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Application Research of Future Network's SDN Technology in Smart Campus

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Abstract. The future network SDN technology is one of the most notable issues, and meanwhile Chinese universities are initiating the smart campus informatization strategy. Based on the prospective application research on engineering and technology, this essay has introduced SDN technology frame and its nature feature, discussed the technology type needed by the smart campus project, presented several application scenes of smart campus project, analyzed a series of key problems which the SDN campus application is to solve, and provided certain engineering references for the colleagues who are the practitioners of smart campus.

Introduction

In 2006, during the study on the Clean Slate program(the Clean Slate Design for the Internet) [1], Stanford university's Nick McKeown and the Berkeley university's Scott Shenker put forward the preliminary conception of SDN (Software Defined Network) together. Its core idea is: by means of untying the tight coupling between the traditional Network control and data transmitting, the net is abstracted to shield the complexity of the bottom level, and provide simple and effective configuration and management for the upper level. In SIGCOMM of 2013, the top academic meeting of the major of computer network, one fifth of paper is closely related to SDN [3]. The authoritative analysis institution Gartner issued future top ten key technology trends at the end of 2012, the second of which was SDN. ITU-T also carried out tracking surveys on SDN synchronously, focused on the SDN scene object and technology frame of the operators' network. Dan Pitt, the chairman of the global open network foundation ONF foretells that the entire switchboard will support Openflow after 2014[4]. Future network SDN technology is becoming hot issue which will be paid most attention in computer network academic world and industrial community.

Chinese universities are to start the informatization strategy of building the smart campus. Domestic scholars in China have put forward the idea of smart campus and construction blueprint in succession, university informatiozation construction's practitioners even take advantages of formulating the "Twelfth Five Year Plan" to make positive preparation, to organize and carry out the building of smart campus[5]. In scores of colleges and universities, such as Peking University, Zhejiang University, Southwest university, Tongji University, Posts and Telecommunications University of Nanjing and so on, smart campus offers teachers and students an economical, high-efficiency extensive network and intelligent management, in which people, people and the campus, human beings and materials, matter and matter coexist harmoniously. By means of application the leading information technology such as web of things, cloud computing, optical networks, mobile internet and application integration, etc., the smart campus integrates the scattered, fragmented information system and resource of schools into an organic entirety, which has highly perceptive ability, synergetic ability and service ability. It provides strong intelligence support for the operation of the school's science and education, campus management and public service.

It is one of the significant behavior characteristics of the information society to serve social organizations quickly and actively with the advanced technology. On the aspect of technological revolution, smart campus is upgrade of digital campuses survival environment. The great upgrade inevitably generates new species, that is, new applications, some of which are likely to be induced

and cultivated by SDN technology. Quickly carrying out the research on SDN technology prospectively applied in wisdom campus will help the smart campus instrumented, integration and intelligentized.

Sdn technology frame and substantive characteristics

SDN's Technology Frame.

Current model architecture of realizing the SDN technology is divided into three layers, the infrastructure layer of which mainly composed of SDN switchboard supporting protocol OpenFlow. The control layer mainly includes an Openflow controller and a network controller system. Its controller is a platform; downward the platform can directly talk to switch which uses protocol Openflow (hereinafter referred to as the SDN switch);Upward it offer open interface for the software of the application layer used for application program to test network state and issue control strategy. The application layer located at top layer consists of much application software which can execute particular control algorithm according to the network information offered by controller, and converts the results to flow control command via the controller and then issues it to the real devices of the infrastructure layer. According to the above discussion, Openflow protocol, network virtualization technology and network operating system are the key technology that makes SDN different from traditional network framework.

SDN's Essential Feature.

1) Centralized Control

the centralized control also makes the whole network may be viewed as being operated and maintained by one equipment, and it's unnecessary to conduct site configuration for the under layer's standard switch device, so as to improve the convenience of network control. Now, this assume has been realized by Openflow protocol.

2) Completely Open Interface

This is the second important feature of SDN, whose main idea is to package Network capability to API of Network Controller System, on which the application and business can acquire internet capability via calling API, thus, the close integration between business and Network is realized.

3) Functional virtualization

By adopting the way that is similar to server resources virtualization, on the virtual machine platform of universal server, SDN technology simulates realizing the function of traditional switch equipment by means of software, to achieve the most flexible equipment capability, which can bring the most convenient deployment and management [6].

Technology types needed by smart campus

Rong Huai Huang and so on, discussed in their literature [7] that five types of technology are required for smart campus – technology of learning situation recognition and the environment perception, technology of campus mobile internet, technology of social network, technology of learning analysis, technology of the organization and share for digital resources. Moreover, With a large range of area, lots of users, and a large traffic data, campus WIFI is generally of large scale, and because its requirements of network coverage is also very high, that is, seamless roaming between indoors, outdoor, auditoriums, dormitories, libraries, public places and so on, should be able to realized, load balancing is especially important, and the phenomenon of communication congestion in local area often appears. Traditional practice can't solve the problems well such as how to make the network adjustment easier, how to make the configuration more flexible, and the cost of installation and use cheaper, the dynamic adjustment and upgrade on demand of network topology structure become extremely important, especially for those regions whose access points need frequent moving.

We deem that the above five type of technologies of smart campus are all built on basis of the computer communication network. SDN technology will be tremendous challenge against the foundation of traditional internet communication - IP technology, so it can be anticipated that SDN

technology will be very likely to dominate several engineering application scenarios of the future smart campus.

Sdn application scenario of smart campus

The First Application Scenarios of the SDN Engineering: the Big Restructuring- Switch Fabric of Campus Network.

Nowadays, the vast majority of campus network in Chinese colleges and universities primarily are three-tier constructions, i.e. the core layer, convergence layer and access layer.This traditional switch fabric has brought two most prominent problems: one is that the exit routes, switching equipment's and server are unevenly busy or idle, so load balance is constantly needed. The other one is that although the campus switching equipment have been upgraded and updated frequently, the internet access speed of campus users is still generally far lower than that of the home users.

After adopting SDN technology, it is expected to change the status quo and the switching fabric of campus network will certainly be greatly recombined. No matter how wide the geographic range of the whole campus is, no matter how vast the numbers of its users is, the topological structure of campus network will present delayering with only control layer and access layer. Under the command of network control system, several sets of SDN controller in control layer do their jobs of network resource scheduling; Access layer is composed of numerous standard switches loaded Openflow protocol. Physically, it still requires the piecewise connecting between switches, but it logically no longer needs transmitting layer upon layer. The whole campus network is expected to fundamentally solve the two major problems of load balancing and upgrade extensions.

The Second Application Scenarios of the SDN Engineering: Campus Network Provides Personalized Service of Slice.

After introduction of SDN technology, the real-time function can be increased for different services and device types, and users' requirements for service quality can be met as required. The support for the virtualization of control plane can come true by utilizing the OS-level (operating system level) virtual machine flow visor; an independent "container" is offered to each virtual router through some of the characteristics provided by the Linux kernel, and on the basis of Sharing CPU and memory resources, to ensure the configurability of the allocation of resources and the mutual isolation between the virtual machine. In the data plane, processing card of dedicated hardware packets strictly executes the configuration from the upper software to the data plane of each virtual router, and the data path of resource allocation and isolation are realized. The noninterference of data from different virtual router has been realized between hardware and software through multiple independent IO channels, which makes it, come true to have the guarantee function of virtualization and isolation. A set of text configuration files define and control the various rules of the network activities, such as permission, read only and refuse, whose scope includes traffic source IP address, the port number or the information of packet header. In brief, having sent a request according to the business needs and after approval, users can use network resources for slicing.

The Third Application Scenarios of the SDN Engineering:Campus Personal Cloud Space.

China's Ministry of Education is advocating achieving one of the goals in the stage of campus informatization when everybody can access learning space. In the age of smart campus, the high-end form of the above mentioned objective is: campus personal cloud. It will be the sole gathering place for various services, Web sites and connectivity, and become the campus users' activity center of calculation and communication. Personal cloud will realize the service transition from the client device to cross-device and based on cloud delivery. The critical difficulty of campus personal cloud is the intelligence of personal attention and learning situation.

What kind of role SDN will act in the intelligence? As we know, the so called "intellisense"must not lack of the support of DPI technology. Deep Packet Inspection (DPI) is a technique of flow detecting and controlling based on the application layer, which can carry on research on different behaviors of the terminal, establish behavior recognition model, and judge the ongoing action or the upcoming action according to user's behavior which has been implemented. All these need access to

the information on the network status, traffic data, optimization strategies, and security control. SDN control plane arises at the right moment. The switch supporting Openflow protocol can be pre-loaded DPI program, applies and perceives subscribers' services, so to speak, SDN is the boost engines of DPI.

The Fourth Application Scenarios of the SDN Engineering–Campus Private Software Customization DIY.

Smart campus is coming. SDN is coming. In future, if campus fanciers of zealots want to compile APP program, perhaps they no longer program just in certain code, and maybe they can use their fingers on a beautiful graphical interface to drag some icons out of the rich and powerful database, display them in the order as their own need, attach them with necessary operating parameters, and label simple executive command, OK! Will this kind of personal DIY software be popular? App Inventor, the programming tools from Google LAB (now taken over by MIT) has already been rudiment[8], but the tool remains to increase the northbound interface APP of SDN north interface API, and it remains to be further dumb down nonprofessionally and convenient for college students to DIY. Conclusions

In the proposed algorithm, the multi-objective bilevel programming problem is transformed into a single-level problem by using interpolation functions of the lower level solutions. The process avoids solving the lower level problems frequently, and reduces the computational cost. The major advantage of this algorithm is that it can solve some complex issues, in which the lower level problems are non-convex and non-differentiable. Hence, it can be used to deal with hard multi-objective bilevel programming problems.

The Critical Problems SDN Campus Applications Intend to Solve

SDN technology is still in the exploratory stage, there is still a long way to go if we want it to play a massive role in smart campus. The east-westbound and northbound of SDN's standard has not been established, and there are still many difficulties in improving its own technology. To enter the implementing deployment of the engineering level, we believe that there are severe challenges from the following key questions.

Challenges to SDN Products' Compatibility.

The implementation of API, protocols and vendors must undergo comprehensive testing to ensure the consistency between the standards of industry authorities, of course, the issues of interoperability between various types of SDN controllers should also be included. New products of SDN being applied to smart campus, the conduct of traditional network will be bound to be changed, which may lead to conflicts of existing network services. Therefore, rigorous compatibility testing will be required for each new application and new versions of each application.

The portability of the hardware devices and management modes from different manufacturers, the collaboration between multiple controllers from different manufacturers, and how to achieve smooth evolution from existing hardware platforms to virtualized networks, are the primary problem that must be solved in the transition period when the new SDN technology coexists and co-administrates with campus traditional Ethernet.

Challenges to the Usability of Technology Management .

The concept of BTO is produced along with SDN technology; BTO manufacturers make the network devices the same way as they make PC. Once network equipment is standardized, manufacturers can provide hardware and boot loader, and can also supply drive and operating system for optional use. Finally technical and administrative staff of campus network can select network devices as they choose PC, and then to install the operating system and applications by themselves, thus the rapid deployment and innovation of special services are achieved.

We must answer a question before implementing the above process: How does the school equip with its own network engineer? Many of today's SDN solutions are far from perfect, which need a lot of industry users' customization. There is no real-time command line interface or web-based management at present in SDN' implementation and users have to manage the configuration file to make a variety of adjustments and controlling behavior. It's difficult for schools to have ready-

made SDN technical talents available, and it's infeasible to make great efforts in additional cultivating maintainers or recruiting programmers separately to program to control devices' forwarding behavior. In other words, problems of technology usability should be solved when SDN lands the smart campus.

Risk Challenge to the Open Interfaces.

Northbound programming interface exposed to users directly, and the new SDN network does has a lot of management risk. The IT department of campus has relieved some potential, known risks by taking measures of access control, reliance, encryption, deep packet inspection and so on, but in colleges and universities, facing a large quantity of student fanciers who are wild about adventure and exploration, the programmable API is to some extent tantamount to the kind of dangerous toys like "guns".

Security Challenges to SDN Network.

The new technology is always a double-edged sword. Standing in a different perspective, it may be a great development and innovation, and may also be a great crisis, mass destruction. SDN architecture can connect the performance monitoring with security scanning system of campus network. Meanwhile, if an attacker destroys SDN control layer, they will be able to hide their whereabouts from monitoring and security systems. For the sake of controlling the access request of application programs SDN utilizes the visualization and flexible management of internet flow to guide the flow to specific business servers, which thereby ensure the right direction of application program and flow. But how to insert traditional firewall or IDS/IPS system functions in control hierarchy, a safe and proper solution to it is required to seek.

Conclusion

In smart campus, the greatest contribution of SDN technology is: application-centric visibility, management, automation, configuration and layout have brought great opportunities for the intellisense of information. Apparently it's impossible that all problems can be solved by one single technology, and SDN is not Jack of all trades and master of none and cannot solve any existing network problem either. The technology required to build the setting of SDN is still in its early growth phase of exploration. There are too many unknowns, however, it is deemed that if we are actively dedicated ourselves in research, test and experimentation in the process of smart campus construction of colleges and universities, it is bound to arise application innovation and technical innovation, and even theoretical innovation.

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