Network Virtualization in Data Centers

Yu Wu

September 13, 2013

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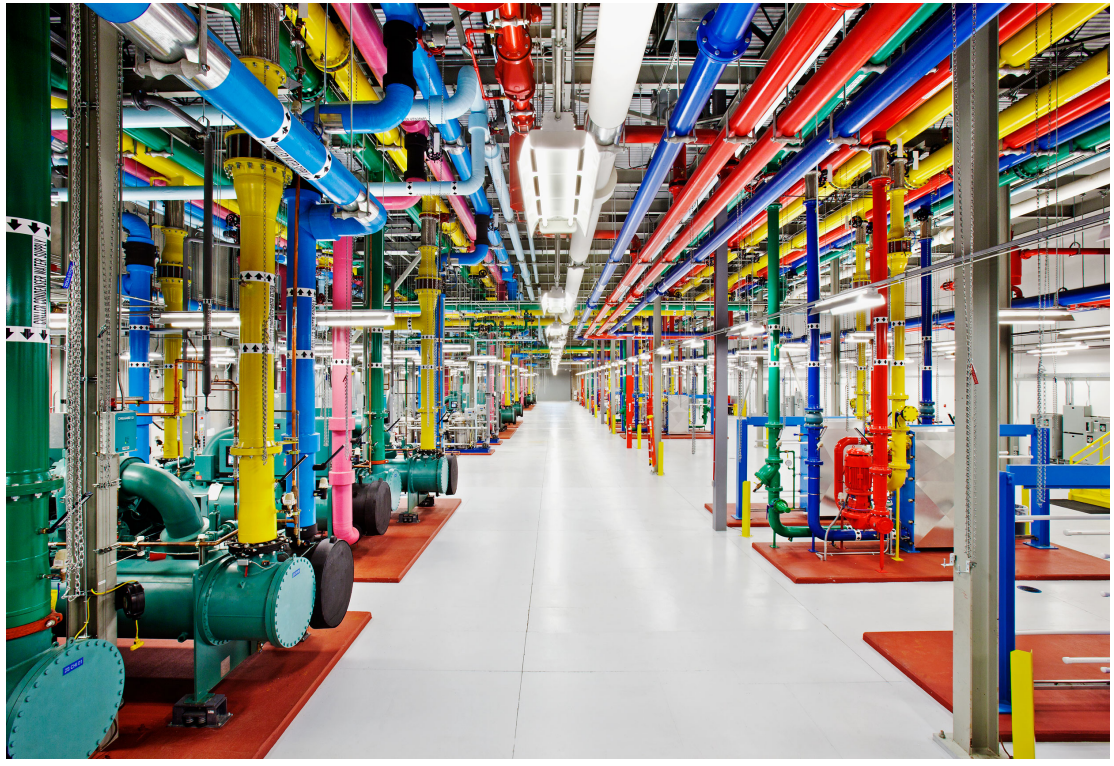
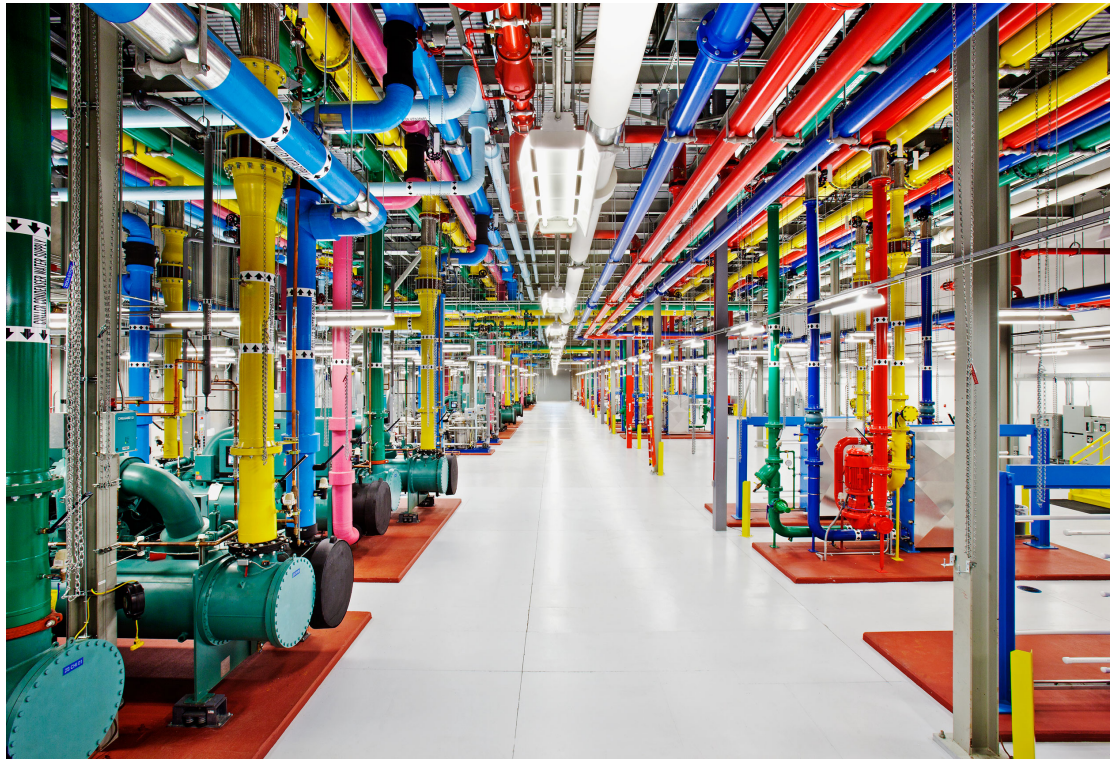
$\Rightarrow$ more efficient underlying infrastructure!



Datacenters have been widely built...
(Amazon, Google, Facebook, *etc*)



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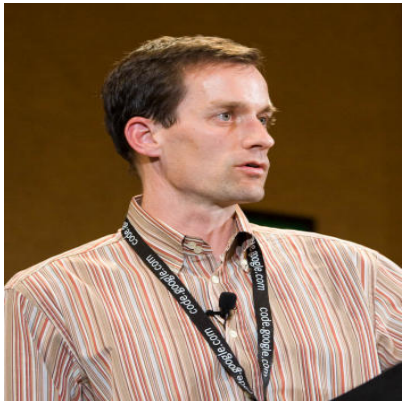
far from ideal! 😢



”Dont’t solve everything all at once”

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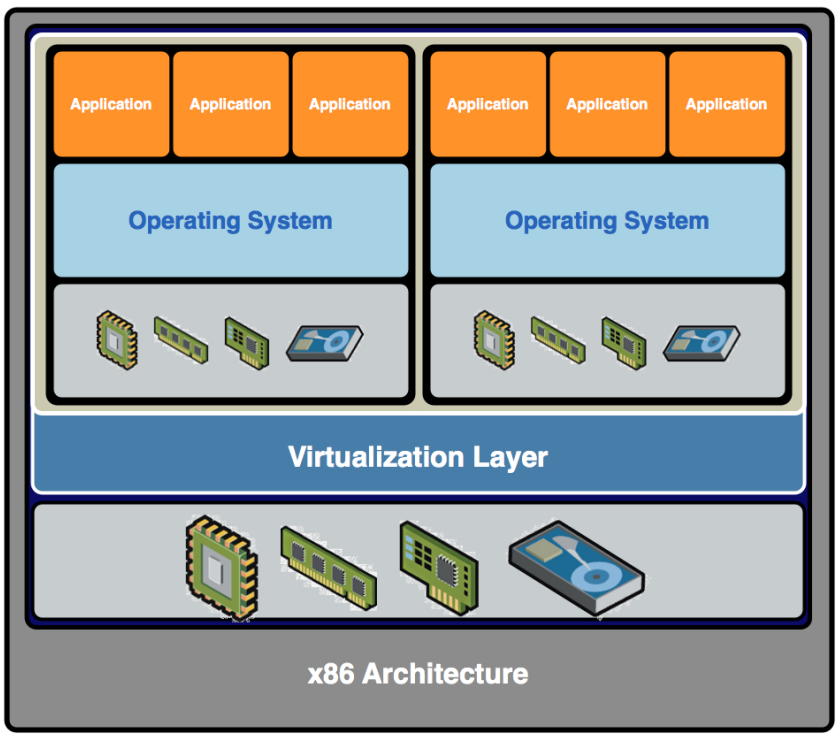

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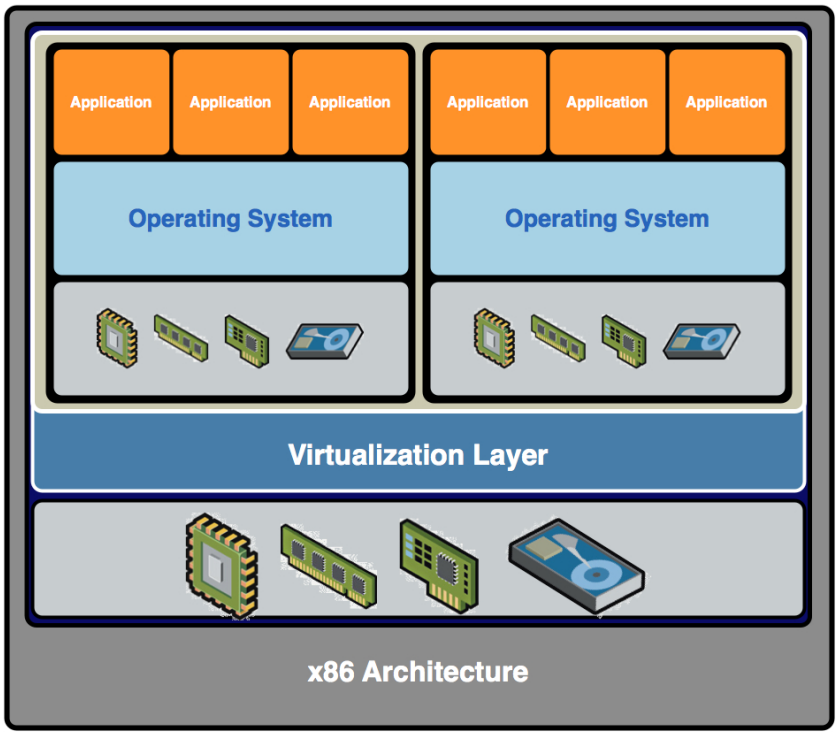

improved performance
isolation, security levels,
server utilization *etc.*

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network virtualization has received significant attention.

network virtualization: multiple virtual networks (VNs) provisioned from a shared physical network substrate.

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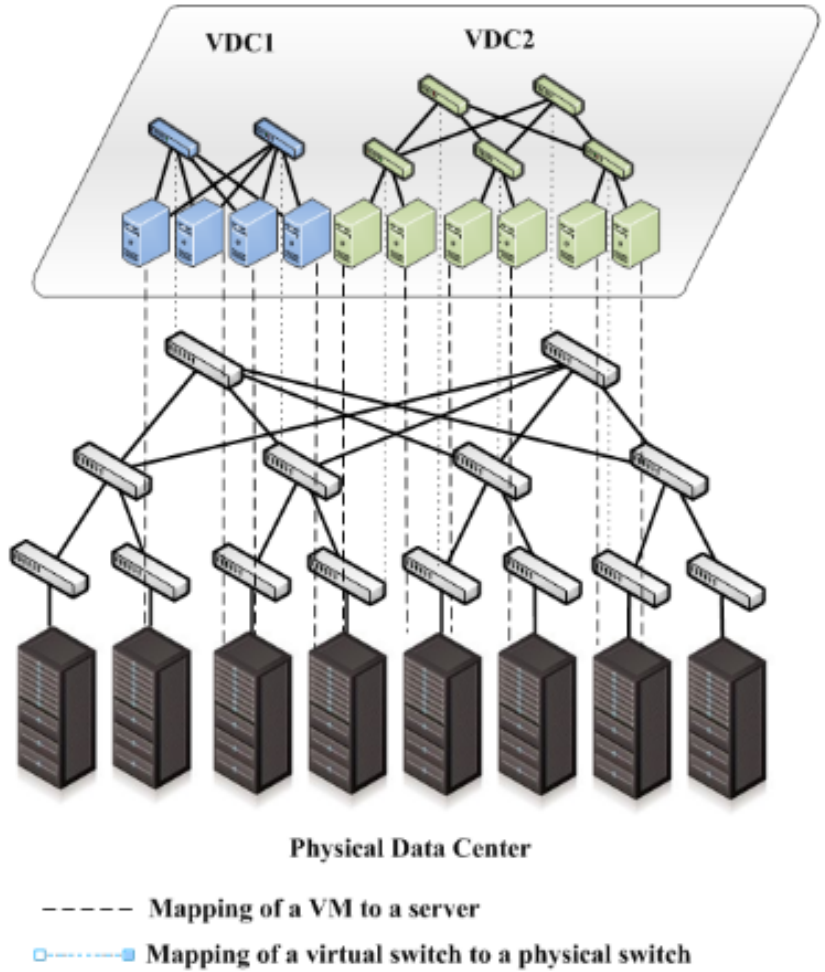
Other benifits include:

- customized network protocols.
- performance isolation, application QoS
- local management policies, security

server virtualization + network virtualization

$\Rightarrow$ **Datacenter Virtualization**



server virtualization + network virtualization

$\Rightarrow$ **Datacenter Virtualization**

a datacenter where some or all of the hardware (servers, routers, switches, and links) are virtualized.

a collection of virtual resources (VMs, virtual switches, virtual routers) connected via virtual links.

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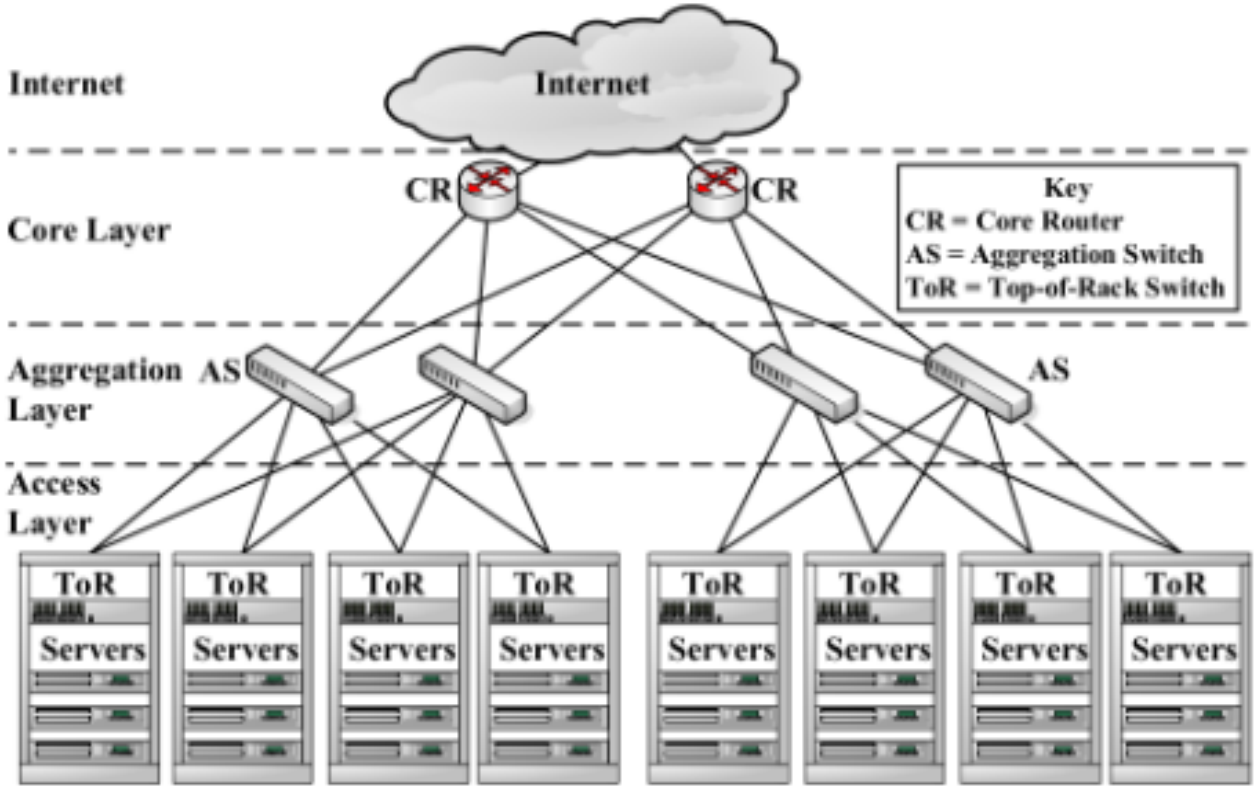
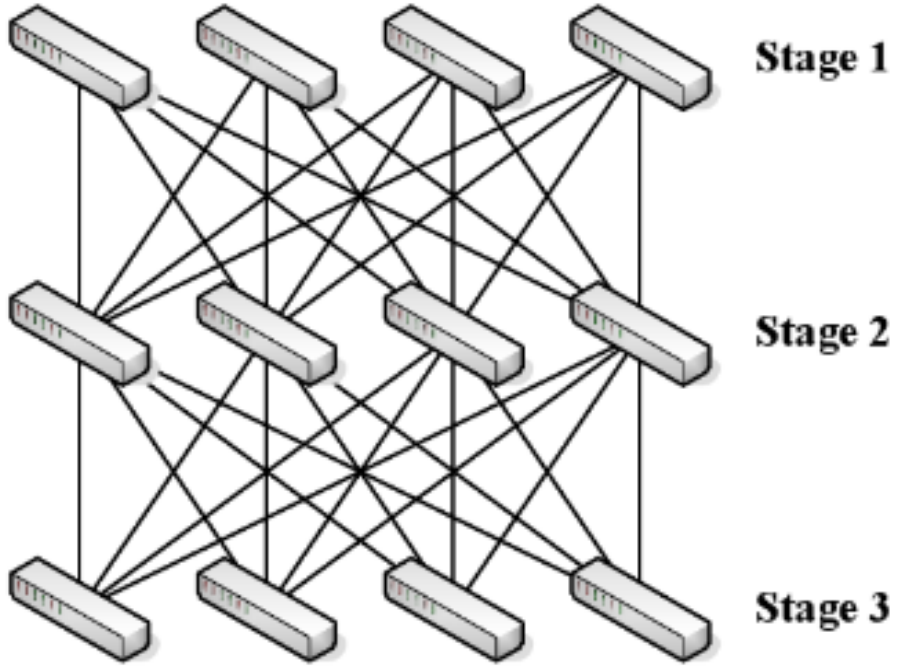
datacenter network is the communication infrastructure.



ToR: connectivity to the servers mounted on the rack
AS: forwards traffic from multiple ToR switches
Core: connectivity to the internet

Clos topology is built up from multiple stages of switches. Each switch in a stage is connected to all switches in the next stage, which provides extensive path diversity.



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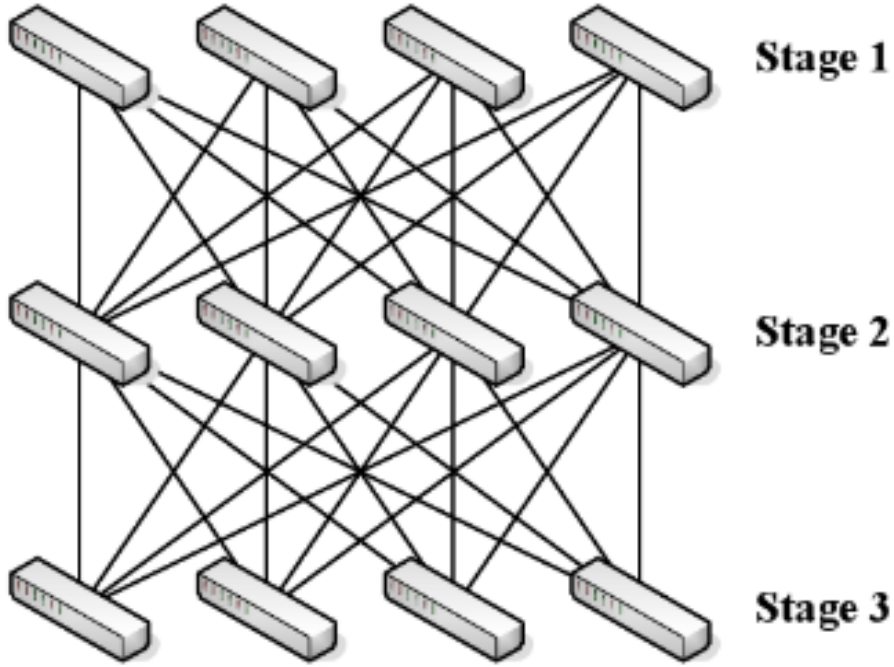

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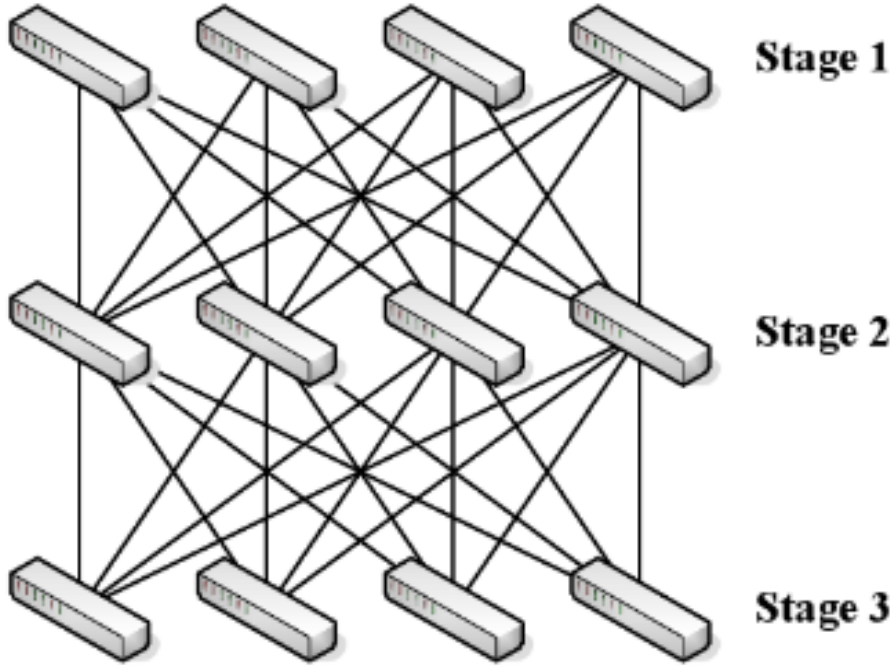

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A practical network topology is the assumption for our modeling work

Different roles in a datacenter ecosystem: (A game theoretical perspective)

- cloud providers (infrastructure owners)
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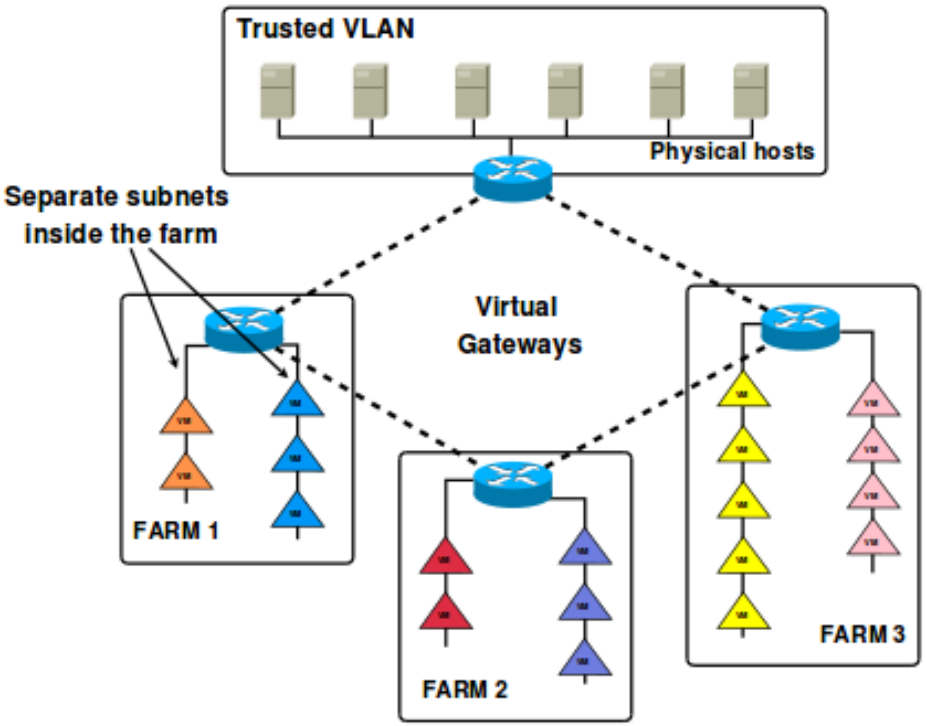
multiple service providers can deploy their coexisting heterogeneous network architectures required for delivering services and applications over the same physical data center infrastructure. (multi-tenant environment)

What concrete challenges should be addressed?

- each single tenant traditionally owns a VLAN whose number is limited.
- limited forwarding tables on commodity switches.
- differentiated services, in terms of the deadlines, latencies, bandwdith *etc.*
- .....

logical partioning of IP networks is essential for better accomodation of applications and services needs.



- tenant-aware addressing.
- no need for configuring switches.
- virtual software routers.
- VNET on each physical machines.
- modified ARP
- NAT-like solutions.

Aled Edwards et al., Diverter: A New Approach to Networking Within Virtualized Infrastructures

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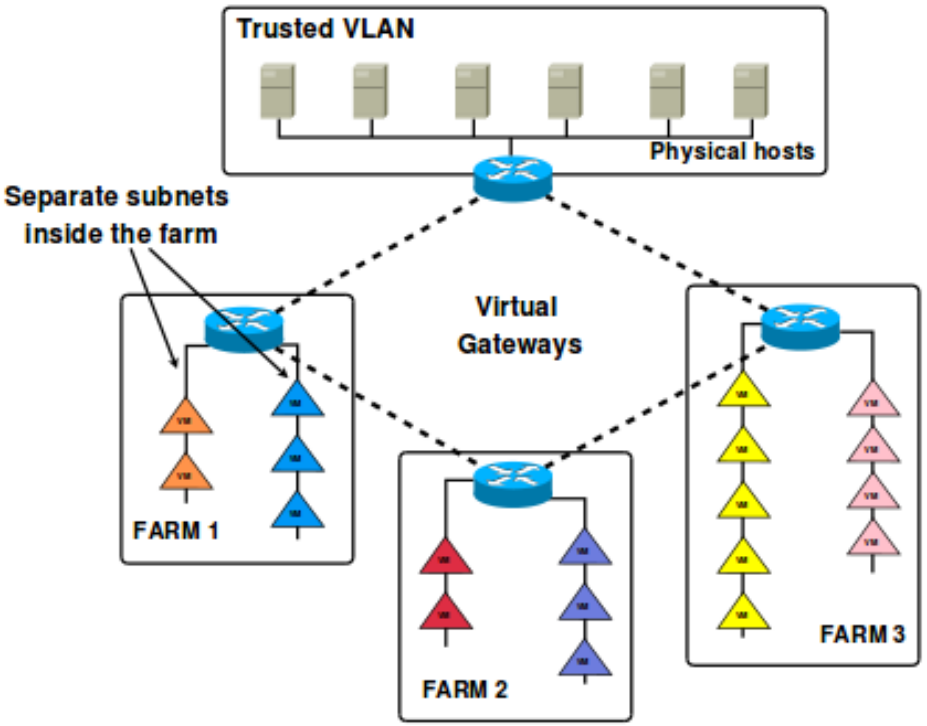

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No QoS guarantee; Performance

Albert Greenberg et al., VL2: A Scalable and Flexible Data Center Networks

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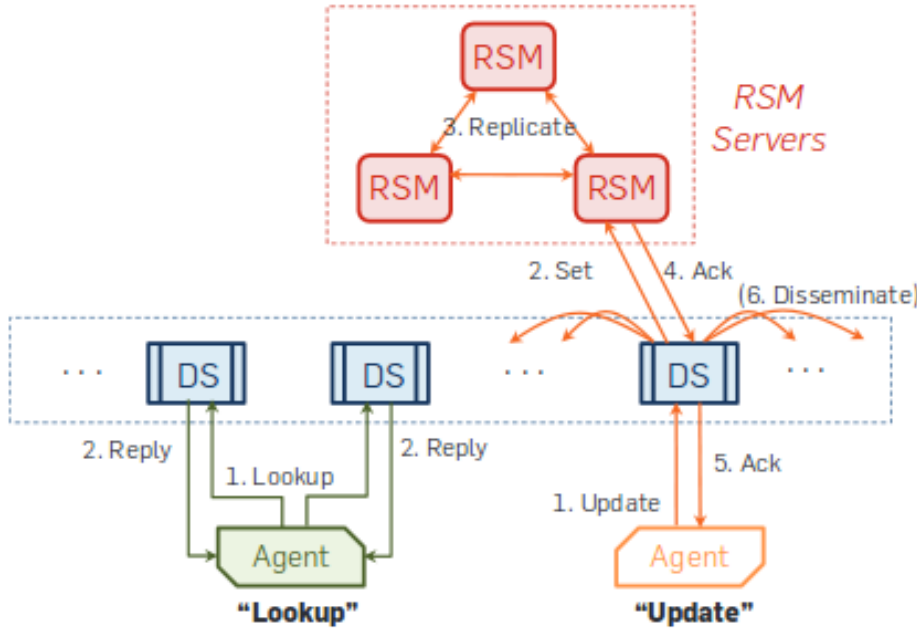
- two types of IP addresses, AAs and LAs.
- AA-to-LA mapping



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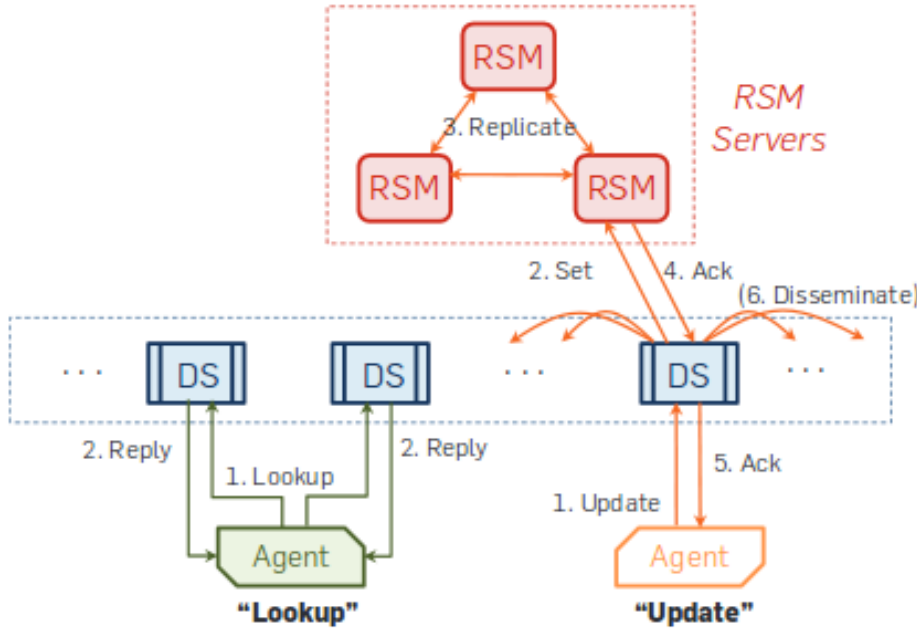

improved scalability; eliminates ARP and DHCP requests

Fang Hao et al., Enhancing Dynamic Cloud-based Services using Network Virtualization

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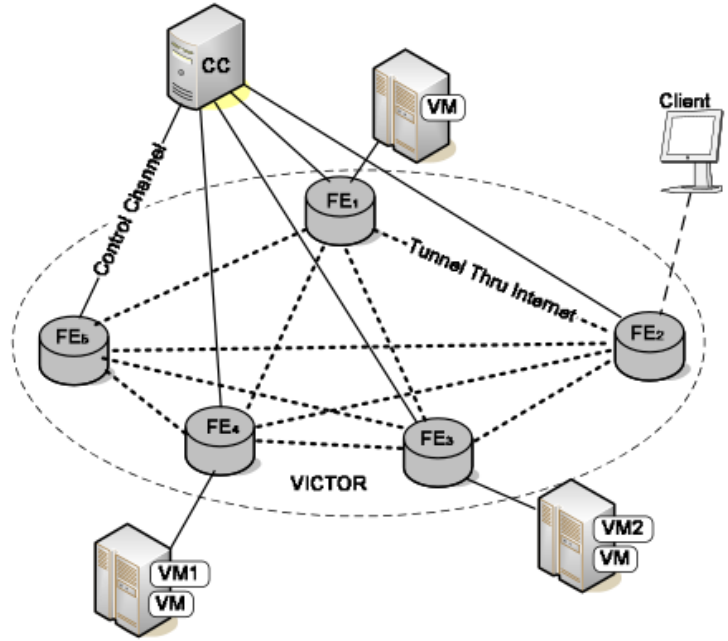
- keep the IP address, not straightforward for different networks.
- a cluster of forwarding elements (L3), virtual routers.
- a central controllers (CC)



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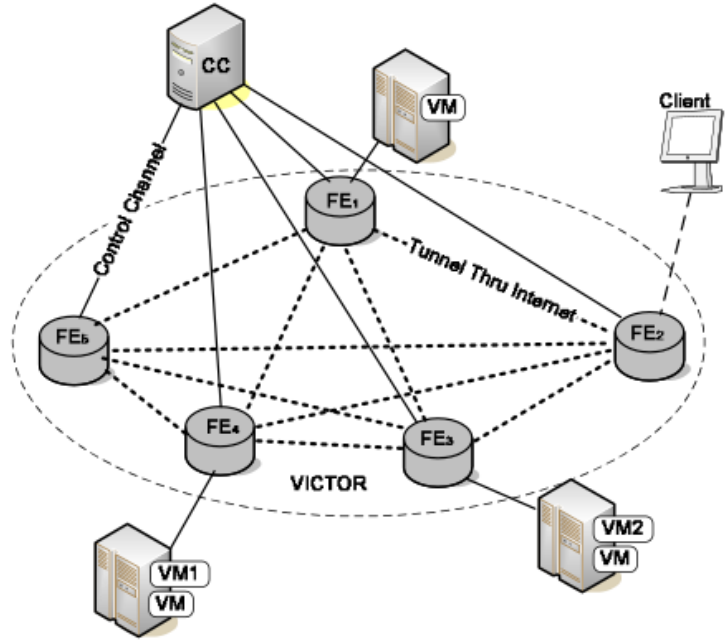

scalability issues

Theophilus Benson et al., CloudNaaS: A Cloud Networking Platform for Enterprise Applications

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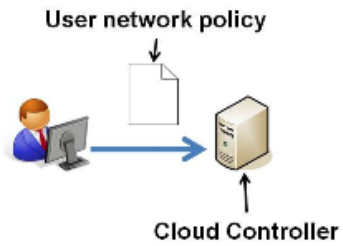

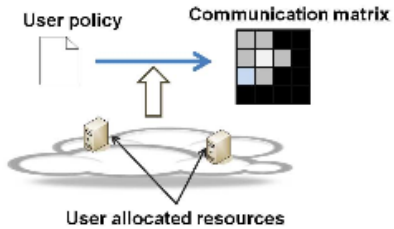

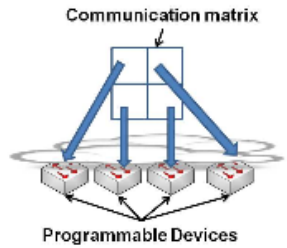

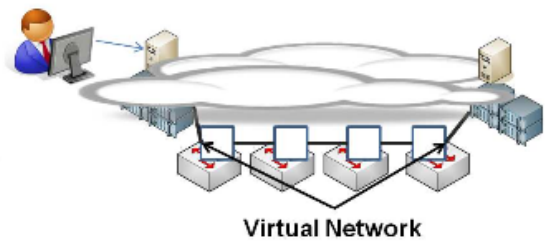

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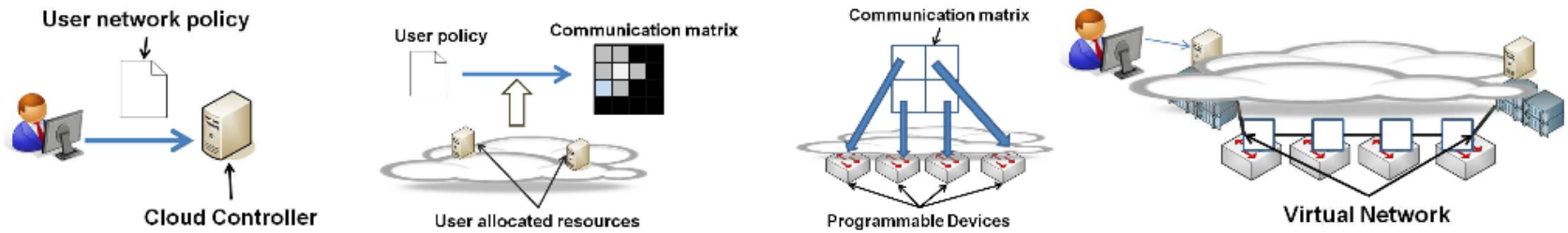

network congestion and poor utilization

Future Research Directions...

Virtualized Edge Data Centers

- Most of the existing studies focus on one large datacenter containing lots of machines
- Far away from end users
- results in higher communication cost and potentially sub-optimal service quality in terms of delay, jitter and throughput.

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challenges: how to best divide the service infrastructure between remote and edge centers? How to efficiently manage services hosted in multiple data centers? ...

Virtual Datacenter Embedding

- efficient mapping of virtual resources to physical ones. (NP hardness)
- existing research focuses on VM embeddings. Other resources should be considered as well.
- resource demand changes, reconfiguration cost.
- energy cost. The main challenge is to jointly optimize the placement of VMs and VNs.
- fault tolerance.
- failure of a physical link can drag down muliple virtualized datacenters that share the link.
- embed virtualized datacenters across multiple geographical regions.

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what is the ideal physical network topology?

Programmability

- increase flexibility to facilitate the introduction of new protocols, services and architectures.
- SDN (programming network control plane)
- problems of current standard, OpenFlow.

Network Performance Guarantees

- diversed performance requirements, latency, throughput, deadlines, etc.
- confict objectives for network performance and network utilizations.
- a good trade-off
- other challenges: TCP incast problem.

Pricing

- important in multi-tenant environments.
- fair and efficient.
- coupling among multiple virtualized resources.
- market-driven
- auction, game theory

Q & A
Thanks