

**Active Nets and Real-Time Control:
Oil and Water, or Oil and Vinegar?
April 22nd, 1999**

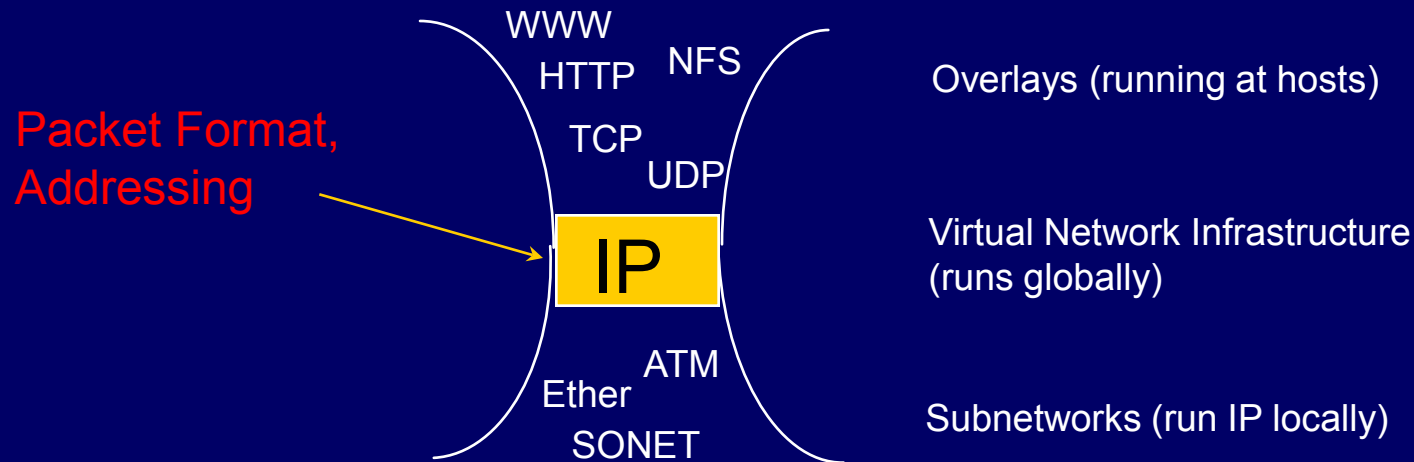
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<http://www.cis.upenn.edu/~jms>

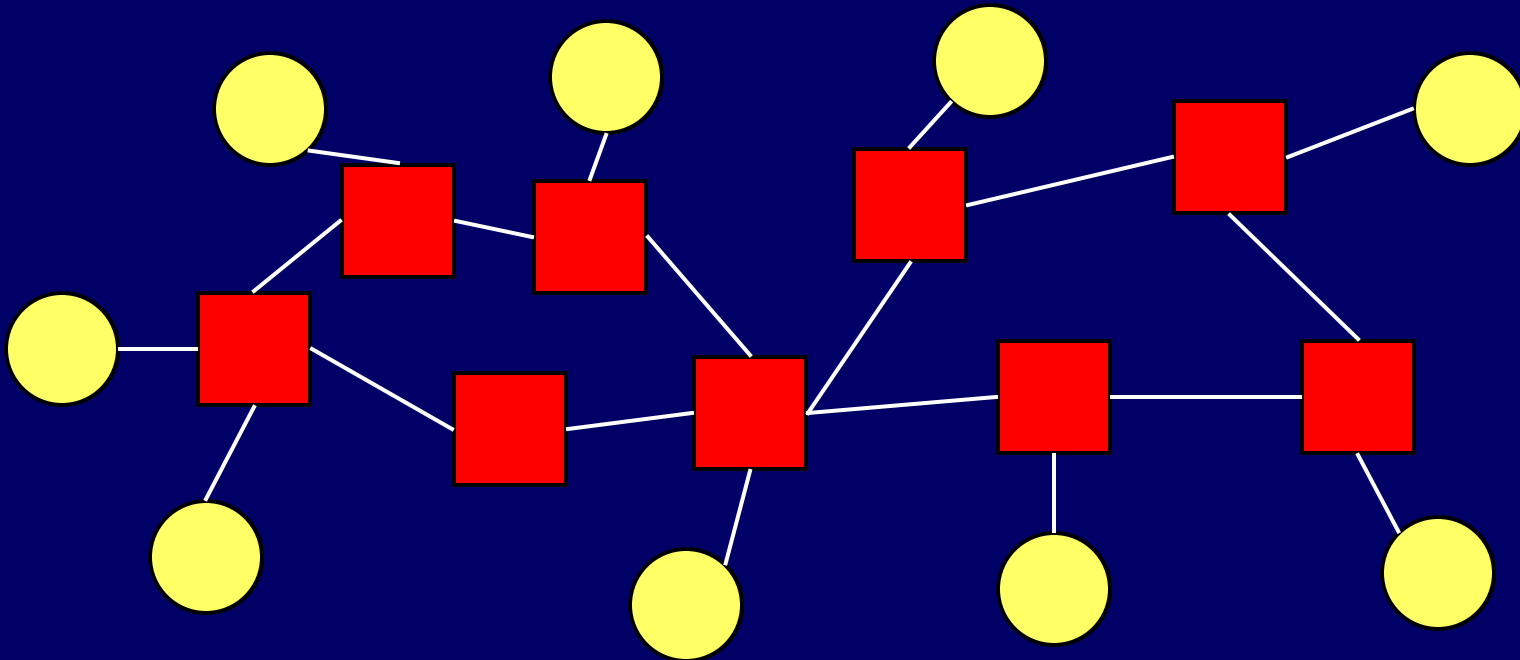
Virtual Infrastructures, e.g., IP

- IP is a network interoperability layer
- Interoperable through minimality:



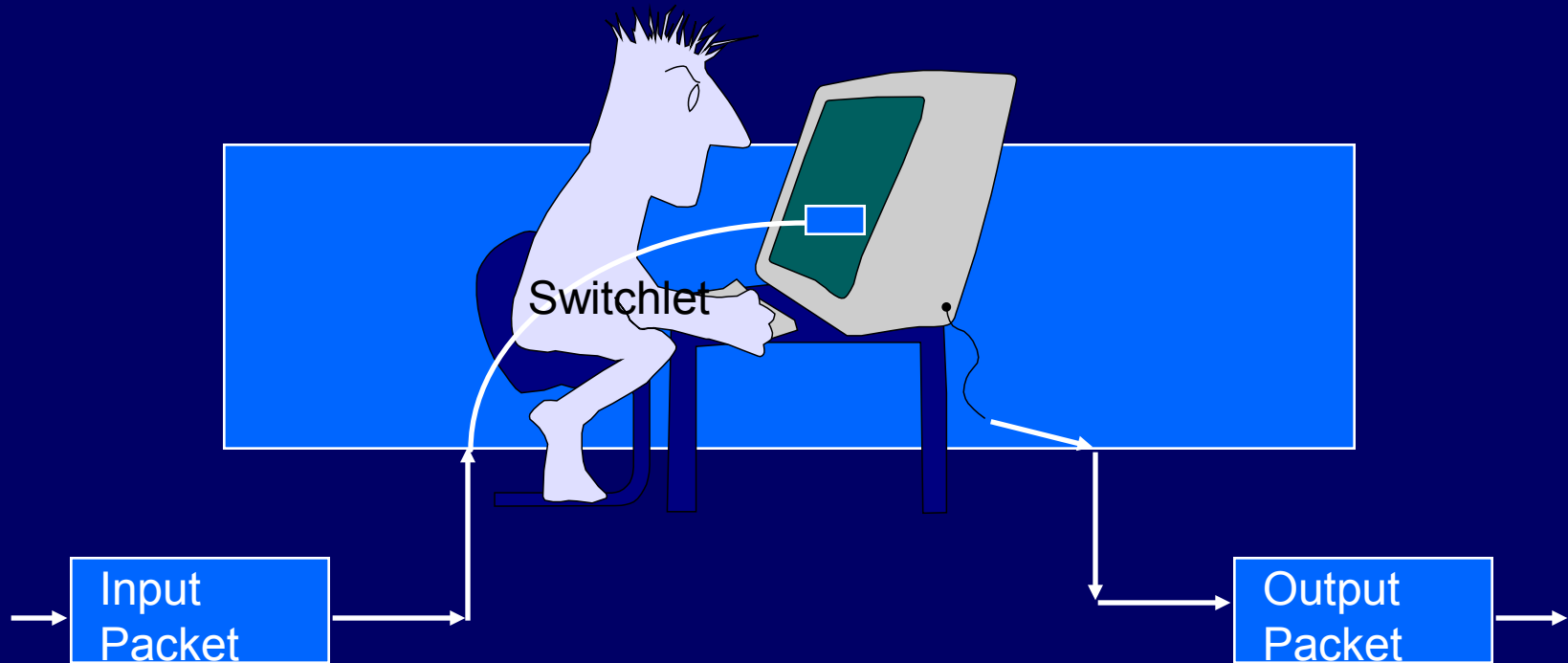
“Passive” Networking

- Smart hosts on the edges
- Passive switches in the center



Active Networking Nodes

□ Store, COMPUTE and Forward!

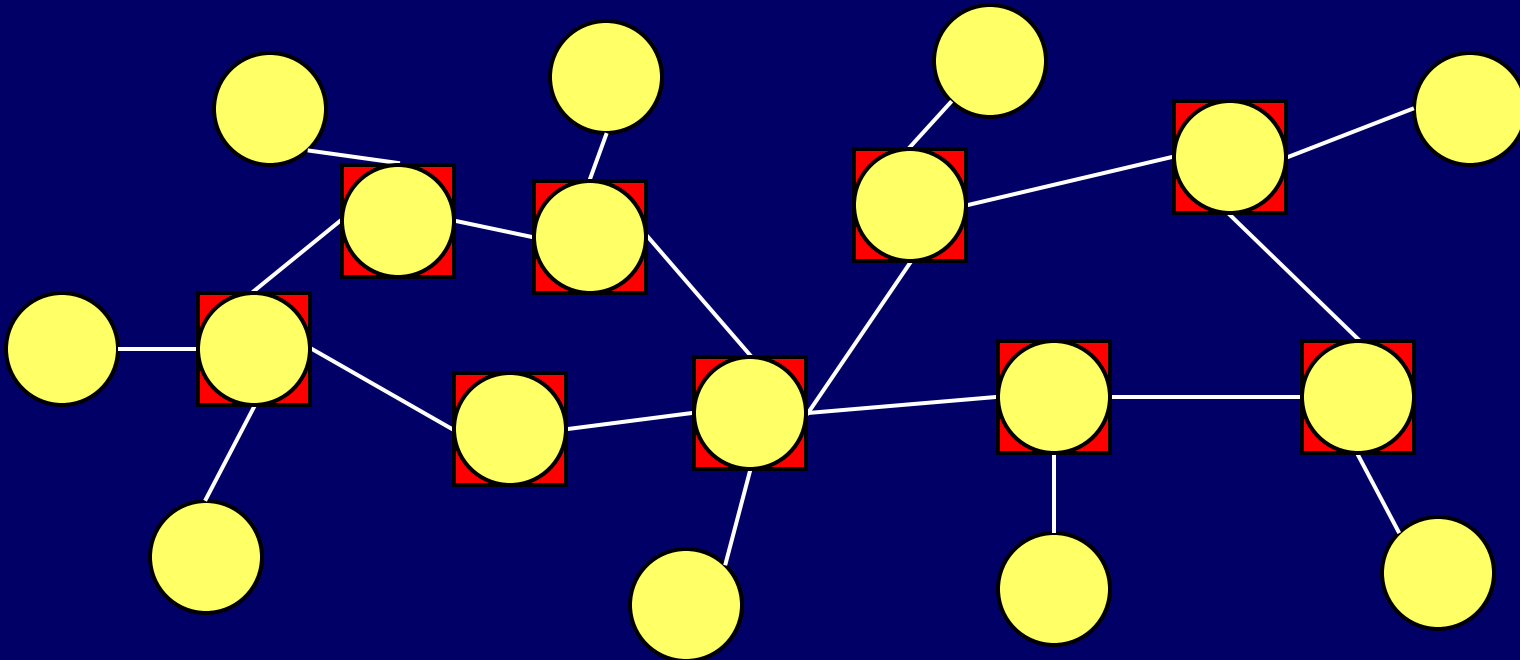


Active Network Model

□ Packets (“switchlets”) can change the behavior of the switches “on-the-fly”

☞ In-band active packets

☞ Out-of-band active extensions



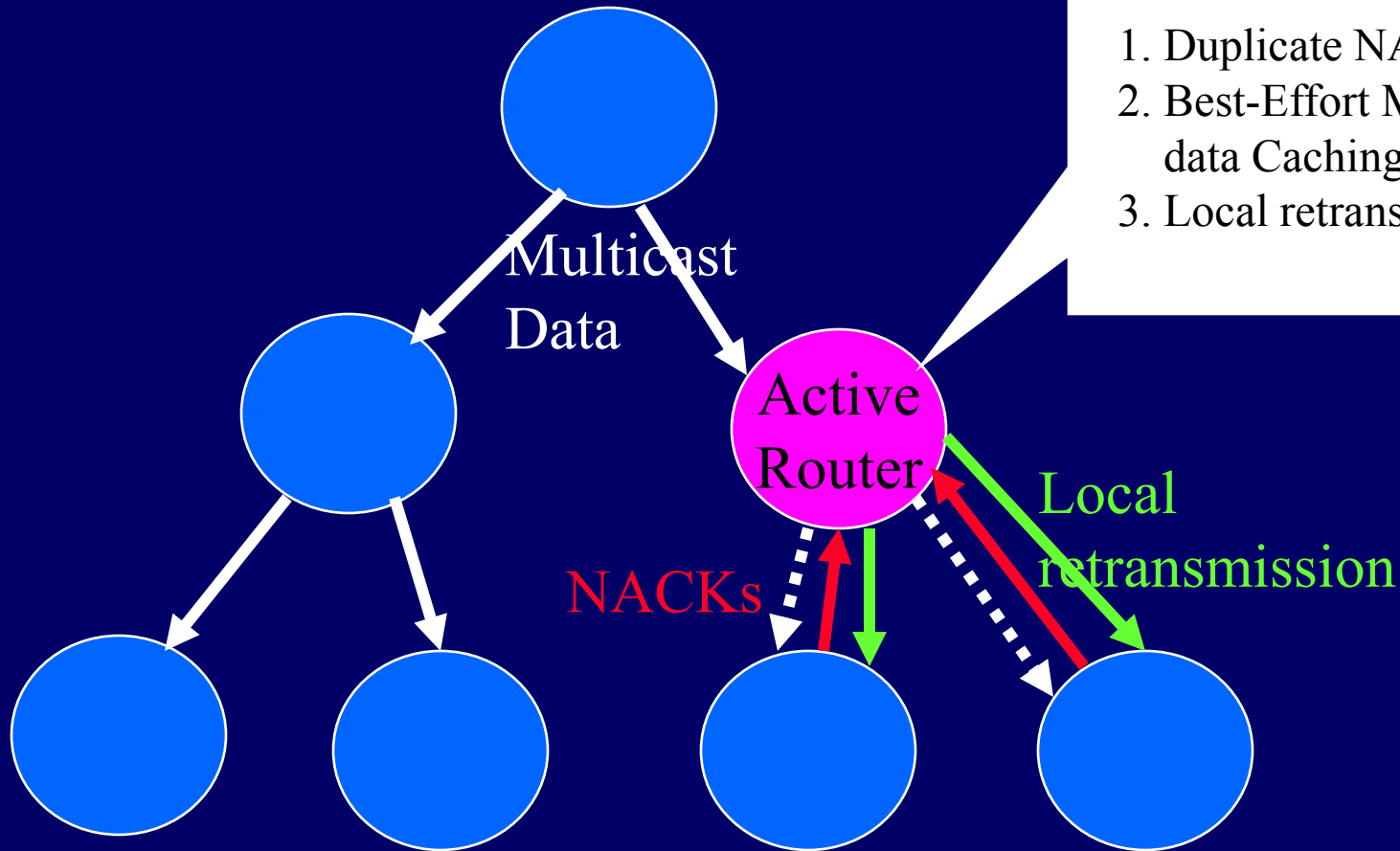
Why Do This?

- Faster response to problems and possibilities in network
- Per-user protocols
- Allows experimentation
- Accelerates network evolution
- Example Applications
 - ▣ Auctions
 - ▣ Reliable multicast
 - ▣ Sensor Fusion

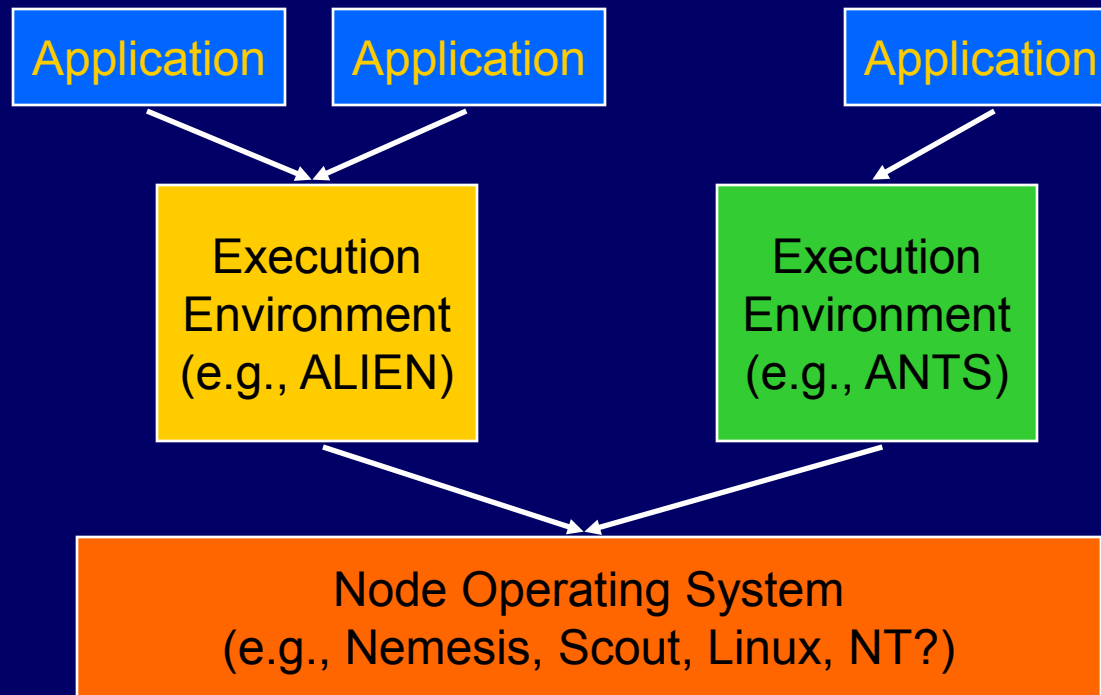
An Example Active Application: Active Reliable Multicast (ARM)

- Reliable Multicast plagued by “ACK implosion” when an error occurs
- Retransmission expensive
- In MIT’s ARM, Active Elements are embedded in the multicast tree (not all tree nodes need be active for ARM to work)

ARM techniques

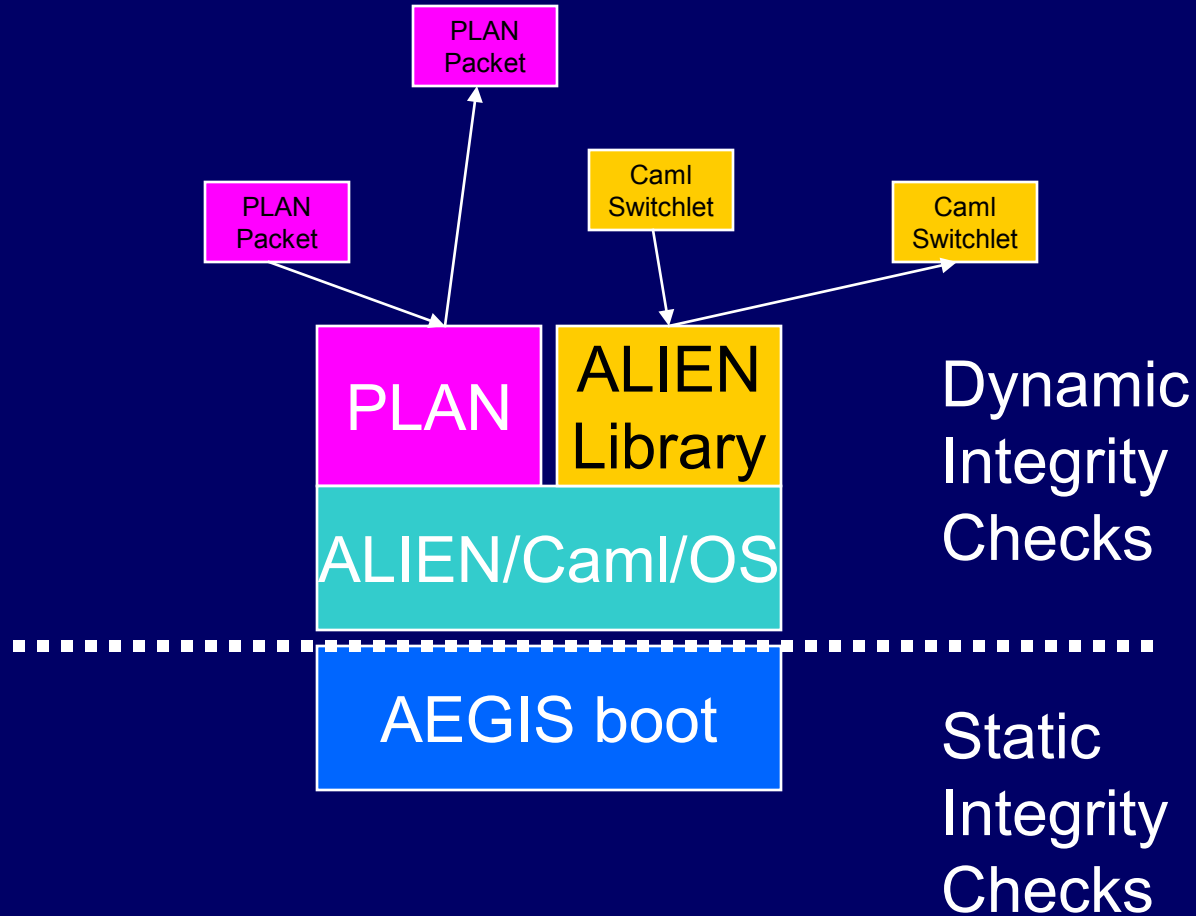


Active Network Architecture



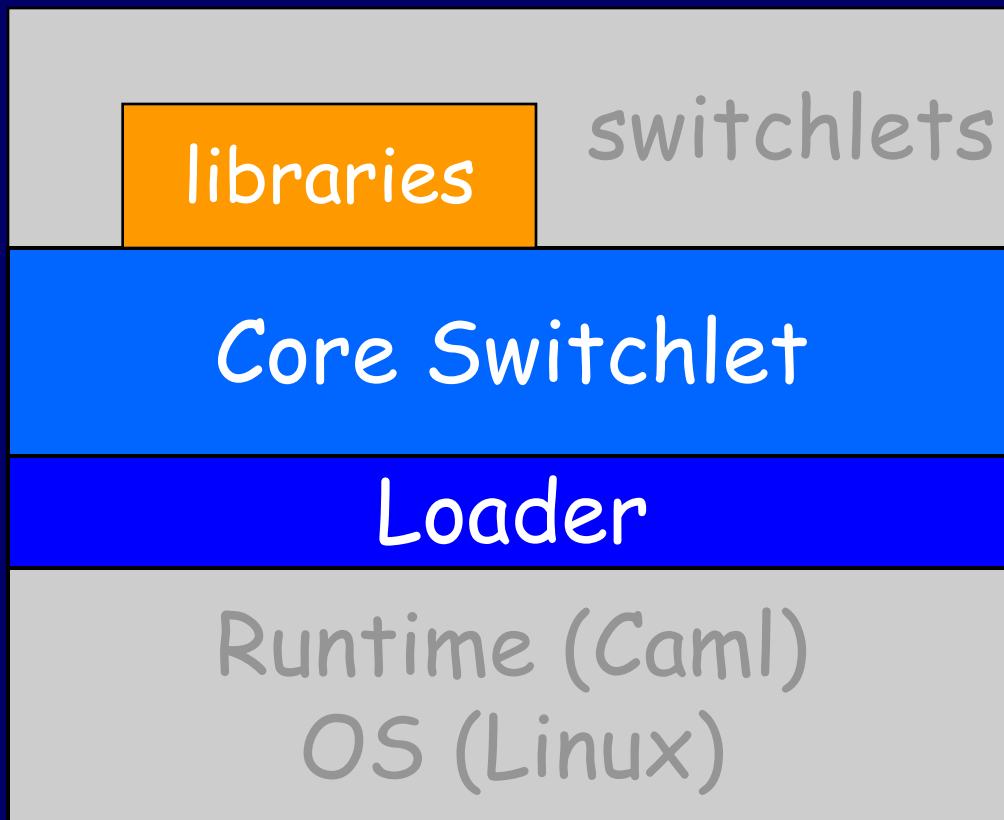
(see April 1999 "IEEE Computer")

Example: SwitchWare Architecture



ALIEN in an Active Element

- Three layer architecture



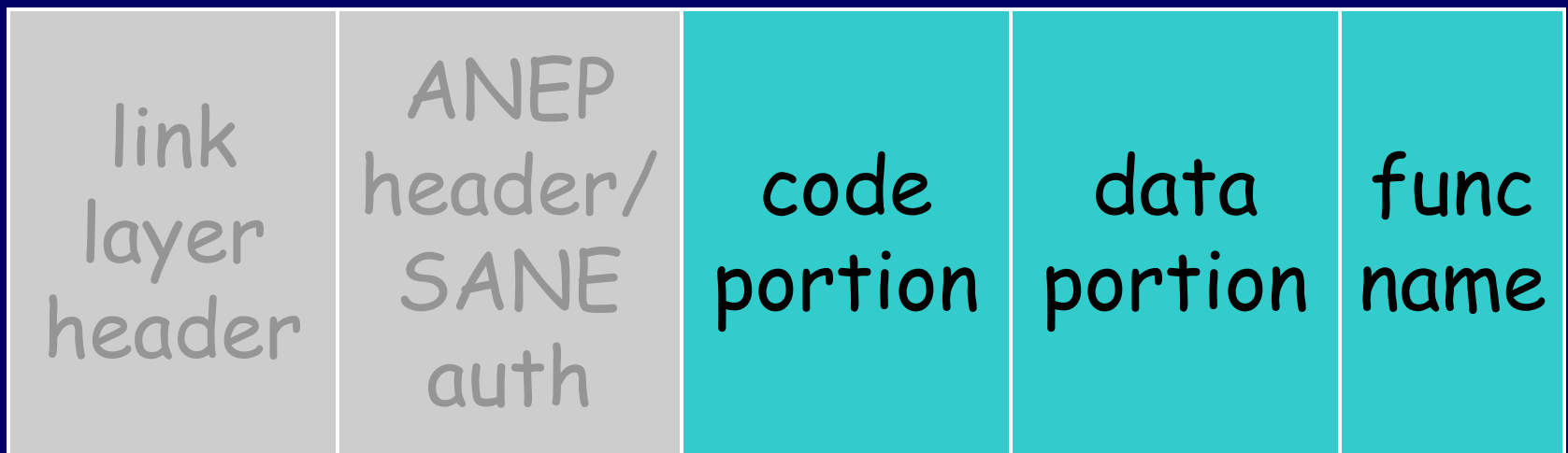
Active Packets in ALIEN

□ If ANEP header indicates ALIEN

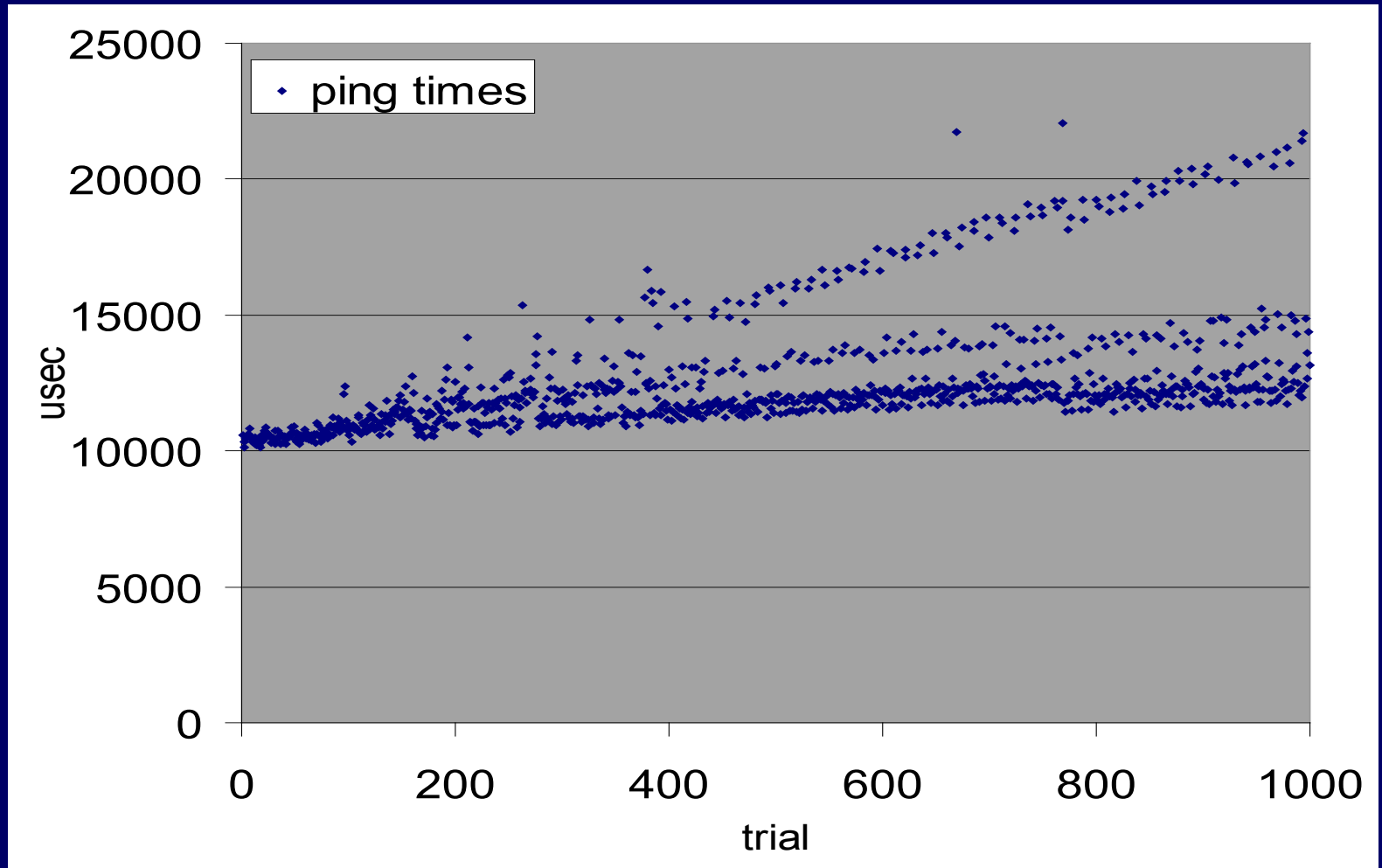
☞ SANE processing as part of ANEP

☞ Code portion is loaded

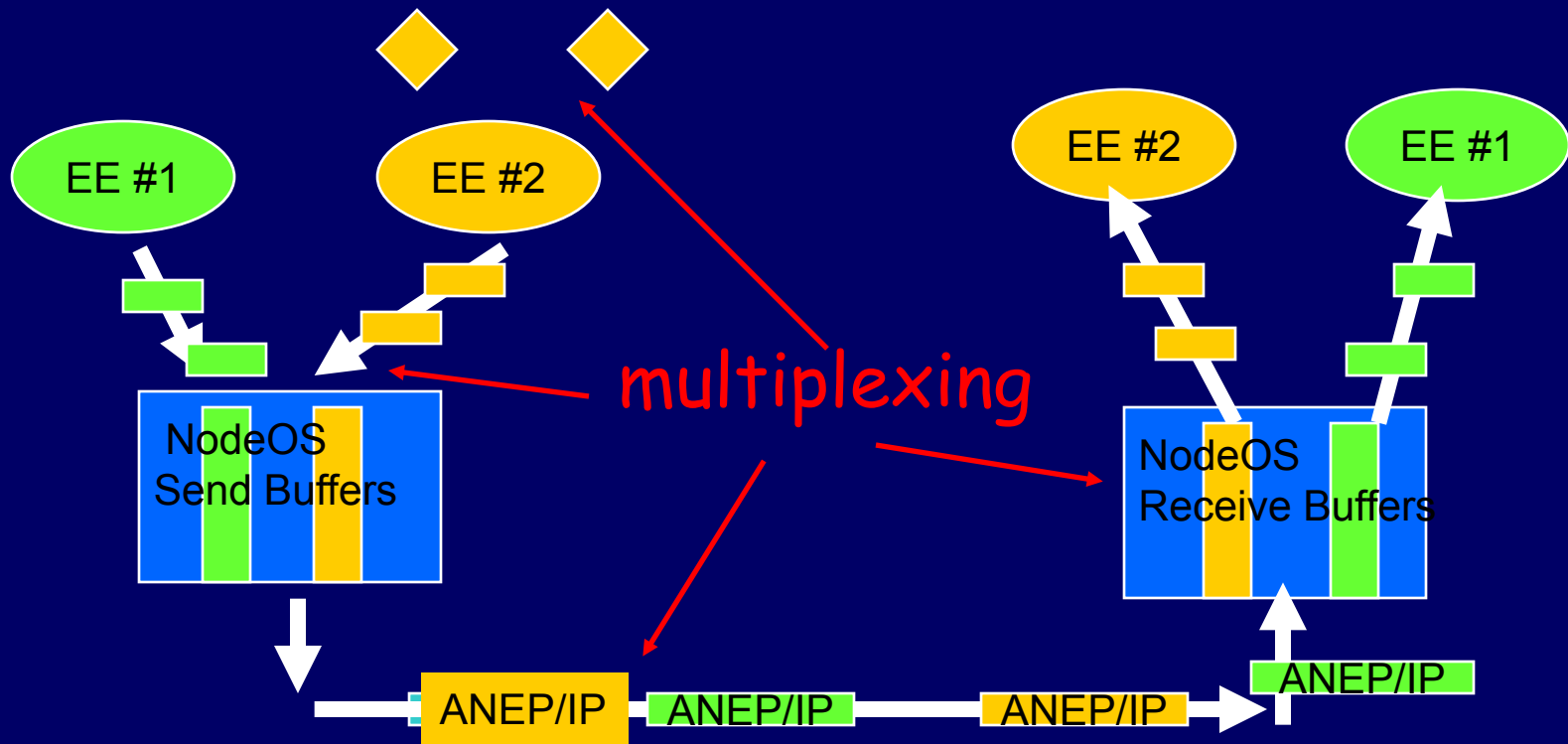
☞ *func* is called with code, data, and func name as arguments



saneping Performance (533 Mhz Alpha PC, 100M Ethernet)



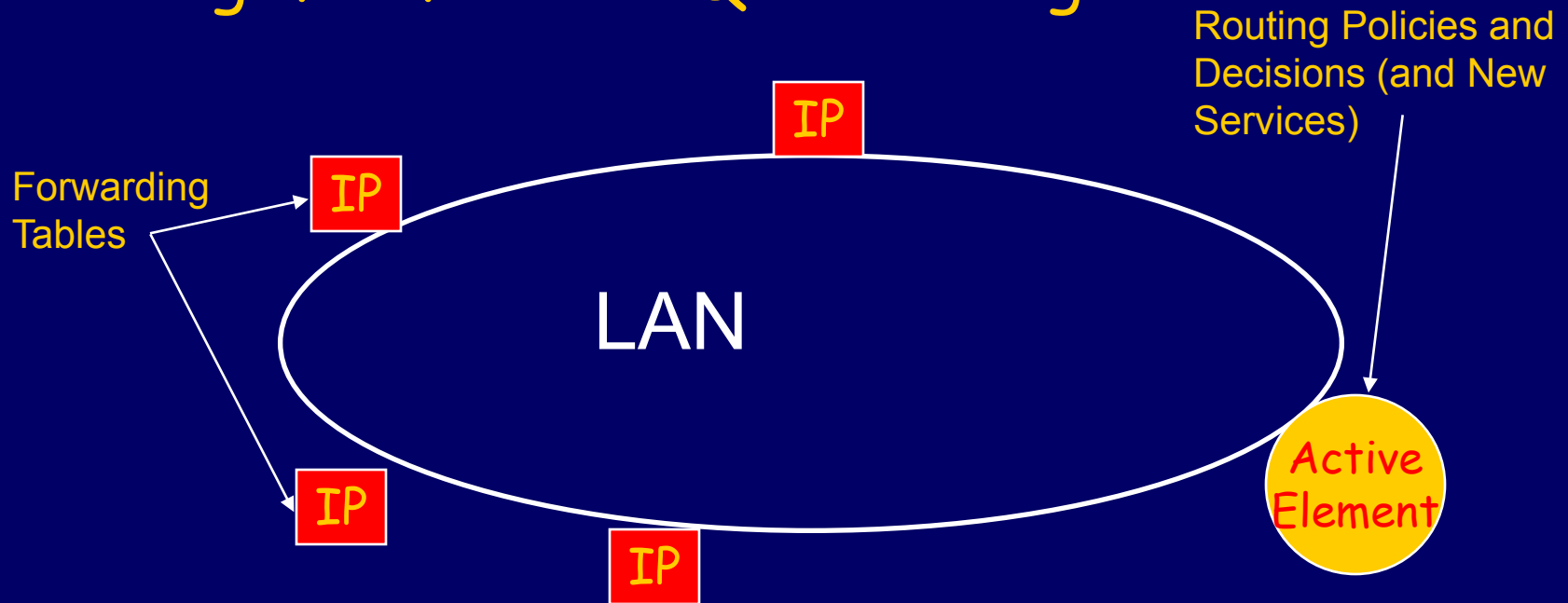
End-to-End Resource Management Challenges (e.g., for R.T. control):



Active Router Control (ARC): Local Management -> Global Policy

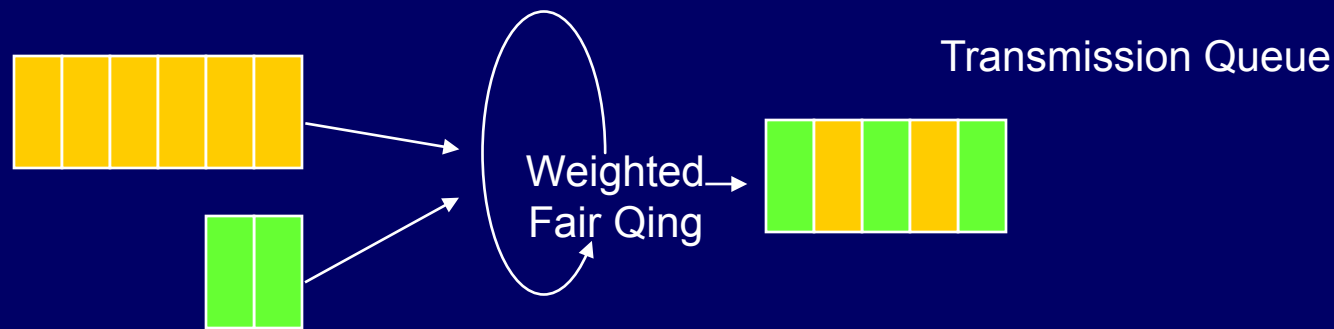
□ IP Routers + Active Elements

📖 e.g. for flexible QoS routing



Example A.N. Node Solution: Loadable “Queue Management”

- ❑ Discriminates between “flows”
- ❑ Separate queue for each current flow
- ❑ Queues are serviced WFQ
- ❑ Control via RSVP, QoS Broker, etc.



Arrival Queues

Resource Controlled Active Network Element (RCANE)

□ Manage CPU, Memory and Bandwidth

- 📁 Challenge: Modern PL heaps (GC)

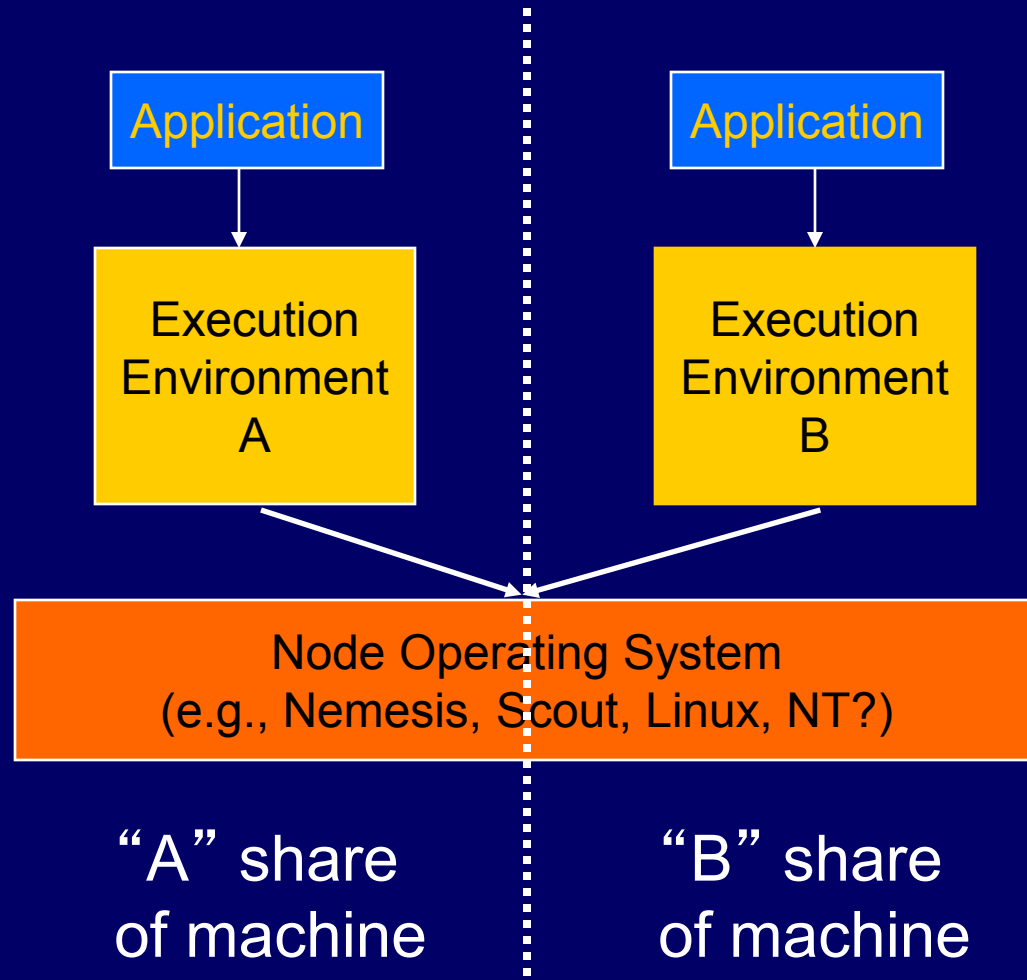
- 📁 Challenge: Interrupts

- 📁 Challenge: CPU/Mem/BW tradeoffs

□ Approach

- 📁 Experimental RCANE with Cambridge (UK) using Nemesis O.S. for NodeOS and SwitchWare E.E.; NSF-funded at Penn

RCANE Vertical Architecture:



Summary and Conclusions

- Introduced S-C-F and Active Nets

- Resource Management

 - ▣ Challenges for [soft] real-time

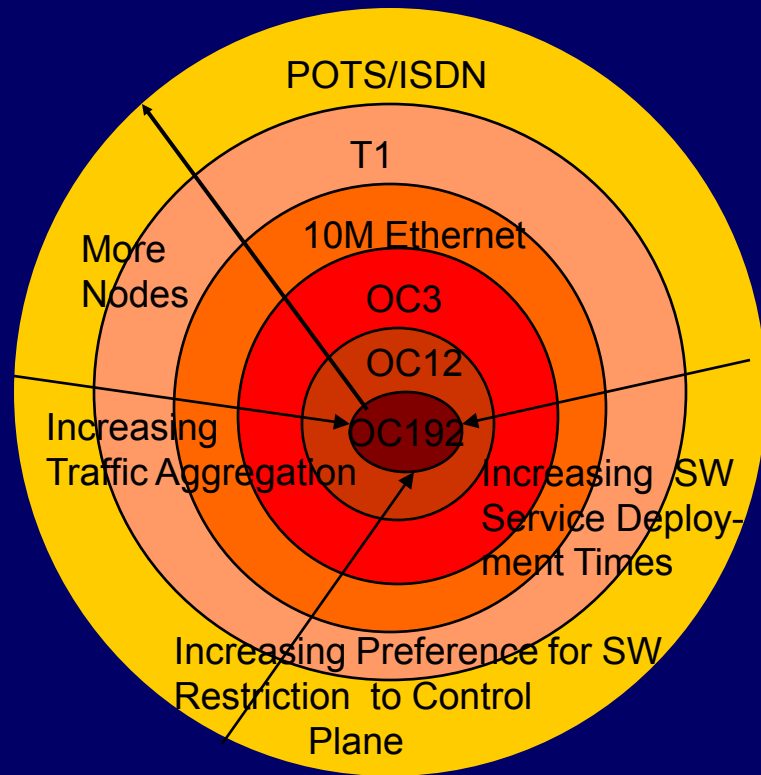
 - ▣ Short-Term Advantages of A.N.

 - ▣ Longer-Term: NSF/EP SRC-funded Penn/Cambridge RCANE project

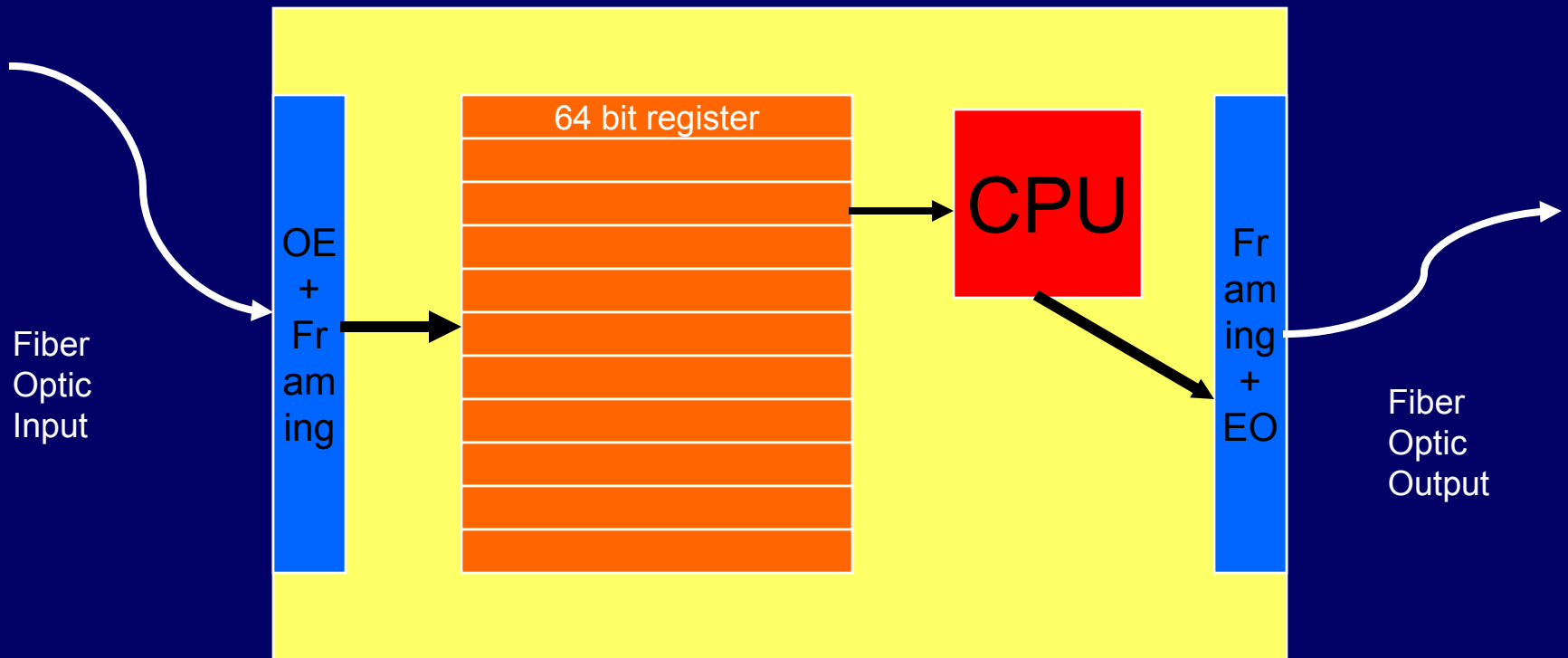
- Big Idea: Distributed systems can now exploit a host/network role *continuum!*

- Thanks: DARPA, NSF, 3Com, Intel, HP

Activation potential at various commercially deployed rates:



Fiber-coupled processing?



Register-Only Media Processor (ROMP)