Design of Service Abstraction Model for Enhancing Network Provision in Future Network

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***Abstract*—The emerging research of SDN and NFV have been promising to provide flexibility in network provisioning based on service requirement. However, current network provision methods of SDN and NFV do not have a formalized model of describing dynamic requirement of the services. The usage of audio/video services may be the example of the services with dynamic requirement. The orchestrator of SDN and NFV needs to understand the service requirement in order to provision the network dynamically and systemically. Hence, innovative service abstraction is needed to model the service requirements. This paper describes our initial effort to design a service abstraction model for enhancing network provisioning in future network. We consider audio/video services as the target service of our initial service abstraction model and develop the XML based service abstraction model. Moreover, we present a communication mechanism to submit and deploy the XML-based service abstraction model to the orchestrator.**

Keywords—Software-defined networks; Network Function Virtualization; Service Abstraction Model; Network Provision

I. Introduction

Nowadays, there are many applications supported by various services and network technology. The increasing number of mobile devices, the development of advanced technology such as Internet of Things may emerge various services with dynamic requirements. For example, currently, it's common to stream the video from a drone. The drone is moving from one place to another while streaming the video service and can be watched by certain users through their devices. This application needs the networks that support the Quality of Services (QoS) requirements of the video service and maintain the connection to control the drone. The various number of users that watch the video service and mobility of the drone become the dynamic aspect of the service. This condition emerges the challenges for the future network to support dynamic requirements of the services.

Software Defined Network (SDN) and Network Function Virtualization (NFV) [1] are the emerging research of the network. Although SDN and NFV have different purposes, their approaches are similar. SDN and NFV separate control plane from data plane of the network and enabling programmable network. Generally, SDN and NFV consists of three layers, 1) Application Layer; 2) Middle layer (The controller for SDN and the orchestrator for NFV); 3) Underlying Network. The researches on SDN and NFV mostly focus on protocols to bridge the communication between the middle layer to the underlying network. The protocols provide network abstraction of the underlying network to the middle layer. The middle layer then provides an API to the application layer so the applications run on top of the application layer can interact with the underlying network. With this approach, NFV has a role in providing the network function requested by the services and SDN has a role as the glue between the network functions provided by the NFV.

However, the network provision based on service requirements in SDN and NFV do not have a formalized model of describing the dynamic aspect of the services yet. In this paper, we propose our initial effort to model service requirements into service abstraction model which is delivered to the controller for provisioning the network dynamically and systemically. To present viability of our approach, we develop an initial design of XML-based service abstraction model for audio/video services which contain various characteristics related to multi-rate services, and implement the communication mechanism to deliver the abstraction model.

The rest of this paper is organized as follows. In section II, we summary the state-of-the-art of the research in network provisioning. Section III presented the design of our initial service abstraction model. Finally, section IV will conclude the paper and gives the future plans.

II. Related Work

A. Resource Reservation Protocol (RSVP)

Resource Reservation Protocol (RSVP) [2][3] is a network-control protocol that allows an Internet application to reserve bandwidth on each node for its traffic data flow along a given path. RSVP has two important set of numeric parameters called Tspec and Rspec [3]. Tspec defines the traffic characteristics of the data flow that a sender will generate while Rspec defines a desired quality of service. Tspec is indicated through five main parameters. The first two parameters are the parameter of the leaky token bucket model. The token bucket rate specifies the rate at which the sender sends the data and the token bucket size indicates the buffer size in the scheduler. The peak rate is the fastest data transfer rate between sender and receiver. The last two parameters specify the minimum and maximum packet size respectively. The Rspec component contains two parameters: the reserved rate, which specifies the desired bandwidth, and the slack term, which indicates the desired end-to-end delay of the receivers. However, RSVP may fail the network provision if the network elements cannot support the requirements of the services.

B. Network Description Language (NDL)

Network Description Language (NDL) is proposed in [4], [5] and implemented using XML/RDF format. NDL is used to create a distributed Topology Knowledge Base (TKB) which contains information about reachability graphs, showing connectivity rules among physical and/or virtual entities. NDL describes the network topology using three classes and six properties. The three classes are Location, Device, and Interface. The six properties are locatedAt, hasInterface, connectedTo, description, name and switchedTo. The classes of NDL is used to abstract the network devices with its capability and interface. The usage of XML/RDF in NDL shows effectiveness of XML for describing abstraction model.

C. Audio/Video Services Parameter

Audio and video services are some of the examples of network services, which have dynamic aspects. The various number of viewers who can join or leave the service may have impact to the performance of the services. In addition, nowadays it is common to stream audio/video using drones, which move from one place to another. Audio and video services become our target to describe the service parameters for dynamic network provisioning into an abstraction model.

The audio/video services usually consume a large portion of network traffics, and it affects the performance of the entire network significantly. QoS metrics are the traditional method to balance network load and to maintain good performance of online services and network elements [6]. The common parameters of QoS metrics are network throughput, bandwidth, packet loss, delay, and jitter. Although QoS metrics can reflect the performance of the network and its components, they does not represent the actual experience of the users. In addition, from the viewpoint of users, other factors can also contribute to the measurement of the demanded quality of users such as the standard of video, framerate and bitrate.

Recently, the Quality of Experience (QoE) has been studied intensively for providing a holistic measure of the perception of the quality of users [7], [8]. The user experience of video streaming services is measured by four different categories of parameters [9]: System Level, Content Level, User Level, and Context Level. System Level considers network parameters (packet-loss, delay), end-device parameters (system hardware, screen size), and application parameters (video buffering strategies, browser). Content Level considers the properties of the video file such as bit rate, frame rate, format, etc. User Level reflects psychological factors such as the expectations of users, browsing history, and hour of the day, while Context Level provides the environmental factors associated with users such as the user's location and purpose of using the service (entertainment, education). Accordingly, QoE is a user-centric metric that captures the overall acceptability of users to the service and includes the end-to-end factors.

Future internet gives opportunities to new services and applications. These future services need to adapt to the enormous number of mobile devices with low computing resources. The upcoming video and audio service can also take the form of virtual reality and hologram games, which required massive remote computation. The changes in computing environments and devices present more parameters for the audio and video services such as the computing resources, remote storage and memory.

III. SERVICE ABSTRACTION MODEL

A. The concept of Service Abstraction Model

In this paper, we propose our service abstraction model for the orchestrator. With our service abstraction model, the orchestrator can understand the requirement of the requested services and provision/maintain the performance of networks to support the services. To deal with the dynamic aspects of the services, the orchestrator can easily change the networks accordingly. For example, the change in the number of viewers of the video services is described in the abstraction model and the orchestrator manages the required bandwidth for the change. Our service abstraction model will abstract the parameters of the services to support legacy and future network services. The concept of service abstraction model is depicted in Fig. 1.

In the service abstraction model, the requirements of a service are described into a service abstraction description. The requirements are represented by three sets of parameters: Content, Context, and Resources. Content provides the service related parameters such as resolution and standard of video, bit rate of audio, and quality of service (QoS). Context provides user related parameters concerning interest, service location and schedule. Resource supplies the requirements of infrastructural resources. These parameters are presented in XML format and are parsed at service abstraction description module. After that, the requirements of a service are transferred to the orchestrator through the communication manager module. Finally, orchestrator will process the requirement and generate an appropriate network for the user to access the desired service.

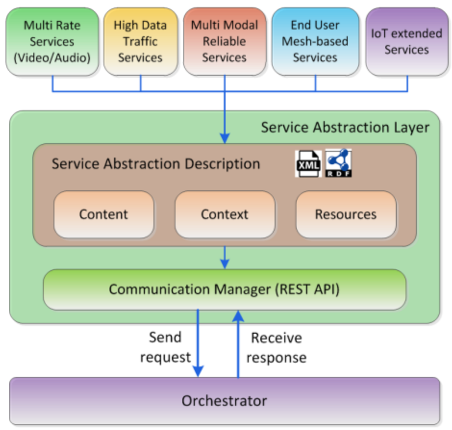

Fig. 1. The Service Abstraction Model

B. Parameter-based Audio/Video Services Categorization

As depicted in Fig. 1, the service abstraction layer receives service parameters from the applications or inputed by the users. However, not all the service parameters is given by the applications or the users. The service abstraction layer needs to categorize the service based on the given parameters. Based on the service category, the service abstraction layer can generate appropriate service abstraction model in XML format and send it to the orchestrator. To categorize the services, we analyze the differences in service parameters by utilizing the decision tree method [10], which is based on rules and conditions. The decision tree is used to represent the rules related to the network services in which (1) each non-leaf node denotes a test on an attribute that belongs to a set of characteristics of the service, (2) each branch node represents the output of the test, and (3) each leaf node depicts the network service. Fig. 2 illustrates how a decision tree is used to categorize the services.

C. Service Abstraction Model for Audio and Video Services

In this paper, we design a service abstraction model for audio and video services that utilizes QoE metrics to describe the requirements of service in future network. The three important sets of parameters are the content, the context, and the resource as depicted in fig. 3.

The content set contains parameters which describe the quality of the video/audio content in terms of standard, frame rate, bit rate, format, bandwidth, and delay time. First, the standard defines the quality of the video with regard to its resolution such as Full HD, 2K and 4K. The next parameter defines the frame rate of the video (fps). The bit rate (Kbps) represents the quality of the audio. The format defines the encoding such as NTSC or PAL for video, and WMA or MP3 for audio. The desired QoS for the requested video/audio quality is also described in the content set with regard to the desired bandwidth (kbps) and the maximum delay time (millisecond).

The second set of parameters defines the context of the services with respect to its category, location, time and user. The category defines what type of service is demanded such as video streaming or video conference. The location specifies where the demanded service is located while the time specifies the service schedule and event time. The last parameter identifies the user who are requesting the service.

The resource set presents new parameters for upcoming video and audio services of the future network. We consider four types of resources: network, computing, memory space and storage. The network resource specifies the available network interface for connecting user to the desired service such as 3G or Ethernet interface. The computing resource specifies the desired number of nodes which are used to run the service. Thirdly, the memory space represents the desired amount of RAM memory that each node running the service should have. The storage field defines the desired amount of storage that can be consumed by the service.

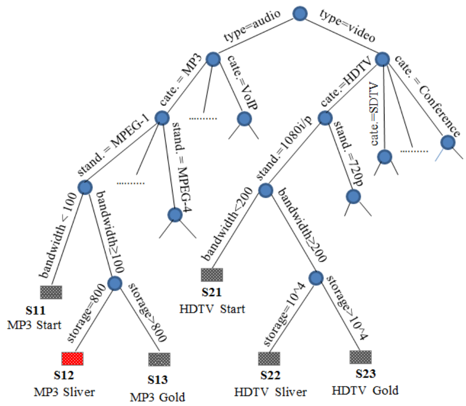

Fig. 2. A Decision Tree Explanation of Audio and Video Service

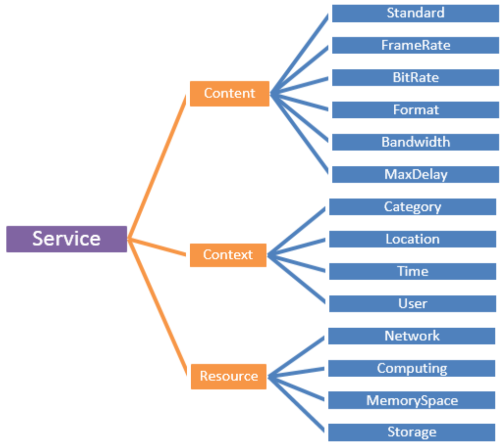

Fig. 3. Template of Audio/Video Service

```
<videoXML>
    <content>
        <standard>HD 1080p</standard>
        <framerate>60fps</framerate>
        <bitrate>8000kbps</bitrate>
        <format>WMV</format>
        <bandwidth>400kbps</bandwidth>
        <maxdelay>200ms</maxdelay>
    </content>
    <context>
        <category>HDTV</category>
        <location>US</location>
        <time>2016/05/27 15:00:00</time>
        <user>User Name</user>
    </context>
    <resource>
        <network>3G,Wifi,LAN</network>
        <computing>4nodes</computing>
        <memoryspace>1024MB</memoryspace>
        <storagespace>10240MB</storagespace>
    </resource>
</videoXML>
```

Fig. 4. An example describes a Video Service in XML format

To interchange data between service abstraction layer and orchestrator, we utilize the XML format as the medium of exchanging since it provides an understandable description of each parameter in the user’s request for the video service. An example for describing a video service in XML format is illustrated in Fig. 4.

D. The Communication Mechanism

In section III.A, we have described the layer architecture of our proposed service abstraction model. In the proposed architecture, a communication module is designed to exchange the XML file, which describes the service abstraction model, between the service abstraction layer and the orchestrator. In this section, we explain briefly the communication mechanism that occurs between the service abstraction layer and the orchestrator. Fig. 5 shows our initial design of the communication model.

The service applications will communicate with the service abstraction layer using XML format. The incoming requests will be handled by the request handler manager and stored in the database. Each service request will have a status flag. Initially, the status flag will be set into "pending" status. The monitoring agent will inspect the entire "pending" service request in the database and send them to be processed by the orchestrator via communication agent. The communication agent will send XML request to the orchestrator and in return receive the XML response regarding the service request whether it will be accepted or rejected. Then the status of each request in database will change accordingly.

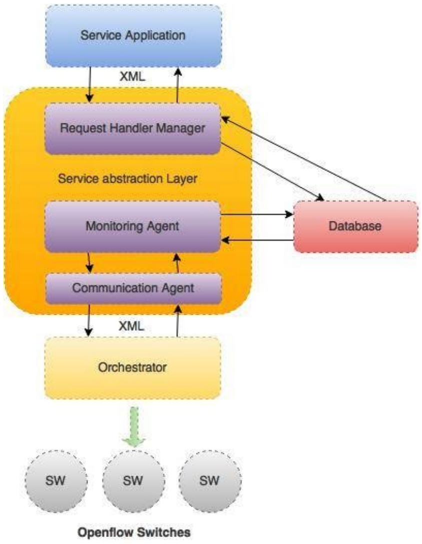

Fig. 5. Communication Mechanism between the Service Abstraction Layer and the Orchestrator

IV. Conclusion

This paper proposes a service abstraction model for network provision based on service requirement, especially for multi-rate services. Our service abstraction model has included QoS and QoE parameters of multi-rate services and can be implemented using XML format. This XML format can be exchanged between service abstraction layer and the orchestrator. The orchestrator then uses the model described in the XML format to dynamically provision the network.

This paper presented our initial work. Our eventual goal is to develop a *thin abstraction layer* to arbitrate between complex and dynamic requirements of services and flexible and fragmented network environments. To pursuit this goal, we are going to improve the service abstraction model for various future services with various dynamic requirements, which can be easily extended for new future services. Also, we are going to design a framework for the service abstraction layer to deliver the service abstraction model to both of SDN/NFV orchestrator and intended users of requested services.

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