MASSACHUSETTS INSTITUTE OF TECHNOLOGY
SLOAN SCHOOL OF MANAGEMENT

15.565 Integrating Information Systems:

Technology, Strategy, and Organizational Factors

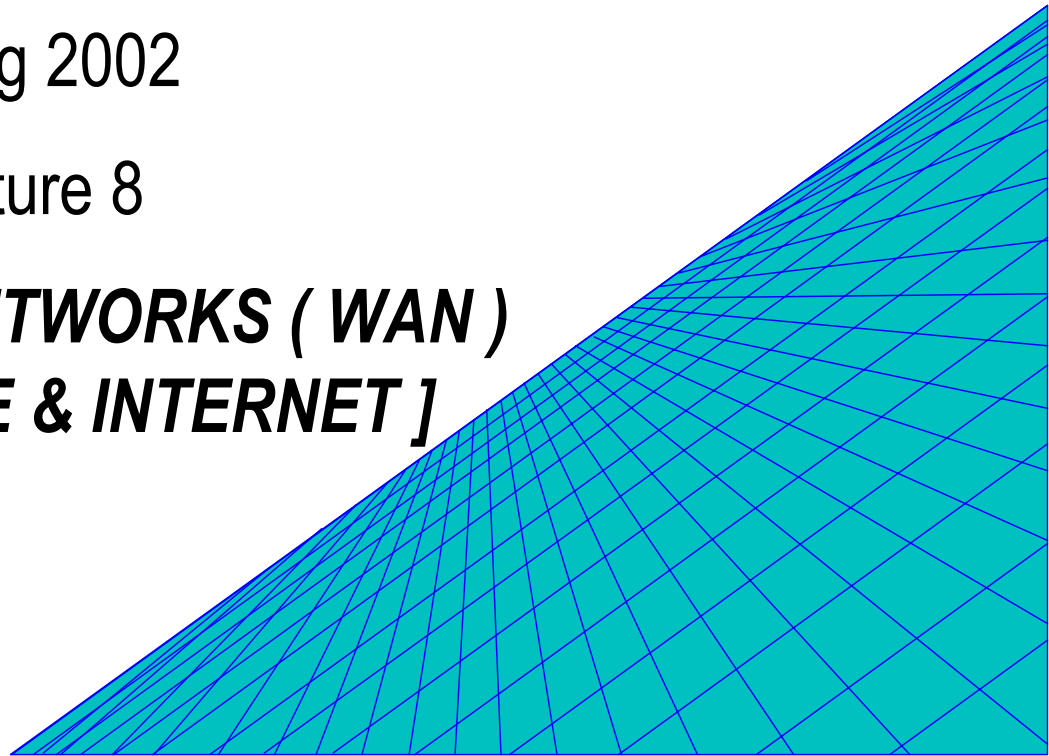
15.578 Global Information Systems:

Communications & Connectivity Among Information Systems

Spring 2002

Lecture 8

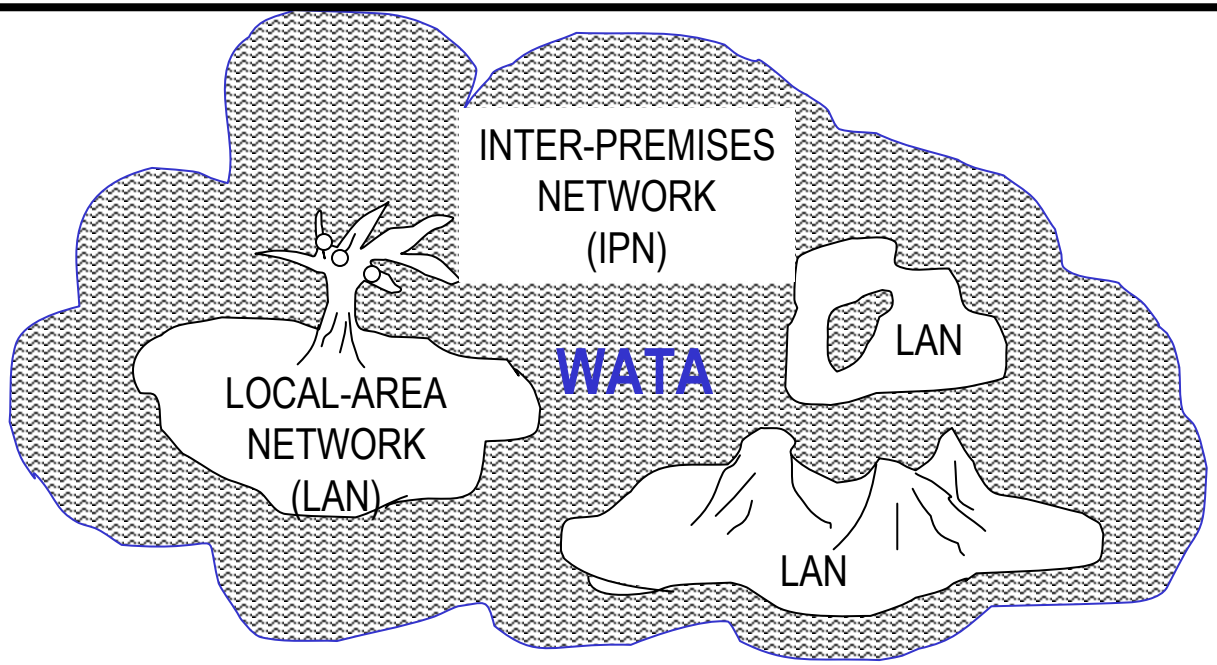
WIDE-AREA NETWORKS (WAN)
[TELEPHONE & INTERNET]



WIDE AREA NETWORKS (WAN)

- CONNECTING BETWEEN INFORMATION ENTITIES IN CLOSE PROXIMITY
  - USUALLY ON COMPANY PREMISES
  - LOCAL AREA NETWORK (LAN)

- CONNECTING BETWEEN INFORMATION ENTITIES IN DISTANT LOCATIONS
  - INTER-PREMISES NETWORK (IPN) / WIDE AREA NETWORKS (**WAN**)



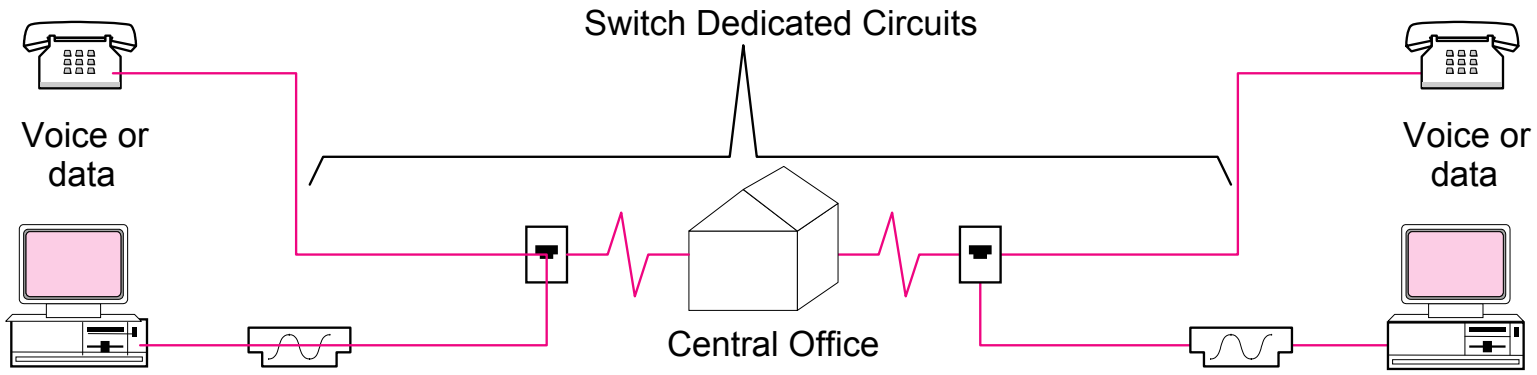
- **WIDE AREA TELECOMMUNICATIONS ABILITY (WATA)**

TWO FORMS OF WIDE-AREA NETWORK COMMUNICATION

- **Circuit switching (Traditional Telephony)**
  - A dedicated end-to-end connection is established for the duration of the connection
  - Used in telephone network
  - Like using a “private road”
- **Logical / Packet switching**
  - Messages are divided into small packets
  - Each packet is separately routed to the destination
  - Different packets can take different paths and times
  - Packets are reassembled into messages at the destination
  - Like using a “shared highway”

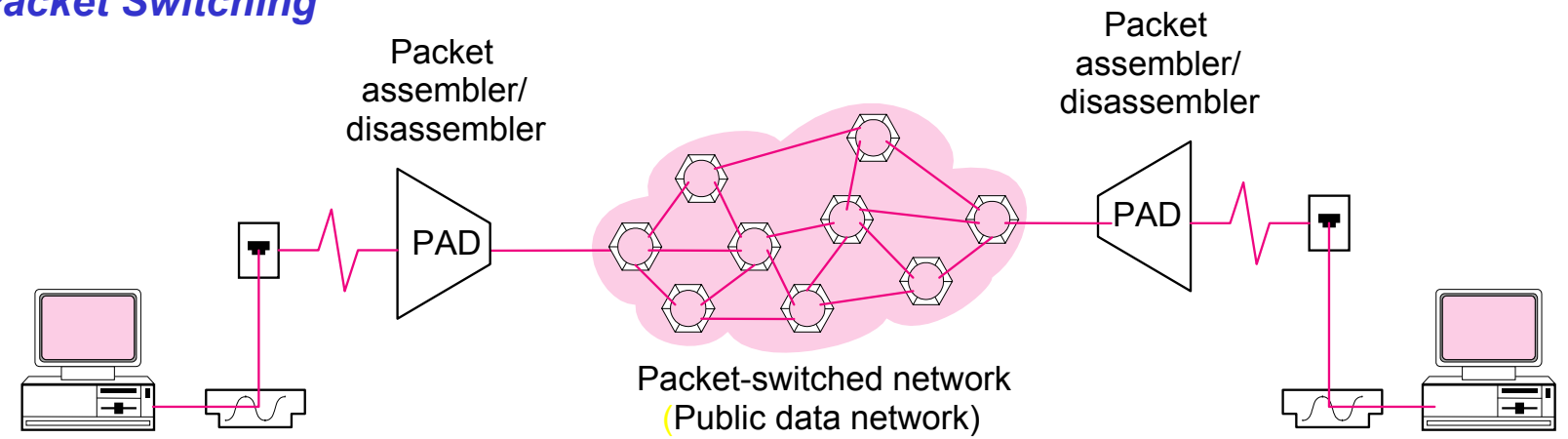
CIRCUIT SWITCHING VS. PACKET SWITCHING

Circuit Switching



All data or voice travel from source to destination over the same physical path

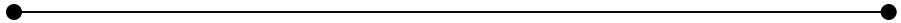
Packet Switching



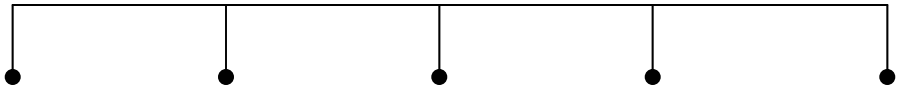
Data enter the packet-switched network one packet at a time;
Packets may take different physical paths within packet-switched networks.

EARLY EVOLUTION OF TELEPHONE SYSTEM ("POTS")

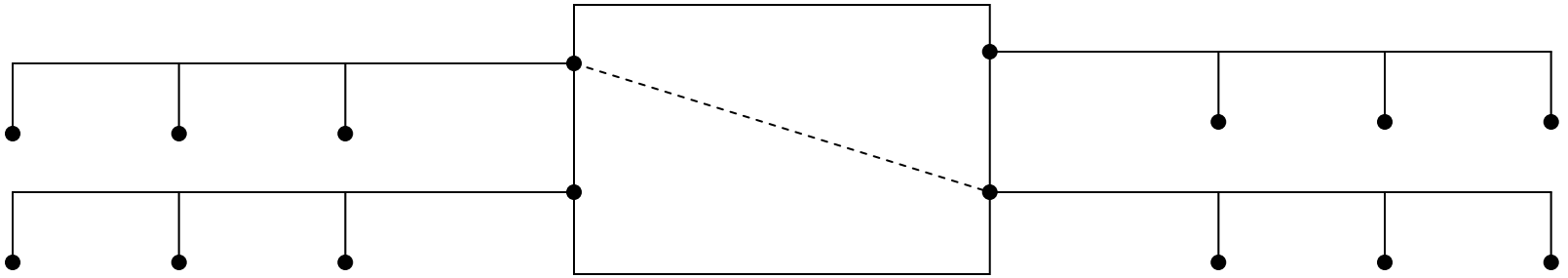
- ALEXANDER GRAHAM-BELL -- 1876
- TWO PARTY



- PARTY LINE (RINGING)

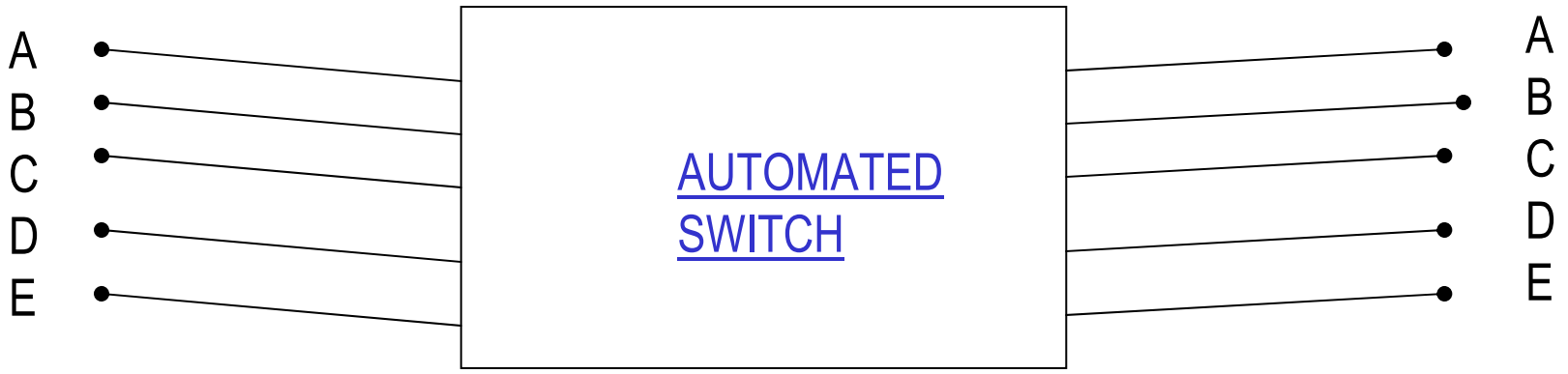


- MANUAL "SWITCHED" PARTY LINE



- HOW DO YOU HANDLE VERY LARGE SCALE?

EARLY "STEP-BY-STEP" AUTOMATIC CIRCUIT SWITCH



- ALMON B. STOWGER DEVELOPER – 1889
- NO MAJOR IMPACT UNTIL AT&T STARTED USING AROUND 1919 (AND MERGED 100's OF INDEPENDENT TELEPHONE COMPANIES)
- ISSUES
  - -- CALL SETUP
    - UP TO 30 SECONDS
  - -- TRAFFIC CAPACITY [e.g., 10,000 lines]
    - NUMBER OF ORIGINATORS (10%) [e.g., 1,000 lines]
    - NUMBER OF DIALERS (1%) [e.g., 100 lines]
    - "BLOCKING"

MULTIPLE CO-OPERATING CIRCUIT SWITCHES

- LOCAL "LOOP" (90% LESS THAN 20,000 FEET)
  - -- BYPASS OF LOCAL LOOP (DIRECT CONNECT TO YOUR PBX)
- "TRUNKS" BETWEEN SWITCHING OFFICES
- AT&T LONG DISTANCE NETWORK HAD CLASSES OF SWITCHING OFFICES
  - CLASS 1 -- REGIONAL CENTER (12)
  - CLASS 2 -- SECTIONAL CENTER (67)
  - CLASS 3 -- PRIMARY CENTER (230)
  - CLASS 4 -- TOLL CENTER (800)
  - CLASS 5 -- END OFFICE (10,000)
  - -- CENTREX vs PBX
- SWITCHING TECHNOLOGIES
  - -- ELECTROMECHANICAL (NO. 5 CROSSBAR [1948])
  - -- ELECTRONIC (#1 ESS [1965], #5 ESS [MIT], #4 ESS)
- ROUTING
  - -- COULD TAKE 9 CONNECTIONS
  - -- TIME-OF-DAY IMPACTS (NYC TO MIAMI)

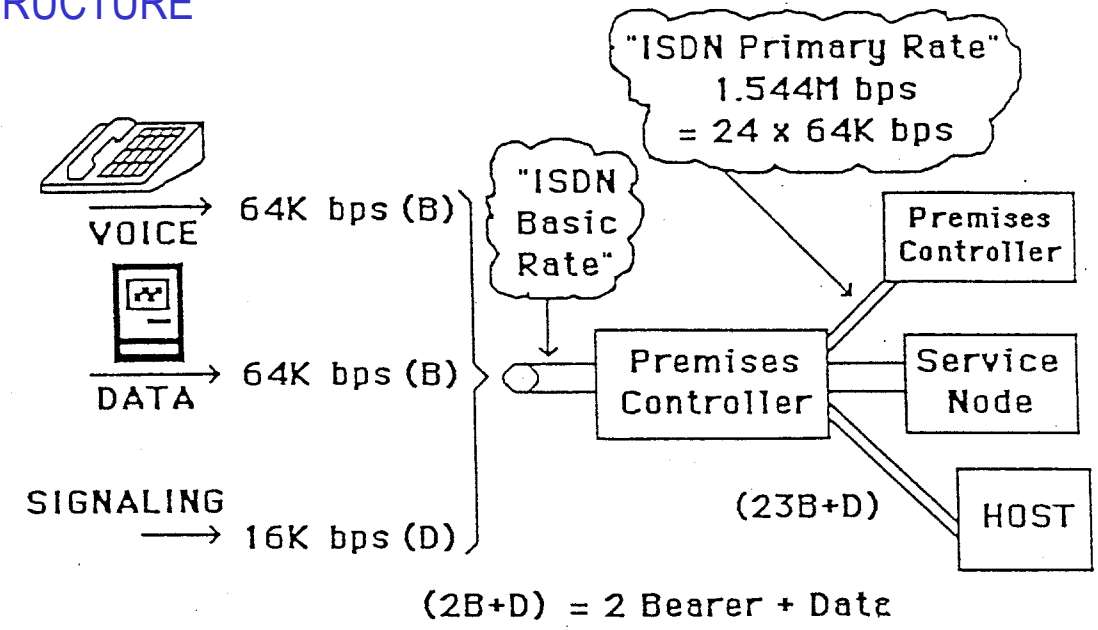
TRADITIONAL AT&T LONG DISTANCE NETWORK

SIGNALING ISSUES

- SIGNALING (INCREASED INTELLIGENCE WITHIN NETWORK)
  - -- "IN-BAND" VS. "OUT-OF-BAND"
  - -- COMMON CHANNEL INTER-OFFICE SIGNALING (CCIS)
    - -- 1976 (2.4K BPS)
    - -- 1985 (56K BPS) -- CCS-7
  - -- ADVANTAGES
    - CENTRALIZED DATABASE (COLLECT, CREDIT CARD)
    - 800 SERVICE
    - REMOTE CALL FORWARD
    - CALLER ID / AUTOMATIC NUMBER IDENTIFICATION (ANI)
    - CALL RETURN
    - REPEAT DIALING (WITH MESSAGING)

INTEGRATED SERVICES DIGITAL NETWORK (ISDN)

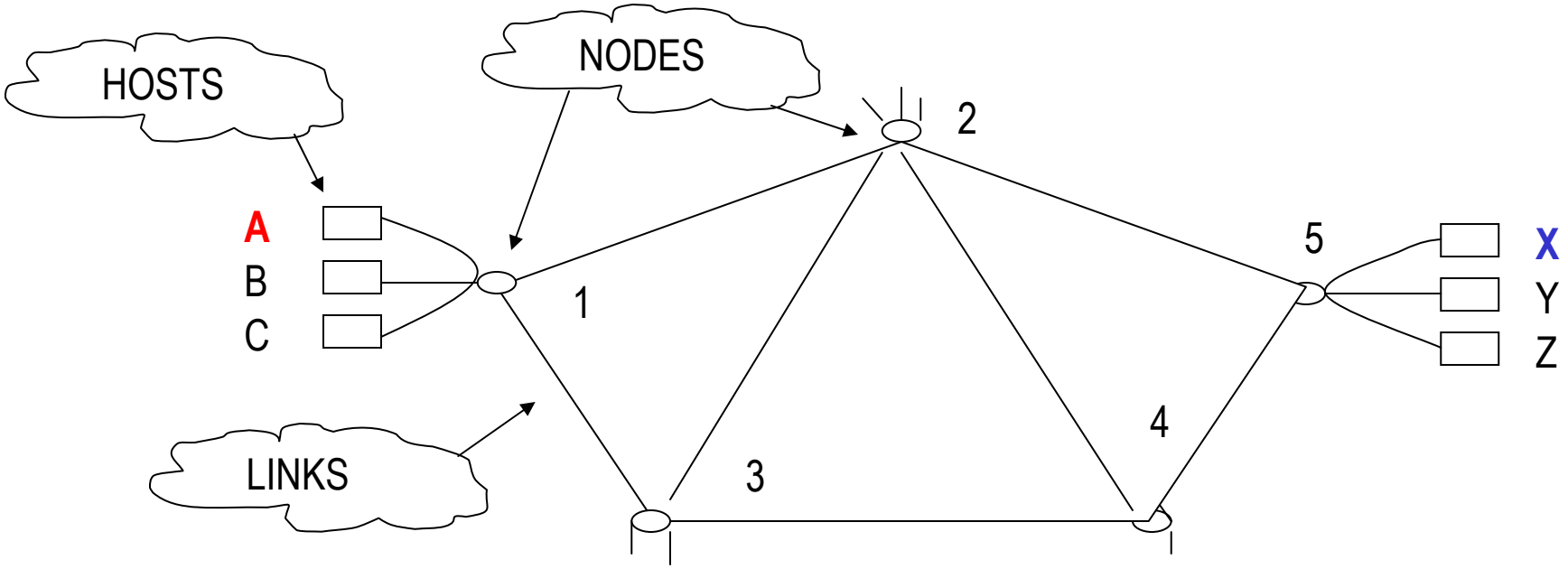
- INTERNATIONAL STANDARDIZATION EFFORT
  - WORLD-WIDE COMPATABILITY AND CONNECTIVITY
  - DIGITAL NETWORK WITH INTEGRATED DIGITIZED VOICE / DATA / IMAGE
- BASIC STRUCTURE



- KEY CONCEPTS
  - SIMULTANEOUS VOICE AND DATA
  - FEATURE/FUNCTIONALITY SIGNALING
  - ORIGINATING STATION IDENTIFICATION PROVIDED (AUTOMATIC NUMBER ID)
  - USE OF T1 COMMUNICATION LINES
  - SHARED NETWORK SERVICES (SWITCHING)

LOGICAL (MESSAGE) SWITCH NETWORKS

- LOGICAL SWITCHING (store - and forward) VS. CIRCUIT SWITCHING
- STATIC PHYSICAL COMMUNICATION NETWORK



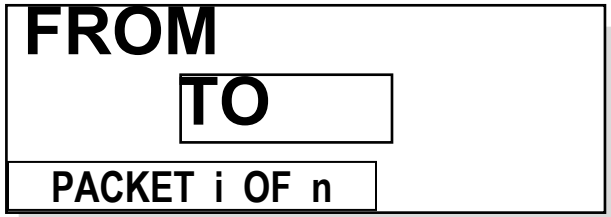
A MESSAGE TO BE SENT FROM **A** TO **X** MAY BE ROUTED THROUGH NODES

1-2-5 1-3-4-5 1-2-4-5 1-2-3-4-5 ETC.

ROUTING BASED UPON

- SPEED OF COMMUNICATION LINKS
- RELIABILITY & AVAILABILITY OF LINKS AND NODES
- NETWORK TRAFFIC LOAD

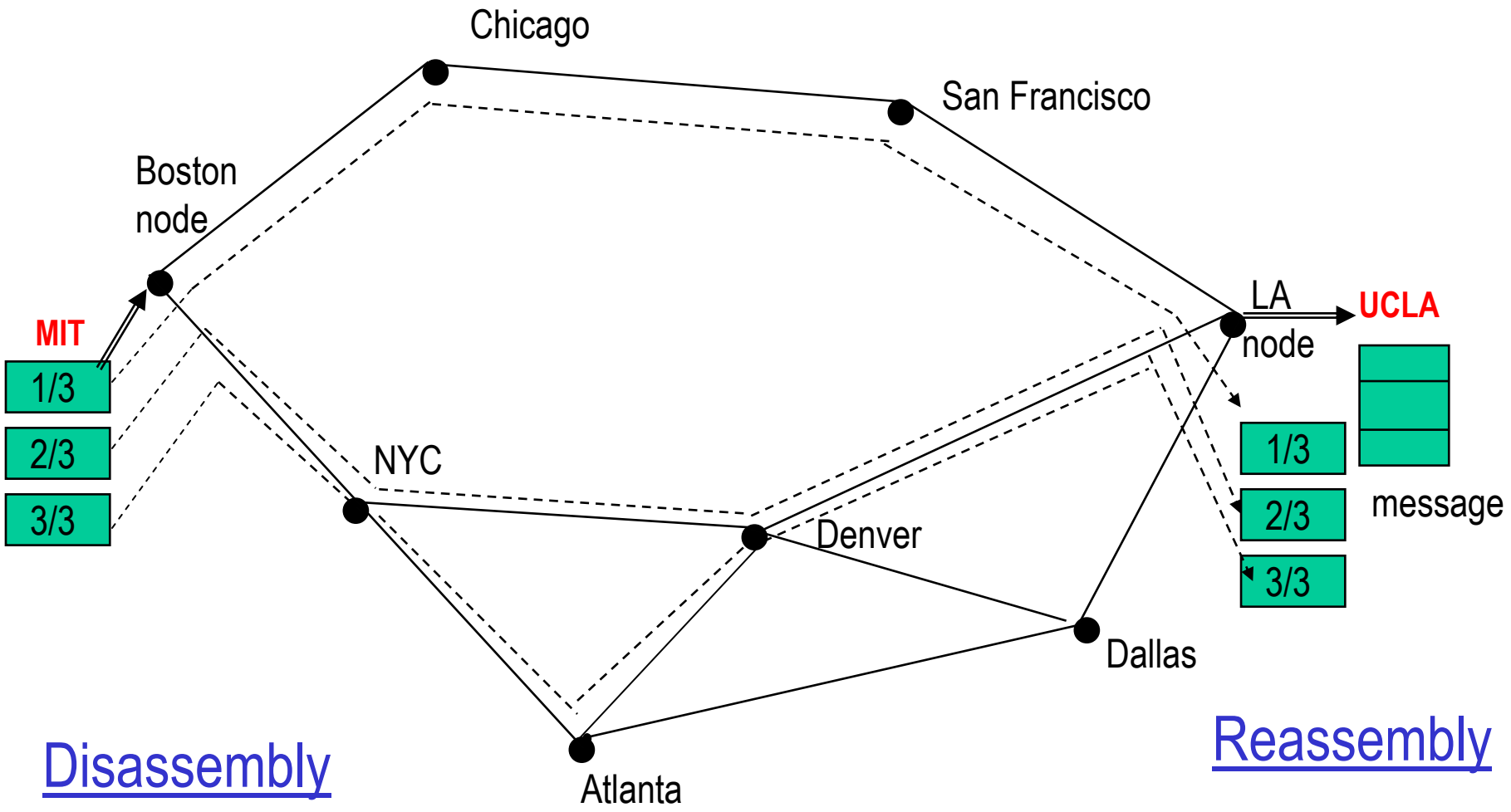
PACKET-BASED COMMUNICATION



Processing
- Disassembly
- Routing
- Re-assembly

- Applications exchange packets
  - Message divided into packets
  - Envelopes of data with To / From addresses and packet number
  - Packet size / length is fixed
- Networks support packet forwarding / relaying
  - Computers are connected to switches, routers, etc.
  - Switches sort and forward packets, like post offices
  - Lots of different physical layers can be used
  - Networks can be interconnected

PACKET ROUTING



CIRCUIT SWITCHING vs PACKET SWITCHING: SUMMARY COMPARISON

Circuit switching	Packet switching
Minimum delay	Variable delay
Very inefficient use of connection capacity	Much more efficient use of connection capacity
When overloaded, unable to make connection at all	Can almost always connect, but may be long delays
Both ends of connection must use same data rate	Data-rate conversion is easy

THE INTERNET: A NETWORK OF NETWORKS

Based on TCP/IP protocols

MIT

Local Area Network #1 (LAN#1) *[MIT]*

LAN #2

Harvard

LAN #3

Regional Network #1 (RN#1)
[NEARNET -> GTE Planet]

MIT

Backbone Network #2
[SprintLink, E-Net, J-Net]

Backbone Network #1
[NSFNET -> MCI,etc]

RN#3

AOL

gateway

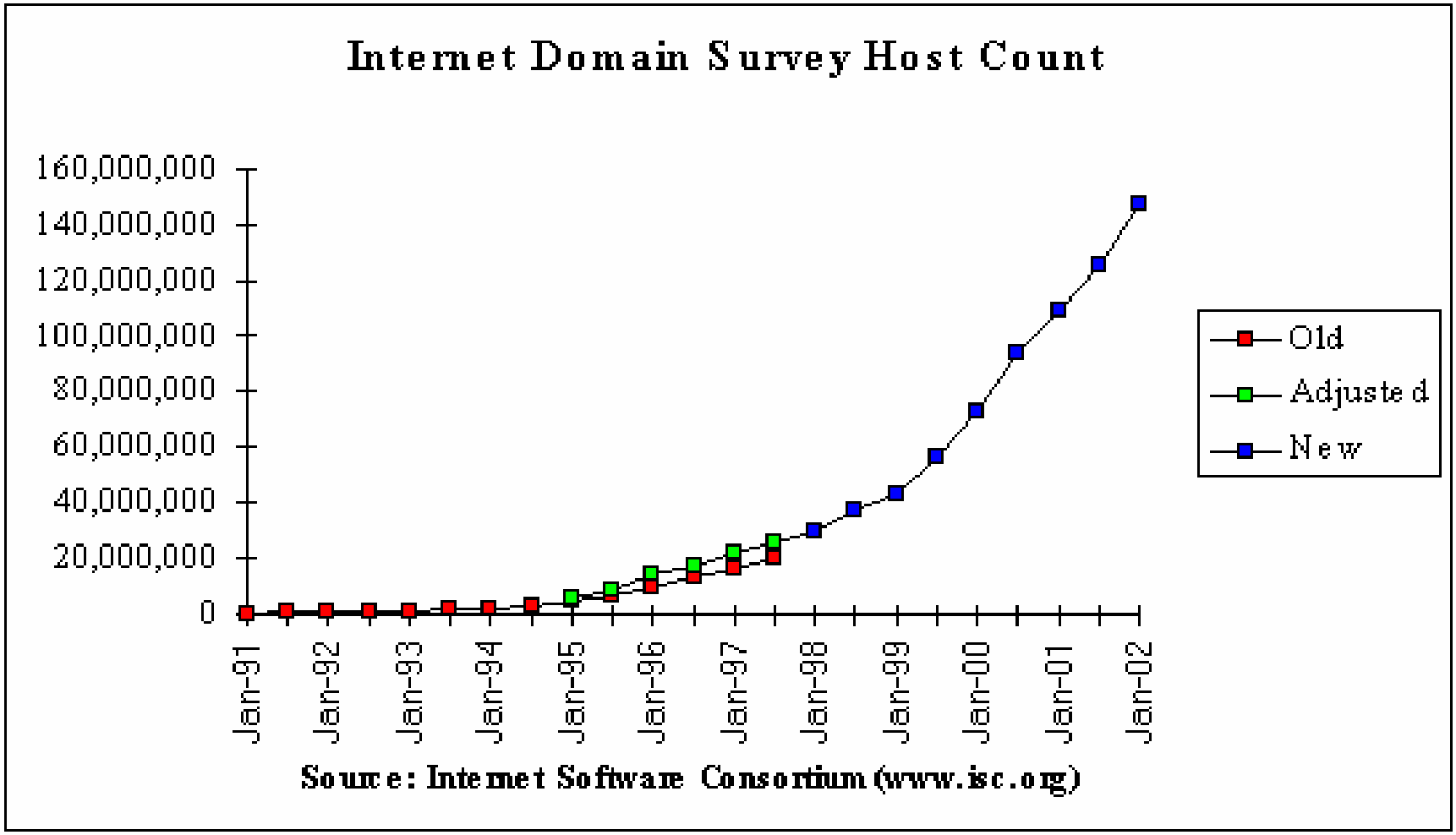
RN#2

UCLA

Local Area Network #n

Connections:
DS1 = 64K, T1 = 1.5M
T3/DS3 = 45M
OC-1 = 155M, OC-12 = 622M

INTERNET GROWTH

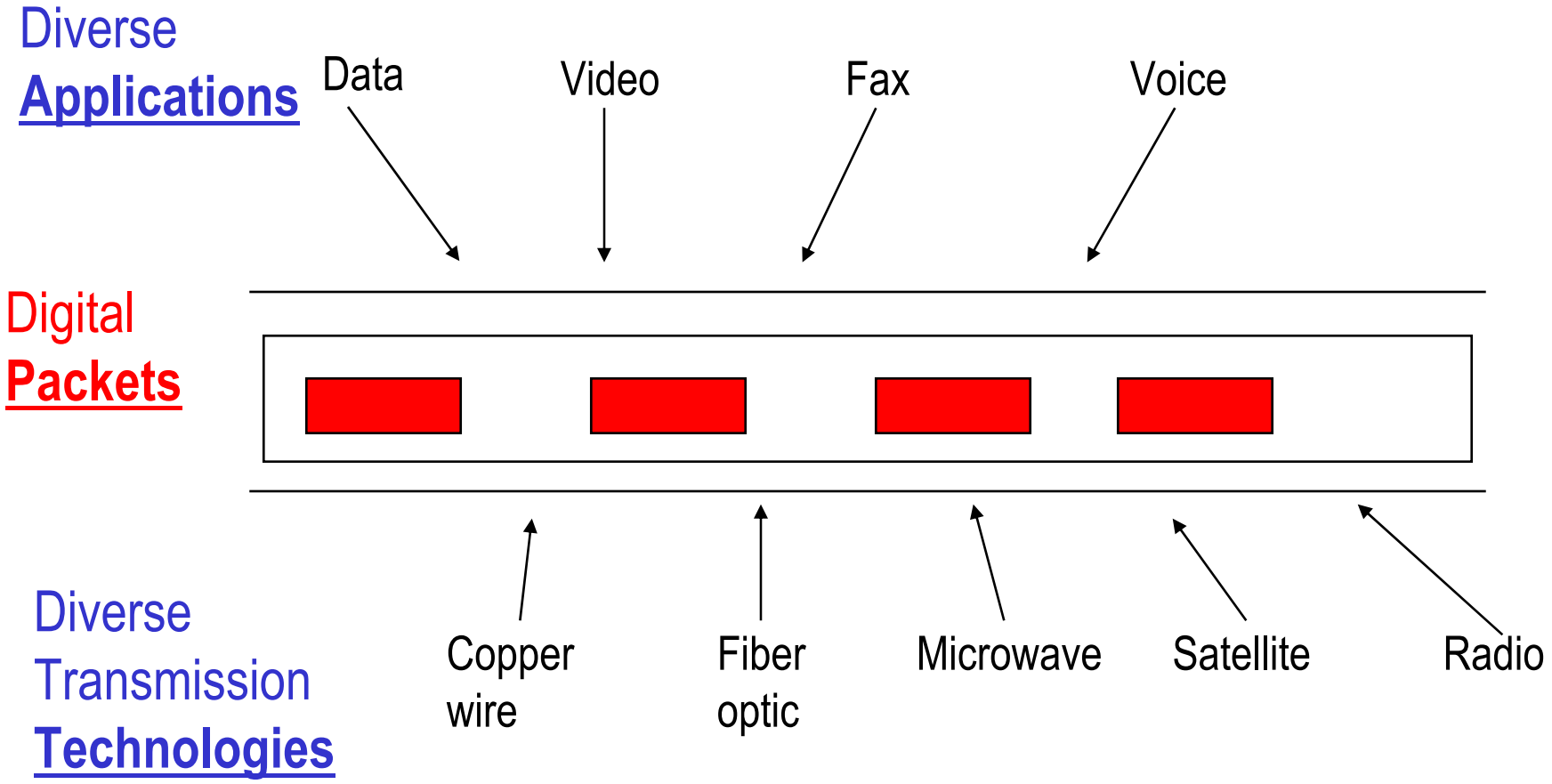


Source <www.nw.com>

WIDE AREA NETWORKS (WAN):
Network convergence business Drivers

- Market Volume: Internet traffic is doubling every 3 to 6 months
- Trend shift: Current network is dominated by voice, but data are quickly catching up
- Market Revenue: Carrier revenue: $200 billion+
- Legal: Telecommunications Act of 1996 allows almost anyone to sell almost anything
- Consumer view: Too many providers , too many services → opening for “one stop shopping” converged network vendors

THE FUTURE: DIGITAL CONVERGENCE



EVERYTHING IS JUST A BUNCH OF BITS …