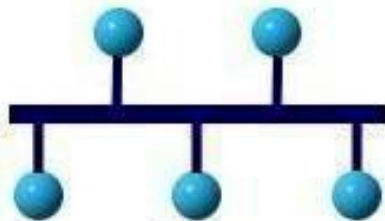


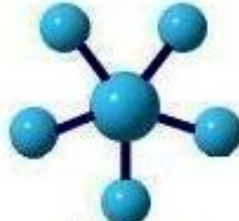
Network Timeline

	Mid 80s	Early 90s	Mid 90s	ca. 2000	Mid 00s
Market	Bell Breakup, NSFNET, Interop	Cisco, et al IPO	Netscape IPO, eBay, Amazon	Google	Facebook
Tech	Mac 1.0, Win 1.0	WWW	Mosaic, Win 95	Server Virtualization	iPhone
App	WP, CAD	Email	Ecommerce		Digital economy
Ethernet	10BASE5, 10BASE2	10BASET, EtherSwitch	100BASE-T	Gigabit Ethernet	10G Ethernet
Net Design	Bus	Star	Trees	Mesh	Fabric

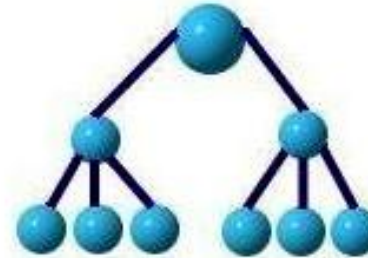
Network Topologies



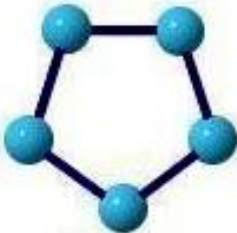
Bus



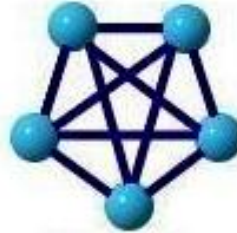
Star



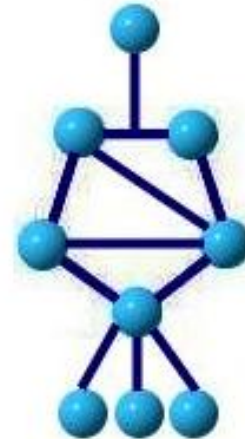
Tree



Ring

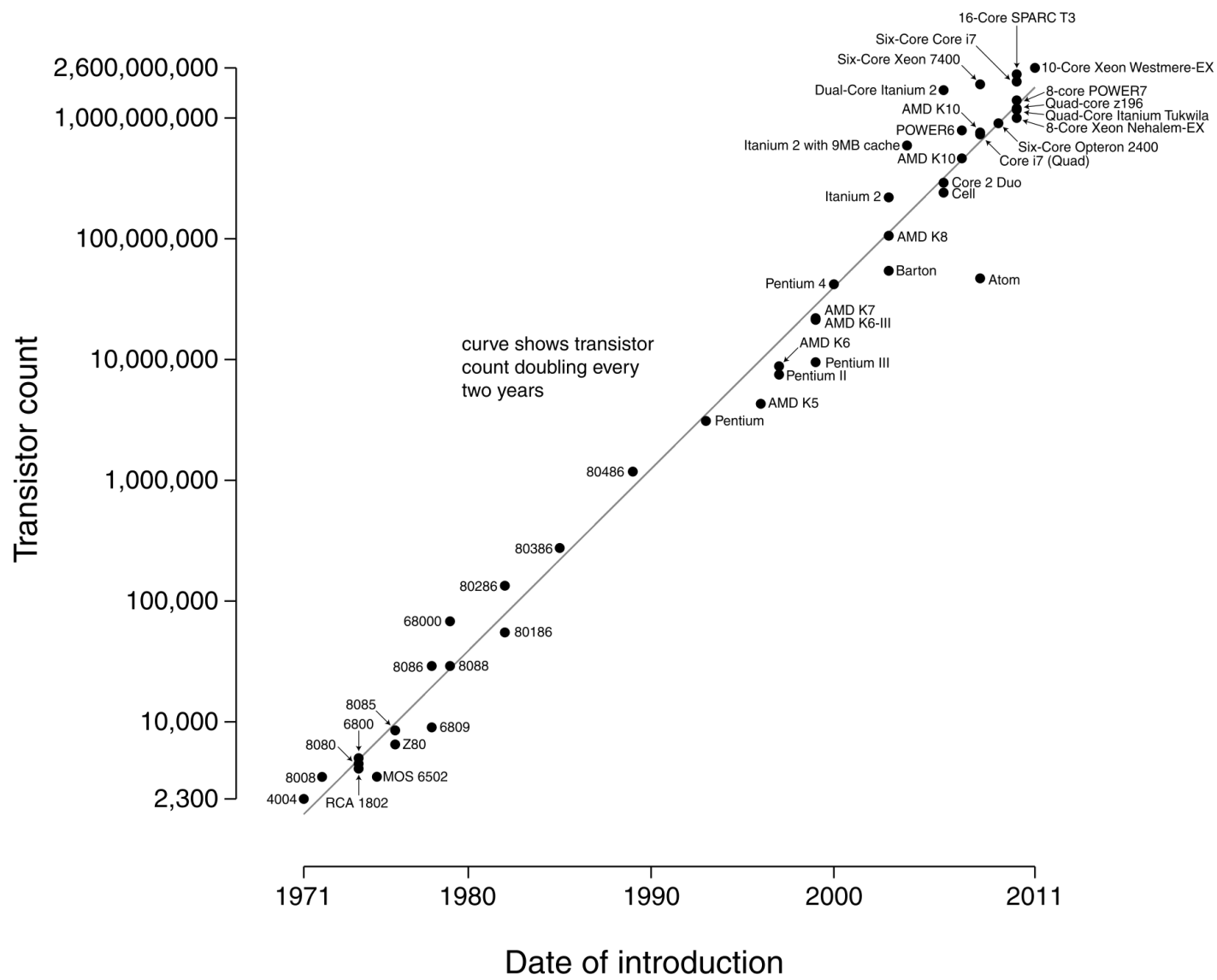


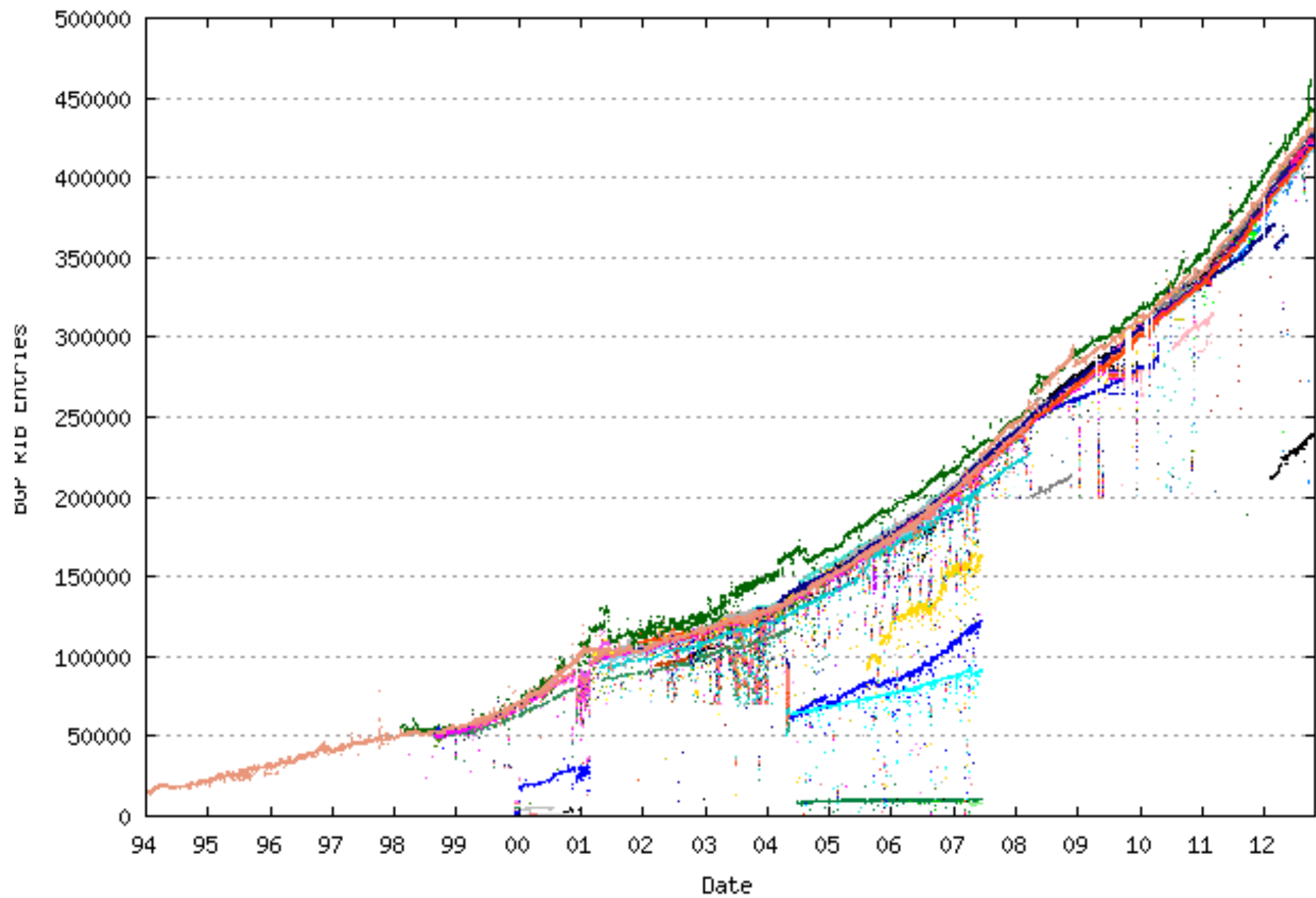
Mesh



Hybrid

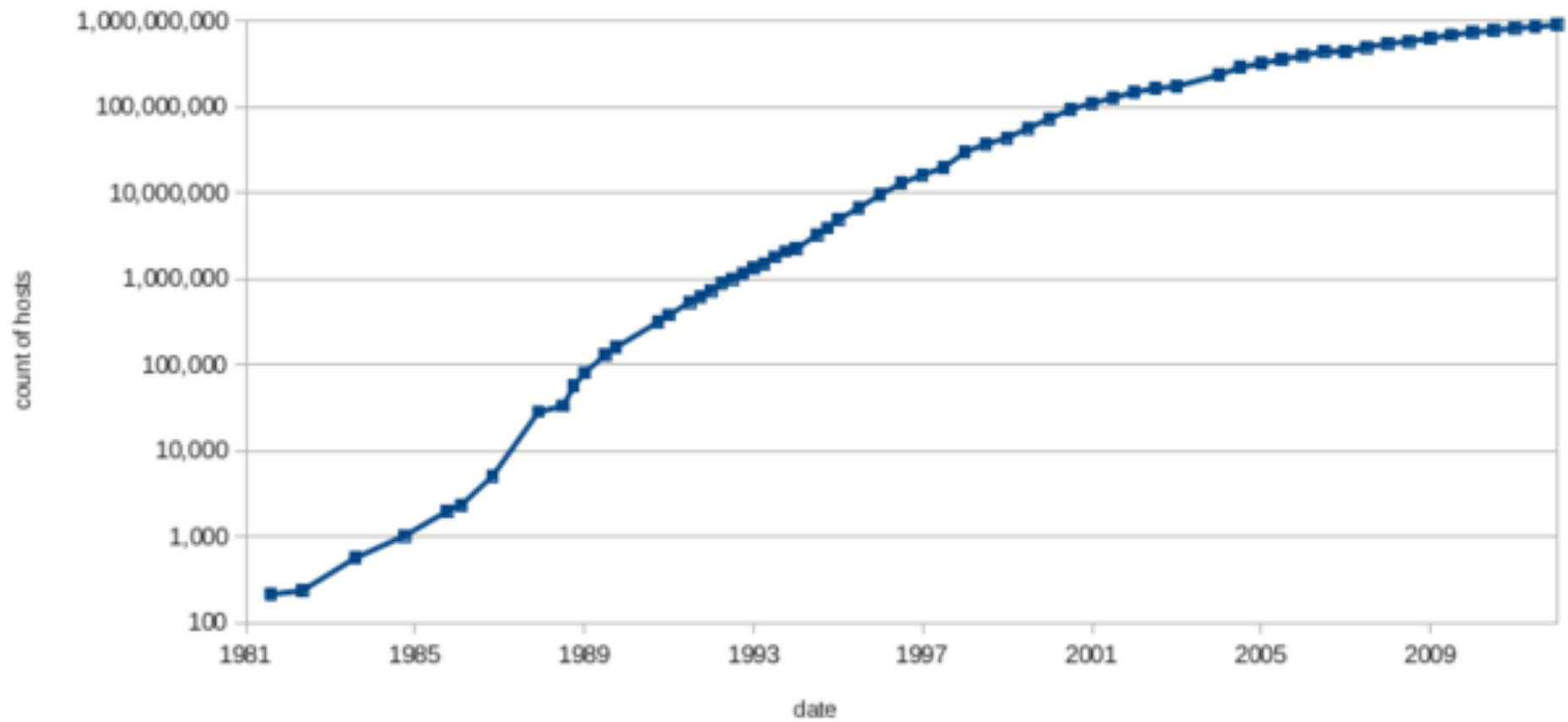
Microprocessor Transistor Counts 1971-2011 & Moore's Law





Internet hosts 1981-2012

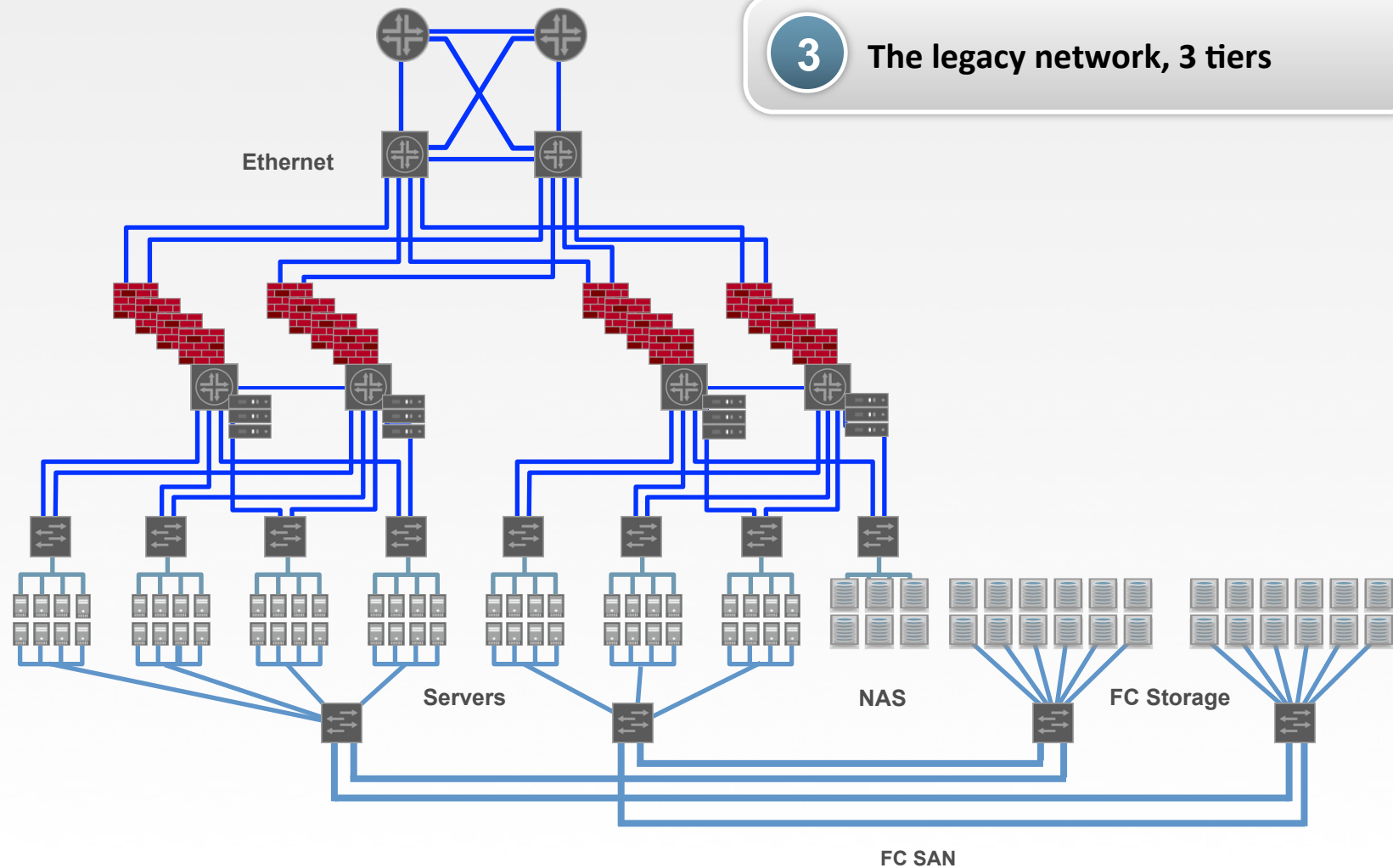
<https://www.isc.org/solutions/survey/history>



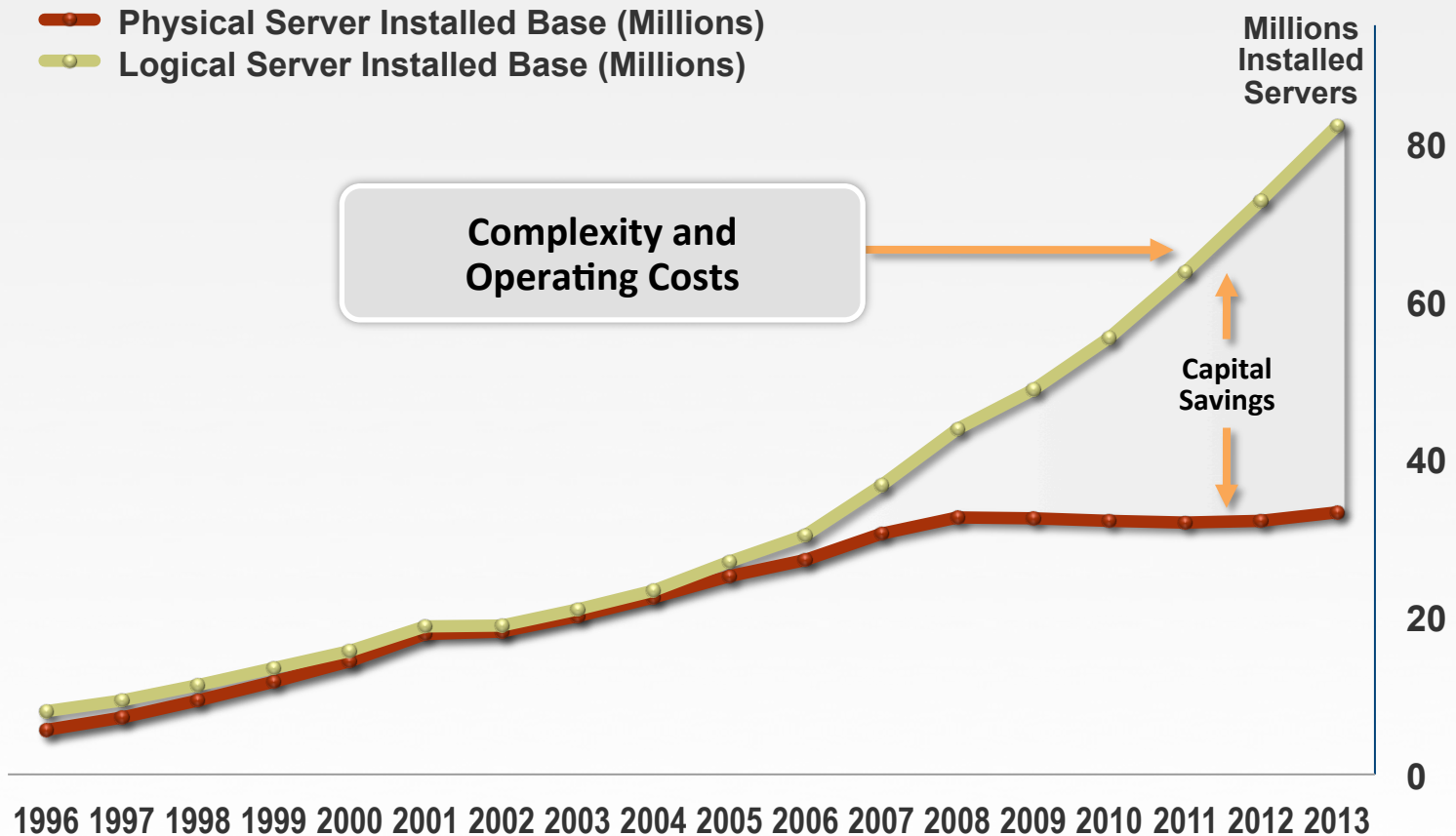
Legacy (tree of trees) Network Design

3

The legacy network, 3 tiers

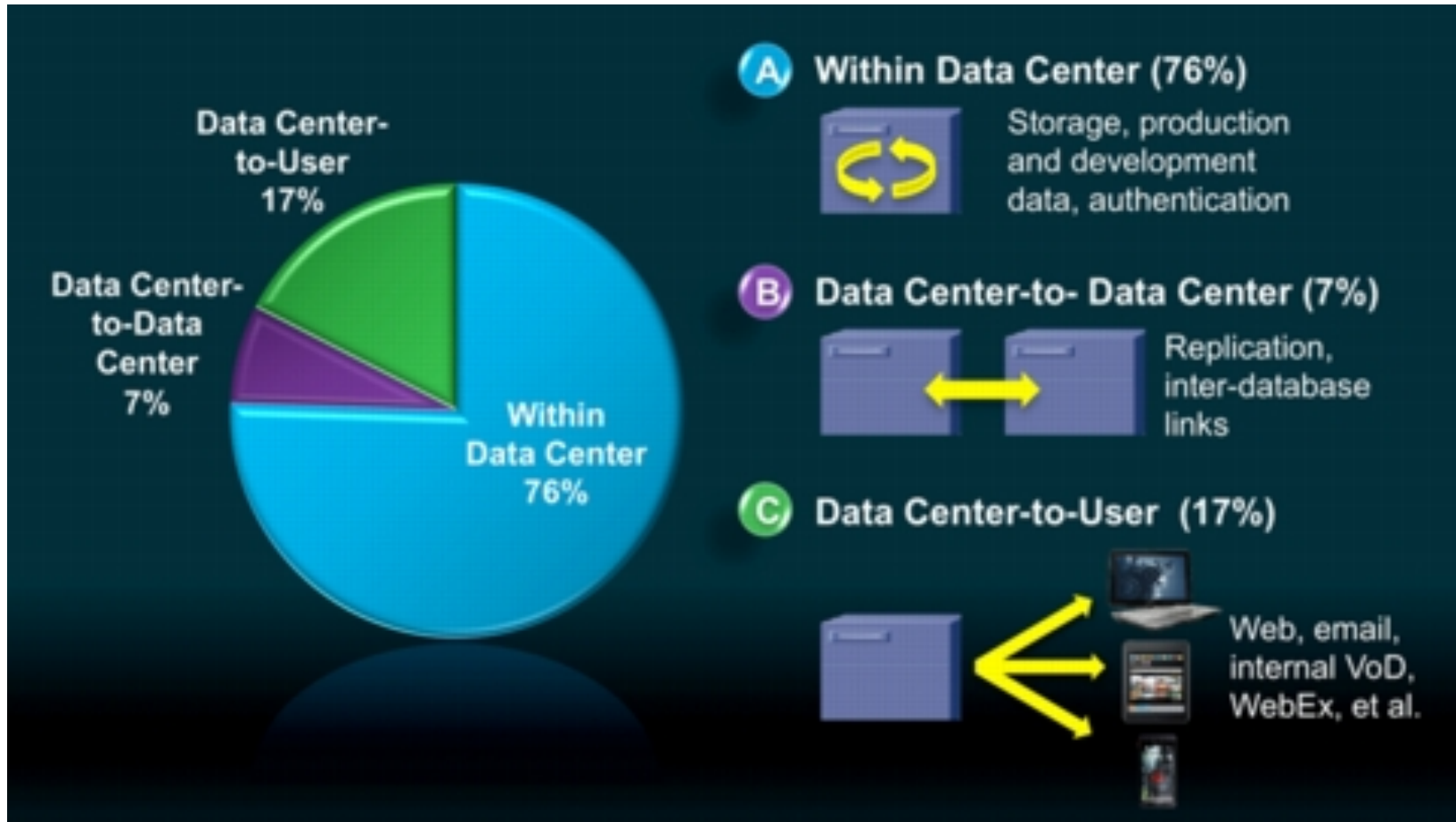


Virtual Servers surpass Physical



Source: IDC

“East-West” Traffic Pattern



Changing roles of the network

Traditional role – connecting users

- North-South traffic



Latency Tolerant

New role – connecting devices

- East-West traffic
- Ideally one hop away

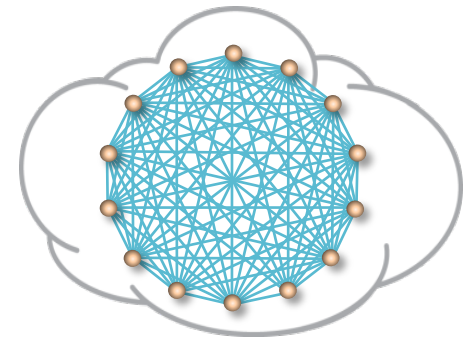


Latency Sensitive



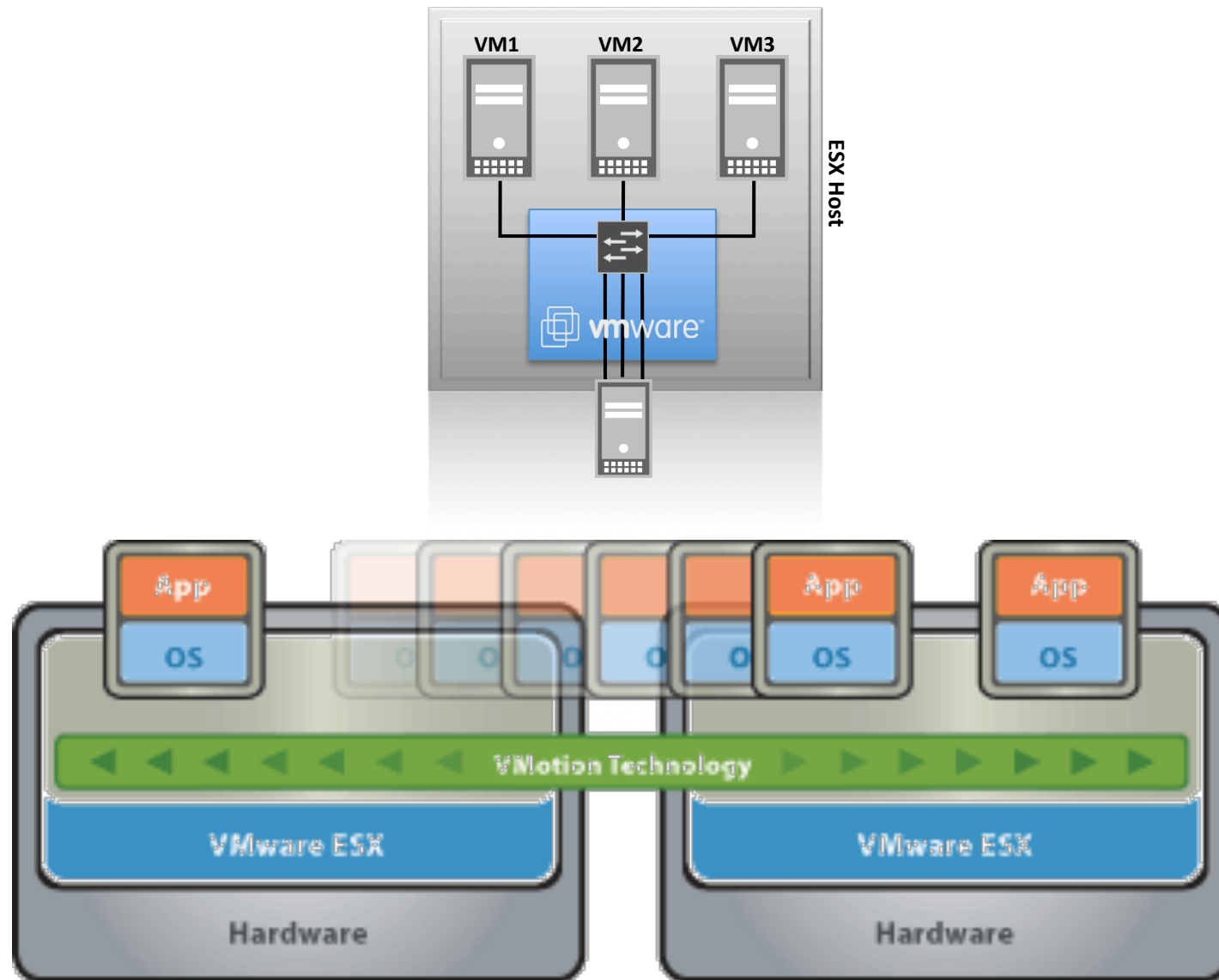
Newest role – foundation of the cloud

- Any-to-any connectivity

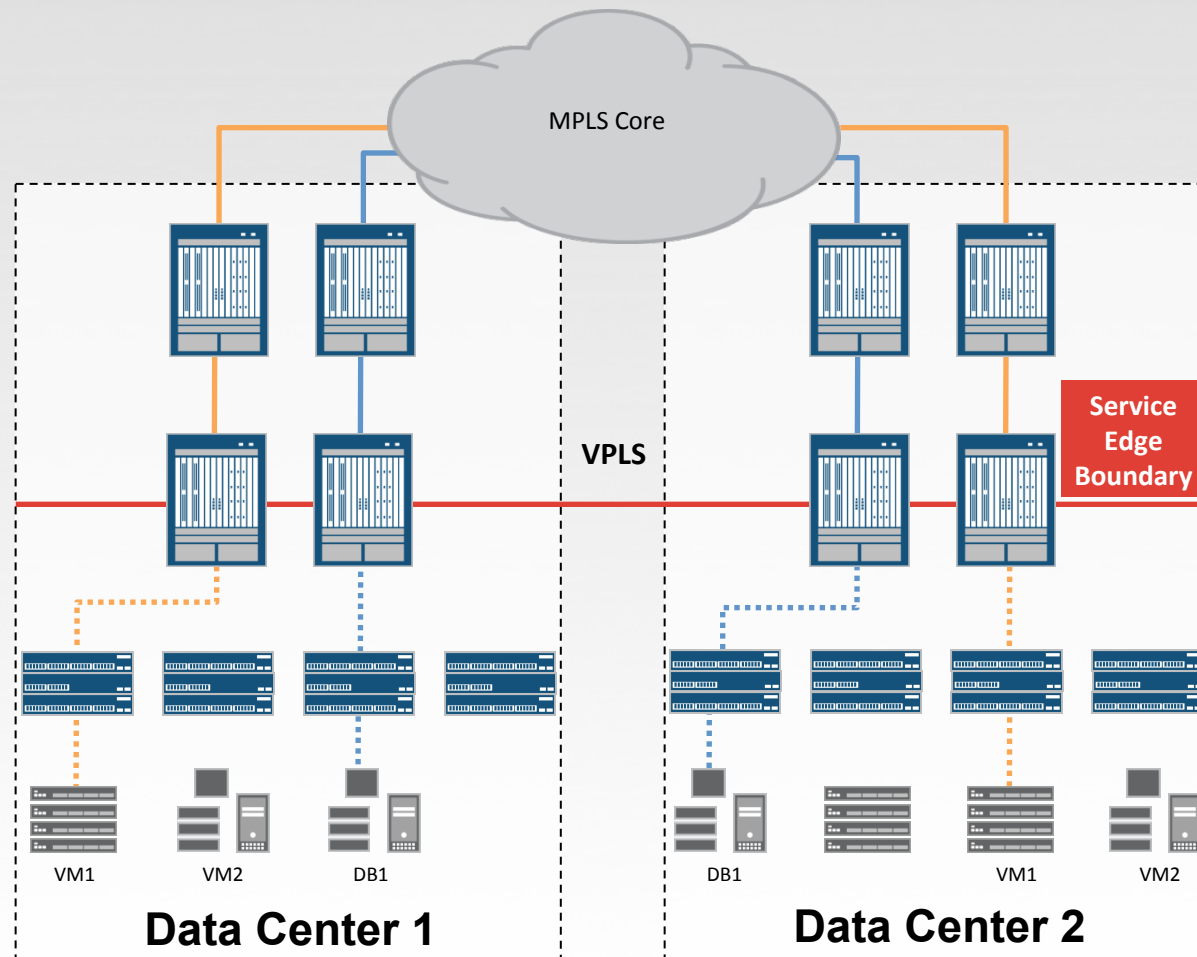


Ideally everything is interconnected and always one hop away

vSwitching and VMotion



Data Center Inter-Connect



Traditional Data Center network Challenges

Performance

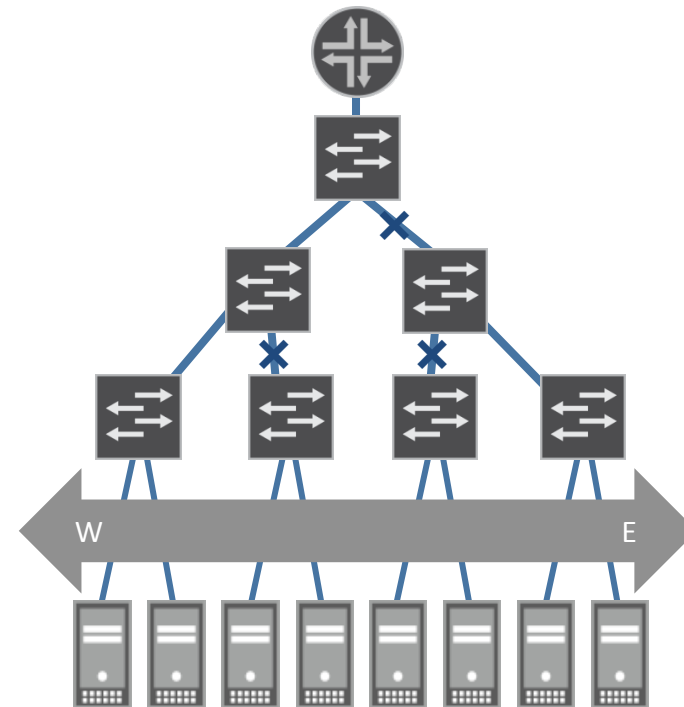
Spanning Tree disables upto 50% of bandwidth, tiered networks not optimized for E-W traffic

Scale

Requires additional layers and adds cost & complexity

Management Simplification

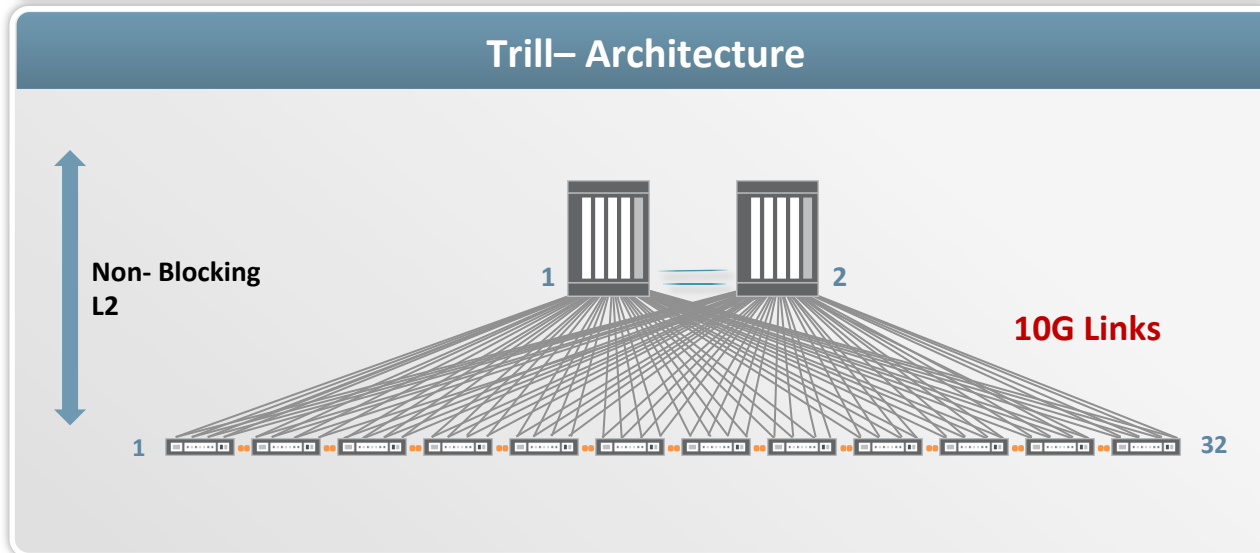
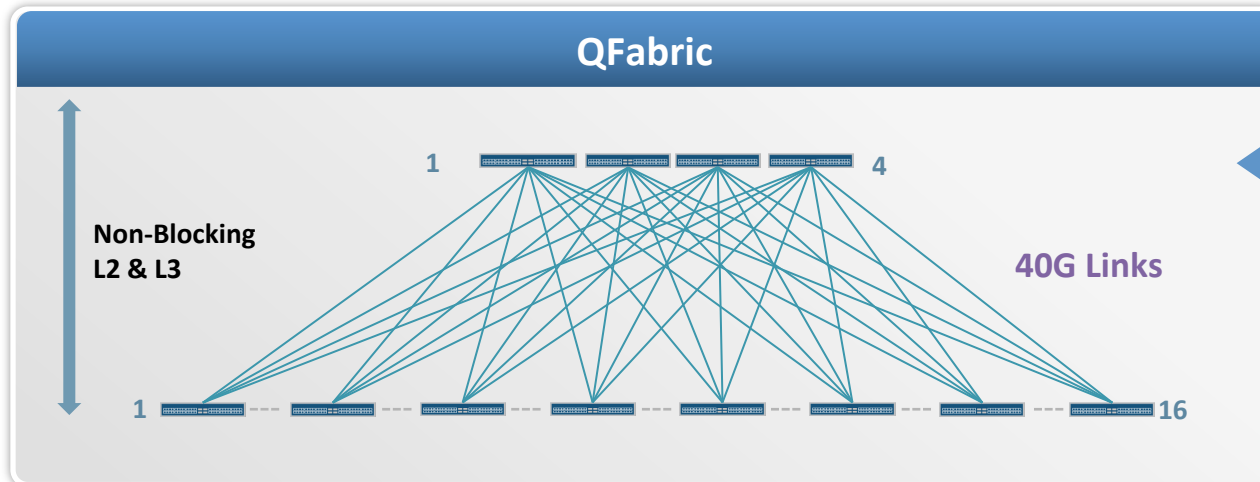
Every device managed separately, multiple networks



Emerging Standards For the Virtual Data Center

	VENDORS	IEEE	IETF
vSwitch (Network Overlay)	VXLAN (Cisco, VMWare, Citrix, RedHat) NVGRE (Intel, Microsoft, Dell, HP) STT (Nicira)		VXLAN (draft) NVGRE (draft) STT (draft)
vSwitch (EVB)	VEPA (HP, IBM, Brocade, Juniper) VN-Tag(Cisco)	VEPA (802.1qbg) VN-Tag (802.1qbh)	
Data Center Fabrics	QFabric (Juniper) FabricPath (Cisco) VCS (Brocade) IRF (HP)	SPB (802.1aq)	TRILL (RFC 5556, 6326)
Data Center Interconnect	OTV (Cisco) LISP (Cisco) EVI(HP)		VPLS (RFC 4762) MAC VPN (draft) EVPN (draft)

Data Center Fabrics



**40G Fabric vs.
10G Fabric**

74% fewer cables

63% less space

29% fewer devices

Full Layer 2 and Layer
3

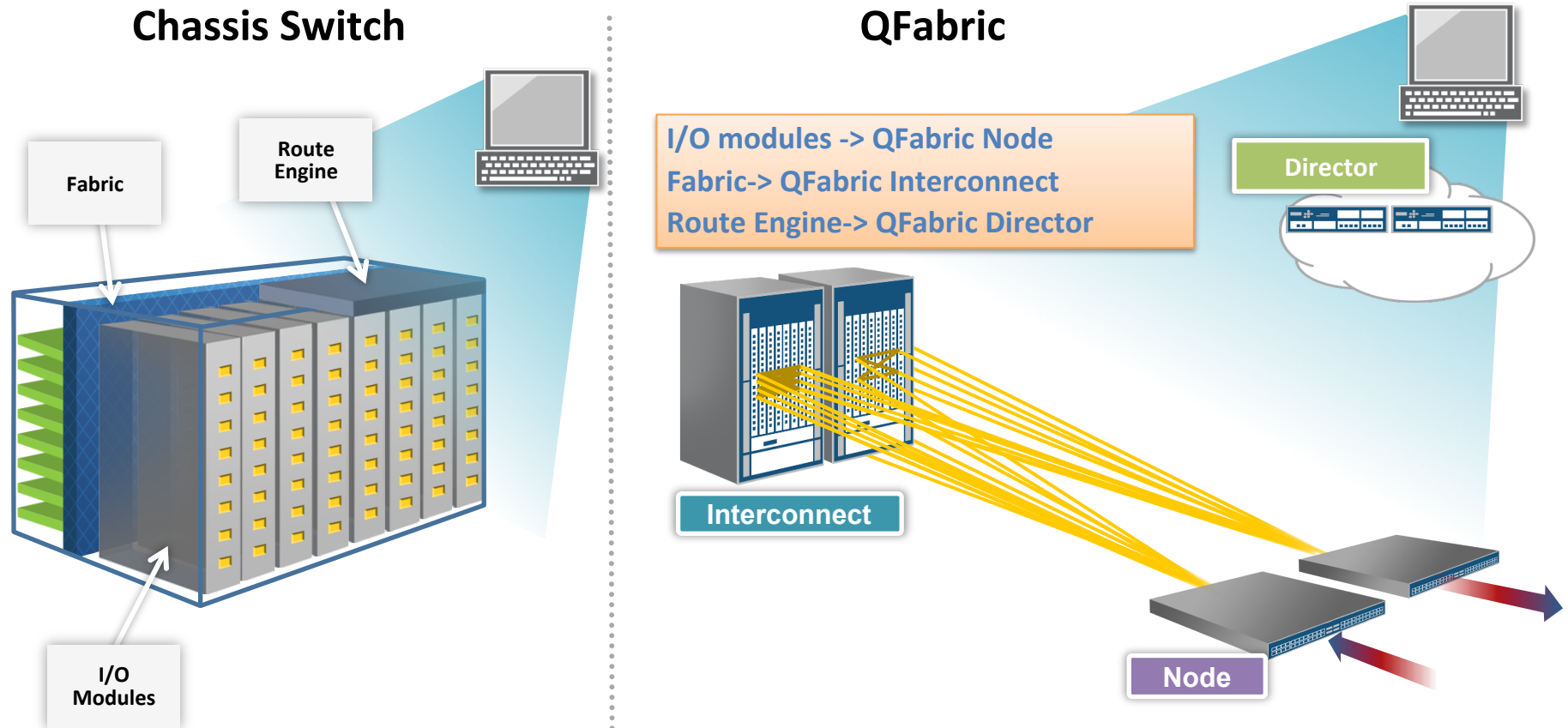
FC-FCoE gateway

Seamless scaling
beyond 768 ports (to
QFX3000-G)

- Predictable performance
- Single device mgmt
- 1-Tier
- Flat, any-any

@3:1 oversubscription

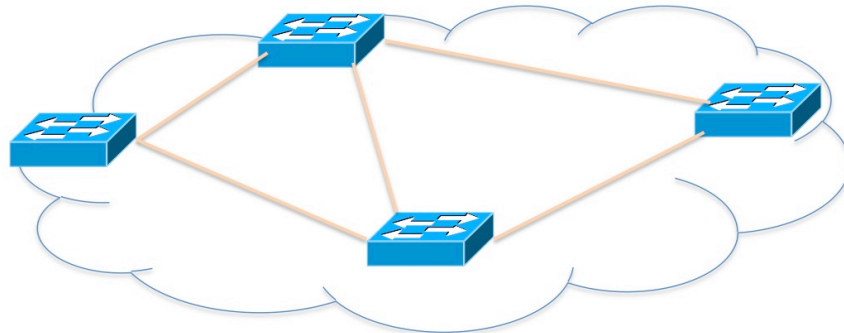
QFabric evolving the single switch model



- Copper traces inside a switch replaced with 40G Fiber links between Node & Interconnect.
- Out of band control plane network (not shown) connects all nodes/interconnects to the Director
- Director enables QFabric to be managed as 1 switch

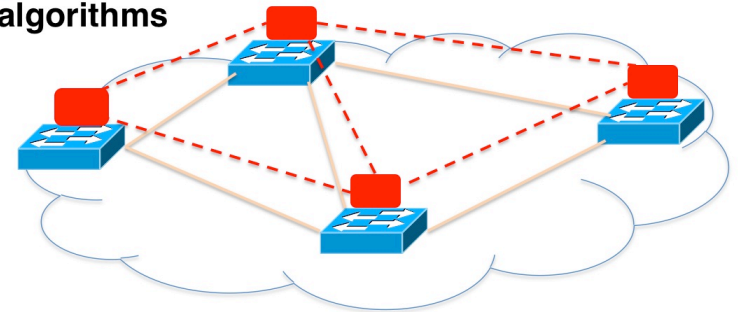
Traditional Computer Networks

Data plane:
Packet
streaming



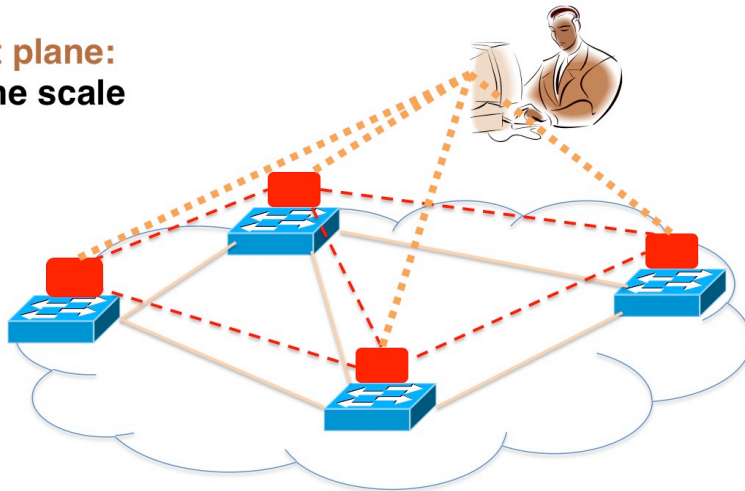
**Forward, filter, buffer, mark,
rate-limit, and measure packets**

Control plane:
Distributed algorithms



**Track topology changes, compute
routes, install forwarding rules**

Management plane:
Human time scale



**Collect measurements and
configure the equipment**

Software Defined Networking (SDN)

