NETWORK VIRTUALIZATION: PRESENT AND FUTURE

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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

Design Principles

- Concurrence
- Recursion
- Inheritance
- Revisitation

Design Goals

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

Outline

- Existing Projects
  - Characteristics
  - Summary
- Future Directions
  - Open challenges

Characteristics of Network Virtualization Projects

- *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)

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)

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)

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)

- 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)

- 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)

- 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)

- 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)

- 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)

- 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

- 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

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

Questions ? | | // Comments