Network Virtualization:
from a Network Provider Perspective

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Virtualization: What do I mean?

- Abstraction concept
  - Hides details of the hardware
  - Provides layer of indirection

- Virtualization offers
  - Isolation & separation
  - Resource sharing
    - Reuse
    - Statefull
Virtualization: Successes

- Virtual servers
- Cloud services
- ...

Why?
- Resource efficiency
- Simplified management!!!
Virtualized networks

Virtualization of Resources
(partitioning of physical infrastructure into)

Virtualized Substrate

Provisioning of Virtual Networks
(demand instantiation of virtual networks)

Virtual Network

Virtual Network

Virtualization Management
Virtual networks ==

- Combination of
  - Server and
  - Networking resources

- Slices of
  - Routers
  - Links
  - Servers
  - End-systems / hosts
Virtual networks: Scenarios

- Different architecture/protocol per VNet
  - Does not have to be IP protocol
  - Some with some QoS and security
  ⇒ Multiple networks in parallel == diversity
- Expose network components to apps/services
  ⇒ Overcome Internet impassé
- Combines cloud with networking
  ⇒ New service ideas
Virtual networks: Scenarios (2)

- Dynamic
  - New ones will come and old ones will go
  - Migration / Expansion / Contraction
  ⇒ Efficiency and new management capabilities
  ⇒ Designed for change
Virtual networks !=

- Virtual private networks (VPNs)
  - VPN is just a service!
- P2P networks
  - P2P is just an overlay!

- Virtual networks should offer
  - Simplified network management
  - Simplified service offerings
  - Business opportunities
Why now?

Hardware support
- Servers, Routers, switches, links, …
- Significant computational resources in the network
- Fast packet forwarding hardware, e.g., OpenFlow

Reality
- Due to regulation, e.g., DSL access in Germany

Need to revisit network management!
- Internet problems:
  - Availability and reliability
  - Security
  - Scale and diversity
  - Support for new applications
  - Economics
Today’s Internet – out of shape!!!

Data plane

Control plane

Redesign needed?

Picture due to Rui Aguilar
Why now?

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☞ All of the these are control plane issues!
Case study: Interprovider Issues and Business Opportunities
Efficient utilization of resources

- Business challenge
  - E.g.: Magnitude of investment cost
    - AT&T plans to invest 17–18 Bn $ in 2009 compared to a revenue of 124 Bn $ in 2008
    - Deutsche Telekom plans to invest 8.7 Bn Euro compared to revenues of 62 Bn Euro in 2008

⇒ Even 1% is substantial!
Efficient utilization of resources (2)

- Technical opportunities
  - Migration of devices (such as routers)
    - similar to server virtualization
  - Traffic load balancing (“migration” of links)
  - Allocation of resources: In what chunks? and when?

- New business opportunities
  - Sharing of physical resources
    E.g., T-Mobile UK and 3 UK
Roles in the Internet

- Traditional roles:
  - Service providers (SP)
    - Google, World of Warcraft, …
  - Internet Service Providers (ISPs)
    - Deutsche Telekom, AT&T, …

- Recently:
  - Physical infrastructure provider (PIPs)
  - Bit-pipe providers
  - Service providers (SP)
Roles with network virtualization

- Service Provider
- VNet Operator
- VNet Provider
- Infrastructure provider
- Infrastructure provider
Tasks: Birdseye view

- Physical Infrastructure Provider
  - Provides Virtual Resources + Resource Control Interface

- VNET Provider
  - Assembles virtual networks
  - Intuitively: provides layer of indirection

- VNET Operator
  - Operates, controls, manages virtual networks
    (e.g., comparable to NOC)

- Service provider
  - Offers the service
Lessons learned

- Isolate tasks => business opportunities
  - E.g.: Magnitude of the investment cost
    even 1% is substantial!
- Don’t forget control interfaces
- Inter provider issues are tricky
- Indirection and resource isolation are great tools
Case study: Network diagnosis aided by network virtualization
Network diagnosis

Problem:
Implementation/configuration issue surface in large-scale, long-term deployments with real user traffic

Goal:
- Do not change network under test
- Avoid probe effect

Diagnosis methods:
- Instrumentation
- Testing
  - Performance improvements
  - Regression testing
  - New software releases
Instrumentation

- Pair production VNet with monitoring VNet
- Copy all/selected packets to monitoring VNet
- Processing is accounted to monitoring VNet
Testing – ShadowVNet

Input dist'ed to Vnet 1.0 and Vnet 1.1

Output of Vnet 1.0 dist'ed to ext entities

V1.0
V1.1
Ctrl

V1.0
V1.1
Ctrl

Ext 1
Ext 2

VNet running V1.0
VNet running V1.1
Control Vnet

Substrate
Run **VNet1.0, VNet1.1** monitoring **VNet**

- Distribute external input to both **VNet1.0** and **VNet1.1**
- **Ctrl** compares output behavior of **VNet1.0** and **VNet1.1** for semantic equality
- Only output of **VNet1.0** is distributed to external entities
Assumptions

- Many VNets
  - Reasonable # of resource per VNet
  - Resource consumption for ShadowVNet OK

- Ability to clone VNets
  - Option A: Clone configuration
  - Option B: Live local migration (without delete)
  - Option C: Live remote migration (without delete)

- Ability to duplicate input traffic
  - E.g., monitoring features of network devices

- Ability to have resource isolation
  - E.g., via OpenFlow
ShadowVNets – realistic?

- Per device?
  - Examples exist: E.g.,
    - BGP on Cisco Routers

- But: Problems usually arise due to
  - Complex networks and
  - User interactions

- ShadowVets to the rescue
  - See Sigcomm demo
Example: VoIP with background load

- Phase 1: Minimal background traffic
- Phase 2: Background traffic increases
- Phase 3: Start ShadowVNet: VNET B
- Phase 4: Enable QoS in VNET B
- Phase 5: VNET B becomes operational
Example: VoIP with background load

- User perceived quality is restored when the ShadowVNet is activated
Lessons learned

- New network debugging features
  - Instrumentation
  - Testing
  - (Distributed debugger)

- Goals
  - To not change network under test
  - Avoid probe effect

- Solution: Network virtualization
  - Isolation
  - Resource accounting