Chapter 6

Wide Area Networking Concepts, Architectures, and Services

Lesson Objectives

- Study WAN switching: Circuit and Packet switching
- Study the concepts of different WAN transmissions and services:
  - Local Loop transmissions alternatives:
    - POTS
    - ISDN
    - ADSL (xDSL)
    - Cable TV
  - WAN architecture and services:
    - X.25
    - Frame Relay
    - SMDS
    - ATM (cell-relay ATM)
    - Broadband ISDN

Goal: To understand the basic concepts of WAN

WAN Goals and Objectives

- WANs provides the communication backbone that make possible long distance transmission of multimedia data between users and between different LANs.
- A WAN is an internet when separate, geographically separate LANs are interconnected by internetworking devices to function as a single virtual network.
- Wide area networking is not limited by distance. It can be used for hundreds of branch offices globally linked using special routing protocols and filters to minimize the expense of sending data over vast distances.

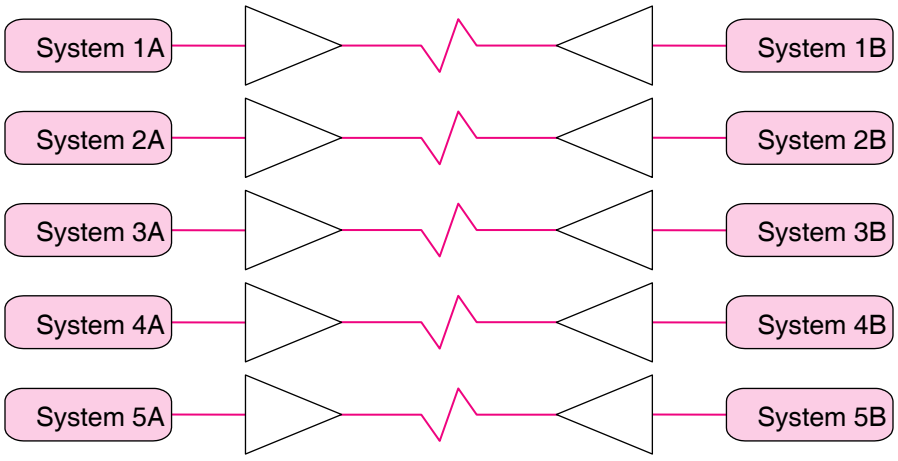
WANs

- WAN media include metallic circuits, fiber-optic links, or wireless links such as satellite, microwave systems.
- Services vary by cost, speed, quality, and the number of links required. In general, it is either private leased line service or public switched network service.
- IT departments are constantly finding ways to minimize bandwidth costs and maximize network availability, efficiency, and performance.
- LANs are privately owned but WANs are hired/leased.

Basic Principles of WAN

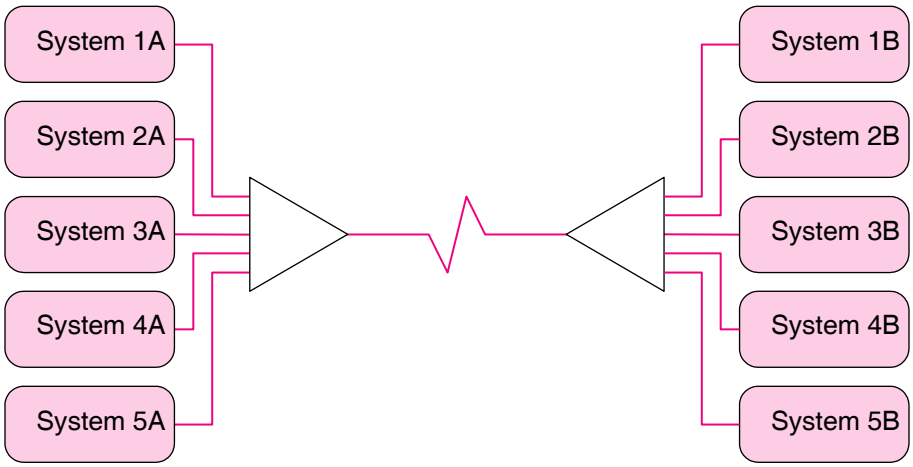
- **Business Issues** in wide area networking, like the desire to maximize the impact of any investment in technology is a central focus.
- Given five systems that need to be linked over long distances, how can be done?
  - A dedicated WAN link for each system
  - A shared WAN link for all systems
- Performance limitations.

A. Dedicated Multiple Wide Area System-to-System Connections



- Dedicated point to point connections

B. Single Wide Area Link Shared to Provide Multiple System-to-System Connections



- Single shared WAN link

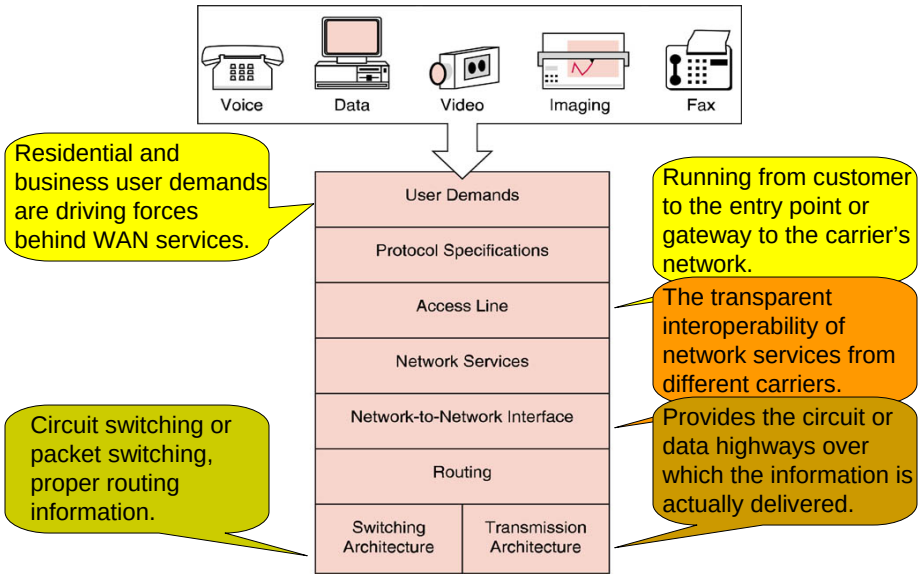
Basic Principles of WAN

- In order to share a single communications link among multiple systems, the two basic principles involved are need to be understood:
  - Packetizing – the segmenting of data transmission between devices into structured blocks or packets of data.
  - Multiplexing – takes packetized data from multiple sources and sends over a single wide area connection.

WAN Design Principles

- Performance
- Cost Reduction
- Security/Auditing
- Availability/Reliability
- Manageability & Monitoring
- Quality of Service/Class of Service
- Support for Business Recovery Planning

Major Components of a WAN Architecture



Wide Area Network Architecture

WAN Architecture = Switching Architecture + Transmission Architecture

- **Switching Architecture:** Methods to ensure proper routing of information from source to destination.
- **Transmission Architecture:** Circuits or data highway over which the information is actually delivered.

Broadband Transmission

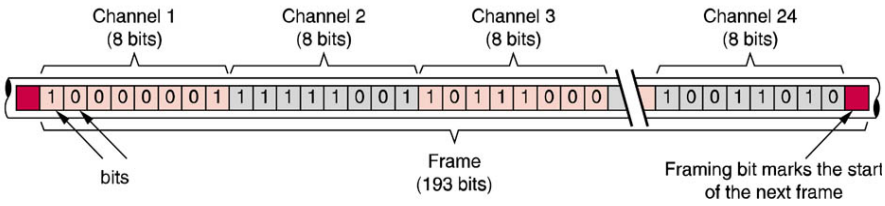
- T-1
- SONET (Synchronous Optical NETwork)

T-1

- It is the standard high capacity digital transmission service in America → 1.544 Mbps
- In other parts of the world the standard is E-1 → 2.048 Mbps
- T-1 is divided into twenty four 64K channels. Each of which is known as DS-0. Some may be used for voice and some for data.
- Each channel consists of group of 8-bits known as time slot. Each time slot represents one voice sample or a byte of data to be transmitted.

T-1 Frame Layout

T-1 Transmission Service
(1.544 Mbps)



24 channels/frame × 8 bits/channel = 192 data bits/frame

192 data bits + 1 framing bit = 193 total bits/frame

193 bits/frame × 8,000 frames/second sampling rate = 1,544,000 bits/second

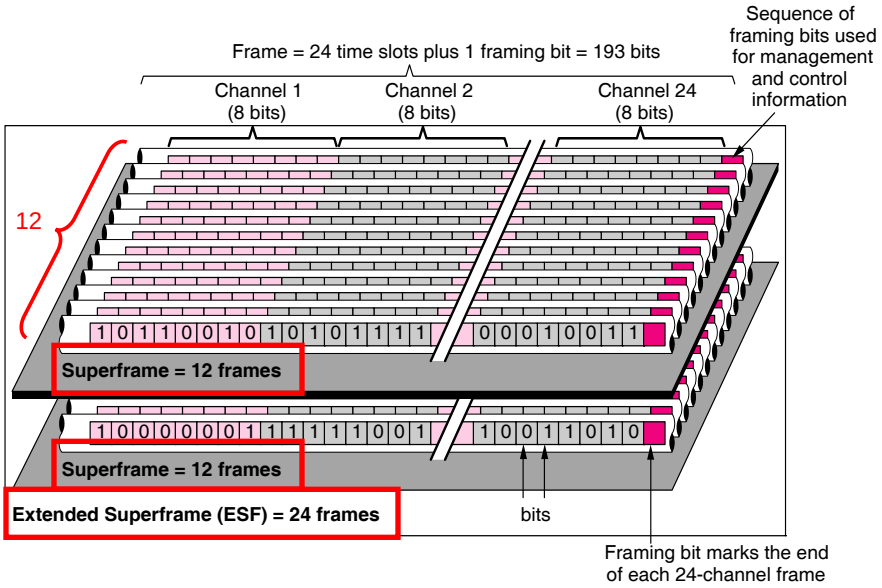
= 1.544 Mbps

= DS-1

= T-1

- A T-1 frame consists of a framing bit & 24 DS-0 channels, each containing eight bits, for a total of 193 bits per frame.

Superframes and Extended Superframes



Digital Service (DS) Hierarchy

Digital Service Level	Number of Voice Channels	Transmission Rate	Corresponding Transmission Service
DS-0	1	64 Kbps	DS-0 or switched 64K
DS-1	24	1.544 Mbps	T-1 or switched T-1
DS-1C	48	3.152 Mbps	T-1C
DS-2	96	6.312 Mbps	T-2
DS-3	672	44.736 Mbps	T-3
DS-4	4032	274.176 Mbps	T-4

- T-1 and T-3 are by far the most common service levels delivered.
- T-1 service is most often delivered via 4 copper wires (2 twisted pair).
- T-3 service is most commonly delivered via optical fiber.
- Some T-1 marketing practices is to sell Fractional T-1 or FT-1.

CCITT Digital Hierarchy

Digital Service Level	Number of Voice Channels	Transmission Rate	Corresponding Transmission Service
1	30	2.048 Mbps	E-1
2	120	8.448 Mbps	E-2
3	480	34.368 Mbps	E-3
4	1920	139.264 Mbps	E-4
5	7680	565.148 Mbps	E-5

Digital Service Hierarchy and CCITT Standards

- CCITT Digital Hierarchy.
- **CCITT** (Comit Consultatif International Tlphonique et Tlgraphique), now known as **ITU** (International Telecommunication Union)

T-1 Technology

- The fundamental piece of T-1 hardware is the **T-1 CSU/DSU** (Channel Service Unit/Data Service Unit). Two devices are packaged as a single unit.
- The CSU is a device that connects a terminal to a digital line. The DSU is a device that performs protective and diagnostic functions for a telecommunications line. Can be thought of as a very high-powered and expensive modem.
- Their primary job is to convert a digital data frame from a local area network (LAN) into a frame appropriate to a wide-area network (WAN) and vice versa.
- Such a device is required for both ends of a T-1 connection, and the units at both ends must be set to the same communications standard.

T-1 Technology

- A T-1 is commonly delivered as a 4-wire circuit (2 wires for transmit and 2 wires for receive) physically terminated with a male **RJ-48c** connector.
- The T-1 CSU/DSU (provide the RJ-48c female connector) will transfer the 1.544 Mbps of bandwidth to local devices like, routers, over high speed connections such as V.35, RS-530, RS-449 or Ethernet that are provided on the customer side of the CSU/DSU.
- A CSU/DSU are often able to communicate status and alarm information to network management systems via the Simple Network Management Protocol (SNMP).

T-1 Technology Implementation