An IMS based Architecture Using SDN Controller

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SDN 제어기를 사용한 IMS 기반 구조

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Abstract The IP Multimedia Subsystem(IMS) is an architectural framework for delivering IP multimedia services to mobile users. In order to guarantee the reliability and Quality of Service(QoS) of a variety of multimedia services, we need a new evolutionary approach that maintains the IMS based signaling platform which can perform the processing of flow through distributed controllers. Software Defined Network(SDN) is an architecture purporting to be distributed, dynamic, cost-effectives as well as adapting and seeking to be suitable for the high-bandwidth, dynamic nature of today's applications. It requires some methods for the control plane to communication with the data plane. One of such mechanisms is OpenFlow which is a prominent standard protocol and interface that is responsible for managing the network resources by using the remote SDN controller. In this paper, we propose a straightforward approach for integrating SDN technology together with the IMS architecture. Therefore we propose and construct a combined architecture model that performs flow processing using OpenFlow via the IMS based signaling platform, which maintains the existing telecom call service. Additionally, we describe some relevant experimentation results from the proposed architecture.

요 약 IMS는 모바일 사용자에게 IP 멀티미디어 서비스를 제공하기 위한 프레임워크이다. 분산 제어기를 통하여 플로우 처리를 수행하기 할 수 있는 IMS 기반 시그널링 플랫폼의 구성은 새로운 진화적 접근 방식으로 다양한 멀티미디어 서비스들의 신뢰성 및 QoS를 보장하기 위하여 필요하다. SDN은 분산 및 동적 그리고 고비용적인 아키텍처이며, 오늘날의 응용 프로그램을 위한 고대역폭 및 동적인 특성에 적합하도록 노력하고 있다. SDN은 제어 평면이 데이터 평면과 통신할 수 있는 방법을 요구한다. 이러한 방법들 중 하나는 OpenFlow이며, 이는 원격 SDN 제어기를 사용하여 네트워크 자원을 관리하는 대표적인 표준 프로토콜 및 인터페이스이다. 본 논문에서는 SDN 기술을 IMS 아키텍처와 통합하기 위한 직관한 방법을 제안한다. 따라서 기존 텔레콤 통화 서비스를 관리하는 IMS 기반 신호 플랫폼을 통하여, OpenFlow를 사용하여 플로우 처리를 수행하는 결합된 아키텍처 모델을 제안하고 구축한다. 또한, 제안 구조로부터 얻은 적절한 실험 결과들을 설명한다.

Keywords : SDN, IMS, OpenFlow, QoS, SIP

1. Introduction

The IP Multimedia Subsystem(IMS) is an architectural framework defined initially by an industry forum called 3G.IP for delivering IP multimedia services to mobile users based on the Universal Mobile Telecommunication System(UMTS). The IMS plays an important role for Public Switched Telephone

Network(PSTN)[7] migration, as well as in mobile Long-Term Evolution(LTE) networks[4,9,10,11]. As the IMS is a kind of multimedia business form, it can meet the present terminal customer demand of the newer and more diversified multimedia business. However, there were no promising applications to re-architect the network that meets the more needs of users by introducing the IMS network element.

Software Defined Network(SDN) appeared a few years ago. SDN is an architecture purporting to be distributed, dynamic, manageable, cost-effectives as well as adapting, seeking to be suitable for the high-bandwidth, dynamic nature of today's applications[1].

The main objective of the paper is to make an integrated system which can guarantee the reliability and Quality of Service(QoS)[3] for various services. So, we propose a rather straightforward approach for implementing flow processing via distributed SDN controllers and the IMS based signaling platform, which maintains the existing telecom call service. The distributed end-to-end service provisioning among inter-domain flow processing platforms is implemented via the IMS signaling framework in which the different actions and functions are to be executed by each platform. The media flow is exchanged among SDN controllers over the end-to-end network service path and contains the information on routing rules and local flow processing actions to be instantiated at the different platforms.

The remaining paper will first give related works about SDN and the IMS. Then a combined architecture model of SDN and the IMS is constructed and proposed. Finally, we will have some results of the relevant experimental operation about the theory we mentioned.

2. Related Component Technologies

2.1 Policy Control of the IMS

In this section, we present policy control in the operation at session establishment. As shown in the Figure 1, The Proxy Call Session Control Function(P-CSCF) receives an INVITE request(1) addressed to one of its terminals[8]. When the P-CSCF obtains both the offer and the answer, it sends an Authentication Authorization Request(AAR)(4) message describing the session to be established to the Policy and Charging Rules Function(PCRF).
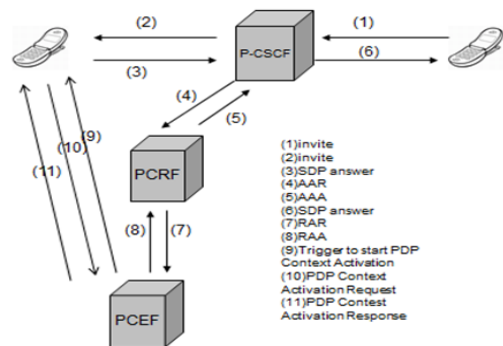

Fig. 1. icy Control for an Incoming Invite Request

In the IMS, policy and charging are specified as part of the same architecture, that is called Policy and Charging Control(PCC), because policy and charging are very much related. With this description, the PCRF selects a set of PCC rules for the session. The PCRF returns an Authentication Authorization Answer(AAA)(5) message to the P-CSCF. The PCC rules are installed in the Policy and Charging Enforcement Function(PCEF) by the PCRF sending a Re-Authentication Request(RAR)(7) message. The PCEF returns a Re-Authentication Answer(RAA)(8) message, and instructs the terminal to initiate the Policy Decision Point(PDP)(9) Context Activation procedure. When the terminal performs the PDP Context Activation procedure, the gateway applies the PCC rules to the media flow.

2.2 SDN

SDN decouples the system that makes decisions about where traffic is sent (the control plane) from the

underlying system that forwards traffic to the selected destination[5] (the data plane).

As the Figure 2 shows, at each of SDN architecture there are many core technologies, whose goal is to separate the control plane and the forwarding plane effectively, to support the logical centralized unified control, and to afford the flexible open interface.
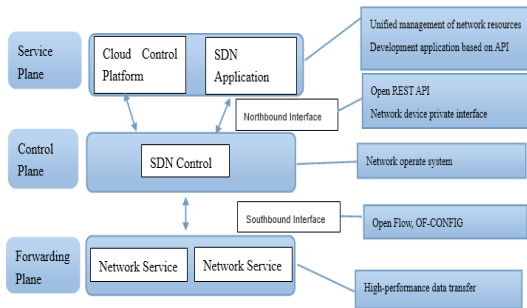

Fig. 2. SDN Core Technology System

This architecture allows network administrators to have the programmable central control of network traffic without requiring the physical access to network's hardware devices. Among them, the control plane is the core of the SDN system, the northbound interface and the southbound interface named center on it. The SDN controller is responsible for the configuration of the physical resources. Besides, it maintains the network rules and distributes the appropriate instructions to the network resources.

SDN requires some methods for the control plane to communicate with the data plane. One such mechanism is OpenFlow which is a standard interface for controlling computer networking switches. The OpenFlow protocol can manage resources by slicing them in a virtualized manner[2] and this aspect of the OpenFlow protocol can be integrated into an IMS infrastructure. The OpenFlow controller is able to dynamically reroute the traffic to alternate network resources, or a different "network slice" in cases of congestion or applying QoS in the IMS network through the IMS policy network elements. The

OpenFlow switch can be a software program or the hardware that forwards packets in the SDN environment.

3. An Architecture for SDN and IMS

This section describes in what manner we deployed and integrated SDN technology together with the IMS architecture.

Figure 3 displays the underlying extensions on the IMS, which are based on the considerations about QoS and OpenFlow on the IMS fabric. To enable OpenFlow functionality together with QoS capabilities, the following components were installed, configured and programmatically extended: the policy control of the IMS, the OpenFlow controller and the OpenFlow switch.
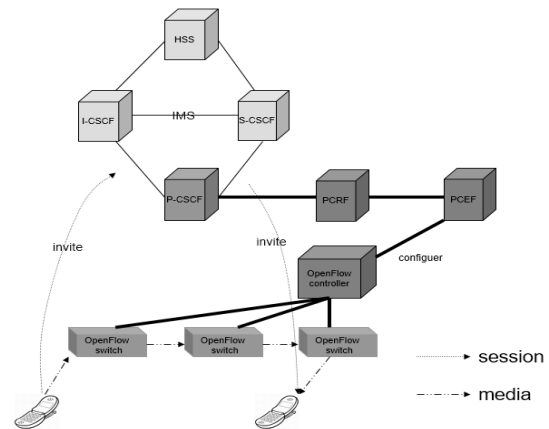

Fig. 3. Combined Architecture of SDN and the IMS

The following sections particularly describe how these components are integrated in the IMS together with their extensions and functionality, and the functions of each component.

As the Figure 4 shows, the P-CSCF is the first connection point between the IMS and the user, that providing the proxy functions of receiving the business request and forwarding them. The session description

established by the user is sent to the PCRF by the P-CSCF. The P-CSCF can also provide the function of interrupting and initiating SIP session in an abnormal condition.
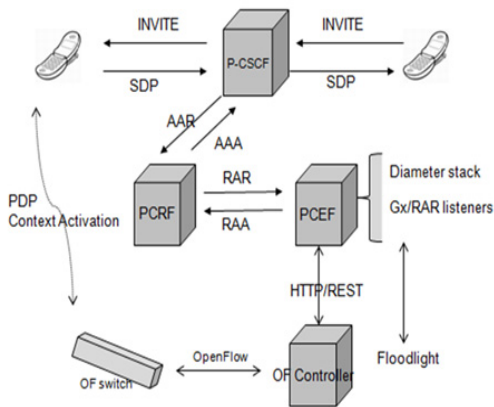

Fig. 4. OpenFlow Integration in the IMS

In consideration of applying QoS based on the IMS networks, two network elements are needed: the Policy Decision Point(PDP) and the Policy Enforcement Point(PEP). The PDP searches related policy rules and sends the message to the PEP. The PEP carries out or enforces it. So there are two IMS components, PCRF and PCEF, are installed to the combined architecture. The PCRF, which plays the role of the PDP, is the element which determines policy rules at the network core. The PCRF sends any interface commands to the PCEF. To be specific, in an IMS call flow, the Session Description Protocol(SDP)[6] message is encapsulated within Session Initiation Protocol(SIP) and carries the QoS parameters. The PCRF examines these parameters, retrieves appropriate policies and informs the PCEF of that traffic flow. The PCEF, which plays the role of the Policy Enforcement Point(PEP), is co-located with the domain gateway and its role is to enforce the policies that the PCRF requires. Within the PCEF module there are a Diameter stack and the Gx interface listeners for events coming from the PCRF.

We should keep communication with the controller of the OpenFlow through its interface, so we did some

changes based on the PCEF. In general, we programmed the PCEF with our own functionality that configures dynamically at runtime the Floodlight OpenFlow Controller to identify the network slice, and the flows should follow the network slice.

The Floodlight Controller is an enterprise-class, Apache-licensed, and Java-based OpenFlow Controller. It is designed to work with the growing number of switches, routers, virtual switches, and access points that support the OpenFlow standard. These are two major features that make us to deploy Floodlight in the combined architecture. Floodlight offers a module system that makes it simple to extend and enhance. And it provides a Representational State Transfer(RESTful) API for accessing controller features, on top of it applications can use it to proactively manage a network.

The PCEF should be enhanced with an API so that it is able to identify bandwidth speeds and the network slice which the flows should follow. The exposed RESTful API of Floodlight makes it easy for applications to access controller features and eventually configure or access OpenFlow devices easily avoiding of other module complexities. And another advantage is that applications can be done remotely. For the IMS architecture, the API is exposed in a url. It is simple to affect or ask the controller.

Then the OpenFlow is configured to control network resources, to alternate network slices, or to connect cloud resources and other application servers. At this condition, the role of the OpenFlow is to dynamically accommodate the network resource and to reroute the data paths depending on the situation of the bandwidth traffic of network data or flow.

4. Experimentation Results

While an IMS call and a session establishment are performed, we can use the IMS testbed and experiment OpenFlow modules. We provide an example, where the

experimenter is done with integrating the OpenFlow into the testbed. We built an OpenFlow environment without OpenFlow hardware devices.
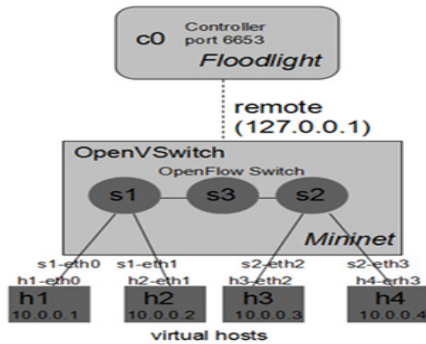

Fig. 5. The Topology View of the Integrated Model

Ubuntu creates the virtual environment by using VirturalBox. As the Figure 5 shows, running on the Ubuntu environment, Floodlight is installed as the OpenFlow controller and Mininet is used to simulate the OpenFlow switch, and the host as well as the definition of network topology.

Fig. 6. A View of the Mininet Terminal Console

When the Floodlight is running, it should be attached to the OpenFlow network as the OpenFlow controller. Mininet is the good simulation tool that we chose to implement the establishment of switches.

To do that, type:

$ sudo mn --topo tree, depth=2, fanout=2 --controller=remote, ip=127.0.0.1, port=6653.

To access the web console of the controller, type in a browser:

http://localhost:8080/ui/index.html and the Floodlight is running as shown in the Figure 7.
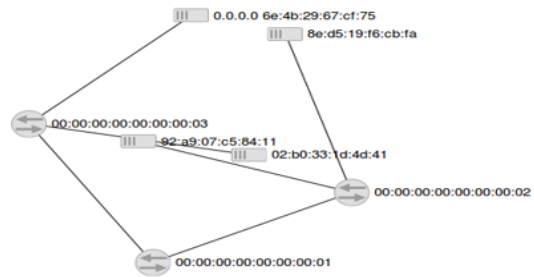

Fig. 7. A View of the Floodlight Controller Console

5. Conclusion and Future Work

On the basis of the IP Multimedia network, the SDN technique is inserted flexibly, it looks to be promising. Inserting the OpenFlow protocol technology in the IMS architecture through the policy of the IMS network can be used to improve the management of the network resources more flexibly and provide advanced QoS.

The next step, in order to create much more and better applications, we will test more diversified technologies. We will finish doing some experiments of having test-beds with two switches based on other experiment infrastructures. One for accommodating internal data networking and another for interconnecting the machines to our public network. This enables us to define different scenarios, involving in some cases about the isolation of resources on same Virtual Local Area Networks(VLANs), while providing some scalability to the infrastructure.

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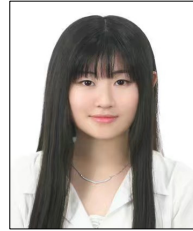
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