shifted from connecting any person to connecting anything at any time at any place [2].

Driven by the IoT vision and continuing efforts towards its realization, contemporary development of wireless sensor networks (WSNs) has placed greater emphasis on providing Internet connectivity to these once isolated networks [3]. The introduction of IP protocol into wireless communication network has been considered unrealistic. So far, the wireless network only uses dedicated protocols because the IP protocol requires larger memory and bandwidth, it’s very difficult to reduce its operating requirements to accommodate microcontroller and low-power wireless connection. The depletion of IPv4 addresses makes IPv6 the trend. The development of IoT technology will further promote the deployment and use of IPv6. IETV 6LoWPAN has the characteristics of low-power and self-organizing network, it is the important technology for the perception layer of IoT and WSNs. The new generation of ZigBee standards has adopted 6LoWPAN. With the deployment of the U.S. smart grid, 6LoWPAN will become the de facto standard, comprehensive alternative to ZigBee standards.

Though, Many studies on 6LowPAN in WSNs were shown [4][5][6][7], we can find that there has been little study of how to manage and operate the IoT easily. In [8] a network management architecture of 6LoWPAN based on SNMP is designed, including SNMP agents for constrained devices supporting IEEE 802.15.4 Radios and Contiki Embedded Operating System and SNMP manager in real IPv6 network. But not all the devices can support the SNMP protocol, the management framework does not apply to a wide range of IoT applications. Chang K D et al. [9] proposed a framework for IoT object management and naming based on the future internet IoT-IMS communication platform. But the method just for devices’ data processing, can not apply to the device and network topology management.

Many researchers have shown that by applying software defined networking (SDN), we can dramatically simplify network configuration and resource management. Software defined networking (SDN), advocates separating the data plane and the control plane, making network switches in the data plane simple packet forwarding devices and leaving a logically centralized software program to control the behaviour of the entire network. In [10] a unified control system for heterogeneous networks is proposed, which focus on how to use the service resource and network resource together effectively. Hampel G et al. [11] proposes to extend the concept of SDN to controller-programmed and decapsulation operations on top of IP，enable a new paradigm for telecom architectures that allows substituting specialized gateways with generic SDN FEs and centralized control. Z. Shelby et al. [12] explores how SDN can provide better mechanisms for common network management and configuration tasks across a variety of different types of networks.

Although many prior researches have exposed the potential benefits of applying SDN in computer networks to facilitate the evolution of network technologies, there has been little study about how to apply the SDN to the management of the IoT.

Overall, SDN introduces new possibilities for network management and configuration methods. This paper combined SDN with IoT proposed an network management framework, which can improve the reconfigurable and flexible. The structure of the paper is organized as follow. Section 2 presents a introduction of IoT. Section 3 discusses the architecture of the SDN. Section 4 proposed the IoT management framework based SDN. Section 5 describes the implementation of the framework. Section 6 gives a brief conclusion about the paper.

II IoT

What is IOT? In a narrow sense, the Internet of things refers to the network which connects things in order to realize intelligent identification management of things. In a broader sense, the Internet of things can be seen as the integration of information space and physical space, and all the things are digitalized and networked so people can interact and access the information more efficiently between things and things, things and people, people and reality environment. Also, IoT adopts all kinds of information technology and new service models, thus to integrate the application of informatization in the human society.

The three layers of IoT structure is depicted in figure 1.

Perception layer solves the problem that how can data be gathered from human world and the physical world, and it is regarded as a core layer of the Internet of things. Its main functions are things identification and intelligent acquisition. The perception layer is composed of basic sensing device (such as RFID tag and reader-writer devices, all kinds of sensors, cameras, GPS, etc.) and perception network (such as RFID network, sensor network, etc.).

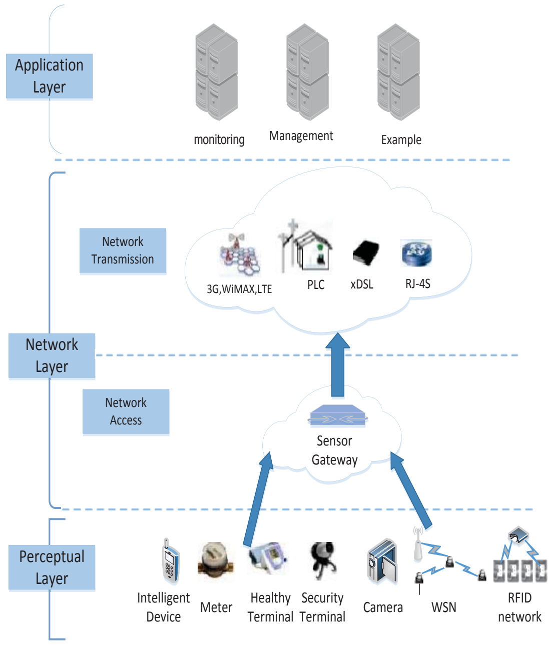

Figure 1: IoT structure.

Also known as the network layer, transport layer is to solve the long distance transport of data which was gained by the perception layer. Within a certain range, it mainly completes accessing and transmission function. It is the way of information exchange and data transfer.

Application layer is also known as processing layer, it solve the issues of information processing and human-machine interface. The data from network layer processes into all kinds of information systems. And the systems interact with people through a variety of devices.

At present, M2M is the most commonly used application form of the Internet of things. The industry focuses on M2M because it puts emphasis on the practical application.

III SDN

Network state changes continually, and operators must manually adjust network configuration in response to changing network conditions. Operators use external tools, or even build ad hoc scripts to dynamically reconfigure network devices when events occur. As a result, configuration changes are frequent and unwieldy, leading to frequent misconfigurations. SDN was proposed to address these challenges which conventional paradigm for network control faced. By decoupling the control plane from the data plane, it can provide programmability to the network. Highly scalable and flexible networks can be designed to adapt to changing the business needs. Figure 2 depicts the architecture of SDN.

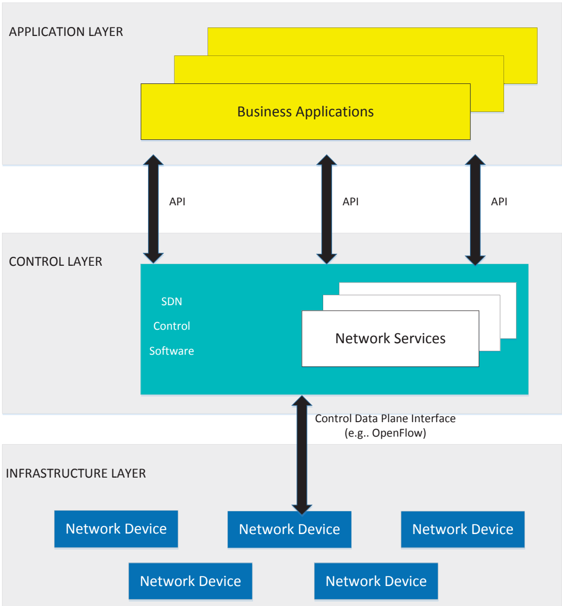

Figure 2: SDN Architecture

It allows the software independent from the hardware. The SDN control Software in the control layer sends control information via an interface to SDN infrastructure layer. Compared with the traditional network architecture, the control units are concentrated in SDN architecture. The switches or routers refresh their tables by receiving the control information from the control center. By centralizing network state in the control layer, management, configuration, security, and network resources are optimized through flexible, dynamic and automated SDN programs.

SDN architectures support a set of APIs that makes it possible to implement common network services, including routing, multicast, security, access control, bandwidth, management, traffic engineering, QoS, processor and storage optimization, energy usage, and all forms of policy management, custom tailored to meet business purposes [15].

IV PROPOSED FRAMEWORK

With the development of IoT, the embedded technology based on IEEE 802.15.4 gets widely used due to its unique advantages. The interaction between perception layer devices relies on access gateways at present which is not a real P2P communication. Once the gateways are not available, the whole network will fail. Meanwhile, because of differences at the higher layer of protocol stack, nodes applying the same access technology utilized in a given network can not enter a new network. This leads to strict limitation to the possibility for network management. This problem can be solved by applying SDN paradigm which envisions that the functionality performed at the network and higher layers of the protocol stack are defined through software and can be changed easily [17].

SDN decouples the control plane form the data plane in IP network. Assuming all the IoT devices support IP protocol stack and are IP-addressed. We can abstract the network as a two-tier structure. One is data plane, the other is control plane. The topology of the network is managed by the controller. We take the approach that resembles routing table used in routers. The nodes receive commands from the controller to refresh their routing tables to restructure new network structures. At the traditional IoT, the topology is fixed, unchangeable. So if the gateway breaks down, the networks can not continue to work by adjusting themselves. But in the introduced SDN, the network can reconfigure according to the change of environment. The framework of we proposed depicts in figure 4.

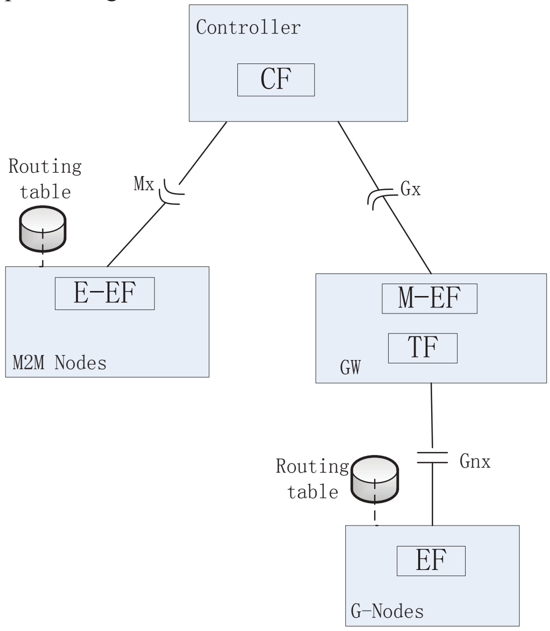

Figure 4: Proposed Framework

We can see the framework contains four parts. They are Controller, M2M nodes, Gateway and General Nodes. The Controller manages all commands of the networks. It is programmable. The M2M Nodes are these devices or networks which support the M2M protocol. The Gateway is used to connect the devices that can not support the M2M protocol. In the architecture, we can see three reference points. They are Mx, Gx and Gnx. They complete the commands transmission between the entities. The transmission procotol at Mx and Gx is M2M procotol. At Gnx, transmission protocol may be private. M2M Execute Function (M-EF, EF) analyses and executes the commands issued by controller. Because many devices not support the M2M, the gateway needs a Transform Function (TF) to convert the commands to adapt for their own control protocols.

We can see that, by using SDN in IoT , the controller can manage the network dynamically. The nodes can implement the real P2P communication do not rely on the transmission of gateways. This will promote the development of IoT.

V IMPLEMENTATION

In order to verify the feasibility of the framework, we do a test in our project. The architecture is depicted in figure 5.

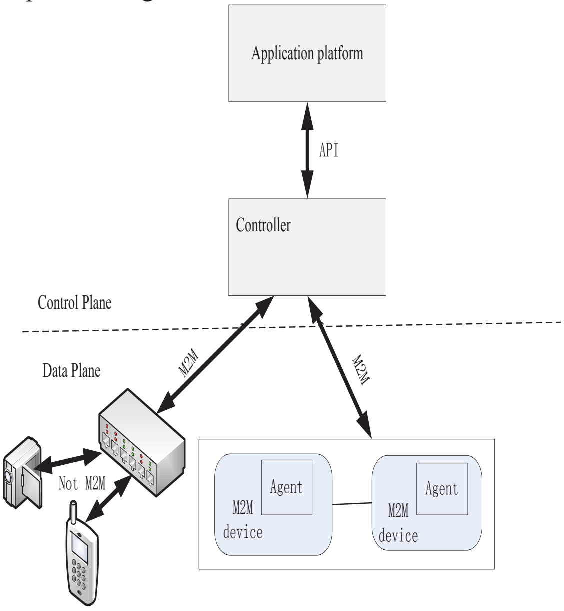

Figure 5: Application Architecture

Our project was made up of two parts, one is control plane, which consists of the controller and application platform, the other is data plane, which makes up devices and networks. There is an agent resided in M2M device or M2M gateway. It corresponds to the EF mentioned earlier. The agent receives the commands from the controller and then analyses it. The common dispose is to rewrite the routing information files.

In the project, we store the routing information in files. By the commands analyse, every node reserves the routing information of its neighbors. When it needs to send a message, it reads the file to find out where should the message be sent to. When the topology needs to be changed, the controller sends the new routing information to the nodes, the agent rewrites the routing file. Thus, it can reconfigure the system simply without redeploying.

VI CONCLUSION

The paper addresses the integration solution between SDN and IoT. We can see that the extension of the SDN paradigm to IoT can have a significant impact on such network management and device management. As highlight in the paper, combined SDN with IoT can make the IoT much simpler to manage and reconfigure. Future work will investigate the distributed management of addressed device.

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