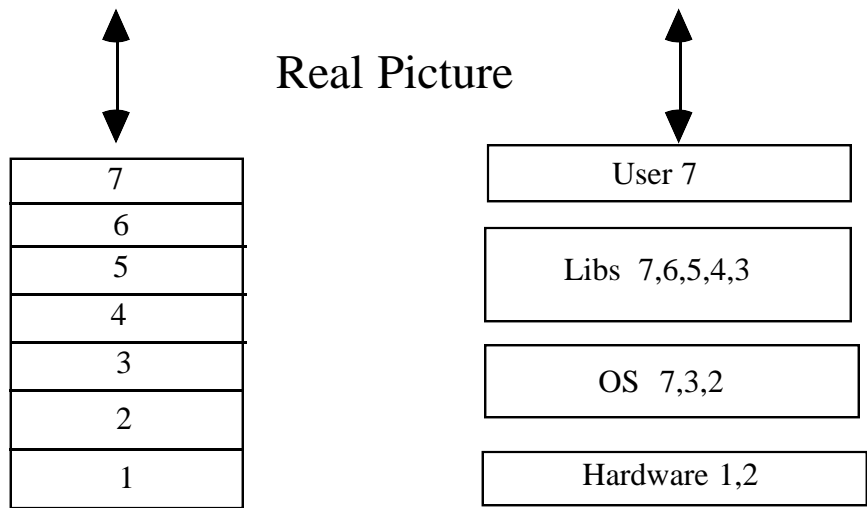


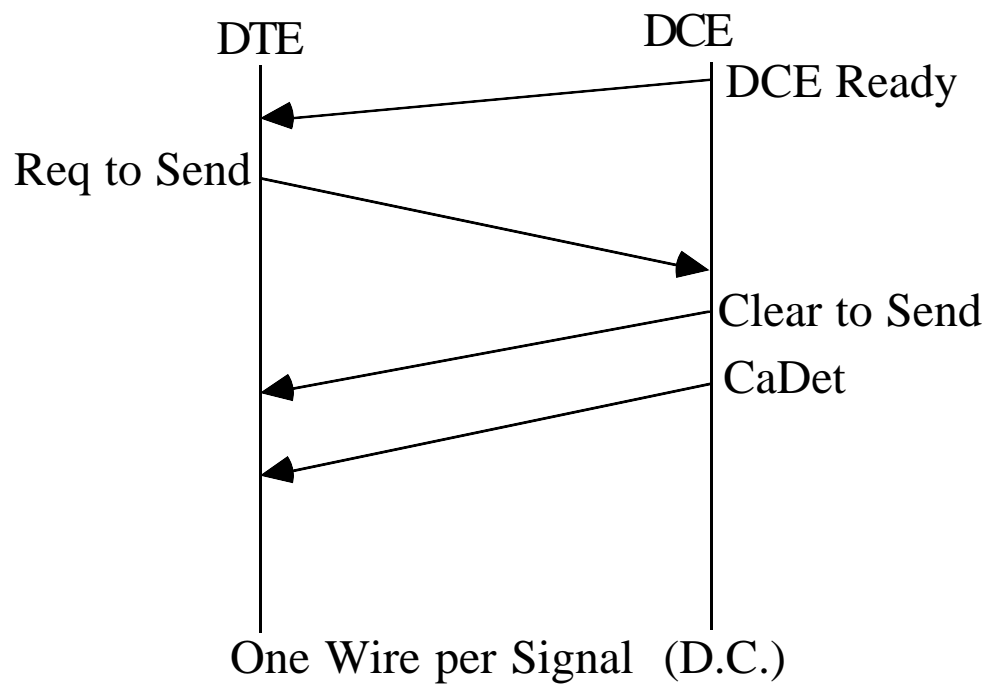
Lecture 3

Implentation of Protocol Stack

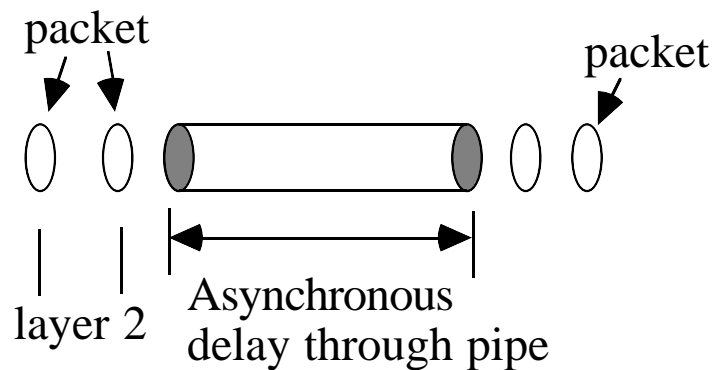
Application		Subroutine Lib, User Code (in OS Commit Protocol)
Presentation		Subroutine Library
Session		System Process Outside OS or Subrotine Lib
Transport		In Operating System
Network		
DataLink		Network Adapter Card
Control	MAC	Chipset(IEEE802.x)
Physical		



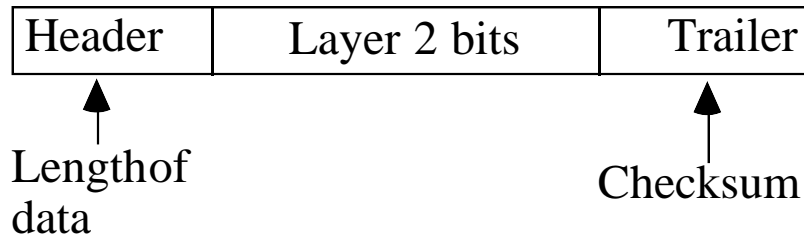
- Layering (see Fig 1.8, Bertsekas Gallager)
 - General Concepts:
 - Modules
 - I/O description - blackbox
 - off the shelf reusability
 - Service
 - Layered Protocol View
 - Distributed Black Box
 - Protocol = distributed algorithm
- Physical Layer
 - Virtual Bit Pipe (characterized by R bits/sec with error rate of 10^{-4})
 - Modems = Interface (noop's if digital medium)
 - DL interface:
 - sync bit
 - async bit
 - async char
 - Simple Protocol needed
 - how many wires, voltages, pins
 - how many microsec's a bit lasts, if simultaneous, 2-way communication is ok.
 - how does communication start and end?
 - RS232C: example (fig 1.9), - each end is Finite State Machine and stores state



- Data Link Control Layer (or Data Link Layer)
 - Provides virtual, reliable, asynchronous variable length packet pipe on unreliable bit pipe
 - Packet = string of bits from layer 3
 - Asynchronous pipe in two ways
 - Asynchronous delay through pipe due to:
 - 1) error recovery
 - 2) variable length packet
 - Asynchronous insertion of packets due to:
 - 1) No data
 - 2) pipe full, due to errors



- Frame:



- 3 types

- Data Frame
 - Ack Frame
 - Piggyback

- DLC:

- may regulate traffic (slow sender to receive rate or if no receive buffer)
 - always guarantees ordering
 - usually (not always) guarantees reliability (detect corrupted, lost, duplicated frames)

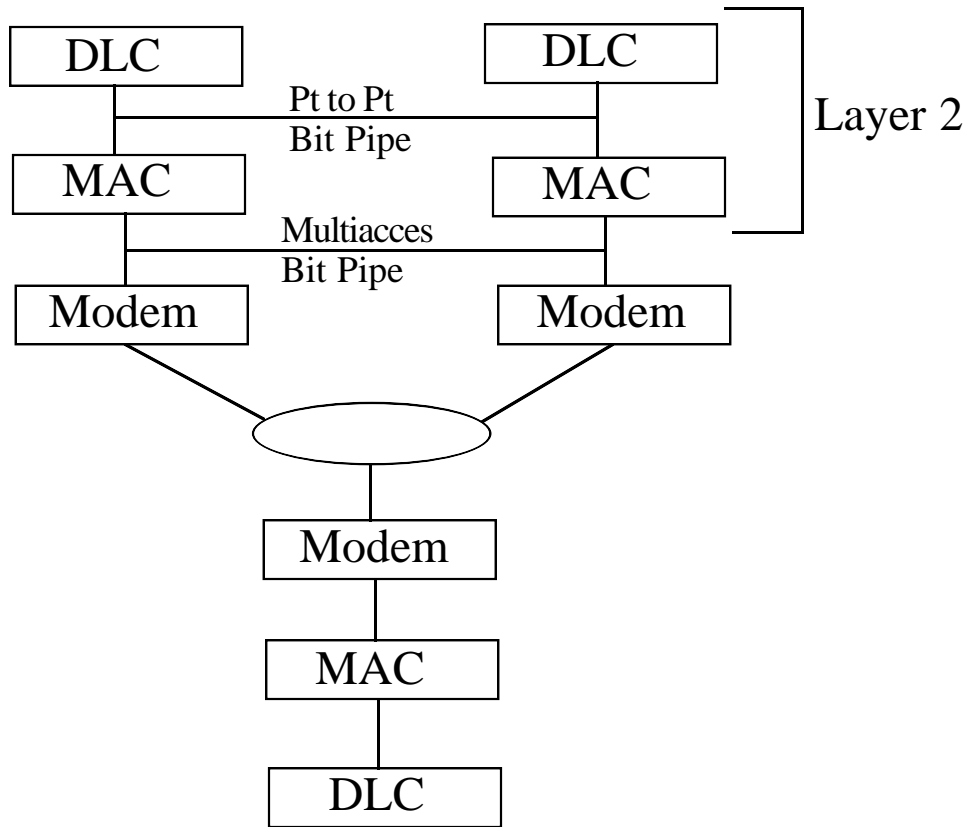
- *Question:* If layer 2 guarantees reliable pipe, does layer 3 & above need error detection?

- *Answer:* Yes, since it resets if 1 endpoint's layer 2 crashes. Also if multihop packet.

- Runs over

- Point - to - point
 - Multiaccess (add source, destination address to header)
(satellite, radio, cable, optical fiber)

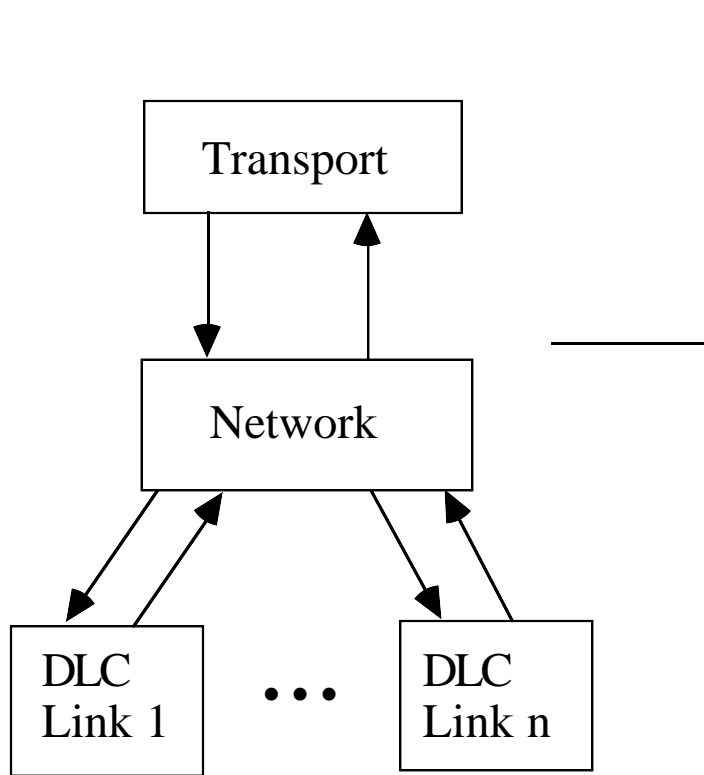
- In layer 2:



• Layer 2 Summary of Functions:

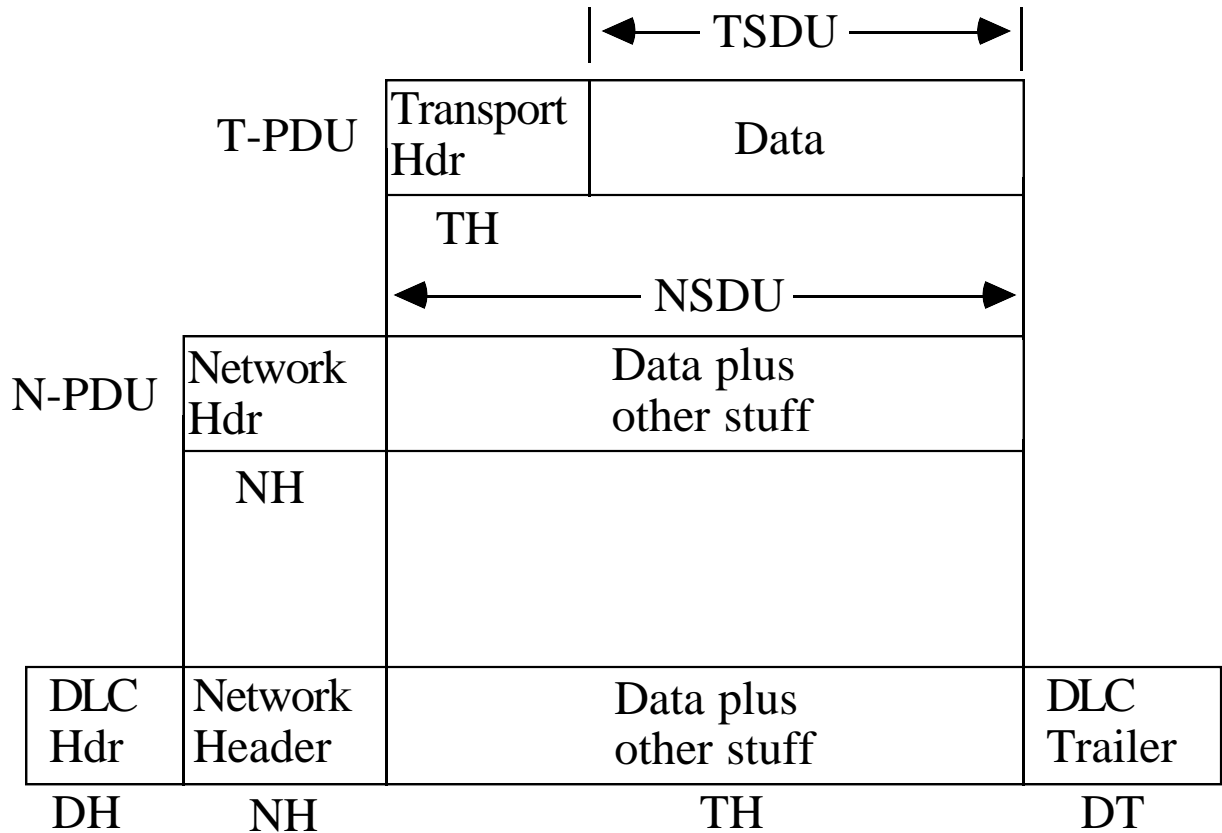
- Error detection and recovery
- Flow Control
- Provides asynchronous interface for layer 3 (if layer 2 is synchronous or intermittent synchronous)
- MAC (if multiaccess medium in layer 1)
- Addressing (if multiaccess medium in layer 1)

- Layer 3: Network Layer



Could bridge
2 LANs or,
be a backbone
switch

Encapsulation:



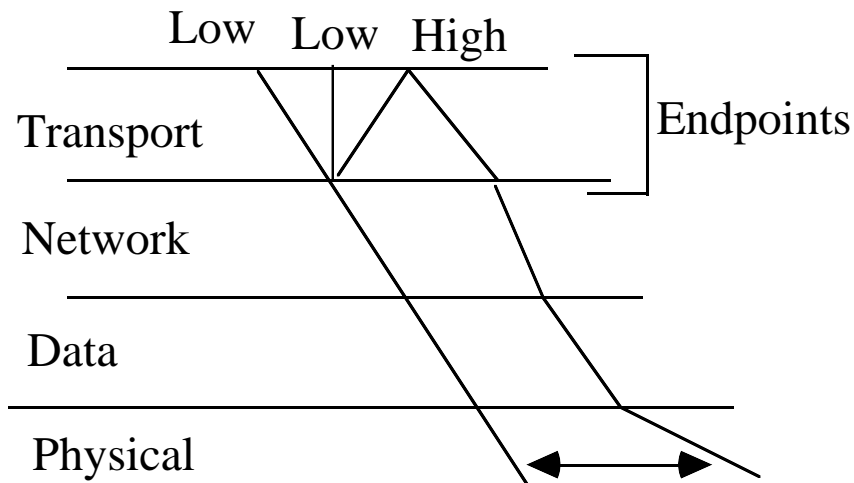
- Network Layer's jobs:
 - Routing (which outgoing link?)
 - Flow control
- Miscellaneous
 - Network gets hit by packets from 2 directions: layer 4 and layer 2

- Network can generate its own *control* packets:
 - Source quench
 - Say if a link failed
 - Net management
 - Establish, close connection
- VC Networks operation - Layer 3 must:
 - Select path/route for VC upon connection establishment
 - Insure during connection that all packets follow selected path
 - Control packets to optimize route selection
- Datagram Networks - Layer 3 must:
 - Route each packet individually
- Network layer can provide:
 - Virtual connection-oriented service
 - with virtual circuit op or datagram op
 - Always in LAN, FIFO
 - Datagram connectionless service
 - with datagram op
 - only in WAN, Reordering
 - Examples:
 - ISO - connection-oriented and connection-less, both on X.25 VC
 - TCP (connection-oriented) and UDP (connection-less) both on IP (using datagrams)
- Flow Control
 - Local access
 - In MAC layer for an endpoint

- In network layer in subnet node
- Global problem
 - Congestion control/management
- Techniques
 - Buffer management
 - Access control to subnet
 - Routing to spread load
 - Bits in packets to pass info on congestion
 - RTD measurement to detect congestion
- Connection-oriented - easier, versus
Connection-less - harder flow control
- In higher data-rate, higher link capacity networks:
 - no feedback before transmission ends maybe
 - errant node can still flood net
 - expect same utility, because new applications
may eat up bandwidth
- Internets (Internet sublayer)
 - needed because there are multiple LAN
protocols
 - TCP/IP - SNA gateway
- *Question:* If LAN uses 1500 byte DL packets,
LAN2 uses 512, which layer splits/assembles
packets?

- Transport Layer (layer 4)

- Reliable end-to-end delivery (if network is unreliable) (TCP)
- Breaks messages into packets, reassembles
- Multiplex low data rate sessions onto same network session



- Split one high data rate transport session into multiple network sessions
- End-to-end flow control, recovery from link/node failures
- Sometimes transport flow-control/error recovery overlaps/fights network, DLC (want integrated solution)
- Operating system implements transport

- Layer 5: Session layer

- Allows ordinary data transport (as layer 4 does) with enhancement
- Who pays for service?
- Load sharing on multiple processors
- Access rights (remote login)
- 411 service: look up where in network a service is available (IP address, TCP-port)
- *Note:* "Session" initiation divided between layers 5,4,3

(following from Tanenbaum 7.1)

- Only the OSI suite has it; other protocols either don't provide its functions or do it in other layers
- Seven groups of OSI service primitives:
 - 1&2) Connection establishment and release (like layer 4 except):
 - one TL connection can be used for many short sessions
 - release is "orderly" at layer 5, "abrupt" at layer 4
 - 3) Data transfer (like layer 4)
 - 4) Token management (whose turn is it to talk?)

- 5) Synchronization: move session entities back to known state if an upper layer error occurs (layer 4 only recovers from common errors in layer 1 - 3). Roll back to last synchronization point and re-start.
- 6) Activity management (partition message stream into files)
- 7) Exception reporting.

- Layer 6: Presentation

- Translation to/from universal data representation (float, char) (Suns, XDR)
- Encrypt, decrypt
- Data compression, decompression (video file, image, multimedia network)

- Layer 7: Application

- File transfer
- Mail exchange
- Transaction protocol
- RPC (requires processes to marshall data)
- Virtual terminal (how to move curse)