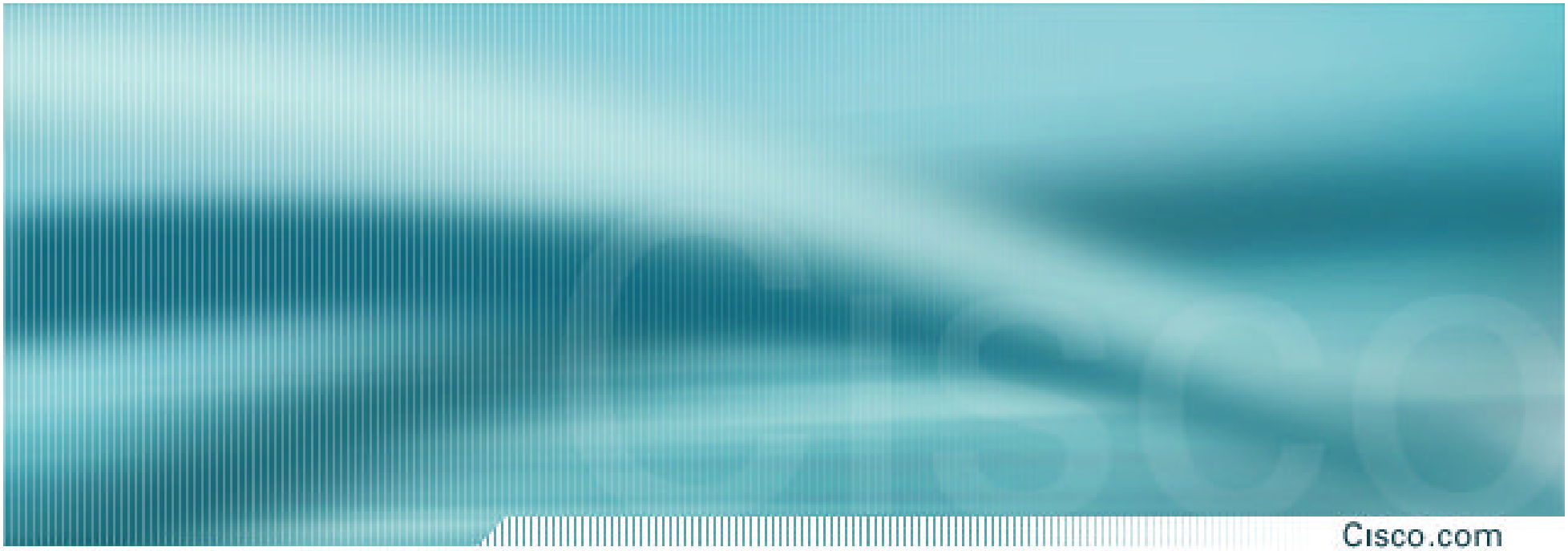
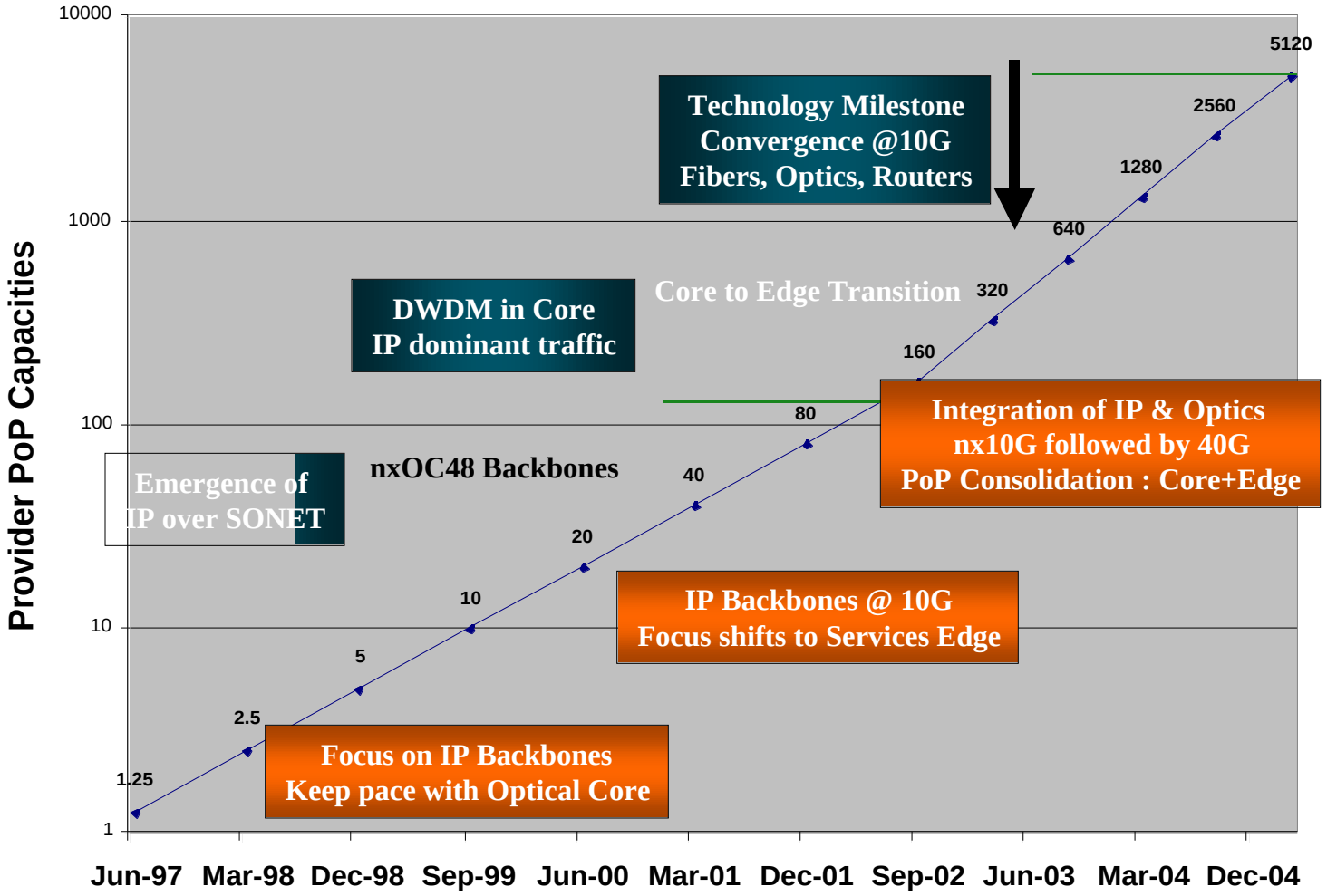


Building Core Networks and Routers in the 2002 Economy

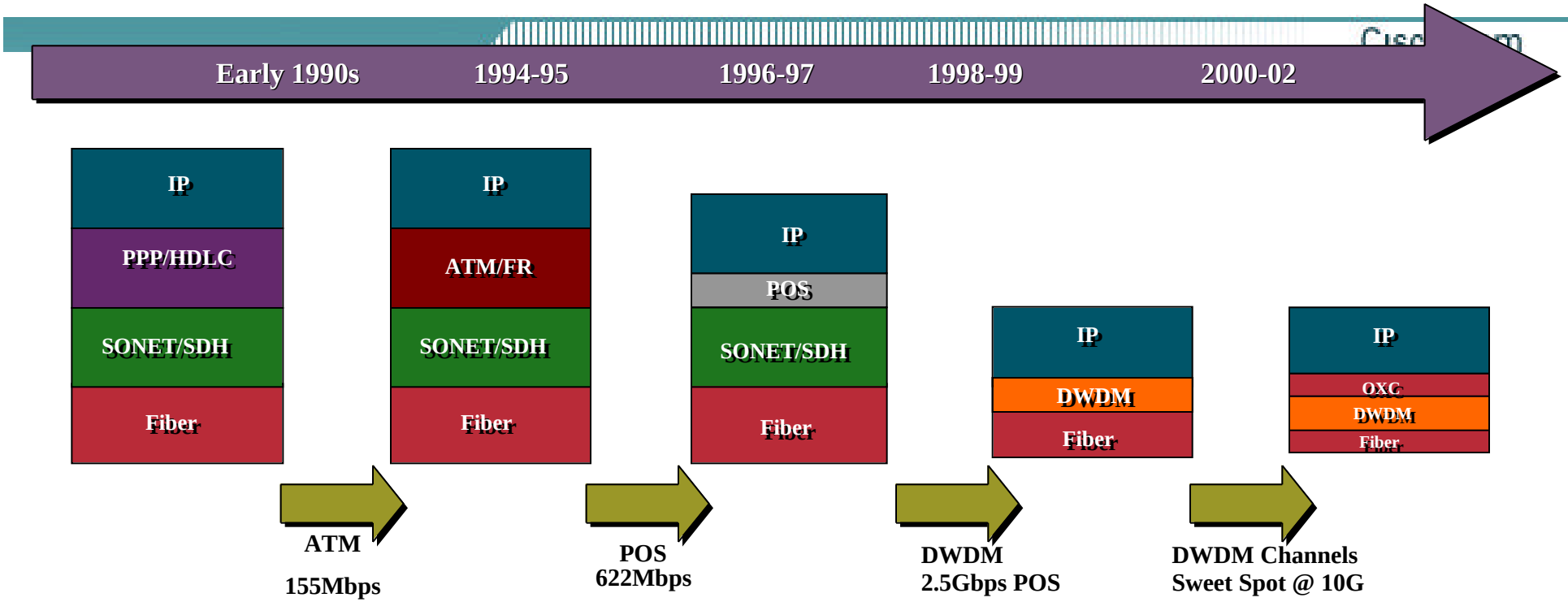
June, 2002

David Ward
Cisco Systems, Inc.
(mailto:dward@cisco.com)

Internet Backbone Growth
Key Inflections & Trends



Internet Architecture Evolution



IP over TDM	IP over ATM	IP over SONET	IP over DWDM	IP @ 10G
• DS3 overlay • Voice dominates • Internet Commercialization	• ATM overlay • Voice dominates • Web based applications appear	• IP @ OC12/STM4 • Rapid growth in IP traffic recognized • Internet Data Centers	• Routers connect to the fiber directly • IP dominates • Backbone buildouts	• 10G sweet spot for Fiber, Optics & IP • Everything over IP • New services on edge

Requirements

- VPN (MPLS + IP encap)

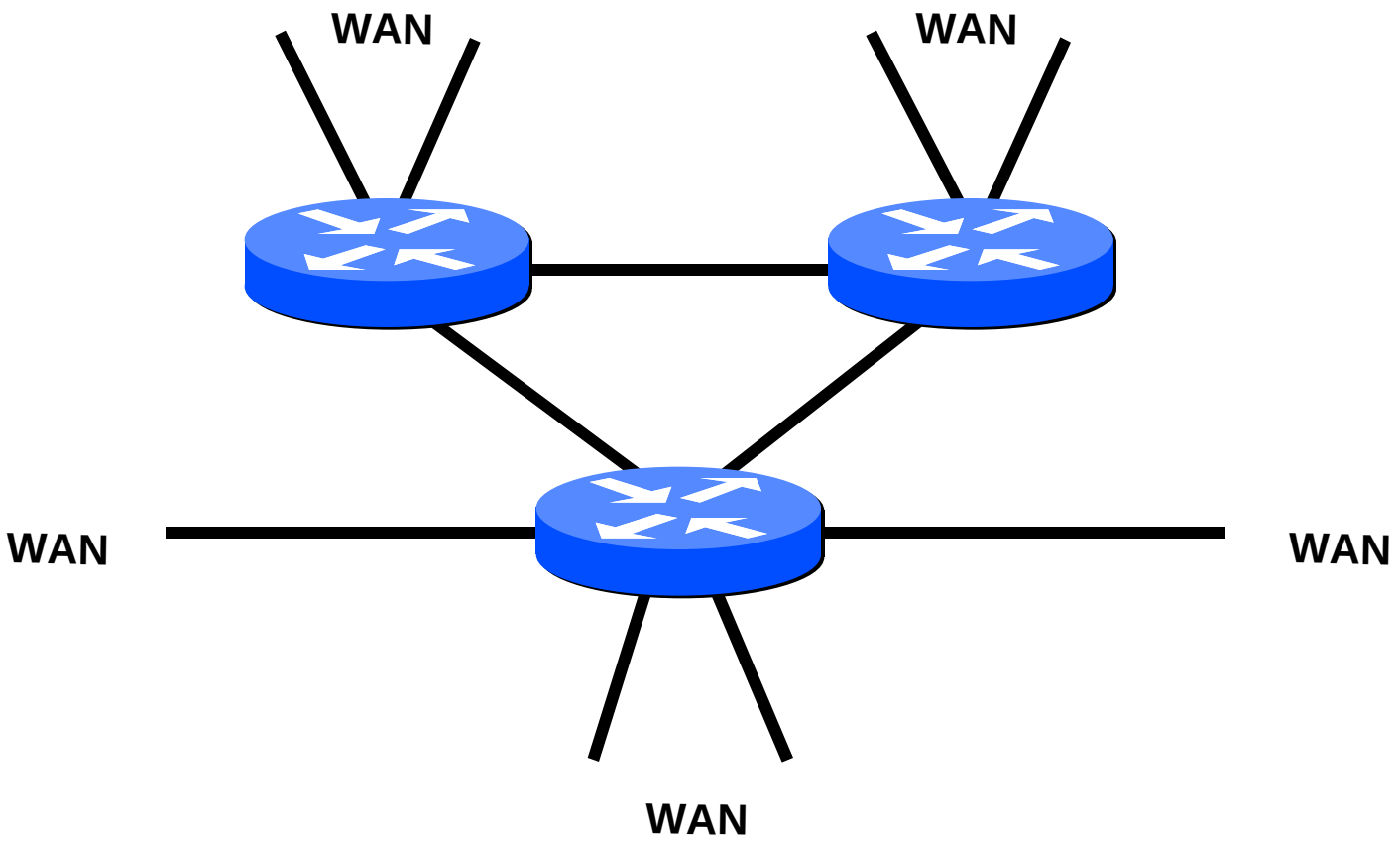
- Small, Low Power/HVAC
- 10 -> 40 Gbps
- Improved performance
- Easy to Manage
- Features
- Low prices
- High Availability
- QoS
- Early deliveries

FLEXIBILITY

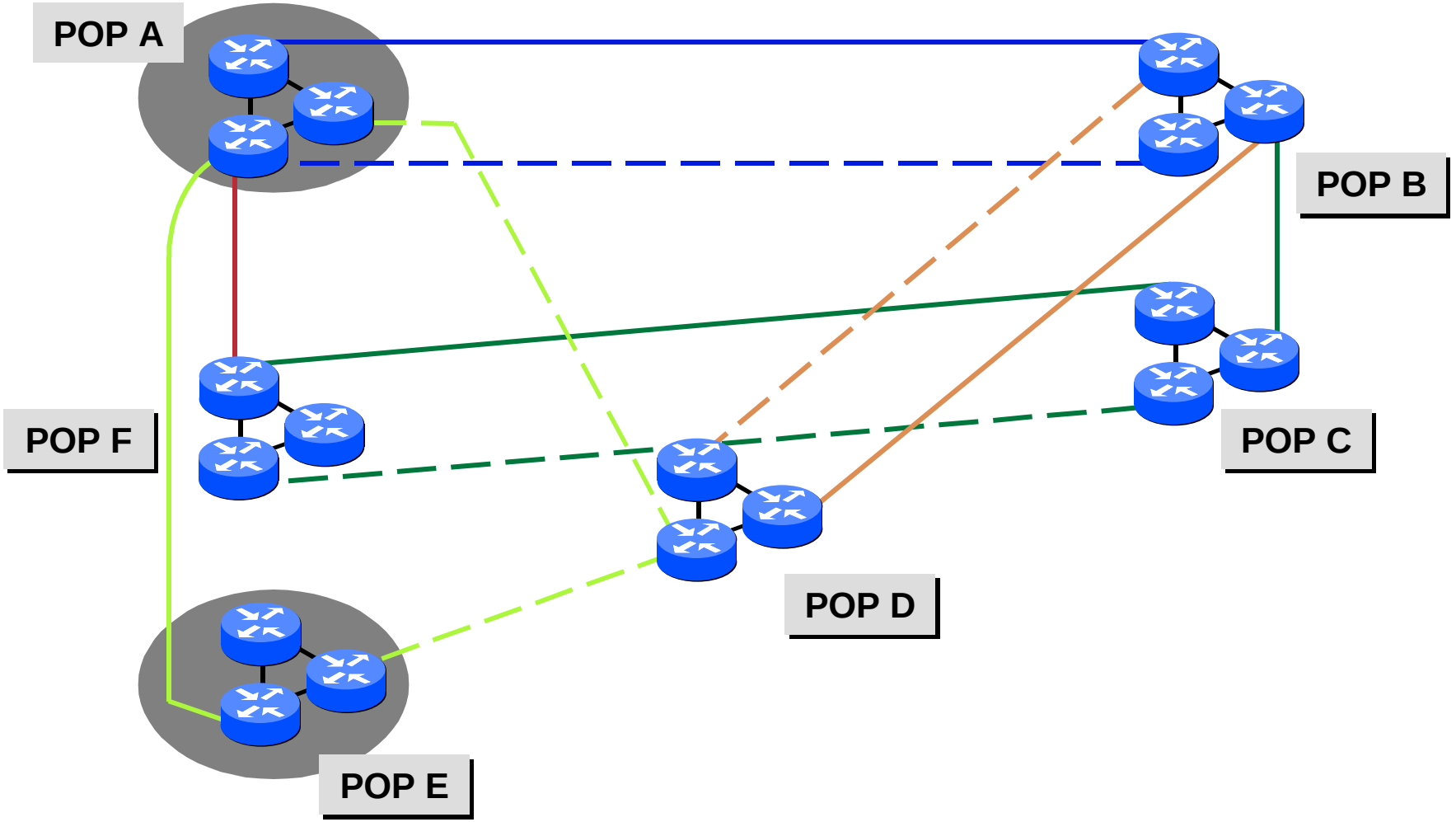
SENSE OF URGENCY

Anything Else?

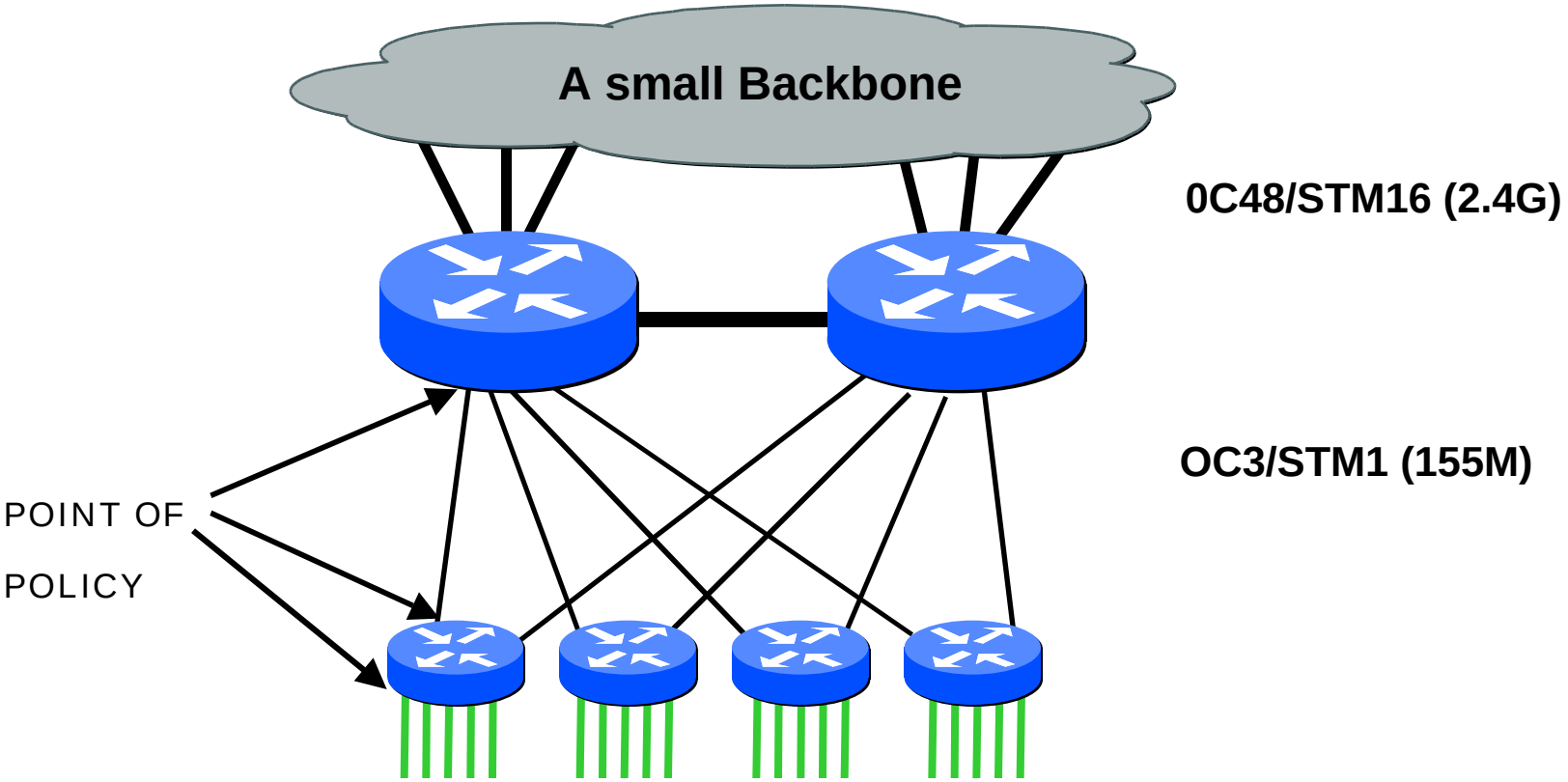
The Net – Core Section



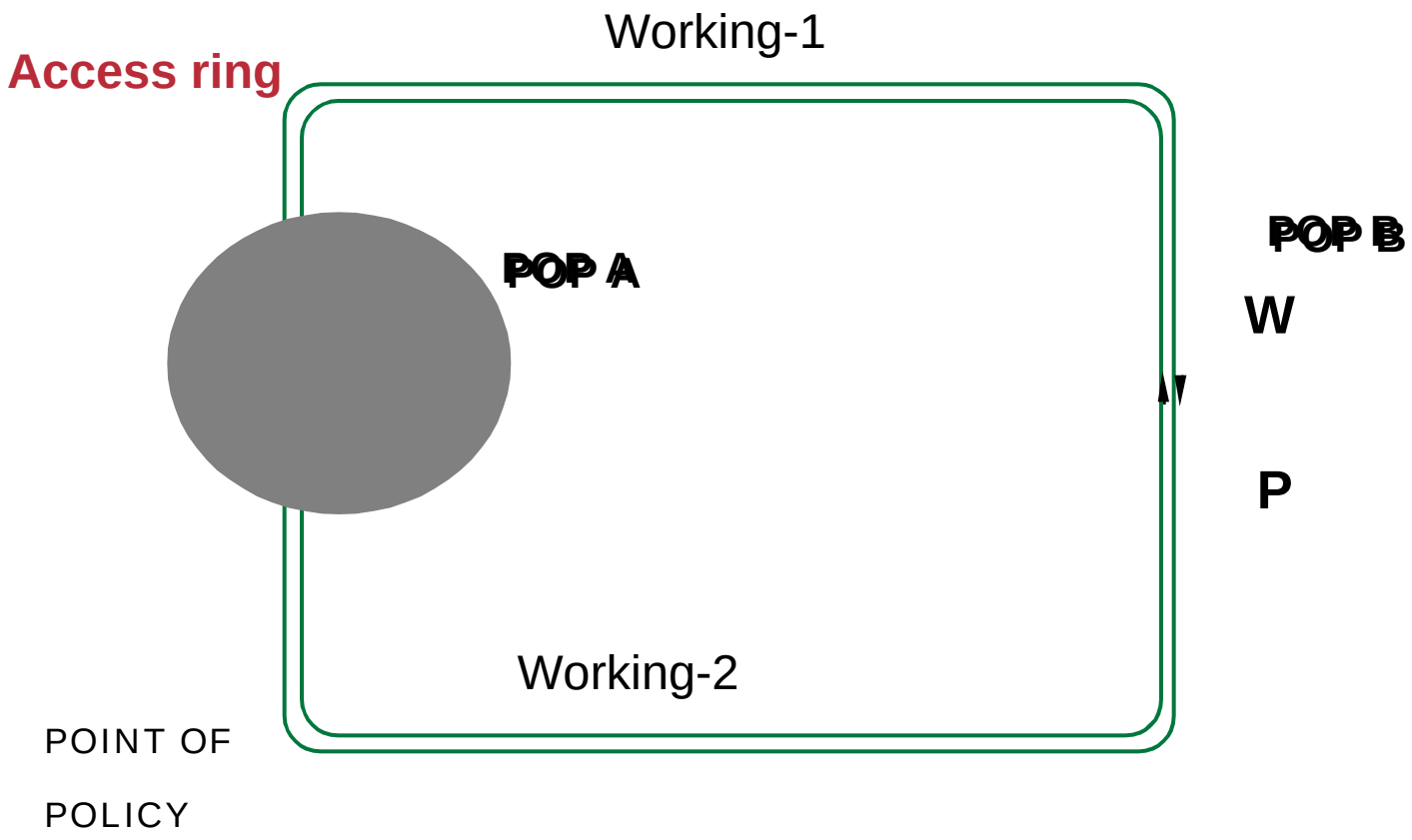
A Generic Backbone



One way of interconnecting boxes: Lots of mesh, need TE

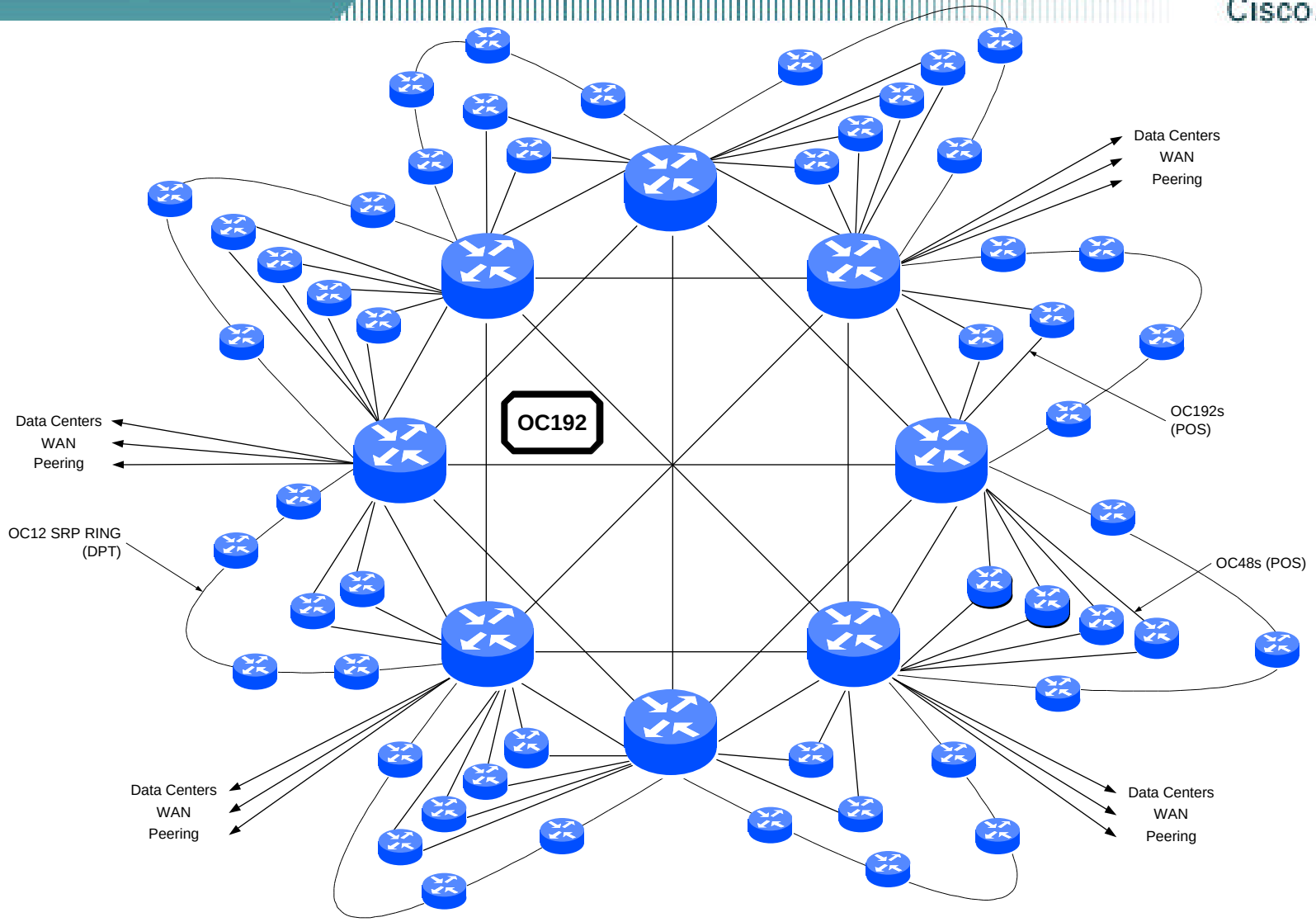


Another way of interconnecting boxes: Goal = reduce meshiness

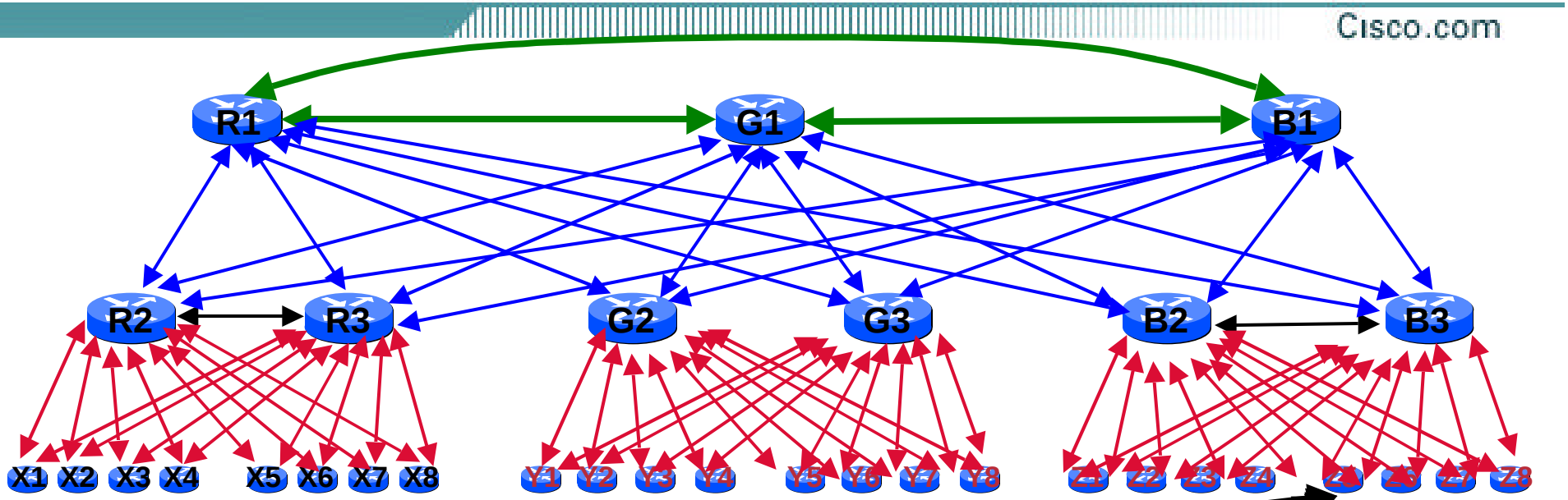


Rate limiting and granular scheduling

POPs interconnected



It’s all about building a better Network



- **Multiple Tables**
- **Multiple Topologies**
- **Multiple Overlay Networks**
- **Multiple Address Families**
- **Multiple Logial Routers**

Conflicts

- **Dumb Packet Pushers vs all the features at all locations**
  - **One box, chipset, codebase that covers all network niches**
  - We tell each other that Internet routers are simple.
    "All routers do is make a forwarding decision, update a header, then forward packets to the correct outgoing interface."
  - We know the internet isn't this simple either
- **Some newer features**

  Multicast
  IPv6
  DiffServ, IntServ, priorities, WFQ etc.
  Latency requirements
  Packet sequence
  Others: Drop policies, VPNs, ACLs, DOS traceback, measurement, statistics, …

Software

- **Software on a Router *used to do* three things**
  - **Forwards packets - IPV4 unicast**
  - **In the correct direction - route me**
  - **Makes it easy for the operator to engineer traffic - CLI**

- **Now**
  - **Forward Packets and perform X0's of treatments, stats, etc**
    - **V4 uni && v4 mcast && V6 uni && V6 mcast && MPLS && tunnel && Optical Control && Traffic Engineering**
  - **Route but, allow for selectable algorithms depending on topology, adjacency, N-level policy search**
    - **Converge instantaneously**
  - **End to end manageability solution with guru hooks, pointy-clicky and infinite storage for stats and packet sniffing**

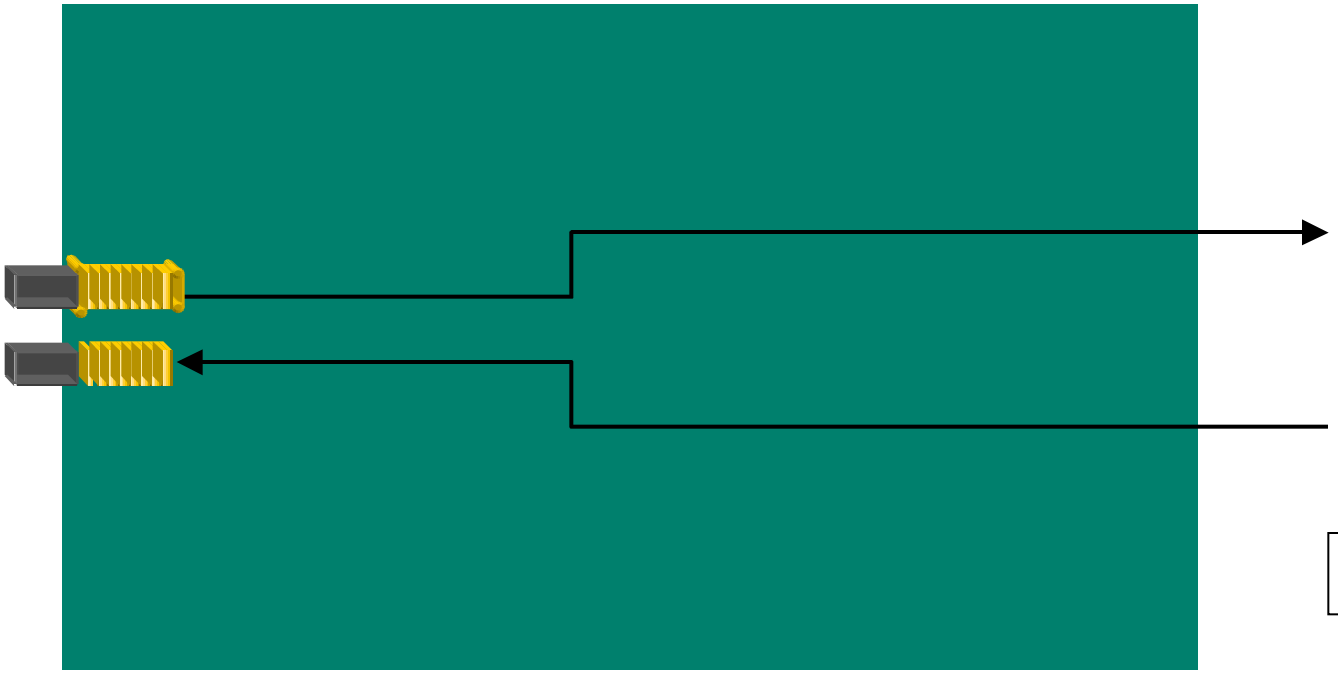
It all makes perfect sense

- New ***regulations***
- ***Security***
- New services or different ***services*** to get customers
- ***Converging*** infrastructure
- Can't afford overlay deployment strategy
- ***Acquisition*** and converging internet
- New POP architecture to ***reduce capex*** costs
- New manageability architecture to ***reduce opex*** costs
- ***Better billing*** and statistics systems
- Must have packet based system with same ***High Availability*** as current circuit delivered services
- Reduce maintenance windows - ***increase uptime***

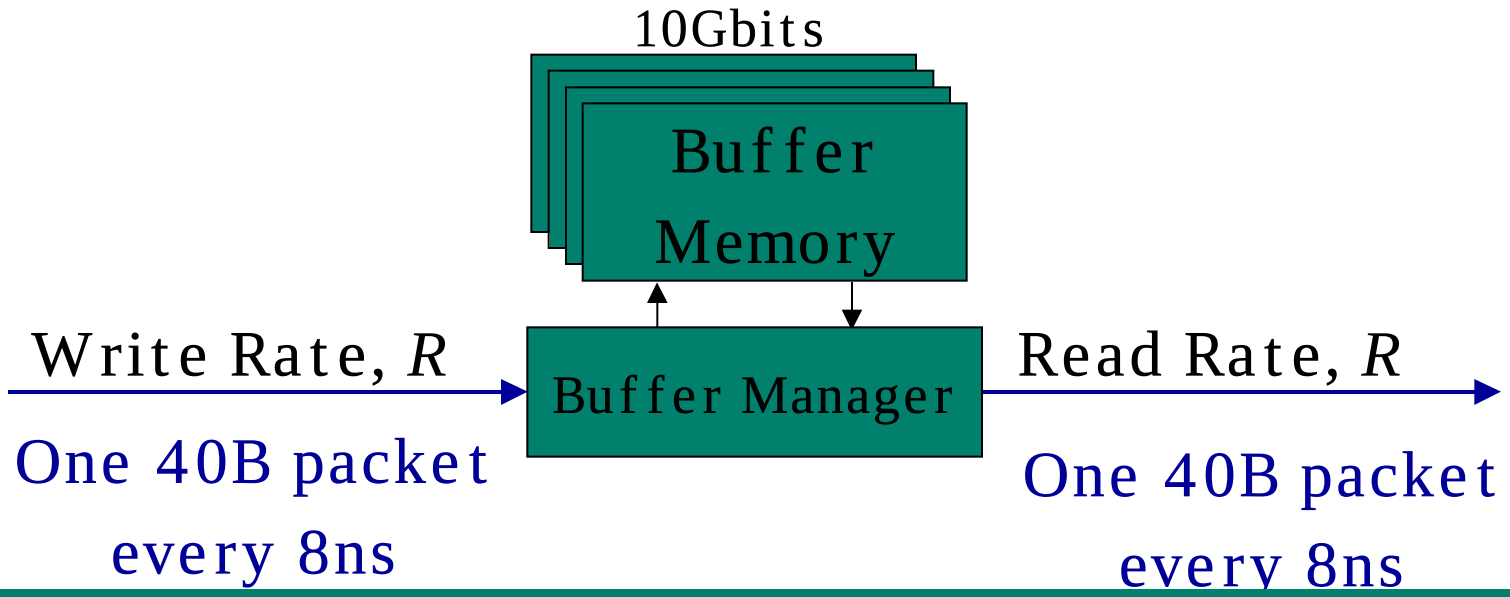
Some of the hard stuff

- Keeping up with Moore's Law for all the parts
  - **The bottleneck is memory speed.**
  - **Memory speed is not keeping up with Moore's Law.**
- It's all about the Software: "The Software is the Router"
  - Features, High Availability, # Lines of Code, Testing
- Control Plane is an ***Asynchronous, Distributed System***
  - Analogy to Supercomputer
    - ***Not*** peer to peer, ***Not*** Grid, ***Not*** Clusters
  - Specialized for Network processing and Routing Convergence
- Lack of simplicity of network design due to complex service offerings leads to complex devices

It’s all about the Hardware

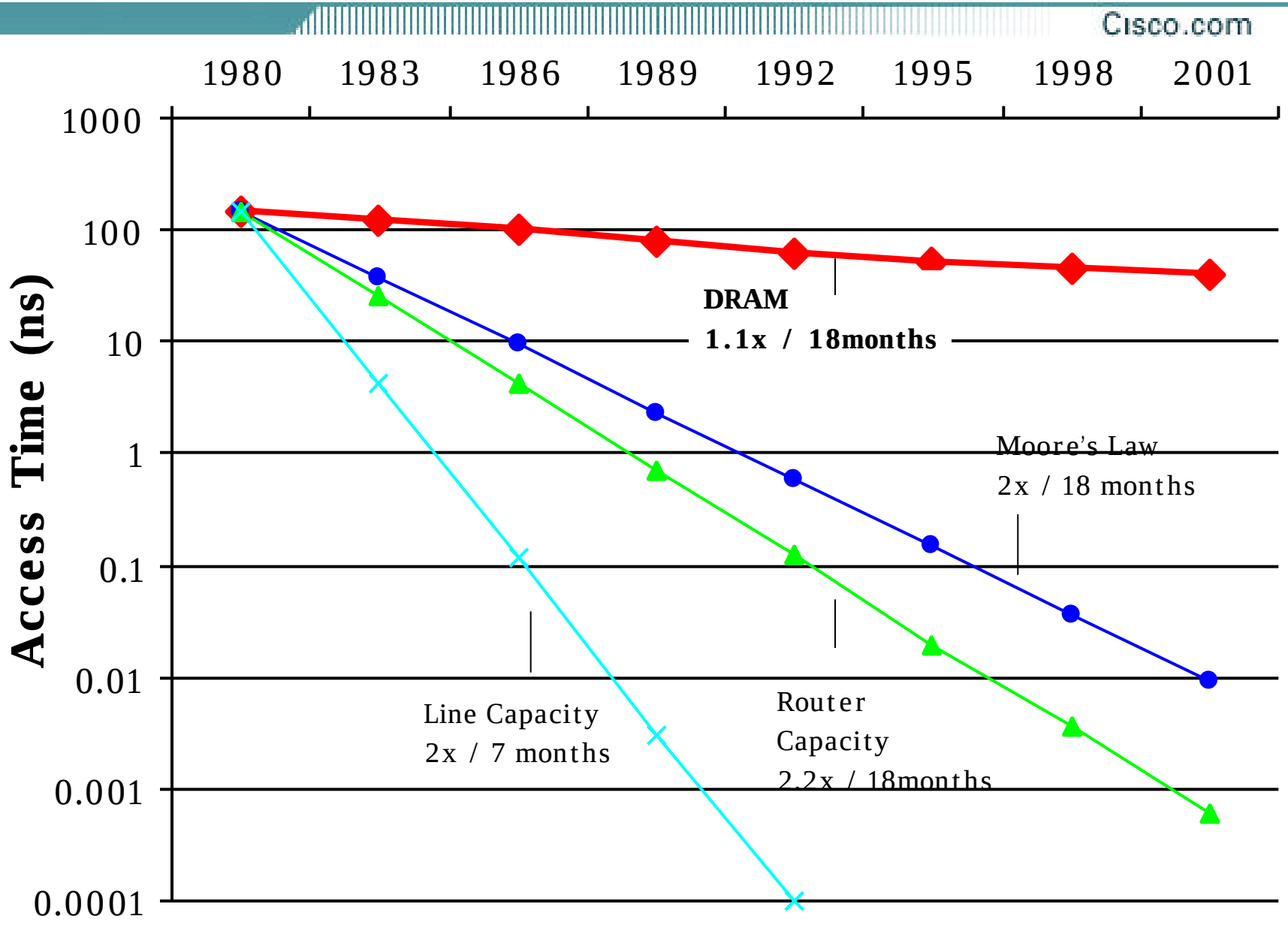


Packet buffers



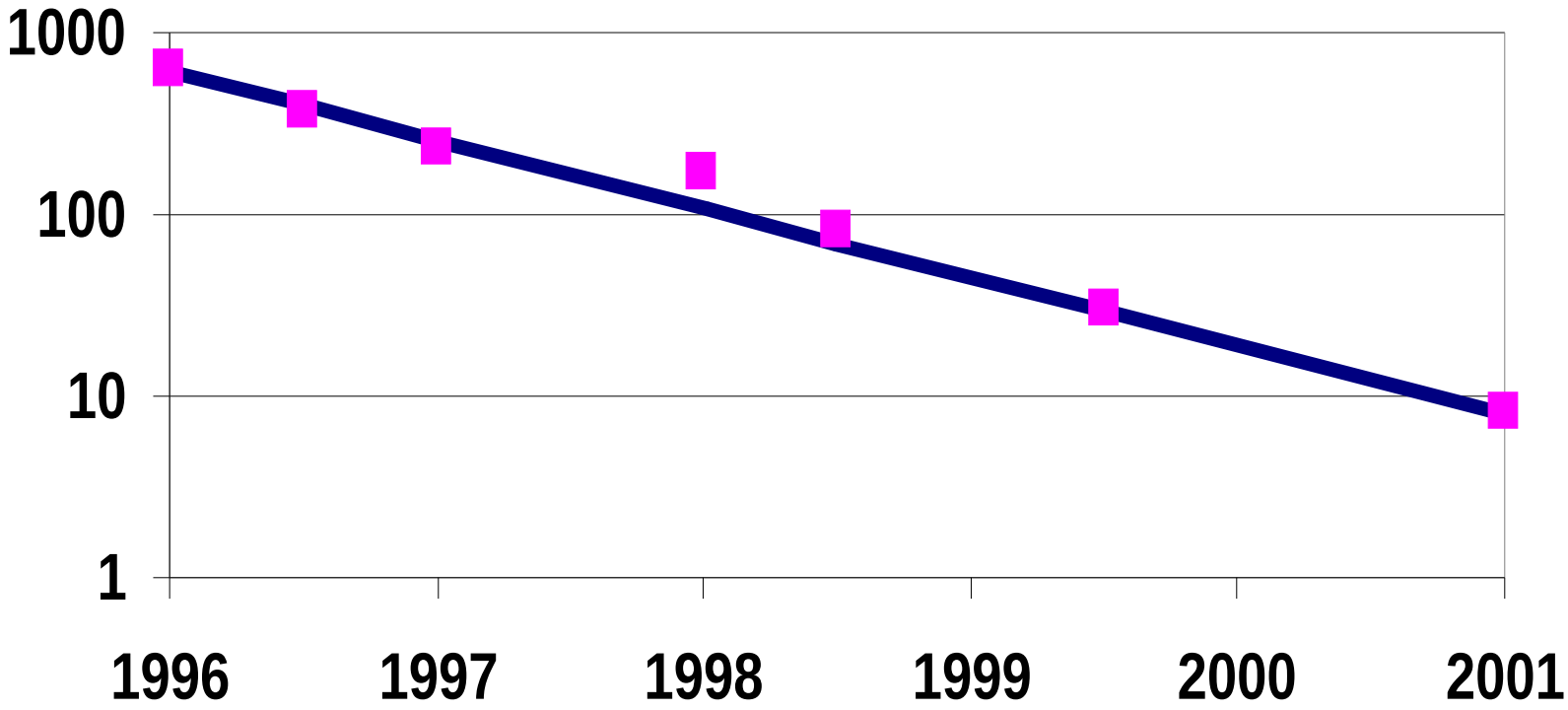
- Use SRAM?
  - \+ Fast enough random access time, but
  - \- Too low density to store 10Gbits of data.
- Use DRAM?
  - \+ High density means we can store data, but
  - \- Can't meet random access time.

Memory Bandwidth



Packet processing

CPU Instructions per minimum length packet since 1996



Summary

- CPU speeds, Memory access issues - channeling Seymour
  - Power/Heat, cost, size, weight
- Control Plane Complexities
- Feature list always getting longer, rapidly changing
- Economy is hosed - growth is slower
- Big, dumb, core box not going to build networks with required services
  - Most Core routers become the new edge or have customers
  - In ‘reduced mesh’ case, core routers needed all features
- It never was easy to build a Router and it never was easy to build a Network - if it was ….


Cisco Systems
Empowering the
Internet Generation℠