



Network Virtualization and New Generation Network Research

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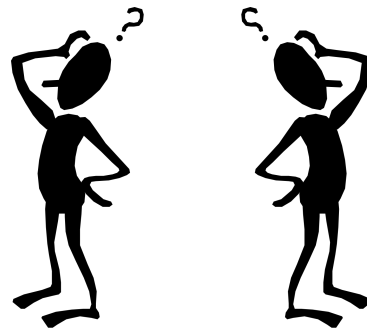
NICT

IA/JANOG Workshop

JUL. 9th, 2008

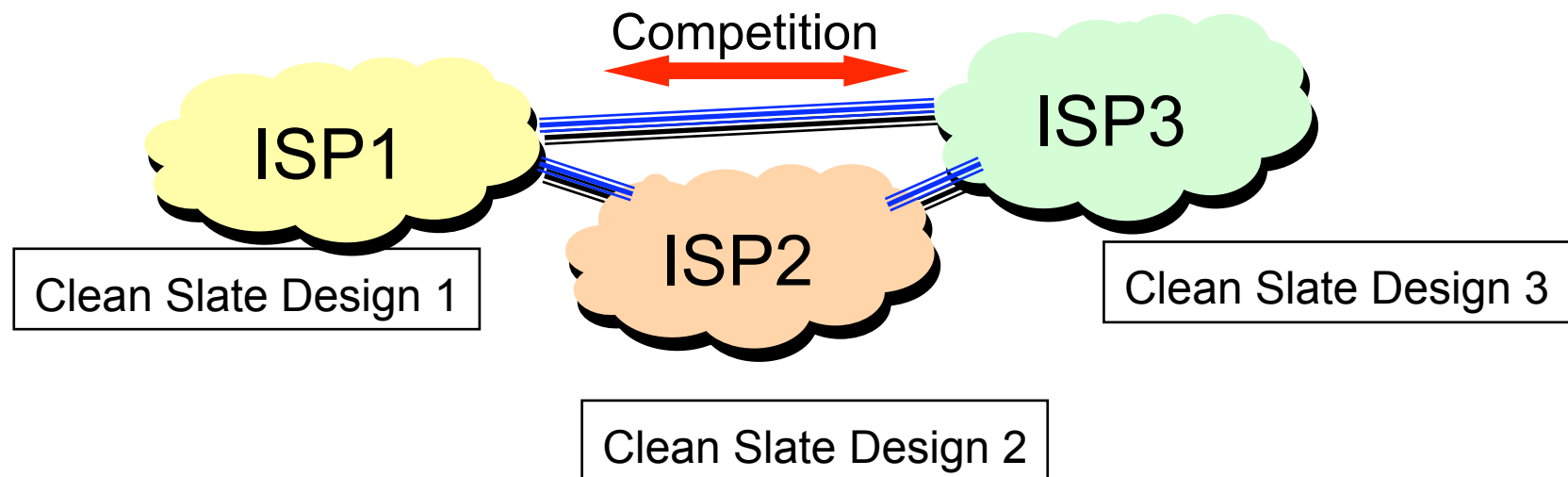
“Clean Slate” Network Designs

- ✚ “Clean Slate” has become a buzz word...
 - ▣ Everybody allured by the propaganda
 - “Throw away the past and build a new one from scratch”
- ✚ Two Fundamental Problems
 - ▣ Which to adopt among many “clean slate” architectures?
 - ▣ Can we choose only one?
 - ▣ Do we allow multiple ones to co-exist?



One Method: Horizontal Competition

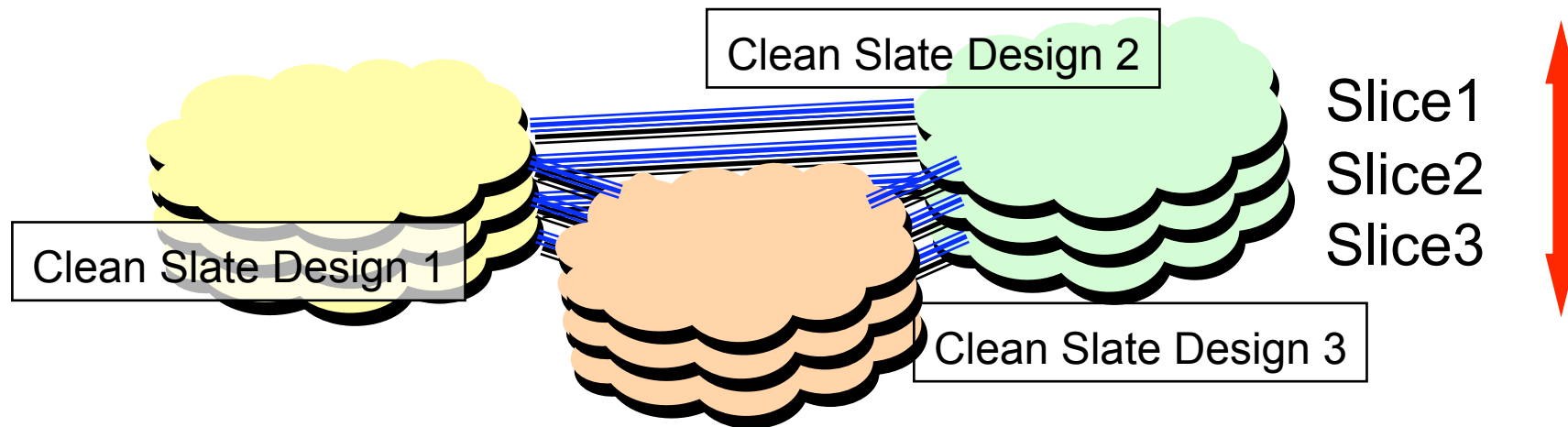
- Competition between ISPs/Test-beds
 - Each ISP/Test-bed implements proprietary networks/services
 - Federation of test-beds [[GENI narrow waist WG](#)]
 - Future network may be initiated from enterprise networks!



Vertical Competition and Cooperation

- Allow an architecture to reside in a “slice” of resources

Competition and Cooperation



Allowing multiple network designs to coexist may be a new generation network (meta) architecture

How?

“Network Virtualization”

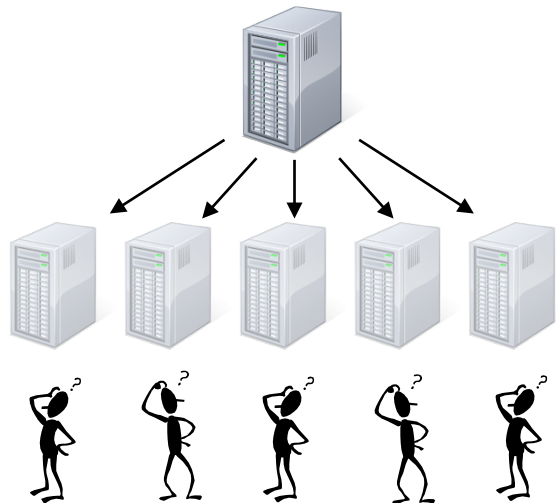
What is Virtualization?



Virtualization

- a transparent abstraction of computer resources
- making **a physical resource** appear as **multiple logical ones**

Virtual Machine (Machine Virtualization)



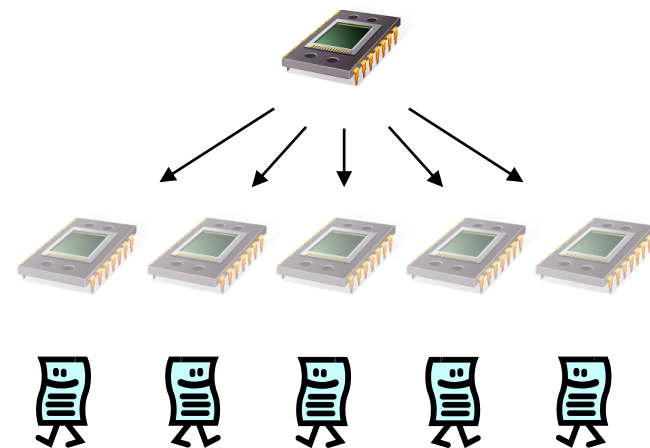
duplicates of a real machine

Virtual Memory (Memory Virtualization)

Physical Resource



Logical Resources



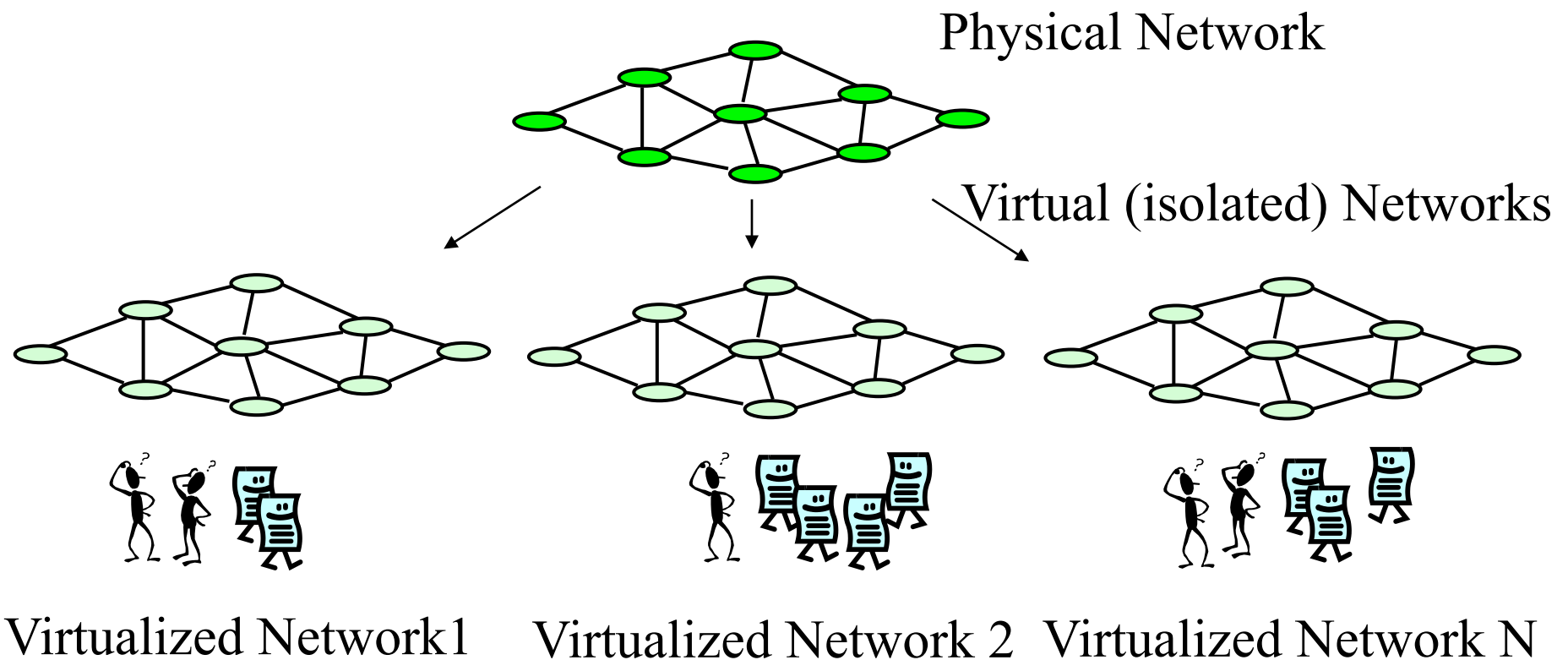
Multiple Users

duplicates of a real memory

Network Virtualization?

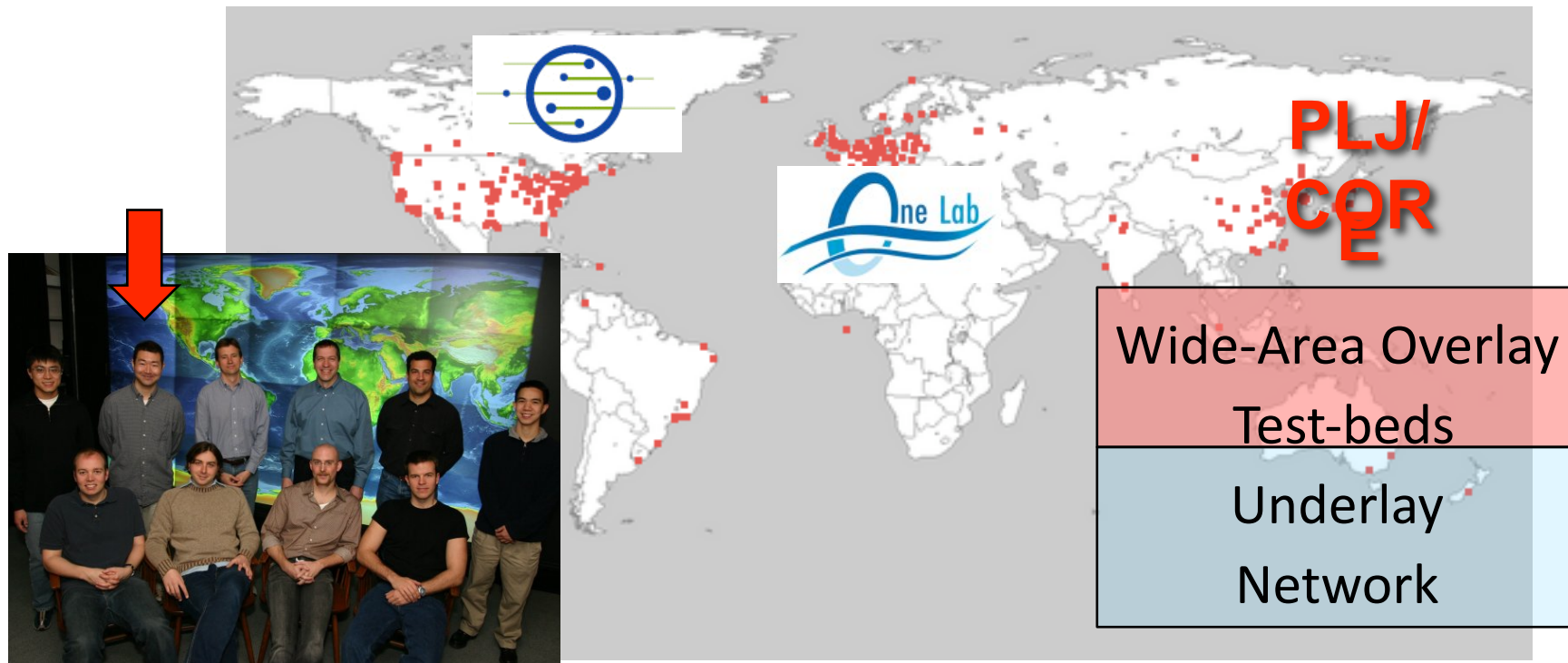


- a transparent abstraction of network
- making **a physical network** appear as **multiple logical ones**



PlanetLab Overlay

- ✿ The largest and most popular **overlay network testbed**
- ✿ Currently consists of 850 nodes at 420 sites (30+ countries)
- ✿ 850+ Projects
- ✿ **Overlaid on top of the Internet**



Brief History of PlanetLab

- PlanetLab 1.0 (2002-3)

- UNIX account slivers

- PlanetLab 2.0 (2003-4)

- Vserver slivers

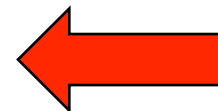
- PlanetLab 3.0 (2004-2006)

- PLCAPI 1.0

- PlanetLab 4.0 (2007-)

- MyPLC1.0
- Federation Idea

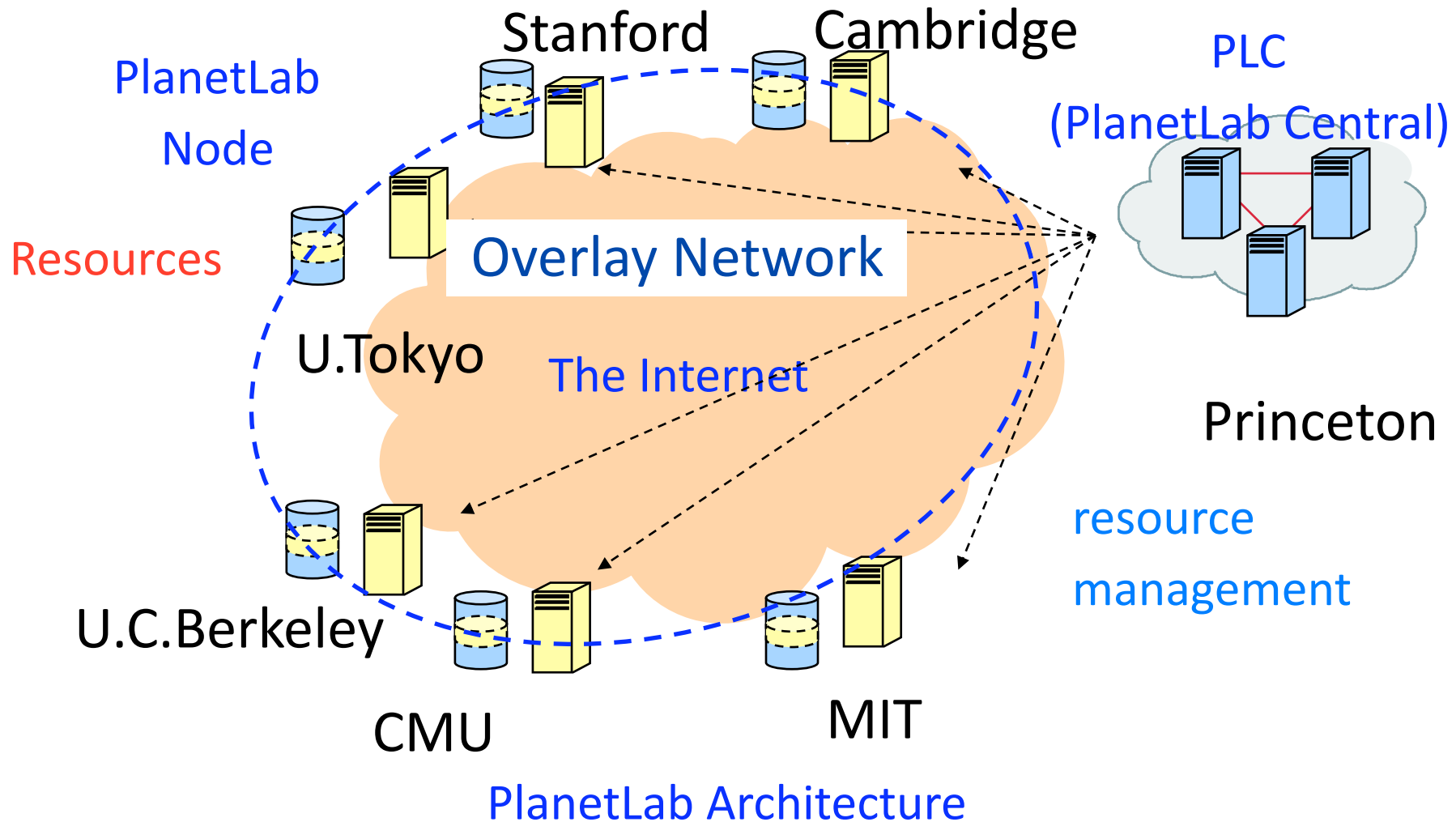
- PlanetLab 4.2 (2008)



We are here

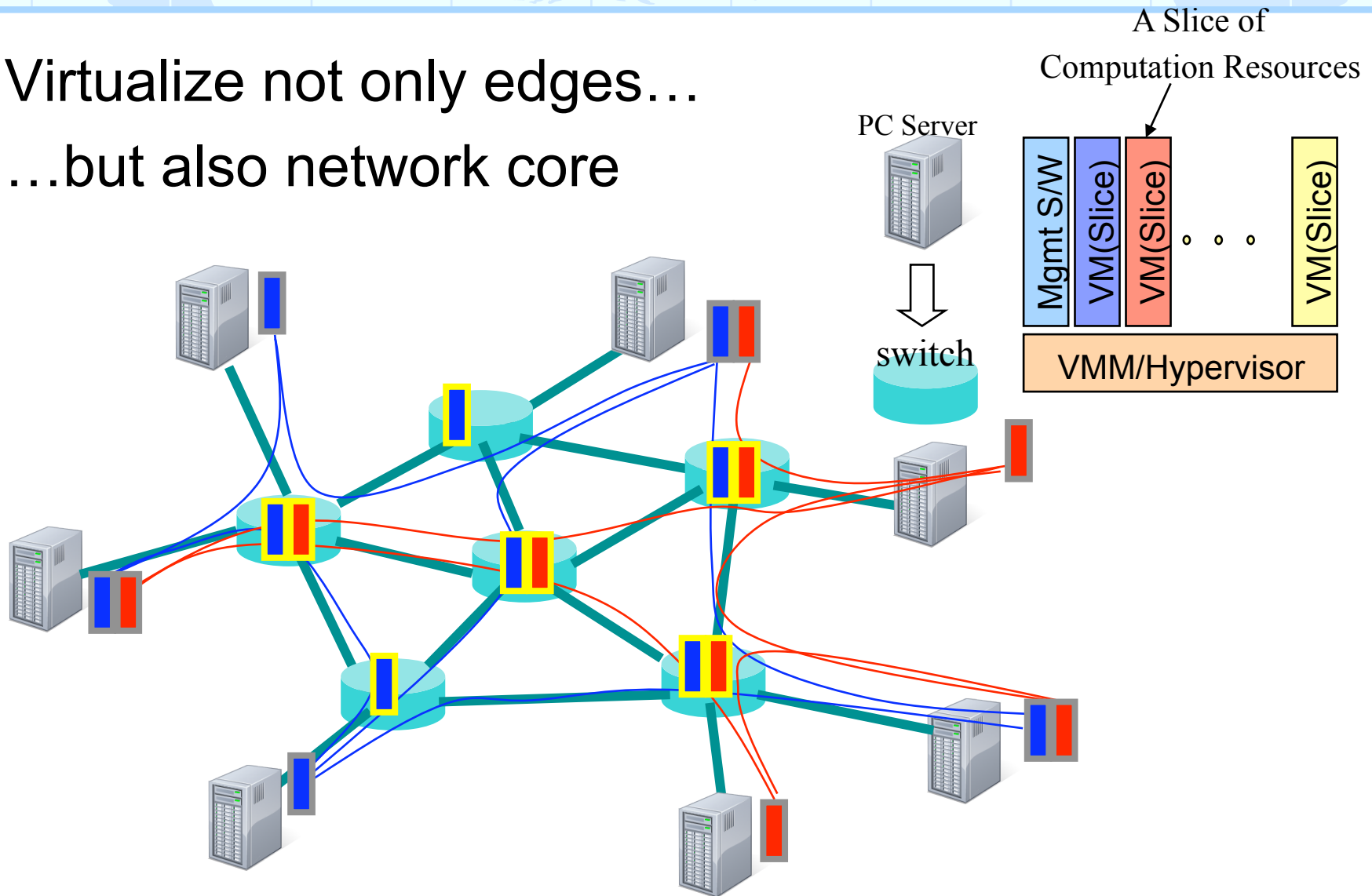
- Federation (PLE, PLJ, (PLK, PLC,=>PLA?))
- New Development (RSpec/GENI-wrapper, New Node Type, Monitoring, QA,VINI)
- Network Virtualization

PlanetLab Architecture

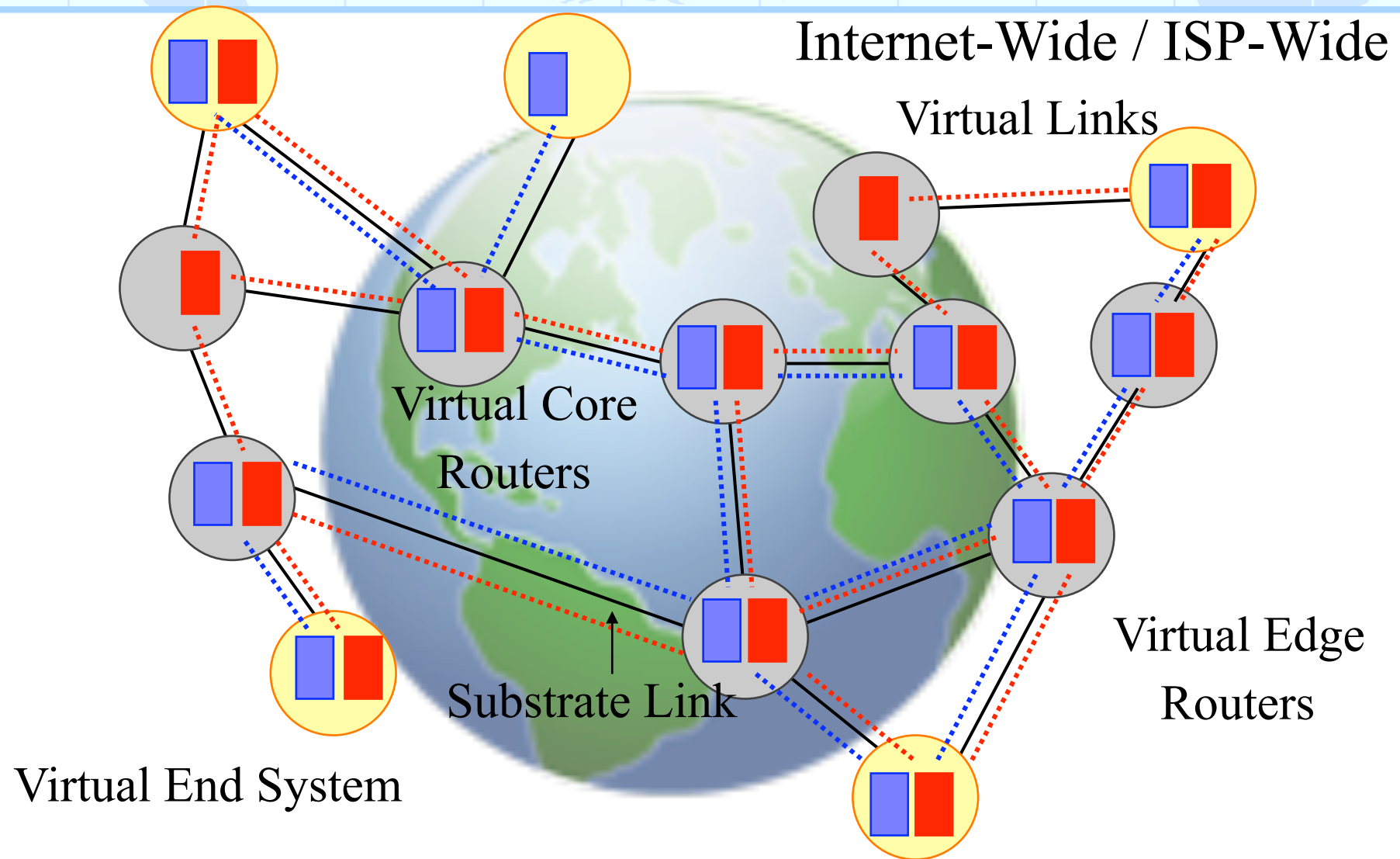


Overlay to Network Virtualization

- Virtualize not only edges...
- ...but also network core



Is Ubiquitous Virtualization Feasible?



Vertical competition & cooperation between slices
(Red:Legacy, Blue:Experimental)

Purpose of Network Virtualization

Existing vehicles to “test” future networks

- Emulab
- PlanetLab/OneLab/EverLab/CORE

Future test-beds

GENI

- VINI (planetlab) [\[A.Bavier et.al. Sigcomm2006\]](#)
- ProtoGENI (emulab)

Others

- G-lab (wurzburg/Germany)
- OneLab (EU)
- Core(NICT/Utokyo/Japan)

“Network Virtualization” has been evolving
as a technique to enable test-beds

Can Net-Virtualization be an Architecture ?

✿ Fully Virtualized Network

- Network-virtualization capable routers everywhere...
- No single new generation network architecture
 - Each proposed architecture implemented in a “slice”
 - “Competition Principles” and “Natural Selection”
 - Only successful slices (architectures) will survive...
 - Self-Evolvable network
- Or fully virtualized network could be a single new generation network architecture...

What's possible with Virtualized Internet

- ⊕ This will be an intense research area!
- ⊕ **Isolation** enabled by network virtualization
 - Control/Data plane separation
 - 4D Architecture [[A.Greenberg, J.Rexford et.al. Sigcomm 2005](#)]
 - SORA [[J.R.Lane and A.Nakao et.al. ACM ROADS 2007](#)]
 - Remove cross-talks between various QoS networks
 - “Application Specific Internet”
 - Achieve better robustness
 - PathSplicing [[N.Feamster et.al. HotNets 2007](#)]
 - Can purchase and lease “your own Internet”
 - CABO [[N.Feamster et.al. CCR2007](#)]
 - Virtual Topology Embedding
 - Embed a desirable virtual topology into a real network
 - DDoS Mitigation via Virtualization
 - Burrows [[S.H.Khor and A.Nakao et.al. Sigcomm LSAD 2007](#)]
 - Overfort [[S.H.Khor and A.Nakao to appear IPDPS 2008 SSN](#)]

Control / Data Plane Separation

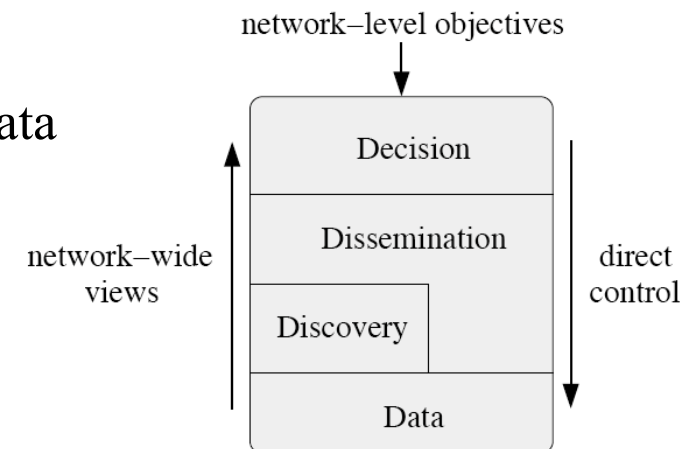
✿ A Clean Slate 4D Approach to Network Control and Management *[A.Greenberg, J.Rexford et.al. Sigcomm 2005]*

✦ Four Planes:

- Decision, Dissemination, Discovery, and Data

✦ Extended C-D Separation

- Could exploit network virtualization



✿ SORA: Scalable Overlay Routing Architecture

[J.R.Lane and A.Nakao et.al. ACM ROADS 2007]

✦ Scalable Multipath-Aware Overlay Routing

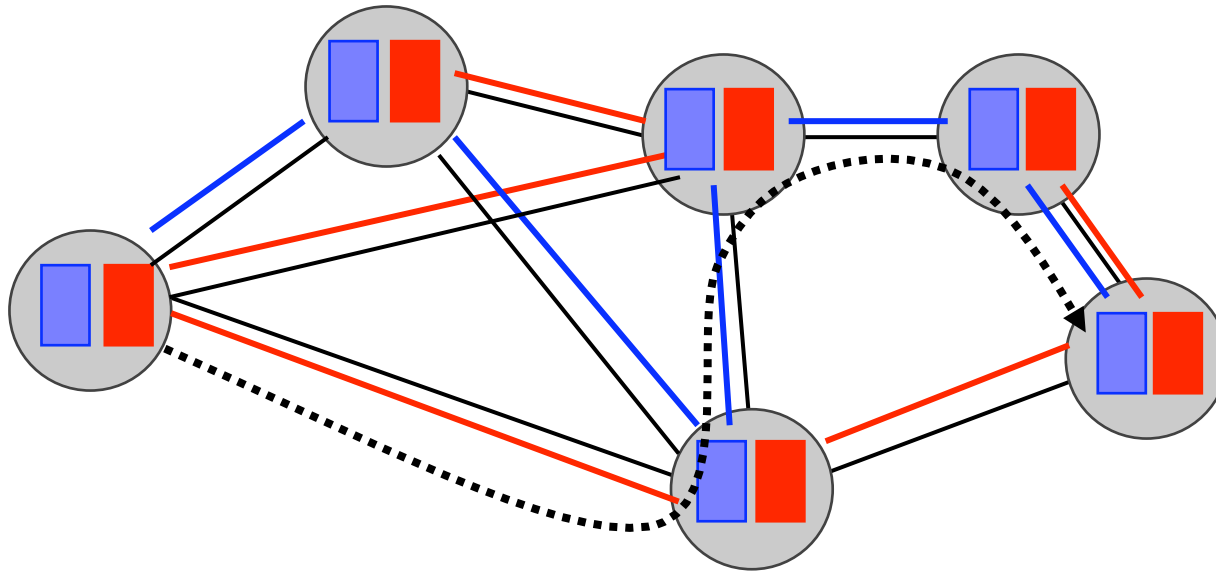
- Overlay Source Routing
- C-D Separation Implemented (Path Computation and Forwarding)
- Pushing End-to-End Principle to routing
- Could also exploit network virtualization

Path Splicing

Path Splicing with Network Slicing

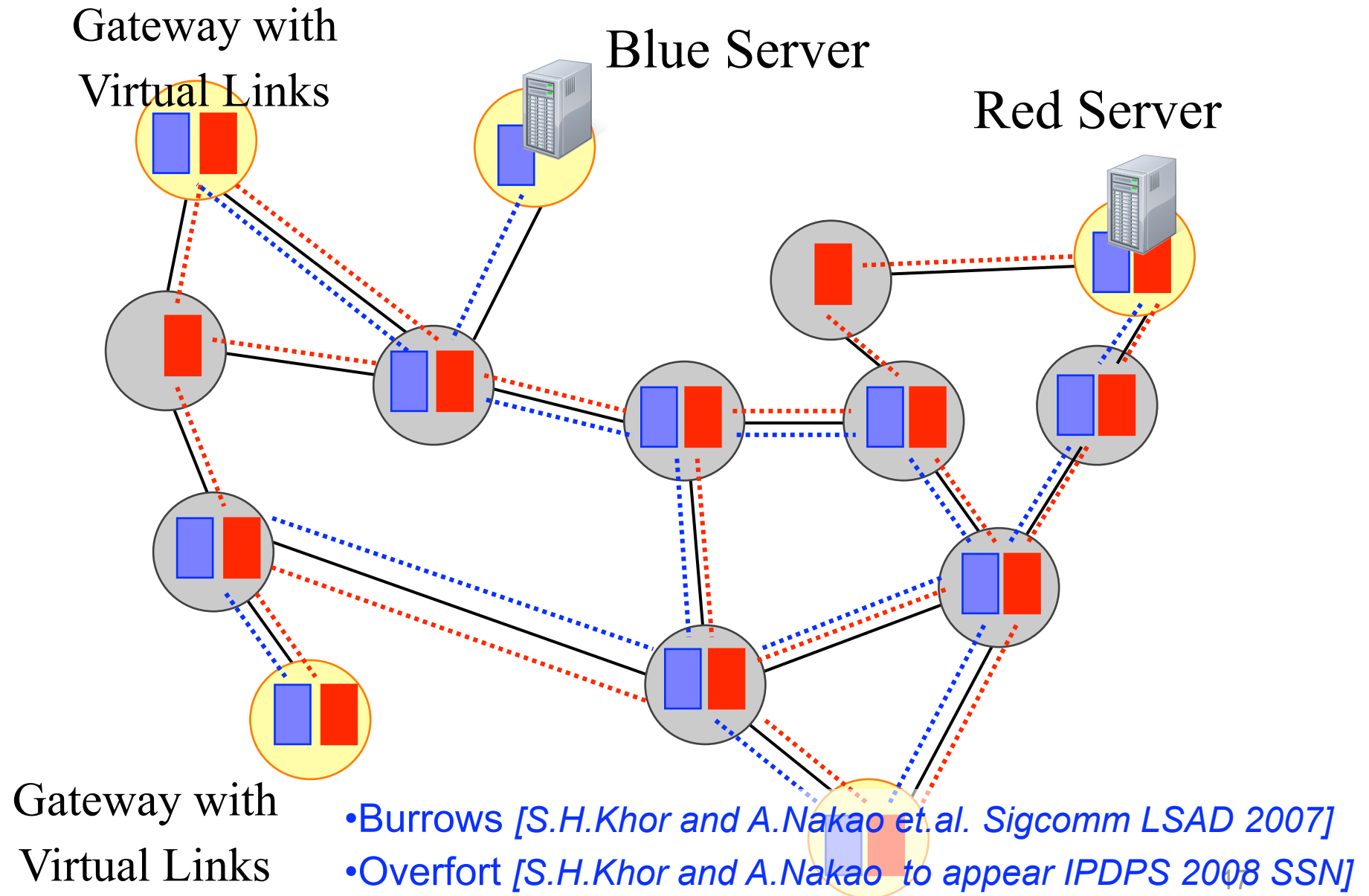
[N.Feamster et.al. HotNets 2007]

- Compute multiple forwarding trees per destination
 - Multiple instances of routing protocols
- Allow packets to switch slices midstream



Switching between multiple forwarding trees

DDoS Mitigation via Net Virtualization



Research Topics

Infrastructure

■ Level / Layer of Virtualization (L3->L2->L1?)

[Hosted L2 Virtualization Performance (Ozaki, Nakao) IPSJ, 2008]

[Hosted L2 Virtualization Scalability (Ozaki, Nakao) Springer, under submission 2008]

■ OS Virtualization and Network Virtualization (Optical)

■ Router / Node Construction

Applications

■ Routing

[AIRONE: One-Hop Source Router (Khor, Nakao) IEEE GlobeCom 2008]

[SORA: Path Selection, (Lane, Nakao) CFI 2008 and IEEE GlobeCom 2008]

[Path Selection (Tschku, Nakao) EuroView 2008]

■ Robust / Efficient Communication via Net.Virt.

[Overfort (Khor, Nakao) IEEE IPDPS 2008]

[Burrows (Khor, Nakao) ACM SIGCOMM LSAD 2007]

[Mantlet: DDoS Mitigation (Du, Nakao) under submission 2008]

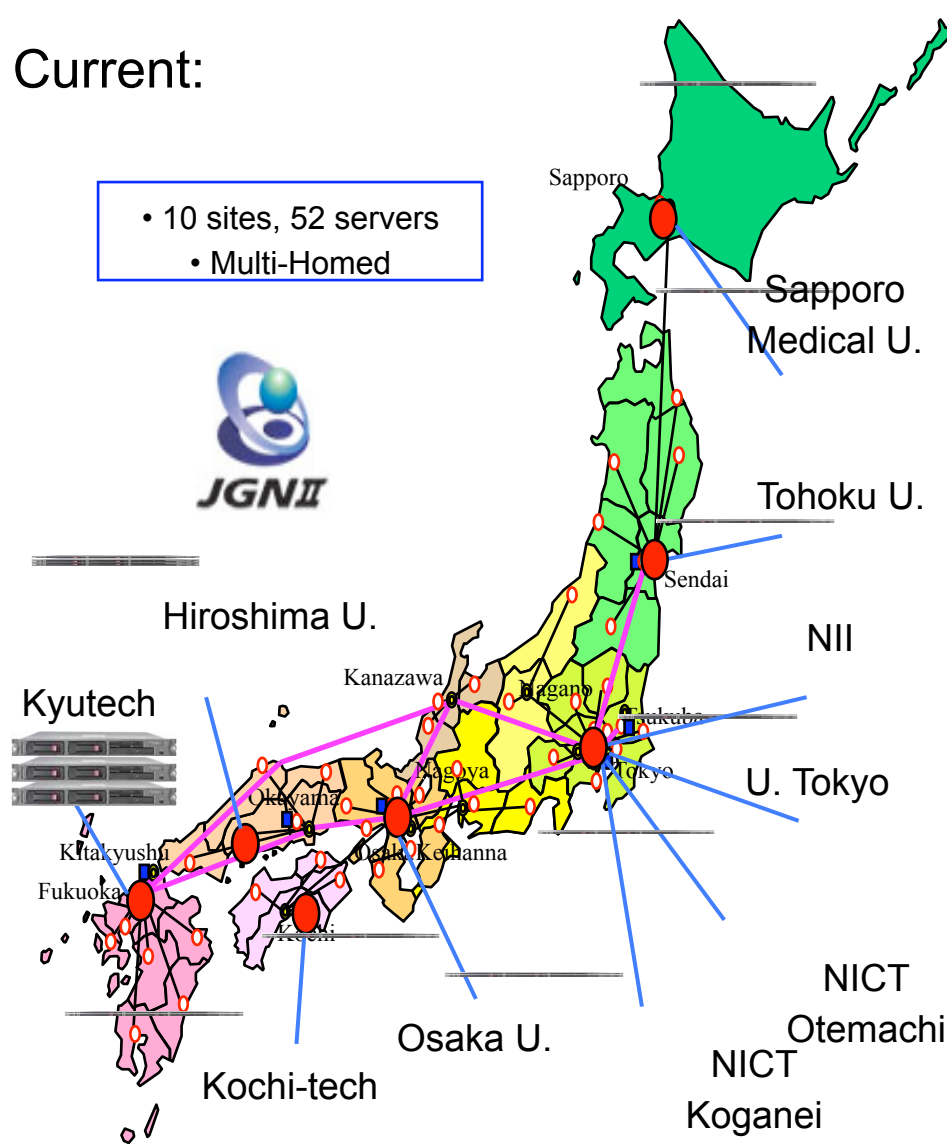
[P2P Carrier Incentives: (Yamamoto, Nakao) short paper under submission 2008]

■ Business Model/ Economic Incentives

CORE: Private PlanetLab

Current:

- 10 sites, 52 servers
- Multi-Homed



THE UNIVERSITY OF TOKYO



CORE

- Collaborative Overlay Research Environment
 - Overlay test-bed based on “Private PlanetLab”
 - Provision resources for mission critical services
- Features we would like to have...
 - Custom hardware to optimize overlay forwarding
 - PoP/Core collocation (nodes “inside” network)
 - Custom hardware to optimize overlay forwarding
- Federation (e.g. PlanetLab, OneLab)
 - Target overlay research
 - Not just on distributed system apps
 - More on network core architectures
- Utilize both private & public environments
 - Local v.s. Global / Provisioned v.s. Best-Effort

New Generation Perspectives to Overlay Network

- Testbed for prototype and evaluate a new generation network design
- Evolutional nature of overlay network to incorporate into the design

Conclusions

- ⊕ Network Virtualization attracting lots of attentions
- ⊕ Our Effort: Network Virtualization Research Labs
 - ▣ Practically started in Oct. 2007 at Hakusan , Tokyo
 - ▣ Conducting research on
 - Next Generation Network Services (Overlay Network)
 - Next Generation Network Architecture (Network Virtualization)
 - ▣ Active collaborations with universities and industry labs
(also international collaboration is very active now)
- ⊕ Budget x Period
 - ▣ \$2.4M x 4 years
- ⊕ Members
 - ▣ 10 full-timers and 10+ part-timers
 - ▣ Still looking for people to Collaborate