Advantages and Disadvantages of Overlay-Based SDN Solutions

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Background

The overlay-based approach to implementing network virtualization leverages tunneling and encapsulation techniques to construct multiple virtual network (VN) topologies overlaid on a common physical network. A virtual network (VN) can be a Layer 2 network or a Layer 3 network, while the physical network can be Layer 2, Layer 3 or a combination depending on the overlay technology. With overlays, the outer (encapsulating) header includes a field (generally up to 24 bits wide) that carries a virtual network instance ID (VNID) that specifies the virtual network designated to forward the packet.

Advantages of the Overlay-Based Approach

The benefits of the overlay-based approach to implementing network virtualization include:

- Virtualization is performed at the network edge, while the remainder of the L2/L3 network remains unchanged and doesn't need any configuration change in order to support the virtualization of the network. The most common approach is to perform the encapsulation at the hypervisor vSwitch, which acts as the virtual tunnel endpoint (VTEP) or network virtualization edge (NVE). As a result, overlay-based solutions can generally be implemented over existing networks with no changes required.

- Support for essentially unlimited numbers of VNs as the 24 bits that are typically used by network overlays to identify VNs can identify slightly more than 16 million VN IDs. While theoretically NV solutions can support 16 million VNs, practical limits are often in the range of 16,000 to 32,000 VNs.

- Decoupling of the virtual network topology from the physical network Infrastructure and decoupling of the "virtual" MAC and/or IP addresses used by VMs from the infrastructure IP addresses used by the physical data center core network. The decoupling avoids issues such as limited MAC table size in physical switches.

- Support for virtual machine (VM) mobility independent of the physical network. If a VM changes location, even to a new subnet in the physical network, the switches at the edge of the overlay simply update mapping tables to reflect the new physical location of the VM. The network for a new VM can be be provisioned entirely at the edge of the network.

- Ability to manage overlapping IP addresses between multiple tenants.

- Support for multi-path forwarding within virtual networks.

- Ease of provisioning virtual appliances in the data path. Network services resident on VMs can be chained together (a.k.a., service chaining) with point-and-click simplicity under the control of NV software.

- For controller-based NV solutions, the controller is not in the data path, and so it does not present a potential bottleneck.

Disadvantages of the Overlay-Based Approach

The limitations of the overlay-based approach to implementing network virtualization include:

- Virtual and physical networks are separate entities, possibly with separate service assurance solutions, policy management, provisioning, and control points.

- As the virtual networks grow and evolve, the physical network does not automatically adapt to the changes. As a result, overlay-based solutions require a lightly oversubscribed or non-oversubscribed physical underlay network.

- Gateways between the virtual network and systems and network service points on the physical network may need to pass high volumes of traffic. If a software gateway running on a VM or a dedicated appliance has insufficient processing power, hardware support for the gateway functionality may be required in physical switches or network service appliances. Some of the more recent merchant silicon switching chips support gateway functionality for VXLAN which is the most popular encapsulation protocol.

- Some value-added features in existing networks cannot be leveraged due to encapsulation. For example, the physical network loses its ability to provide differentiated services based on the content of the packet header.

Overlay-based solutions also create some management challenges. For example, one of the primary benefits of overlay solutions is the ability to support multiple VNs running on top of the physical network. Effective operations management requires that IT organizations have tools that give them clear visibility into the relationships between virtual and physical networks and their component devices. When performance or availability problems occur, both root cause analysis and impact analysis require bilateral mapping between the physical and virtual infrastructures.