

NETWORK VIRTUALIZATION: PRESENT AND FUTURE

Wednesday, May
21, 2008

Mosharaf Chowdhury
Member, eNVy Project

What is Network Virtualization?

Network virtualization is a *networking environment* that allows *multiple* service providers to *dynamically* compose *multiple heterogeneous* virtual networks that *co-exist* together in *isolation* from each other, and to deploy *customized end-to-end* services *on-the-fly* as well as *manage* them on those virtual networks for the end-users by *effectively sharing* and *utilizing* underlying network resources *leased* from *multiple* infrastructure providers.

Basic Concepts

3

Design Principles

- ❑ Concurrency
- ❑ Recursion
- ❑ Inheritance
- ❑ Revisitation

Design Goals

- ❑ Flexibility
- ❑ Manageability
- ❑ Scalability
- ❑ Security, Privacy, and Isolation
- ❑ Programmability
- ❑ Heterogeneity
- ❑ Experimental and Deployment Facility
- ❑ Legacy Support

Outline

4

- Existing Projects
 - ▣ Characteristics
 - ▣ Summary

- Future Directions
 - ▣ Open challenges

Characteristics of Network Virtualization Projects

5

- *Networking technology*
 - ▣ Targeted technology for virtualization

- *Layer of virtualization*
 - ▣ Particular layer in the network stack where virtualization is introduced

- *Architectural domain*
 - ▣ Specific problem domain that virtualization addresses

- *Level of virtualization*
 - ▣ Granularity at which virtualization is realized

Existing Projects (1)

6

Project	Architectural Domain	Networking Technology	Layer of Virtualization	Level of Virtualization
VNRMS	Virtual network management	ATM/IP		Node/Link
Darwin	Integrated resource management and value-added services	IP		
Tempest	Enabling alternate control architectures	ATM	Link	
NetScript	Dynamic composition of services	IP	Network	Node
Genesis	Spawning virtual network architectures		Network	Node/Link

Existing Projects (2)

7

Project	Architectural Domain	Networking Technology	Layer of Virtualization	Level of Virtualization
VNET	Virtual machine Grid computing		Link	Node
VIOLIN	Deploying on-demand value-added services on IP overlays	IP	Application	Node
X-Bone	Automating deployment of IP overlays	IP	Application	Node/Link
PlanetLab	Deploy and manage overlay based testbeds	IP	Application	Node
UCLP	Dynamic provisioning and configuration of lightpaths	SONET	Physical	Link

Existing Projects (3)

8

Project	Architectural Domain	Networking Technology	Layer of Virtualization	Level of Virtualization
AGAVE	End-to-end QoS-aware service provisioning	IP	Network	
GENI	Creating customized virtual network testbeds	Heterogeneous		
VINI	Evaluating protocols and services in a realistic environment		Link	
CABO	Deploying value-added end-to-end services on shared infrastructure	Heterogeneous		Full

Future Directions

- Instantiation
 - ▣ Concerned with issues related to successful creation of virtual networks

- Logistics
 - ▣ Deals with operations of virtual networks and virtual components

- Management
 - ▣ Manages co-existing virtual networks

- Interactions
 - ▣ Handles interactions between players in the *network virtualization environment*

Instantiation (1)

10

- Interfacing
 - ▣ Request format for a virtual network
 - ▣ Make programmability of the network elements available

- Signaling and Bootstrapping
 - ▣ Request for a virtual network
 - ▣ Bootstrap the customized network onto the physical network elements
 - ▣ Use a *separate* network (e.g. Genesis) or *out-of-band* communication mechanism

- Accounting
 - ▣ Prohibit overbooking of network resources through *admission control*
 - ▣ *Distributed rate limiting*
 - ▣ Applied on *complete* virtual networks

Instantiation (2)

11

- Topology Discovery
 - ▣ Within an InP administrative domain and across InP boundaries
 - ▣ *Event-based* and *periodic* topology discovery (e.g. UCLP)
 - ▣ Separate discovery plane (e.g. CABO)

- Virtual Network Mapping
 - ▣ Within single InP domain and across InP boundaries
 - ▣ Known to be a *NP-Hard* problem
 - ▣ *Heuristic*-based solutions
 - ▣ Two versions of the problem
 - *Offline*, where all the requests are known in advance
 - *Online*, where requests arrive dynamically

Logistics (1)

12

- Virtual Routers
 - ▣ Multiple logical routers inside one physical router
 - ▣ Issues of interest
 - Performance
 - Scalability
 - Migration (e.g. VROOM)

- Virtual Links
 - ▣ Similar to tunnels in VPNs
 - ▣ Cross-InP virtual links
 - ▣ *Link scheduling* (e.g. DaVinci)

Logistics (2)

13

- Resource Scheduling
 - Maximize *degree of co-existence*
 - Schedule CPU, Disk and Link b/w

- Naming and Addressing
 - Generic naming and addressing for all the virtual networks
 - *Überhoming*
 - *Allows end users in a network virtualization environment to simultaneously connect to multiple VNs through multiple InPs using heterogeneous technologies to access different services.*
 - *Identity-based routing*

- Failure Handling
 - Isolate failures
 - Prevent *cascading* failures

Management (1)

14

- Mobility Management
 - ▣ Geographic mobility of the end user devices
 - ▣ Mobility of the virtual routers through migration techniques
 - ▣ Logical mobility of the end users in different virtual networks

- Configuration and Monitoring
 - ▣ Enable virtualization from the level of NOCs to lower level network elements

Management (2)

15

- Management Frameworks
 - ▣ Generic management framework for the service providers
 - ▣ Interface between multiple management paradigms
 - ▣ Draw clear line between the management responsibilities of the InPs and the SPs

- Self-* Properties
 - ▣ *Self-configuration* and *self-optimization* for maximizing virtual resource utilization
 - ▣ *Self-protection* and *self-healing* to survive malicious attacks

Interactions

16

- Networking Technology Agnostic Virtualization
 - ▣ Virtualization *on* and *across* optical, wireless and sensor technology among other technologies
 - ▣ Transparently create end-to-end virtual networks across heterogeneous technologies

- Inter-VN Communication
 - ▣ Sharing of resources and information between multiple virtual networks
 - ▣ Creating *compound* virtual networks

- Network Virtualization Economics
 - ▣ Trade node resources (e.g. processing power, memory) in addition to bandwidth
 - ▣ Centralized, decentralized and hybrid markets

Reference

17

- N.M. Mosharaf Kabir Chowdhury, Raouf Boutaba, “A Survey of Network Virtualization”, *University of Waterloo Technical Report CS-2008-25*, Oct. 2008.

Questions ? | | // Comments