

Computer Networks

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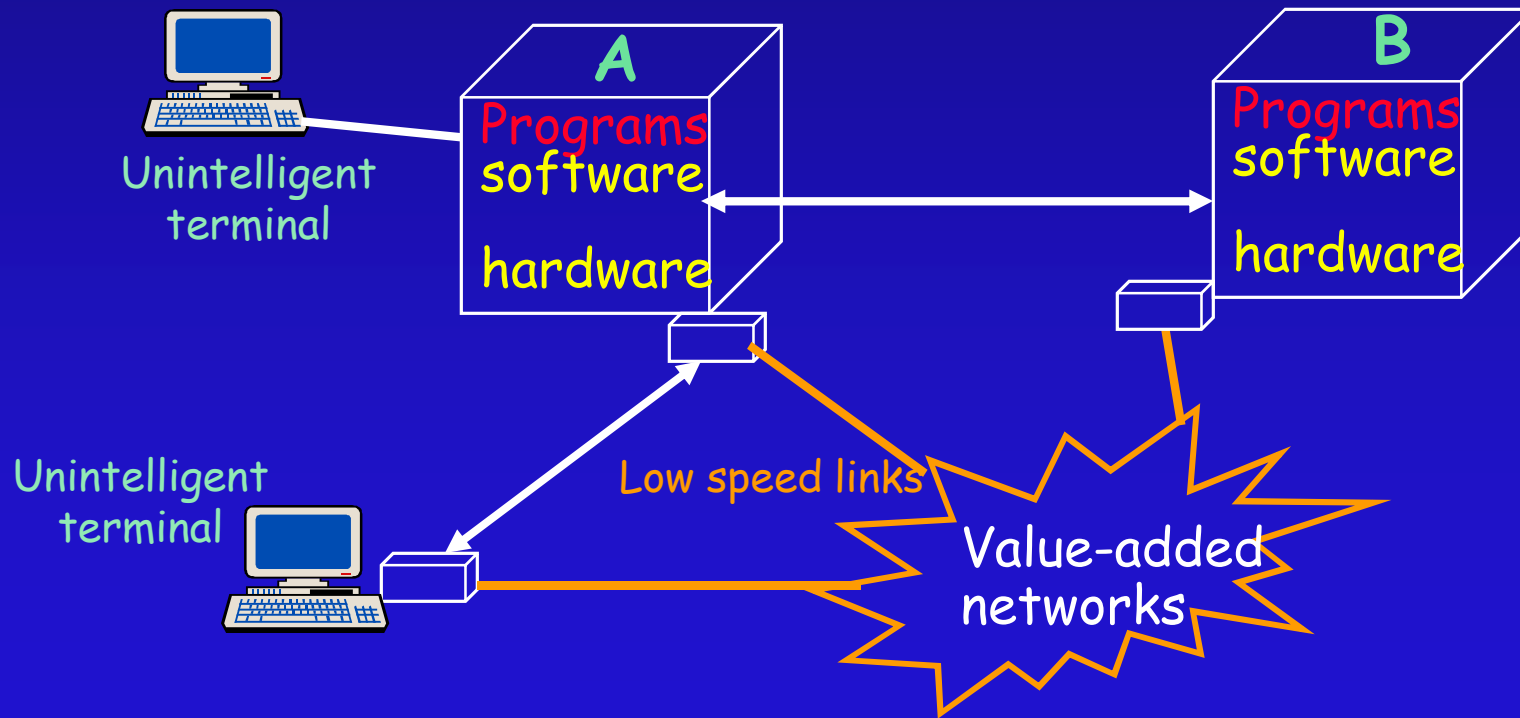
Outline

- Network Evolution
- Network Architecture & Concepts
- LAN and WAN Standards
- Internet and TCP/IP
- Network Convergence

Network Evolution

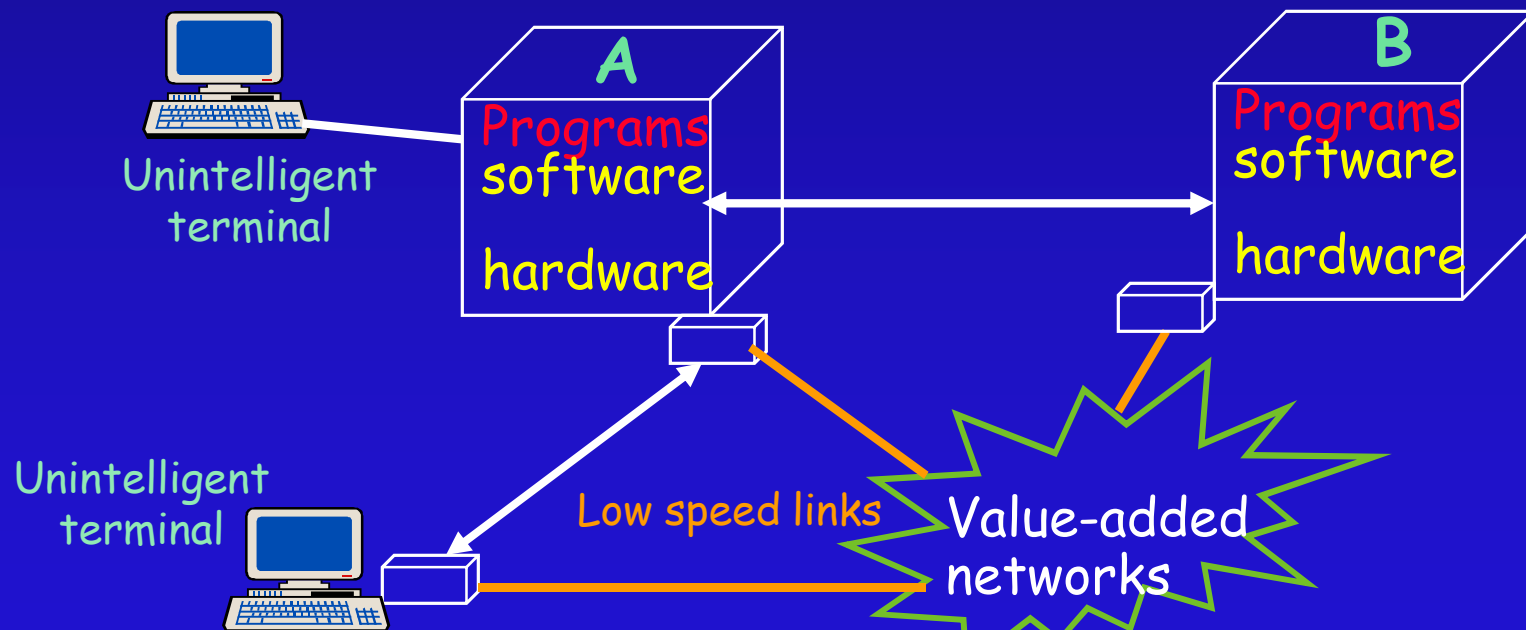
1960s and 1970s: Communications

- Centered around the host (mainframe).
- On a single computer, accessing resources, running programs, and copying files are relatively straightforward.



1960s and 1970s: Communications (contd.)

- Even on a system of only two computers, coordinating resources becomes much more complex.
- Transferring information requires, among other things, addressing, error detection, error correction, synchronization, and transmission coordination.



- Late 1960's -- ARPA (later became DARPA) began a partnership with 45 universities and research institutions to investigate **Data Communication Technologies**.
 - » 1969 -- ARPANET went into operation with 4 nodes.
 - The experiment was a success and ARPANET grew into a network spanning the entire USA.
- 1974 -- Birth of the first LAN (Xerox)

- In early years of networking, each computer manufacturer developed its own communication solution
 - IBM/SNA (1974)
 - Digital/DECnet (1975)
 - Sperry-Univac/Data communication architecture (1976)
 - Siemens/TRANSDATA (1978)
 - Honeywell/Distributed system architecture (1979)

Historical Glimpses (contd.)

- 1977 -- ISO established a subcommittee to develop an architecture/structure that defines communication tasks and which would:
 - » Serve as a reference model for international standards
 - » would facilitate efficient internetworking among systems from different technologies, manufacturers, administrations, nationalities, and enterprises.

Historical Glimpses (contd.)

- 1978 -- Meeting of 40 experts in Washington, D. C. started work that yielded 6 years later the OSI Reference Model.
 - » Paper by Louis Pouzin and Hubert Zimmermann, Proc. Of the IEEE November 1978, pp. 1346 - 1370.
- 1975 -- ARPANET transitioned to Defense commercial agency.
- 1978-80 -- ARPANET protocol were upgraded with TCP/IP.
 - » Paper by Cerf and Khann, IEEE Trans. Comm., May 1974.

Historical Glimpses (contd.)

- February 1980 -- The IEEE started Project 802 to develop standards for the LAN market.
- 1983 -- TCP/IP switchover complete.
 - » TCP/IP adopted as standard by DOD
 - » ARPANET had over 300 hosts.
 - » Over 1200 nodes by 1985.
 - » ARPANET split
 - ARPANET: Academic (Educational, Research)
 - MILNET: Military

Historical Glimpses (contd.)

- 1984 -- The OSI-RM came out.
 - » Defines a strategic outline
 - » Reduces degrees of freedom of standards developers
 - » Centered around the hierarchical decomposition of communication functions
- 1986 -- NSFnet backbone created.
- 1990 -- ARPANET put to rest
 - » 1987 -- over 25000 nodes
 - » 1989 -- 3000 networks for over 200000 users

Historical Glimpses (contd.)

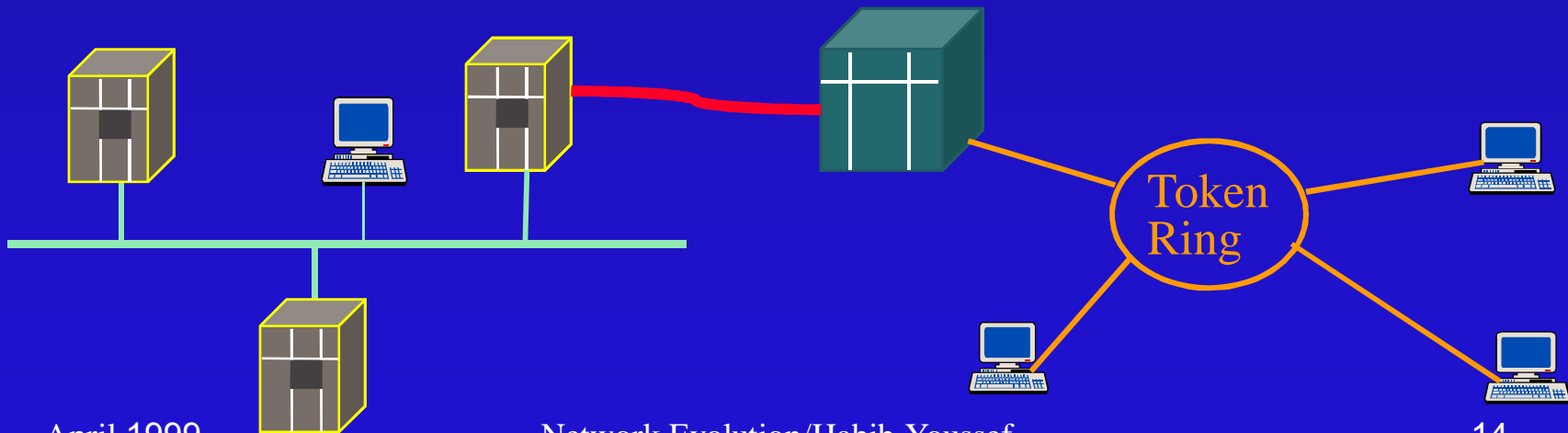
- 1991-- WWW invented & Gopher introduced
- 1995
 - » Over 7 million networks around the world
 - » 150000 users join the network every month
- July, 1998 -- over 36 million networks
- January, 1999 -- 157 million users
- Projected to be 327 million by year 2000

Historical Glimpses (contd.)

- The Internet is an Information Highway
 - » Dedicated communication links (copper, fiber, satellite) functioning as the concrete/asphalt
 - » Usually 56 Kbps to 1.544 Mbps leased lines serve as the on-ramp connecting to regional networks
 - Capacity of T1 highways is 1.544 Mbps
 - that of T3 is 45 Mbps
- The Internet is becoming a platform for most computer needs.

1970s and 1980s: Networks

- The introduction of PCs revolutionized computer communication and networking
 - » LANs evolved to share resources (Disks, Printers)
- Minicomputers and shared WANs evolved
 - » Facilitated the emergence of distributed processing
 - » Applications remained separate and independent, and different communication protocols were developed

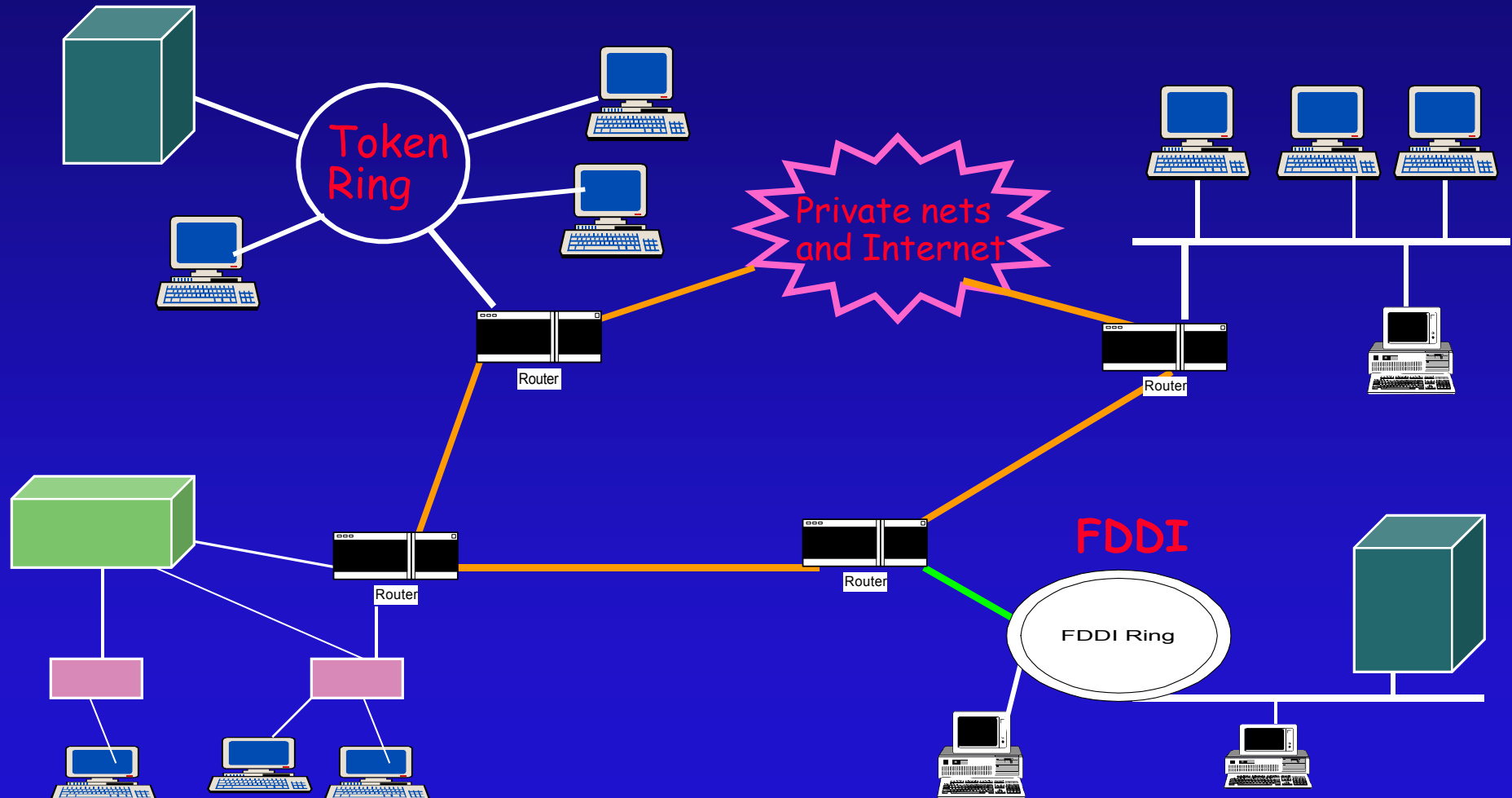


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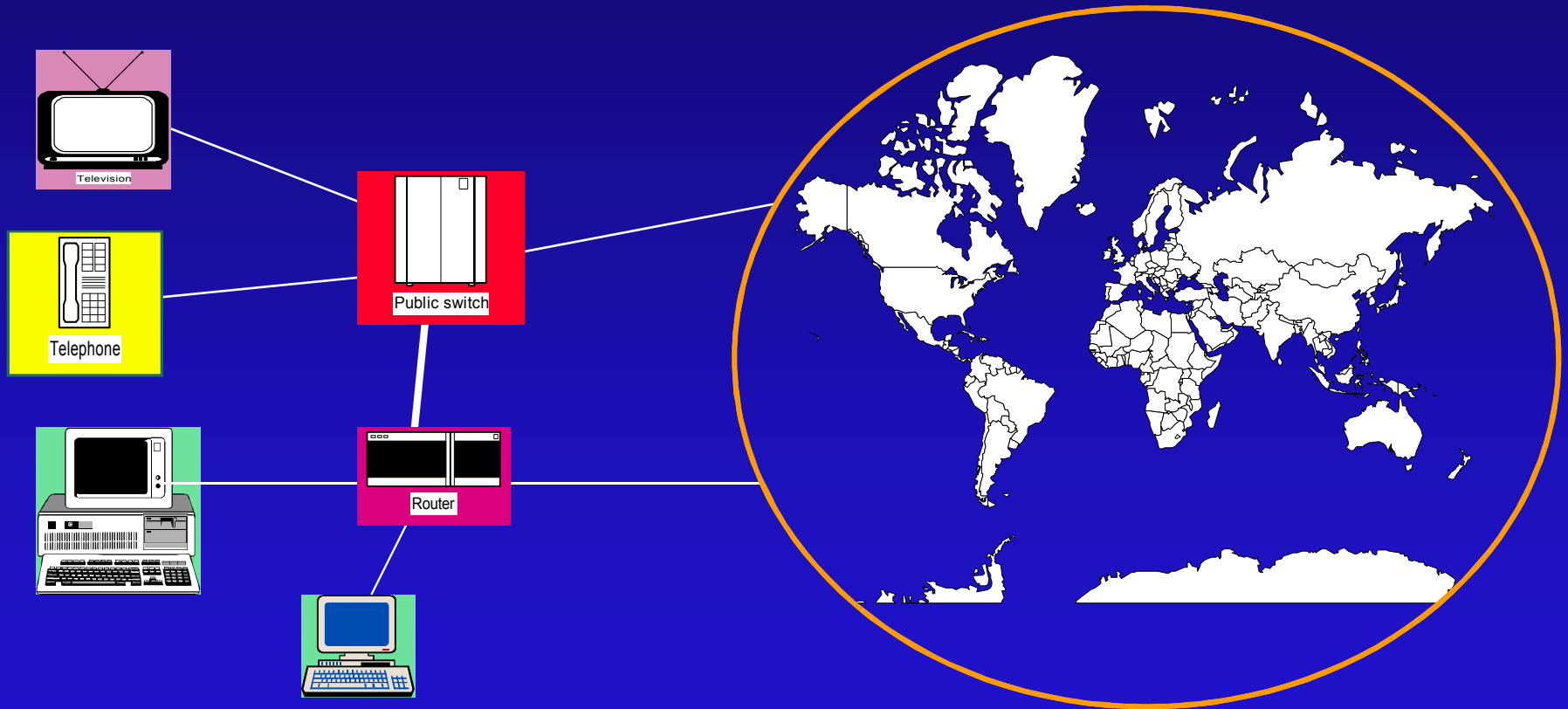
1980s and 1990s: Internetworks



1980s and 1990s: Internetworks

- Most of today's networks are a mixture of old and new technologies.
- The approach to computer communication in most organizations is changing rapidly in response to new technologies, evolving business requirements, and the need for more bandwidth and "instant" knowledge transfer.
- Internetworks tie LANs and WANs, computer systems, software, and related devices together to form the corporate communication infrastructure.

1990s: Global Internetworking



1990s: Global Internetworking

- Users increasingly require more bandwidth.
- Networks will have to meet these demands and provide low delay, bandwidth on demand, and other new services.
- Such networks are characterized by the following:
 - » increasing use of graphics and imaging
 - » larger files and larger programs
 - » client/server computing
 - » bursty network traffic
- Global internetworking will provide an environment for emerging applications that will require even greater amounts of bandwidth.

Application / Bandwidth

- High capacity network is a must to support increasing need for bandwidth.

Application

Digital audio

Compressed video (JPEG)

Document Reprographics

Compressed broadcast-quality TV

High-definition full motion video

Chest X-Ray

Remote query burst

Bandwidth

1.4 Mbps

2 - 10 Mbps

20 -100 Mbps

20 -100 Mbps

1 - 2 Gbps

4 - 40 Mbps

1 Mbps

Enterprise Developments

- The enterprise is a corporation, agency, service, or other organization that will tie together its data, communication, computing, and storage resources.
- Developments on the enterprise network include:
 - » LANs interconnected to provide client/server applications integrated with the traditional legacy applications from mainframe data centers
 - » End-user needs for higher bandwidth on the LAN, which can be consolidated at a switch and delivered on dedicated media
 - » Integration of formerly separate networks so that data, voice and video coexist on a single network
 - » Relaying technologies for WAN service, with very rapid growth in Frame Relay and cell relay (ATM)