INTRODUCTION TO NETWORK VIRTUALIZATION

Wednesday, May 14, 2008

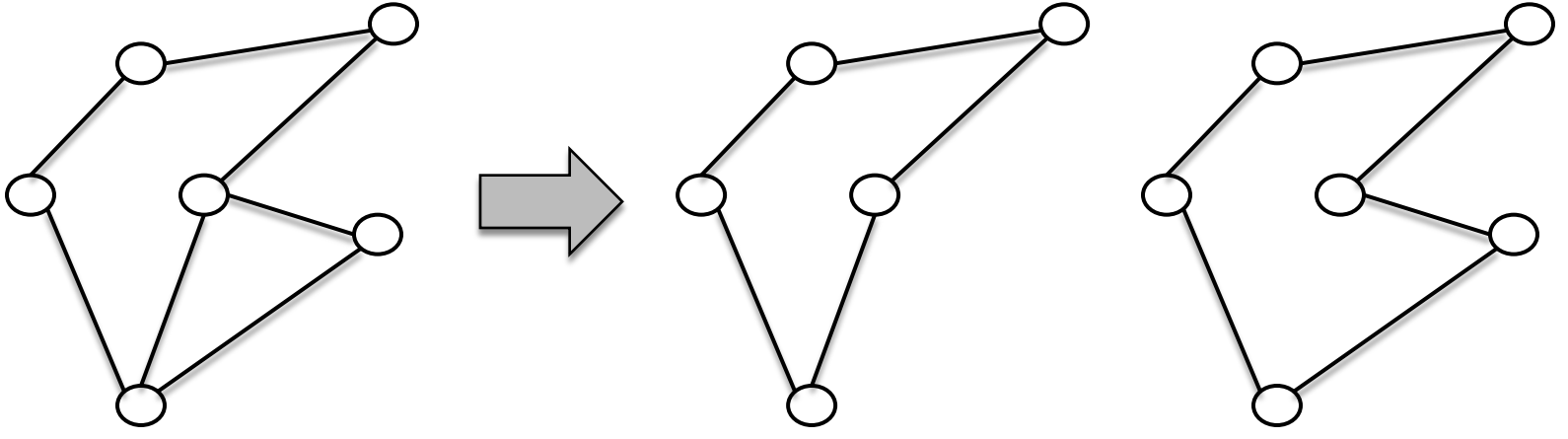
Mosharaf Chowdhury
Member, eNVy Project

What is Virtualization?

- Transparent abstraction of computing platform and resources
  - *Multiple* logical interpretations of the physical characteristics
- Virtualized everything
  - *Virtual machines*: VMware, Xen
  - *Storage virtualization*: SAN
  - *Data-center virtualization*

Network Virtualization for *Dummies*

- Making a physical network appear as multiple logical ones



Physical Network

Virtualized Network - 1

Virtualized Network - 2

Why Virtualize ?

- Internet is *almost* ossified
  - Lots of band-aids and makeshift solutions (e.g. overlays)
  - A new architecture (aka clean-slate) is needed
- Hard to come up with a *one-size-fits-all* architecture
  - Almost impossible to predict what future might unleash
- Why not create an *all-sizes-fit-into-one* instead!
  - Open and expandable architecture
- Testbed for future networking architectures and protocols

Related Concepts

- Virtual Private Networks (VPN)
  - Virtual network connecting distributed sites
  - Not customizable enough
- Active and Programmable Networks
  - Customized network functionalities
  - Programmable interfaces and active codes
- Overlay Networks
  - Application layer virtual networks
  - Not flexible enough

Network Virtualization Model

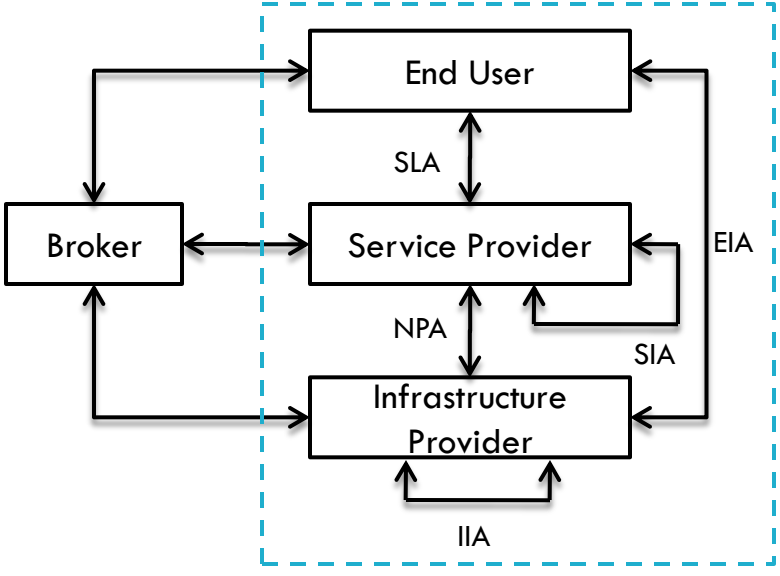
- Business Model
- Architecture
- Design Principles
- Design Goals

Business Model

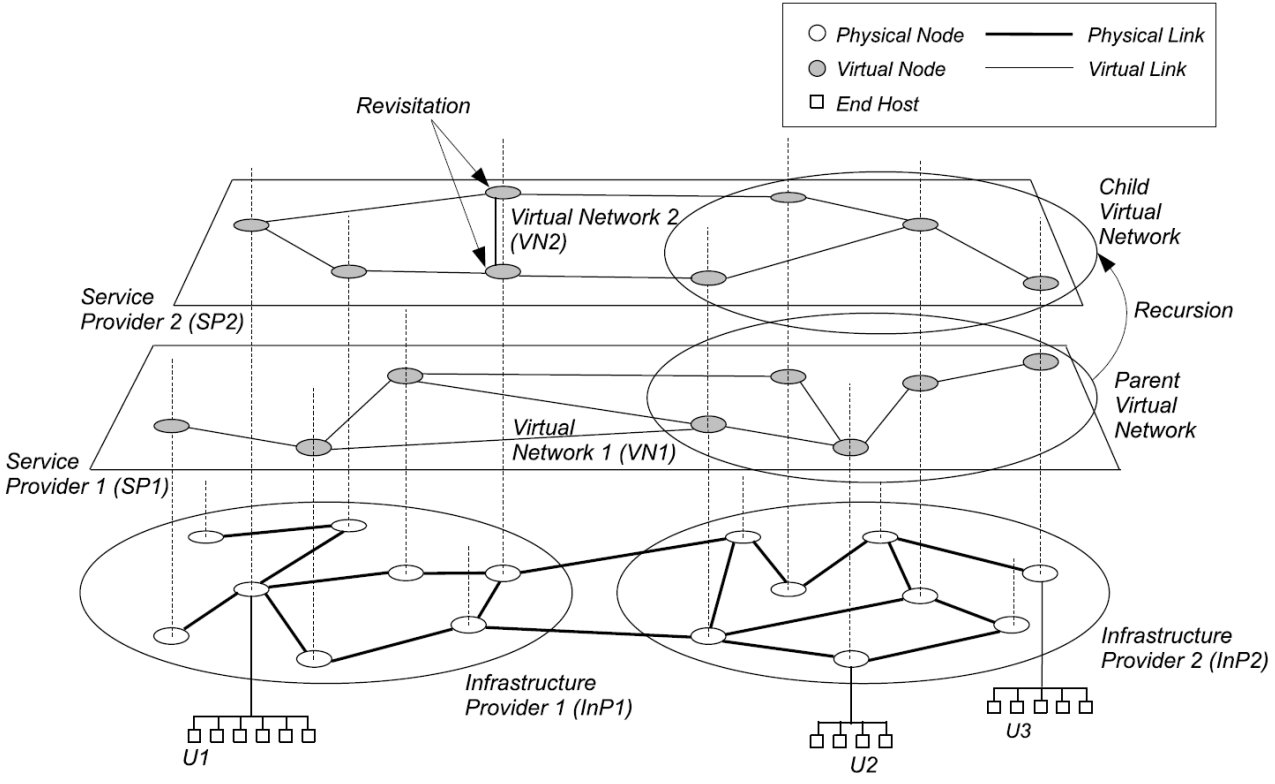
Players

- Infrastructure Providers (*InPs*)
  - Manage underlying physical networks
- Service Providers (*SPs*)
  - Create and manage virtual networks
  - Deploy customized end-to-end services
- End Users
  - Buy and use services from different service providers
- Brokers
  - Mediators/Arbiters

Relationships



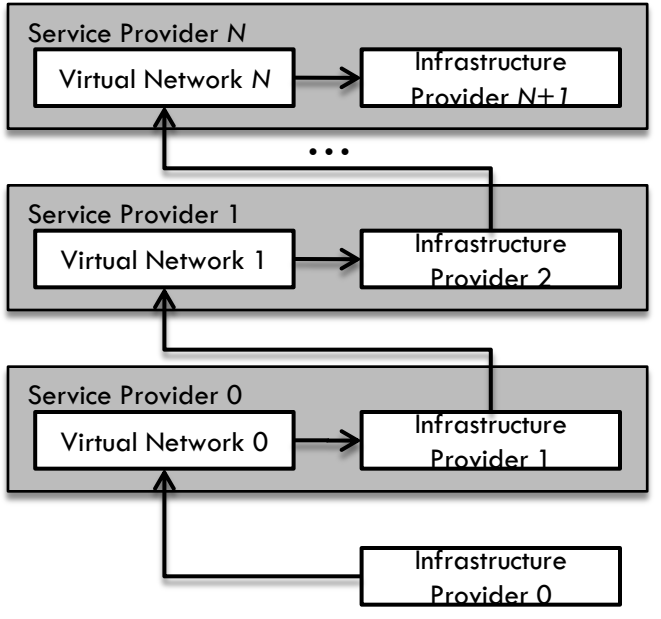
Architecture



Design Principles

- *Concurrence* of multiple heterogeneous virtual networks
  - Introduces diversity
- *Recursion* of virtual networks
  - Opens the door for network virtualization economics
- *Inheritance* of architectural attributes
  - Promotes value-addition
- *Revisitation* of virtual nodes
  - Simplifies network operation and management

Hierarchy of Roles



Design Goals (1)

- Flexibility
  - Service providers can choose
    - arbitrary network topology,
    - routing and forwarding functionalities,
    - customized control and data planes
  - No need for co-ordination with others
    - IPv6 fiasco should never happen again

- Manageability
  - Clear separation of policy from mechanism
  - Defined *accountability* of infrastructure and service providers
  - Modular management

Design Goals (2)

- Scalability
  - Maximize the number of co-existing virtual networks
  - Increase resource utilization and amortize CAPEX and OPEX
- Security, Privacy, and Isolation
  - Complete isolation between virtual networks
    - *Logical* and *resource*
  - Isolate faults, bugs, and misconfigurations
    - Secured and private

Design Goals (3)

- Programmability
  - Of network elements e.g. routers
  - Answer *"How much"* and *"how"*
  - Easy and effective without being vulnerable to threats

- Heterogeneity
  - Networking technologies
    - Optical, sensor, wireless etc.
  - Virtual networks

Design Goals (4)

- Experimental and Deployment Facility
  - PlanetLab, GENI, VINI
  - Directly deploy services in real world from the testing phase

- Legacy Support
  - Consider the existing Internet as a member of the collection of multiple virtual Internets
  - Very *important* to keep all concerned parties satisfied

Definition (Sort of)

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.

Existing Projects

- Four general categories
  1. Networking technology
     - IP (X-Bone), ATM (Tempest)
  2. Layer of virtualization
     - Physical layer (UCLP), Application layer (VIOLIN)
  3. Architectural domain
     - Network resource management (VNRMS), Spawning networks (Genesis)
  4. Level of virtualization
     - Node virtualization (PlanetLab), Full virtualization (Cabo)

Future Works

- Four general directions
  1. Instantiation
     - Creates virtual networks
  2. Logistics
     - Runs them
  3. Management
     - Manages them
  4. Interactions
     - Let them flourish

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