

DTC OPEN HOUSE: May 2, 2003

Networking Research in Digital Technology Center

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Digital Technology Center

Outline

- Networking Trends
- Research Challenges
- What We're Doing in DTC
 - project highlights



Networking Trends

Internet is the network!

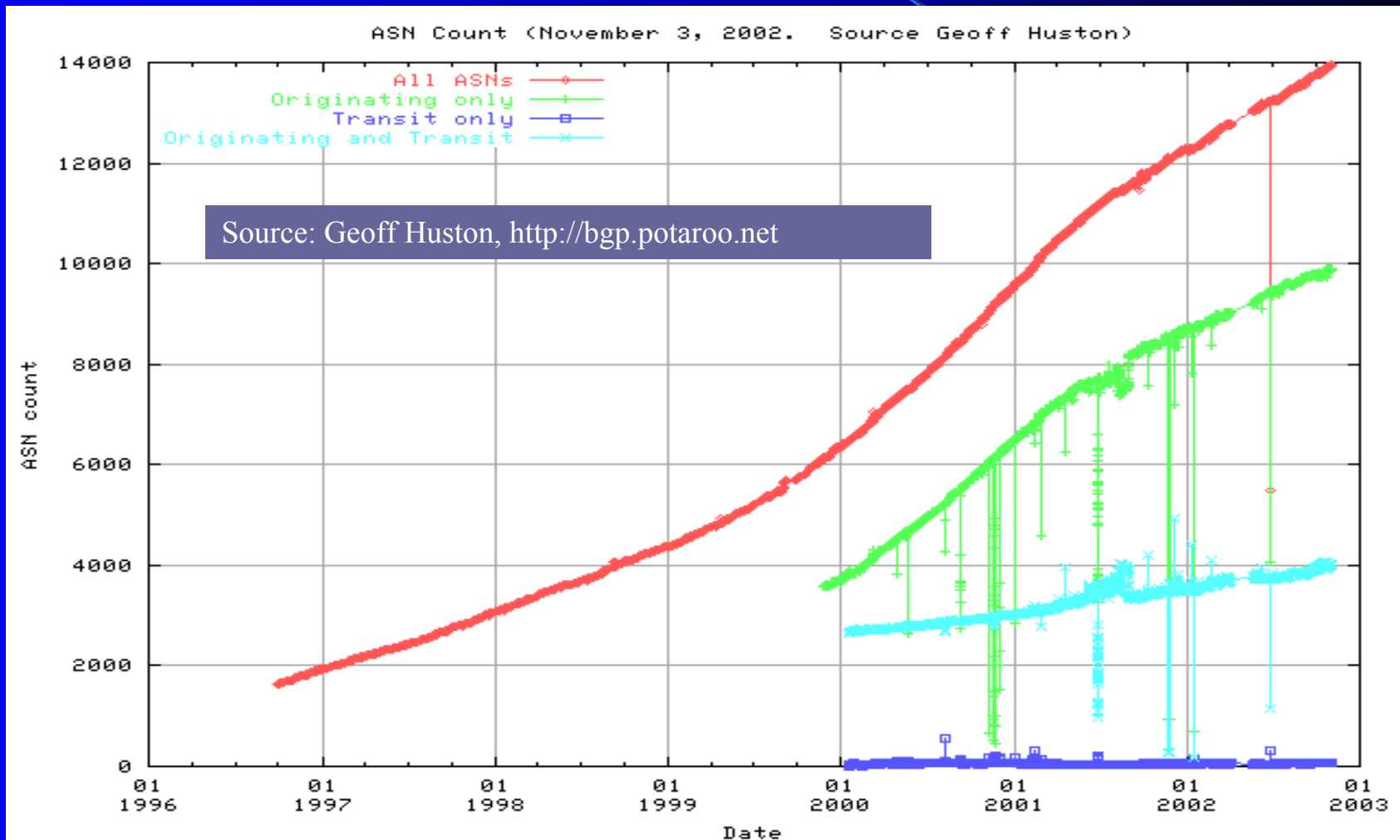
- It's big!
- It's diverse!
- It's complex!
- It's everywhere (almost)!
- ... and it keeps growing and changing!



Internet Growth

measured by number of Autonomous Systems (ASes)

AS: separately administered network domain



What Has Become of Internet

- Cyberspace and Virtual Communities
 - keep in touch with friends and strangers
 - Information Service Platform
 - deliver all kinds of information
 - Global Information Repository
 - store and search for all kinds of information
 - Enormous Super-Computer
 - process information ("grid computing")
- ... we increasingly depend on it!



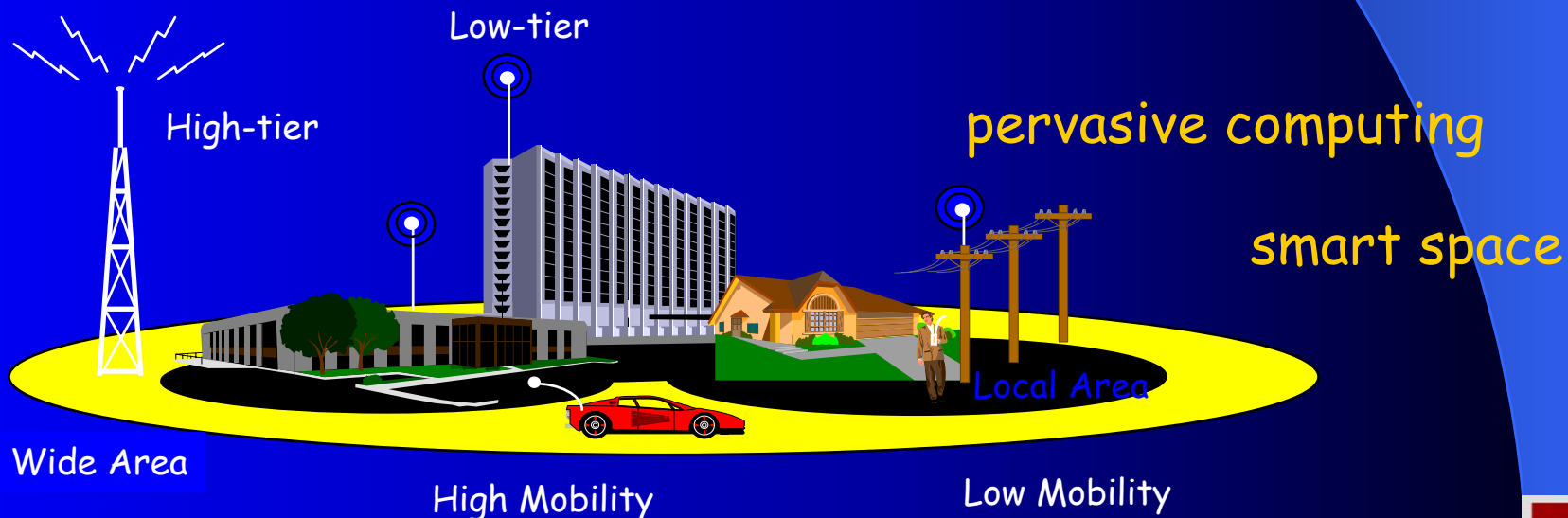
More gadgets are plugged in ...

- servers, desktops, laptops, ...
- PDAs, cell phones, blackberries, ...
- *soon toasters, fridges, ...* 😊



Wireless technologies revolutionizing Internet!

- WiFi, bluetooth, 3/4G cellular networks, ...



Diverging Trends ...

- Internet Core: concentration
 - high bandwidth, dense connectivity
 - data centers: computing, storage, ...
- Internet Edges: diversification
 - "smart" to "dumb" devices
 - PCs with increasing processing and storage capacities
 - small devices with limited computing, memory, power, ...
 - broadband to narrowband
 - "always on" to intermittent connectivity

Challenges and Opportunities!

- overcome heterogeneity, seamlessly integrate
- new services & "disruptive" technologies



New (& Old) Research Challenges

Well, networking is like plumbing ...
nothing really glorious!

- making services *highly available* and *reliable*
 - “always on” Internet, no broken pipes, ...
- providing *quality of service* for applications
 - fast and fat pipes, specialized pipes, ...
- in particular, making Internet *secure*
 - protect pipes against malicious users

Internet: critical global information infrastructure,
big, complex, massively distributed, and changing!



It's All About Services!

Beyond bit pipes!

- Facilitating and enabling creation, deployment & delivery of services
 - existing, emerging and yet to be imagined
- Tapping and realizing potentials of new technologies
 - wireless technologies, sensor technologies
 - harness & leverage "disruptive" technologies
- Is current Internet architecture adequate?
 - what are limitations?
 - how to enhance and evolve Internet (incrementally)?
- *New Internet architecture(s) for service overlays, pervasive computing, smart space,?*



It's Economy, Stupid!

Lesson from burst of "Internet bubble"

- Users:
 - technology adoption depends on users
 - providing values to users
 - useful, enjoyable, make life easier,
- Service providers:
 - generate revenues and reduce costs: capex, opex, etc.
 - viable business models: competitive nature of marketplace

Internet research & development needs to consciously take economic factors into account

➤ stagnation & ossification vs. sustained growth



Networking Research in DTC

Some Project Highlights

- *FILAR*: Failure Insensitive Load Adaptive Routing
 - making individual networks highly available and resilient
- Enhancing BGP (Border Gateway Protocol)
 - making Internet as a whole more stable and robust
- Secure Name Service (SNS)
 - protecting critical information services and resources
- *SOI*: Service-Oriented Internet Architecture
 - unifying service overlay substrate for service delivery
- Internet Economics
- *Pie*: (smart) Personal information environment

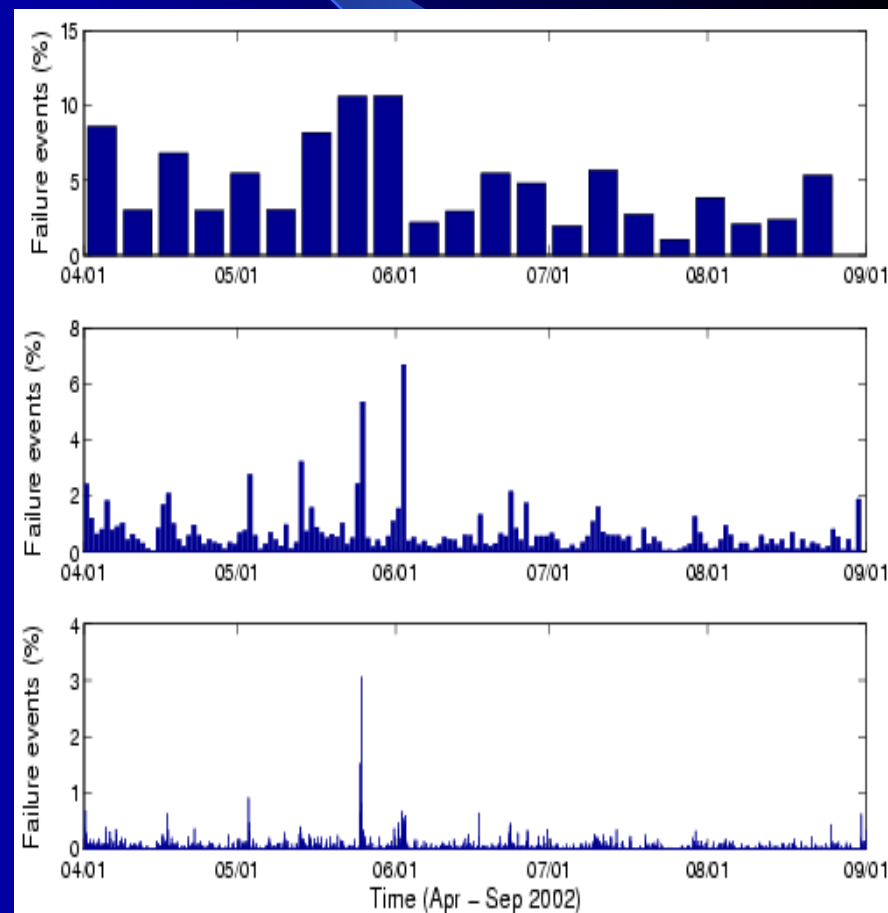


Why Failure Matters?

- Failures occur frequently in networks
 - faulty interface, flaky links, router crashes, fiber cuts, ...
 - mostly transient, last seconds to minutes
 - OC48 link down for 6 seconds: 3 million packets may be lost!

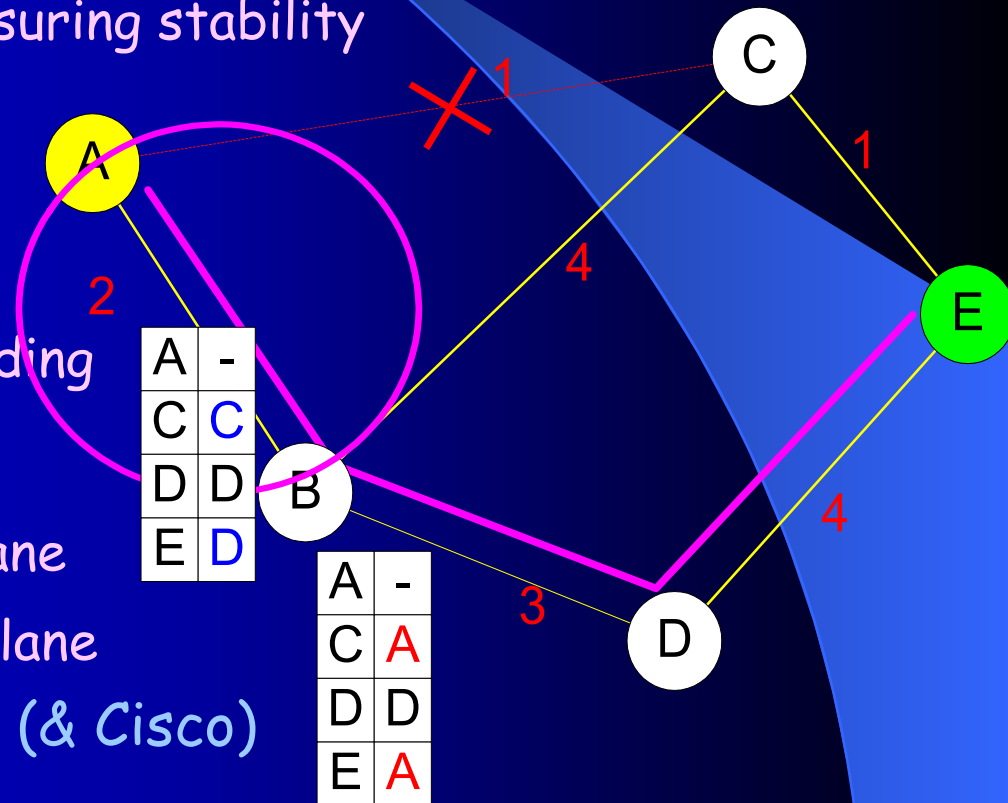
Existing Approaches

- Traditional routing protocols (OSPF/ISIS)
 - react to failures, slow convergence time
- MPLS -based solutions
 - centralized, a lot of configuration, not adaptive
- Packet delayed/lost during failure recovery phase
 - bad for Voice over IP (VoIP) & other emerging applications



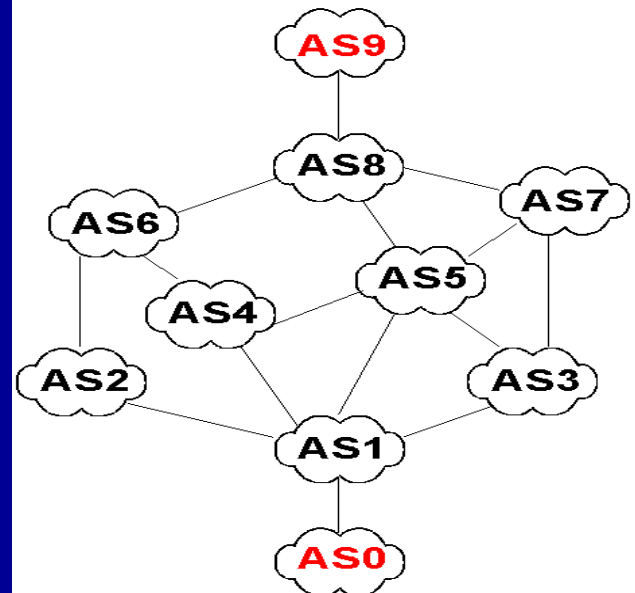
FILAR for High Service Availability

- FILAR: nearly 100% forwarding continuity
 - prepare for (instead of react to) failures
 - adapt to changes while ensuring stability
- Key Ideas
 - local failure inference
 - local rerouting
 - interface-specific forwarding
- Other Advantages:
 - no change to forwarding plane
 - minimal change to routing plane
- In collaboration with Sprint (& Cisco)



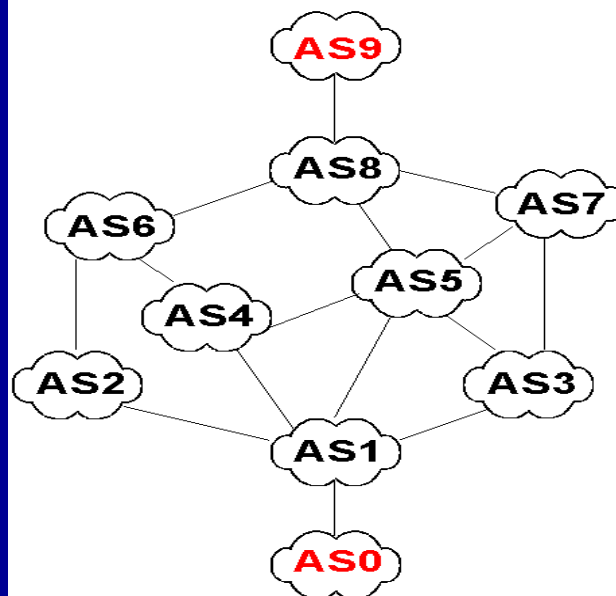
BGP and Internet: A Quick Primer

- Internet comprised of many Autonomous Systems (ASes)
- BGP is *the* routing protocol gluing Internet together
 - announce network reachability to outside world
 - propagate routes learned to neighbors ("path vectors")
 - policy-driven: *selectively* accept/tell what are learned
- Issues with BGP:
 - Local failures/changes have global ripple effects
 - Long convergence time
 - can take up to 15 min
 - Inadequate in supporting many operational/service needs
 - traffic engineering, reliability, ...



Enhancing BGP for Global Stability

- Analyzing global BGP behavior and dynamics
 - from UMN (thanks to NTS) and other vantage points
- Limiting BGP path exploration problem
 - fast invalidation of "obsolete" routes
 - embed "path dependency" using sequence numbers
- Dampening route flaps
 - effectively identify route flaps
 - localize instability
- Codifying routing policies
 - minimize misconfiguration
- "Shadow" control plane
 - policy consistency check
 - diagnostics

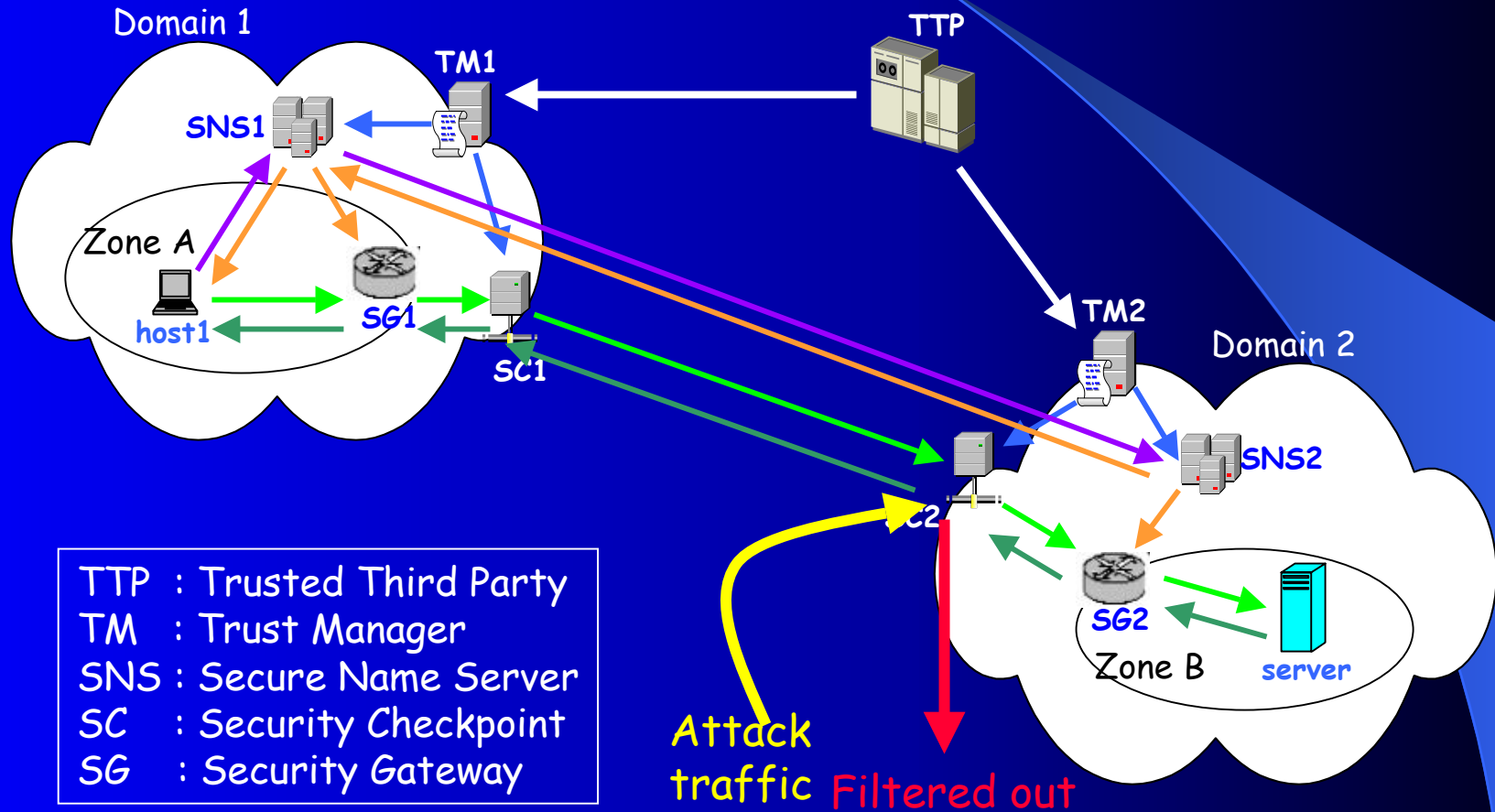


Secure Name Service

- Protecting critical information services and resources
 - front-end and back-end servers, databases, ...
 - prevent unauthorized accesses and denial-of-service attacks
 - Extension of Domain Name Service (DNS)
 - place critical services and resources in *secure name zones*
 - virtualize resources, conceal IP addresses from outside
 - establish explicit trust relations among trusted domains
 - Key Components:
 - Domain-level trust management (domain trust managers)
 - key exchange among domains, users always authenticated
 - Secure name resolution (secure name servers)
 - secure name query returns "secure handle," not IP address
 - Secure packet forwarding (security checkpoints & gateways)
 - packets carry "security tags", authenticated at entry points
- protect, monitor and counter-act



Secure Name Service Operations

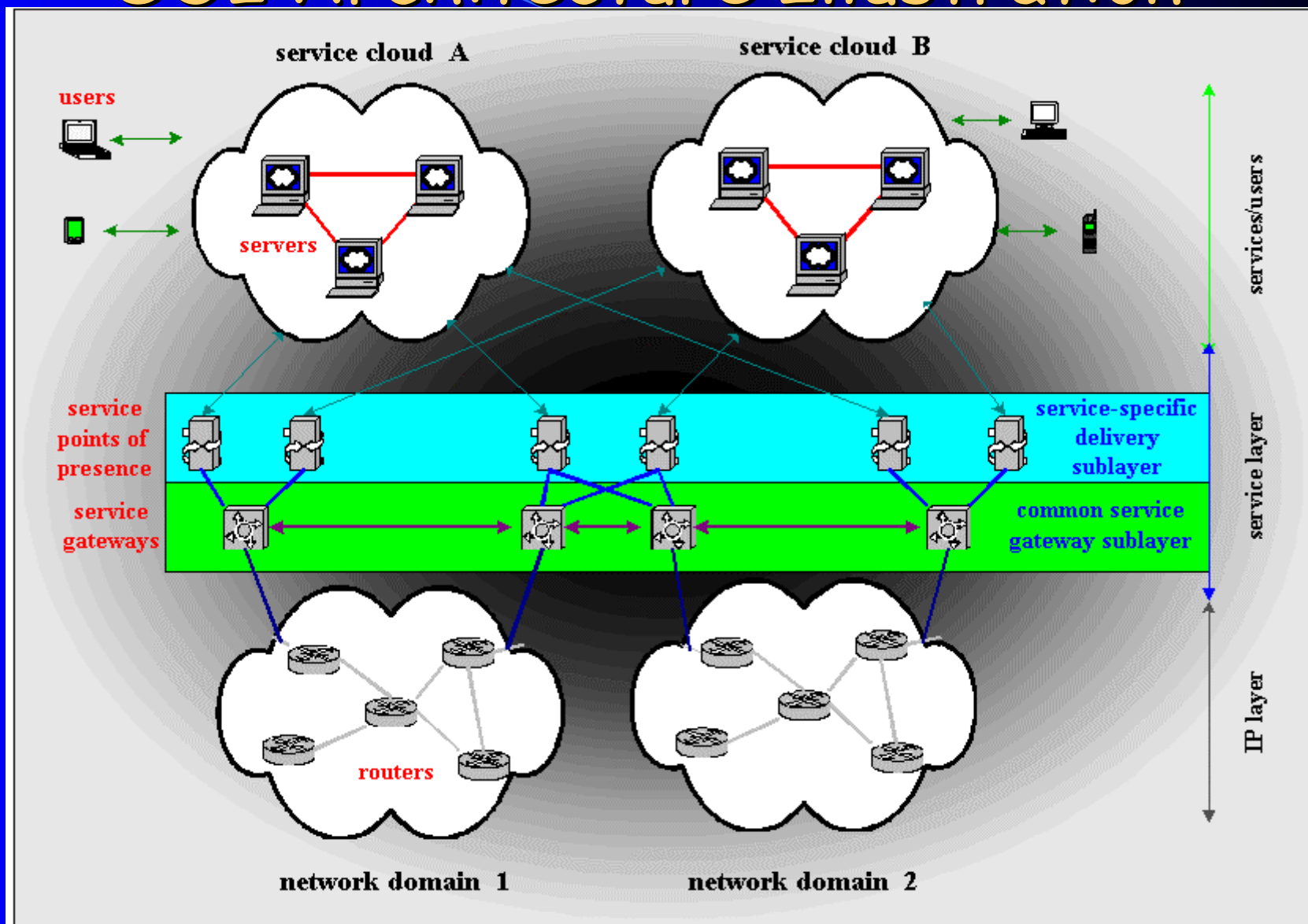


SOI: Service-Oriented Internet

- Beyond network connectivity
 - current IP infrastructure: host-to-host connectivity
- Facilitating service deployment and service delivery
 - rapid service creation and deployment
 - high service availability, reliability, QoS, security, ...
 - flexible built-in support for economic incentives
- Key Abstractions:
 - service clouds: ("application service provider networks")
 - new *two-level location-independent* addressing scheme:
 - *service id* identifying a service cloud
 - *object id* identifying an entity within a service cloud
 - service layer:
 - *unifying service overlay substrate*, built on top of IP



SOI Architecture Illustration



Internet Economics

In collaboration with Andrew Odlyzko

- Internet Evolution and Impact of Economics
 - Business relations between ASes
 - peering, transit (customer-provider), etc.
 - How they shape Internet structure and evolution
- New Business Models for Service Deployment & Delivery
 - Service models: billing, settlement, etc.
 - Cost/benefit analysis, e.g.,
 - economic efficacy of IP multicast and proper settlement model
 - business models for overlay services
- Mechanisms and Architectures:
 - How to enable new services and meet their requirements



Pie: (smart) Personal Info Environment

- Bottom-up approach to (eventually) build smart space
 - start with personal info and computing resources
 - integrate, simplify and make life easier for individuals
 - extend to groups, communities and so forth later
- A Simple Example: LIVIDO
 - *Location Independent Virtual Internet Document Organizer*
 - organize documents virtually across platforms, across file systems
 - auto-synchronization, version control, backup, etc.
 - an undergraduate directed research project
- Pie: extending LIVIDO to other info & resource mgmt
 - personalized name and directory services
 - personalized event handler and notification
 - remote execution, context-aware computing



Networking Faculty in DTC

- "Core" Networking Faculty
 - David Du (networking, multimedia, storage)
 - Zhi-Li Zhang (networking, multimedia, middleware)
 - Yongdae Kim (security)
 - Andrew Odlyzko (Internet economics)
- Will have more soon!
 - ADC/Qwest chairs, CSE new networking faculty
- Others doing research related to networking:
 - Jaideep Srivastavara, Anand Tripathi, Jon Weissman,
.....



Funding and Collaboration

- Multi-Million \$\$ from Gov. Funding Agencies
 - National Science Foundation
- Active Collaboration with Industry
 - Sprint
 - CISCO
 - IBM
 - Honeywell
 -
 - **Industrial Research Partners Always Welcome!**
- More than a dozen Ph.D students, plus many more MS and undergrads involved in networking research



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Thank You !



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Questions ?



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Project Highlighted

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- Internet Economics
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URL: <http://www.cs.umn.edu/research/networking>

