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Policy-based Slice Embedding in a virtualized testbed on KREONET

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***Abstract*— Recently, the software-defined networks (SDNs) are the most promising architecture which are mainly composed of the Openflow switches and the Flowvisor. The SDN provides virtualized separate networks as slices on a physical network according to the customer needs. The Flowvisor can provide customers to have their own controller and let the controller handle flow packets in its slice –a virtual network. In this paper we proposes a policy based slice embedding and have deployed a prototype in a virtualized testbed on KREONET – a Korean R&E network. The slice embedding system is designed as a part of aggregation management system to administer our testbed as interact with Flowvisor and slices can be automatically assigned by network resource provisioning with decision of Policy based Engineering (PBE) module in the system. Several points are considered to make policies for slicing so that slice embedding service for provisioning virtualized networks could be automatically deployable.**

***Keywords*—virtualization, Slice embedding, Flowvisor, KREONET**

I. Introduction

Nowadays, the Software Defined Networks (SDNs) are a new technological direction for the future internet architecture to innovatively resolve traditional network's problems and has been being developed as the future infrastructure in the research as well as industry fields. The architecture is mainly composed of the OpenFlow switches [1] which separate the network Data Plane and Control Plane, permitting external software to monitor and control network resources and the Flowvisor [2] which is used as a virtualization component which provides virtual slice isolation and delegate specific messages to the designated OpenFlow controller. The physical networks in the SDN architecture can be shared in individual virtualized networks so that users can exclusively their own networks by their OpenFlow controller.

GENI [4] and Ofelia [5] are famous testbeds to successfully apply the OpenFlow and Flowvisor concepts. As the physical networks are provided as an individual virtual network to each customer in which a flow table in a physical switch can be organized with flow spaces sliced for customers, switches should be manipulated concurrently by individual customers' multiple controllers. Therefore, operation systems for those testbeds must be complex and should provide full-featured capability to appropriately handle virtualized resources. As an approach going to those operation systems, we have a plan to develop an mechanism to automate the deployment and operation of arbitrary virtualized SDN topologies with minimal intervention by the substrate operator. For our development, we have taken a policy based approach in order to automatically allocate resources a slice by customer's requests.

In this paper, we have described our initial design on a policy based slicing mechanism in order to finally make software defined network management system capable of administrating user-defined related experiments. Our system has been being developed to deploy the viratualized infrastructure in KREONET network infrastructure, validating our idea to the operation production networks. The rest of the paper is organized as follows. In section II KREONET – a Research and Education network in Korea is introduced and related work for the virtualized service based on Flowvisor is described. In section III policy based management system is designed and how we have being developing it is described. Finally section IV concludes the paper and gives the future plans.

II. INFRASTRUCTURE and SDN

A. *KREONET*

KREONET (Korea Research Environment Open NETwork) in figure 1 is a national R&D network supported

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managed and operated by KISTI (Korea Institute of Science and Technology Information) since 1988. KREONET has a high performance network infrastructure that provides R&D resources, including a wide range of information on science and technology, supercomputing, GRID, and e-science applications, to about 200 key R&D centers in the industrial, academic, and corporate sectors.

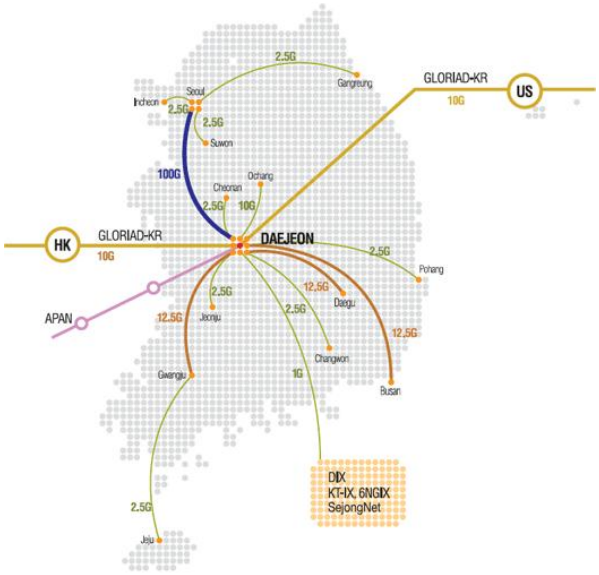

Figure 1. KREONET

KREONET is comprised of 16 areas and 16 local network centers (GigaPoP), and is providing a 10Gbps backbone, in the form of the SuperSiReN to boost their advanced applied R&D and tests with a high performance network. KREONET also provides thirty more 1Gbps high-bandwidth lines as a state-of-the-art applied R&D network for advanced applied R&D.

B. *Network Virtualization based on OpenFlow*

There are many research works for providing virtualized networks using Flowvisor. [5] has proposed an innovative system called ADVisor (ADvanced FlowVisor). In Flowvisor, two slices cannot share the same flowspace and may interfere other's traffic. This work enhances some features to overcome its major constraints. In [6], admission control and bandwidth guaranteeing scheme at Flowvisor has been implemented. For network resource virtualization, bandwidth isolation at allocated switches on a given slice and admission control are required. But, it needs to be implemented in queues of the switch. So, In this paper, admission control and minimum bandwidth guaranteeing scheme are implemented at the FlowVisor. It shows bandwidth isolation scheme among slices in the multi-user environment. [7] introduces isolation problem between the slices of a virtualized switch, and has developed a model that provide the choice between several levels of isolation by corresponding each level to one or more resources. [8] describes a control plane architecture to enable substrate providers to resell their SDN to multiple tenants while minimizing operator intervention by automating the slicing. Like these works, we takes the same approach to use Flowvisor to provide virtualized networks, but as far as we know, the policy based engineering for slicing the virtualized networks is firstly proposed.

III. Policy based Mgmt system

A. *a virtualized network service on KREONET*

In this paper, a service to provide virtual networks to KREONET users is developed. As shown in figure 2, backbone switches in KREONET provide connections to OpenFlow switches such as Pronto switches and Open vSwitches (OVSes), providing a testbed as OpenFlow@KREONET. When a KREONET user requests a virtualized network to OF@KREONET management system, the management system assigns a slice for it, and makes the Flowvisor recognize it and the user's OpenFlow controller be able to control his/her own virtual networks by delivering the OpenFlow messages through FlowVisor(s).

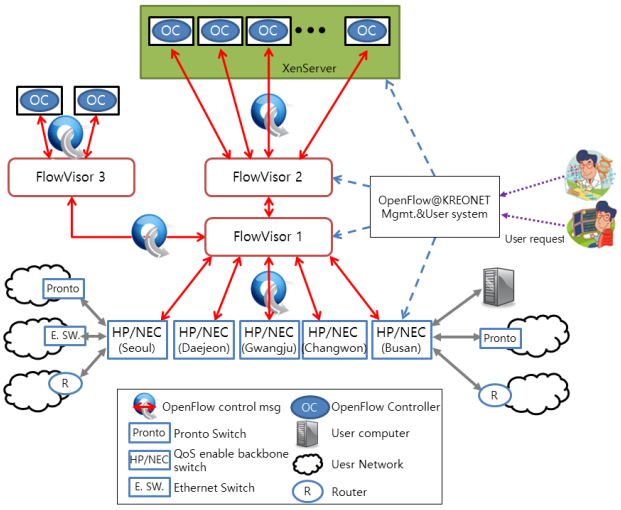

Figure 2. OpenFlow@KREONET

Interaction between the network manager and the management system users for the virtual network service in OF@KREONET can be seen in figure 3. Users can send their requests for virtual network slices to OF@KREONET virtual network management system(VNMS) anytime [9]. If the user request is permitted to provide a slice, the status information for the slice is delivered to the user through the Web interface.

All of processes from user requests to service provisioning are administered by the network manager. The manager investigates user requests and decides how the corresponding virtual networks are allocated according to the user level as well as the network status. In order to automatically administrate this virtual network service, a policy based approach is considered in this paper. The manager in OF@KREONET VNMS set policies to appropriately assign network resources and monitors the resultant network status

by the visualized Web reports without individual intervention of the manager.

After a slice from the user request is decided by the manager, OF@KREONET VNMS assigns an OpenFlow controller through the Flowvisor and provides a proper topology for a slice. Then, users can control their own virtual networks and send/receive their traffic within a slice. Users should be able to monitor their own traffic and the management system should be able to collect network information in multi-levels such as the individual user's network level and the administrative whole network level.

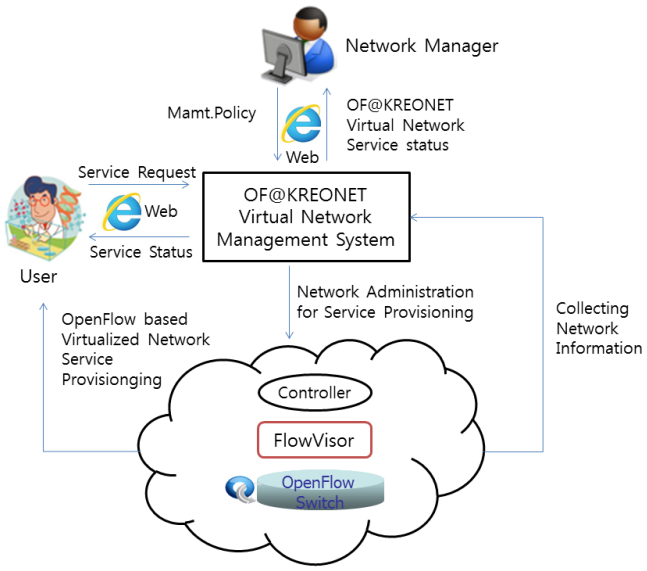

Figure 3. OF@KREONET Virtual Network Mgmt. System

As OF@KREONET VNMS is designed to do operations based on its policy for automatic decision and enforcement of virtual network slice allocation for users, how the functionality of the policy based engineering module is developed should be considered.

B. *The Policy based Engineering module*

OF@KREONET VNMS is for automatically providing services to allocate slices to users as exclusive virtual networks according to requests. When a user sends a request, a manager firstly checks whether resources for it is available or not. So, we can guess the manager as a human being would do the following things:

- The manager always gets information about resource usage by monitoring network status.
- For network resources whose slices and flowspaces are already allocated, the manager always figures out each user's topologies and individual traffic amount.
- When a user requests a new slice, the manager makes VNMS to calculate the topology and needed network resource amount for the slice, and checks the resource available in each link on paths at the topology.
- When a 'regular user' requests a slice, if the requested bandwidth/resource amount plus currently being used amount is over a specific threshold such as 70%, the manager may decide to reject the request itself, or provide partly the requested slice but exclude links that do not have sufficient resources from the topology.
- When a 'premium user' requests a slice, even if the requested bandwidth/resource amount plus currently being used amount is over a threshold, the manager may decide to accept the request and allocate resource to the slice.

Like this, as a manager should figure out the current status and decide how much to provide the virtual network service according to the user level, we can make a module in the policy based approach to play the manager role. Then the network service can be operated automatically without human being's intervention.

Figure 4 shows OF@KREONET VNMS interacting with Policy based Engineering (PBE) module. In order for PBE module to figure out network status, what users have requested as well as what resource for allocated slices is being serviced should be investigated, and current usage information about network traffic should be gotten in the multi-levels such as the individual user/user group level and the administrative network-wide level. In this paper, it is designed that all information about users, users' requests and allocated virtual network resources is stored in the database and the current network usage information is gotten from sFlow system [10] that has been customized to our virtualized network. Then, it is possible for users as well as the administrator to be able to monitor the resource in their view points.

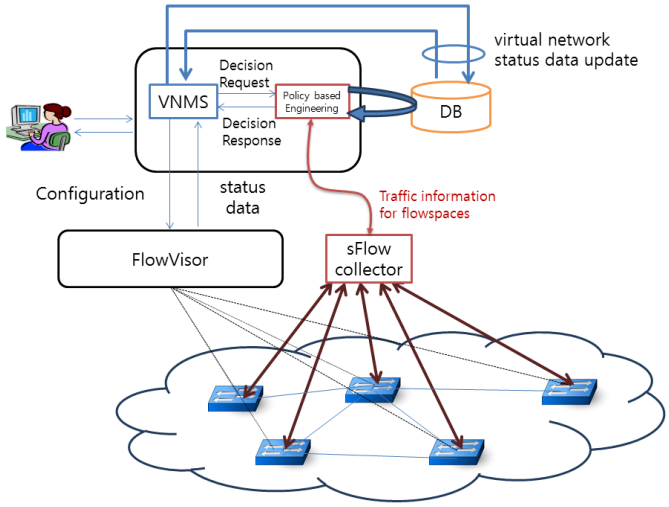

Figure 4. the Policy based Engineering module in OF@KREONET Virtual Network Management System

As we can see, when a user requests a slice, VNMS gets requisite parameters through the web and requests the Flowvisor to allocate the slice and its related flowspaces based on decision from the PBE module. All data generated in this process are stored to the database.

As described, All user requests are passed to PBE module for allocation decision. Then, PBE module first calculates the corresponding topology, and checks whether this topology is overlapped with existing ones or not. And, PBE confirms that the calculated topology is loop-free. Finally if requested resource amount in each link in the topology is not congested, PBE can decide to permit the allocation. For this decision, PBE can use monitored data gotten from sFlow system in the user level as well as the network-wide level. The final decision goes back to VNMS, and information about the allocated slices and flowspaces is stored in the database. We assume the database can always keep the current status information by our mechanism. For these operations, PBE module can be designed as shown in figure 5.

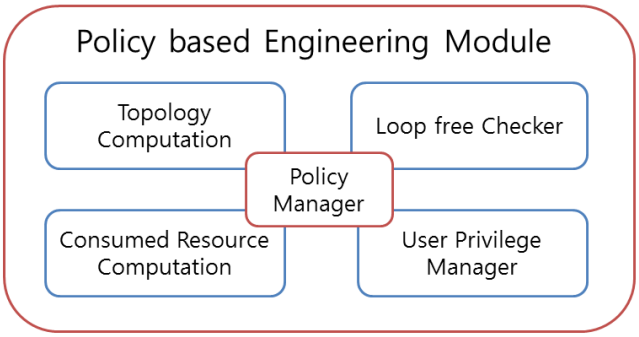

Figure 5. Policy based Engineering module

As explained, the Topology Computation module computes the possible topology from the request and builds a actual a set of nodes and links based on the user privileges and current usage data. How to decide the topology to be serviced is restricted by criteria stated in the policy. The Loop free Checker module is to just check the loop free for the computed topology. The Consumed Resource Computation module is to get current status data from DB and sFlow system and decide which links and nodes are not available, and give the computed results to the Topology Computation module. The User Privilege Manager is to check the policy and constrain the usage of network services for each users.

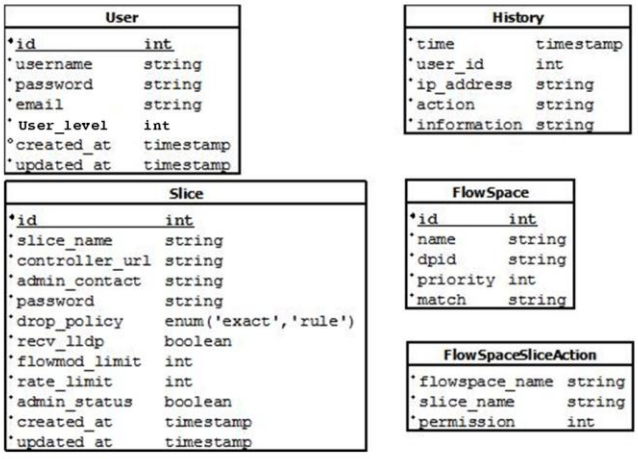

Figure 6. DB schema

The schema for our database is shown in figure 6. It consists of five tables - User, Slice, History, FlowSpace and FlowSapceSliceAction. User table has all registered users and the values includes id, password and etc. Especially an item - user level has one of two values – 'premium' and 'regular'. According to its value, even if a link is congested, the link can be assigned to the requested slice. Slice table stores all the slices defined in FlowVisor and each item has all related parameters. Flowspace table is for created flowspaces. FlowSapceSliceAction has values for relation between slices and flowspaces. History table contains past data.

IV. Conclusions and Future Work

This paper has suggested a policy based engineering module for automatic operations in OpenFlow@KREONET virtual network management system (VNMS) in user-defined network infrastructure. In our system, researchers (KREONET users) can build virtual network isolation slice regarding their set of requirement specification for research and education purposes. We have shown our design for Policy based Engineering module and described its operations and interactions with VNMS. It includes how to handle the data from users and collect status data, and how the decision is taken. We are developing OF@KREONET VNMS with the PBE module. It is expected that our system can automatically provide virtual network services to various users in the KREONET.

This paper only presented our beginning work. Our ongoing work includes a design of the optimization algorithm for aggregation management to maximize the probability of satisfying of a new user flow's performance requirement and minimize the number of rejected flows. In other hand, we also plan to enhance our virtual service platform model by adding OpenStack resource manager to taking care also of OpenStack cloud resources for computing virtual host machine and implement OpenFlow component on Openstack-based cloud environment.

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References

[1] Open Networking Foundation. "Software-defined networking: The new norm for networks," ONF White Paper, 2012.

[2] R. Sherwood, G. Gibb, K.-K. Yap, G. Appenzeller, M. Casado, N. McKeown, G. Parulkar, "Can the production network be the testbed?,"In Proceedings of the Ninth USENIX Conference on Operating Systems Design and Implementation, CA, USA, 2010, pp. 1–6

[3] A. Bavier, et al, "GENICloud and TransCloud: Towards a Standard Interface for Cloud Federates," In Proceedings of Workshop on Cloud Services, Federation, and the 8th Open Cirrus Summit, CA, USA, 2012.

[4] M. Sune, et al. “Design and implementation of the OFELIA FP7 facility: The European OpenFlow testbed,” Computer Networks, Elsevier, 2014, pp. 132-150

[5] Salvadori, E.; Doriguzzi Corin, R.; Broglio, A; Gerola, M., "Generalizing Virtual Network Topologies in OpenFlow-Based Networks," *Global Telecommunications Conference (GLOBECOM 2011), 2011 IEEE* , vol., no., pp.1,6, 5-9 Dec. 2011

[6] Seokhong Min; Seungju Kim; Jaeyong Lee; Byungchul Kim; Wontaek Hong; Jonguk Kong, "Implementation of an OpenFlow network virtualization for multi-controller environment,"*Advanced Communication Technology (ICACT), 2012 14th International Conference on* , vol., no., pp.589,592, 19-22 Feb. 2012

[7] El-azzab, M.; Bedhiaf, IL.; Lemieux, Y.; Cherkaoui, O., "Slices Isolator for a Virtualized Openflow Node," *Network Cloud Computing and Applications (NCCA), 2011 First International Symposium on* , vol., no., pp.121,126, 21-23 Nov. 2011

[8] Zdravko Bozakov and Panagiotis Papadimitriou. Autoslice: automated and scalable slicing for software-defined networks. In *Proceedings of the 2012 ACM conference on CoNEXT student workshop*, CoNEXT Student ’12, pages 3–4, New York, NY, USA, 2012. ACM.

[9] Ardiansyah Musa, Sungmin Hwang, Fiqri Muthohar, Gihyun Bang, Deokjai Choi, Kyungbaek Kim, Wangcheol Song, Seungjoon Seok, Seunghae Kim, "Aggregation management design for user-defined network infrastructure," accepted at The 16th Asia-Pacific Network Operations and Management Symposium (APNOMS 2014).

[10] sFlow. http://www.sflow.org/.

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