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

Switch Dedicated Circuits

Voice or data

Central Office

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

Packet Switching

Packet assembler/disassembler

Packet-switched network (Public data network)

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

  - 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
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

Disassembly

Routing

Reassembly
## CIRCUIT SWITCHING vs PACKET SWITCHING: SUMMARY COMPARISON

<table>
<thead>
<tr>
<th>Circuit switching</th>
<th>Packet switching</th>
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<tr>
<td>Minimum delay</td>
<td>Variable delay</td>
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<tr>
<td>Very inefficient use of connection capacity</td>
<td>Much more efficient use of connection capacity</td>
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<tr>
<td>When overloaded, unable to make connection at all</td>
<td>Can almost always connect, but may be long delays</td>
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<tr>
<td>Both ends of connection must use same data rate</td>
<td>Data-rate conversion is easy</td>
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THE INTERNET: A NETWORK OF NETWORKS

Based on TCP/IP protocols

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

Internet Domain Survey Host Count

Source: Internet Software Consortium (www.isc.org)

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

Diverse Applications

Data Video Fax Voice

Digital Packets

Diverse Transmission Technologies

Copper wire Fiber optic Microwave Satellite Radio

EVERYTHING IS JUST A BUNCH OF BITS …