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Multi-Tenant Networks in SDN

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ABSTRACT: Software Defined Networking (SDN) is a new network architecture that eliminates the limitations of current network infrastructures by separating the control plane from the data forwarding plane. SDN has a long history of efforts to make programmable networks. By centralizing control plane decision making helps to program the forwarding decision. Multi-tenant networks can be created on a SDN controller with Virtual Tenant Network (VTN).The paper aim to discuss the SDN characteristics to design and build multi tenancy.

I. INTRODUCTION

The network which is programmable with minimal complexity, less expensive, easy to integrate with business application and can be controlled by a commodity server is known as Software Defined Network (SDN). Multi-tenant network in SDN is a new revolution of the internet that is rapidly gathering momentum, driven by the advancement of cloud computing, software defined networks and internet of things. As the advance of these technologies it need to communicate with different components hence the complexity increases and there is a need to develop a technology which can give high performance and fault tolerance. In case of Internet of Things (IoT), designing of system is one difficult task as it must maintain several nodes for communication and monitoring of real time data. With cloud computing these huge data can be handled. Apart from this we are concentrating about the networks and networking components

Adoption of SDN architecture helps to share the underlying resources in dataflow for multiple tenants transparently. That's the data center of network is broken up and logically separated as individual networks. Each individual network is called tenants, like tenants in the apartment complex. With the advance use of V-lan, virtual data center and cloud computing technologies the same concept is again come in to picture as Multi-tenant network.

II. SDN Architecture

Software defined network is an approach to develop, manage and monitor networks using the software. Technology transformation makes it difficult to grow with the traditional networking methods. SDN has the power to kick start legacy data centers by offering flexibility, control, and a direct path to virtualization. Some of the key ideas of SDN is the separation of data plane and the control plane. Separation of control plane to external controller will make network service chaining possible, extensibility by programing the network through simple external application.

Some of the benefits of SDN is to increase productivity by reducing the configuration time and fault tolerance mechanism. As most of today's applications need the real-time data fetching, it is possible by enabling the network with SDN. As per the Service Oriented Architecture (SOA) the speed of service should be maintained by automation with SDN.

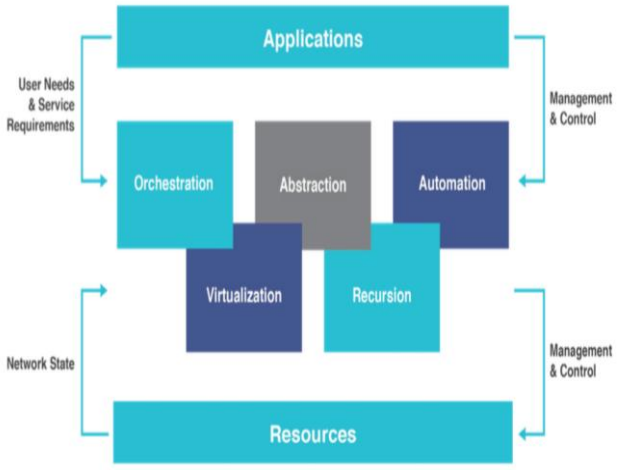

Figure 1. SDN Architecture

Above figure is a simplified architecture of an SDN, consist of three layers.

- Application layer
- Control layer
- Data layer

Control layer provides all the resource to the user as per the requirement. Multi tenancy will be deployed here which adopts SDN architecture, where multiple tenants transparently share

the underlying resources in data plane, without the knowledge of other's existence.

III. Network Function Virtualization

NFV is a network architecture concept that enables the entire network in to multiple virtual networks. NFV allows multiple virtual networks to work or communicate together to create a communication server.

Hypervisor allows different virtual machines to share the common resources without the knowledge of others existence. The concept is like the tenants in the apartment where each individual tenant share the same resources from the apartment but mostly likely without interacting with each other. Hypervisor will slice the resources and allocate each slice to tenants. Tenants are not aware about the resource allocation as hypervisor hides the complexity of entire network.

To provide complete virtualization environment the network should possess similar properties of the computing layer and have ability to support arbitrary network topologies and addressing scheme. Each tenant has the capability to configure the computing nodes and the network. Host migration ensures the migration of corresponding virtual ports. Proven and stable virtualization approaches like VLAN, NAT, MPLS primitives are enough to build automated network virtualization, but these technologies are based on box -by-box basics configuration. There is no unified manner and the main challenges is with the consequence of current network implementation take months while computing implementation take only minutes. These challenges can be overcome by network virtualization function in SDN.

- Slicing the network (auto slice, flow N)
- Multitenant network hypervisors

IV. Slicing the Network

Slicing of the network means to allow multiple logical network slices share the same openflow infrastructure abstraction layer. Make it simpler to slice the open flow switches and allow multiple and diverse networks share the infrastructure

There are five possible slicing dimensions

1. bandwidth
2. topology
3. traffic
4. device cpu
5. forwarding tables

Each network slices connects to a controller. Multiple controllers can co-exist within a single physical infrastructure. flowvisor allow to create multiple network slices and slices can be controlled by different controllers.

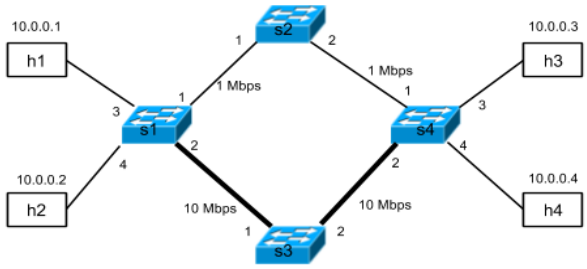

Figure 2. WAN Architecture

From the above figure, the slicing of WAN where each site is represented by separate openflow switches, s1 and s4 respectively. There are 2 paths between S1 and S4. Low bandwidth path is S1-> S2->S4 and a high bandwidth path S1->S3->S4. Slicing can be done by below 2 parameters

A. Topology based slicing

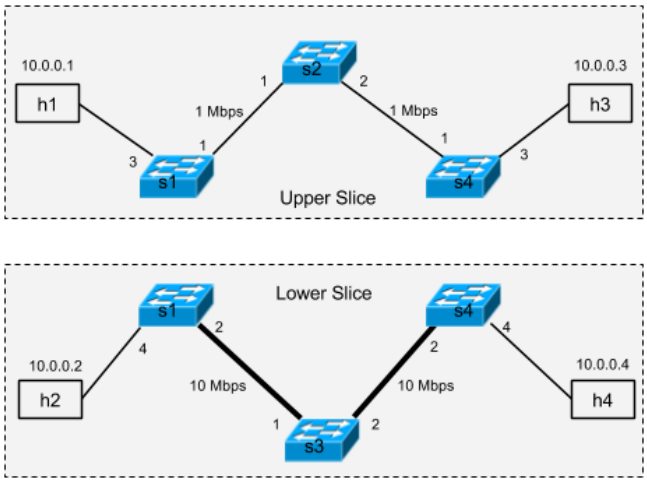

Figure 3. Topology based Slicing

Topology based slicing considering network topology as the parameter to slice. Each switch maintains its own flow table by using the switch data path created by the controller flow rules

B. Flow based slicing

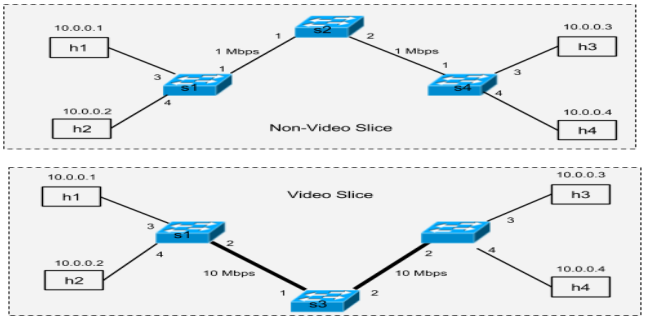

Figure 4. Flow based Slicing

Network can be sliced based on any attributes of flow space. Here the slicing is done according to low and high bandwidth paths. We can priorities these paths by sending video traffic

V. Multitenant network hypervisor

Below are few options to configure the multitenancy is as follows

a) open day light virtual tenant controller

b) configuring tenants

c) isolating segments and tenants

A. OPENDAY LIGHT Virtual Tenant Network

Open-Day light controller creates one container for each virtual network. There virtual networks are managed as separated isolated networks, though they are mapped in to same infrastructure

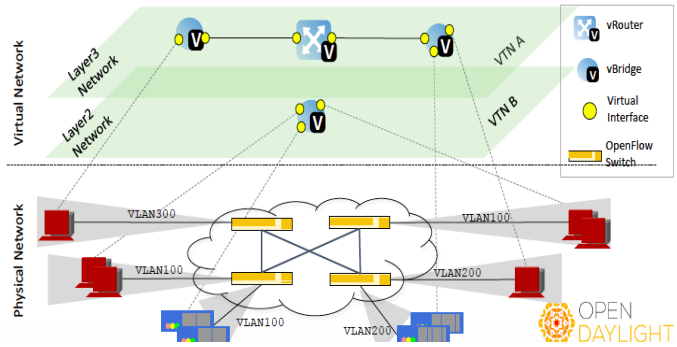

Figure 5. OPENDAY LIGHT Virtual Tenant Network

Open-Day light virtual tenant application provides multi-tenant virtual network on SDN controller. With traditional networking system, it is difficult or impossible for the system to work with unrelated systems. Various independent applications must be implemented in each tenant. This creates a huge responsibility for the network engineers to design, implement and operate a complex network. Virtual Tenant Network (VTN) gained its importance that it will ensure the users to define a network without knowing the physical topology or bandwidth restriction. VTN provides a complete separation of logical plane from physical plane. VTN allows the user to define a network which looks and feel like a conventional L2/L3 networks (virtual router and virtual switch). Once the network is established in VTN the logical plane is separated from physical plane which reduce the complexity post network is designed and automatically mapped to the physical network. VTN provide as better management of resources, reducing their reconfiguration time, minimize the reconfiguration time and minimize the configuration errors.

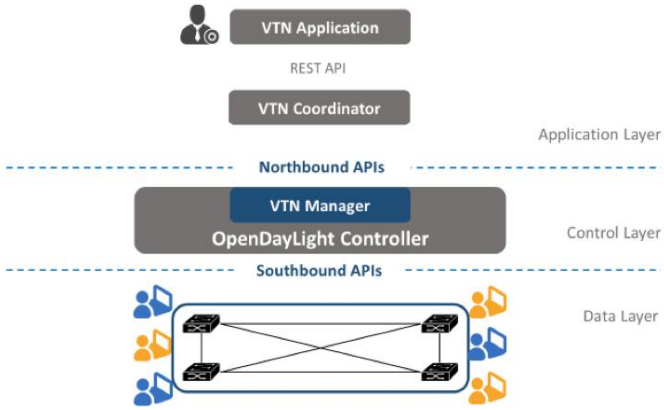

Figure 6. VTN Manager

SDN controller is in the control layer which interacts with the underlying data resources and the applications. By implementing VTN in SDN controller the controller is subdivided in to number of tenants which is logically separate with no knowledge of others existence. A OpenDay light VTN controller with a VTN manager, who controls all the controlling and allocation of the tenant based on segment rule. Criteria should be followed by the VTN manager to monitor and maintain each tenant. Where in application layer the VTN application and VTN controller communicate using the rest API's. Here we are proposing an operator network which is in north bound of SDN controller; these north bound interface will provide a transparent resource sharing from the data plane with a controlled and monitored environment by the VTN controller

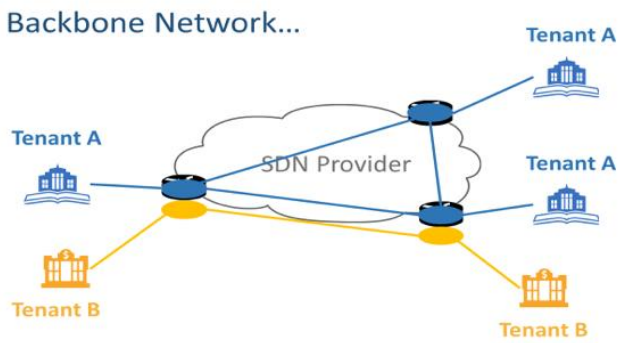

Figure 7. Backbone Network

Each tenant in the SDN controller behaves as a different network using the virtual router and virtual switches hence traffic gets reduced and complexity also minimized. VTN controller will customize each tenant according to the demand of application.

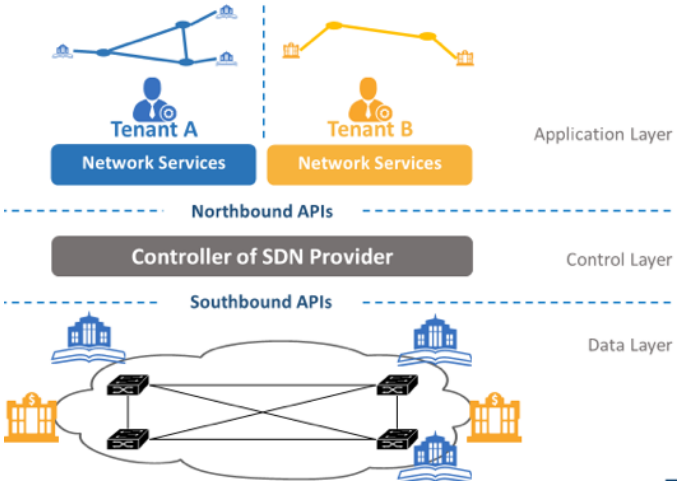

Figure 8. VTN Controller

The general goal is openness of the network; the tenant network can control and monitor. Each tenant is customized according to the corresponding application needs hence the network component itself can get the decision-making capability.

Second goal is security and privacy, as we know security and privacy of the emerging technologies like cloud computing and IOT is questionable. By using the VTN we are using virtual routers for sending packets as it is customised per their needs it will provide privacy and security as well. For connectivity basis, we have the options for intra/inter tenant and external communication. This system provides a resource and service management elasticity.

B. Configuring Tenants

Configuring the tenant is a challenging task for the VTN manager, where while configuring the tenant it should meet the requirement of that application. For configuring tenant VTN manger has several options to determine the type of machine is corresponding with the virtual network. These include:

- Location information such as the switch and interface to which a machine is attached
- Packet information such as the layer 2 MAC address, the layer 3 IP address, or VLAN
- External information that can be mapped to either location or packet information
- Any combination of the above

These policies are determined by the "segment rule" in RESTAPI, and each member of the virtual network segment is considered attached to an interface in the virtual network segments.

The VTN manager in controller will create multiple tenants according to the application needs. Each tenant is independent with different design and configuration parameters

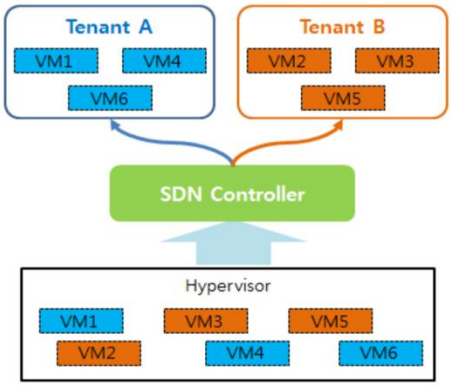

Figure 9. Configuring Tenants

Hypervisor will have pool of resources (virtual machines) which will be divided among these tenants on the basis of requirement.

Segmenting each tenant with multiple segments

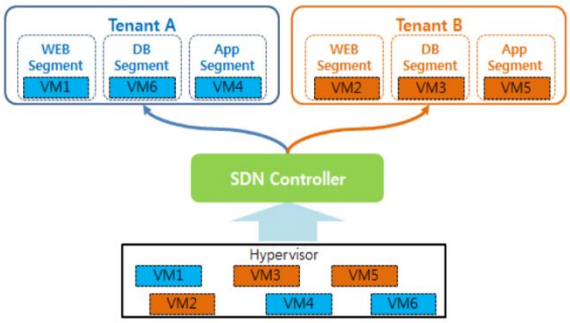

Figure 10. Configuring Segments

Each tenant can be segmented in to multiple VMs and further grouped into logical, virtual networks. Website visitors can be categorized as web segmentation that share common traits such as location, device used to access the site, hour of the day, and other behaviors. Likewise, the DB segments and APP segments are also separated and these VMs are distributed among each segment.

These segmentations can be done in three different ways

- MAC address and cost policy based
- IP-subnet and cost policy based
- VLAN and cost policy based

a) MAC address and cost policy based

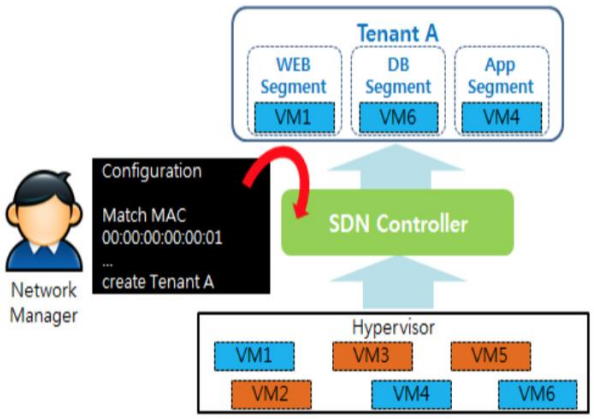

Figure 11. MAC based configuration of segments

Tenant network can be defined using each device MAC address. VTN manager in controller saves all the device MAC addresses in each tenant. Whenever there is a need for the application to connect with the particular device, VTN manger will checks the cost assigned to it and the router will behave accordingly.

By defining the cost policy base, the low-cost packets and high cost packets are routed separately. Network Manager can define the routing options to route the packet based on the cost.

b) IP-SUBNET AND COST POLICY BASED

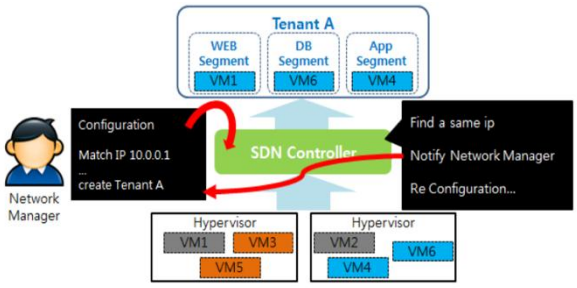

Figure 12. Configuring same private IP in tenant

VTN manager defines the tenant based on IP-address. When the app needs to communicate to a particular device it will check the ip address and send the packet to the ip address of the corresponding device resides in the tenant. The problem with this is the controller should know all the device information. Which is not feasible in the real time.So the controller based on the ip cannot match the actual device. In order to resolve this controller needs to find a device function. Network Manger get the notification from these function. The administrator can assign the same private ip in cloud to cloud network. Tenant will be the parent of segment; we can find the right device by adding the parent details along with the parent details.

c) VLAN and COST policy based

The third approach is configuring the tenant segment based on VLAN ID. Each VLAN has a unique id by using this id we can define the tenant segments

d) Isolating Segments and Tenants

isolating the segment and tenant means to separating each tenant and segment for specific application such that it does not have the information about others existence. Setting a virtual router is one of the methods for isolation.

VI. Virtual Router

Each tenant creates a virtual router so that the segments in the tenant as well as with other tenant communication can be separated. Hence isolated communication is possible. Virtual routing is responsible to determine the actual policy that should apply to the flow

The application allows you to control connectivity and traffic patterns in several different areas

- Between hosts within a given virtual network segment.
- Between different virtual network segments of a given tenant.
- Between virtual network segments of different tenants.
- Between hosts, virtual network segments, tenants, and the external network.

a) Routing between segments

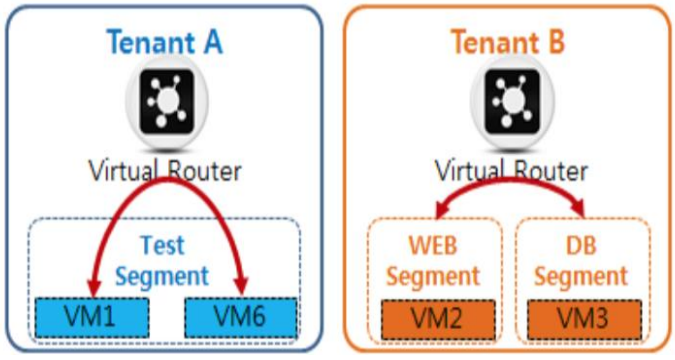

Figure 13. Routing between segments

Routing rules on the virtual router will be specified once the

Router interfaces are configured and connected.

b) Routing Between Tenants

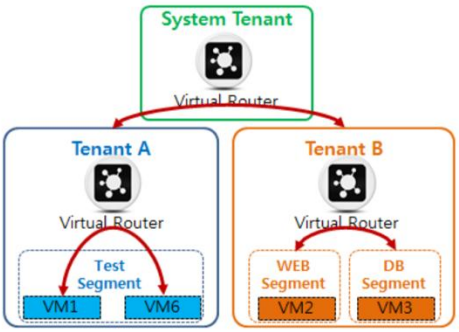

Figure 14. Routing between tenants

The main difference in the configuration of distributed virtual router and tenants distributed virtual router is the routes are not between the virtual routers, it's between the tenants.

c) Routing to external network

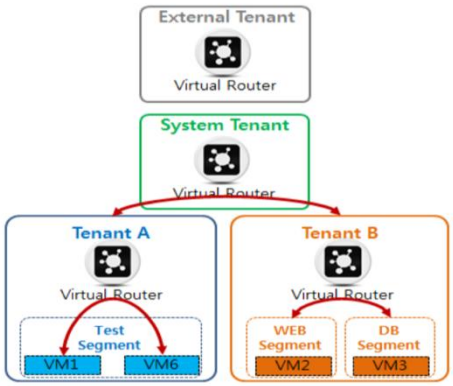

Figure 15. Routing to external network

To communicate among different tenants and communicate with outside world, we need to configure system tenant/system virtual router and external tenant accordingly

VII. Key Benefits

1. Virtualization concept can be adapted by segregating different logical flows with respect to logical network.
2. Dynamically applying security policy will improve security based on user's context.
3. Provide seamless mobility.
4. Provide application aware infrastructure to interact with network through SDN controller.
5. Better management of network infrastructure by a centralized controller.
6. No touch device level conflicts
7. SDN provides a way to multicast tree without complex protocols and optimize streams based on types of end devices.
8. Improved productivity by improving user experience, data security, time and speed of service.
9. Decrease operation and capital expenses.

VIII. Conclusion

The network should be application aware. It must be aware aboutthe traffic flow, and it must understand the characteristics and requirements of the application that initiates the packet. Business units now want the agility to access applications, infrastructure, and other IT resources on demand. Organizations with these criteria and with requirements for multi-tenancy, VM migration and scalability challenges should consider SDN offering in multi-tenancy.

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