CS551
Layering and Addressing

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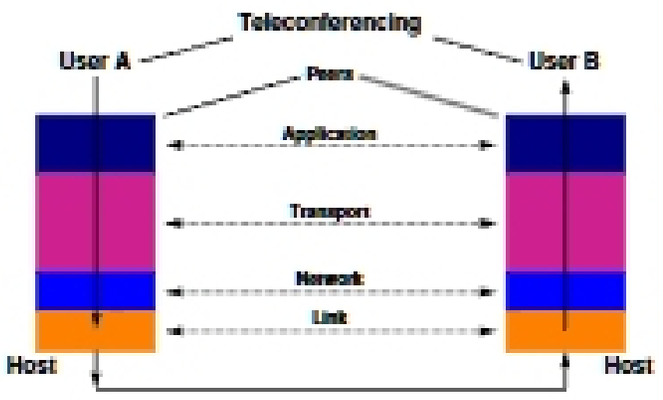
Protocols

- Set of rules governing communication between network elements (applications, hosts, routers)
- Protocols define:
  - Format and order of messages
  - Actions taken on receipt of a message
- Protocols are hard to design
  - We need design guidelines!

Layering

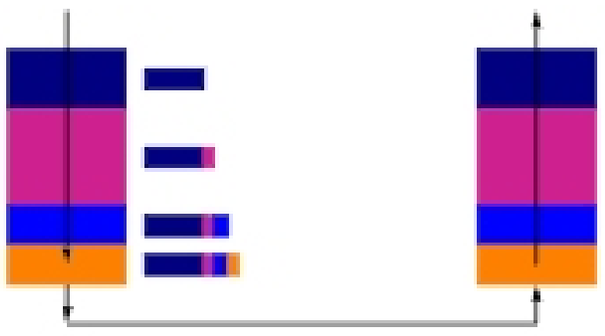
- Layering: technique to simplify complex systems



Layering Characteristics

- Each layer relies on services from layer below and exports services to layer above
- Interface defines interaction
- Hides implementation - layers can change without disturbing other layers (black box)

Layer Encapsulation



OSI Model: 7 Protocol Layers

- Physical: how to transmit bits
- Data link: how to transmit frames
- Network: how to route packets hop2hop
- Transport: how to send packets end2end
- Session: how to tie flows together
- Presentation: byte ordering, security
- Application: everything else!

Layering General Issues

- Reliability
- Flow control
- Fragmentation
- Multiplexing
- Connection setup (handshaking)
- Addressing/naming (locating peers)

Example: Transport Layer

- First end-to-end layer
- End-to-end state
- May provide reliability, flow control, and congestion control

Example: Network Layer

- Point-to-point communication
- Network and host addressing
- Routing

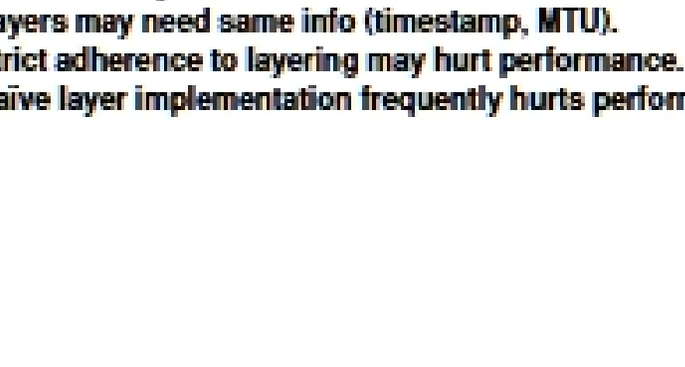
Is Layering Harmful?

- Sometimes..
  - Layer N may duplicate lower level functionality (e.g., error recovery).
  - Layers may need same info (timestamp, MTU).
  - Strict adherence to layering may hurt performance.
  - Naïve layer implementation frequently hurts performance.

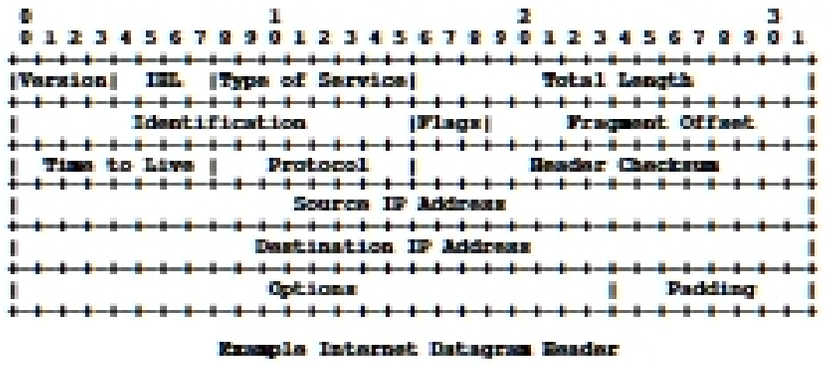
Course Focus

IP & TCP

IP



IP Header



Example Internet Datagram Header

IP Functions

- Type of service
  - Not used until recently
- Identification, flags and fragment offset
  - Fragmentation
- Time to live
  - Bounded delivery
- Protocol
  - (De)multiplexing higher layer protocols (analogous to *port numbers* in TCP)
- Length
  - IP packet length limited to 64K
- Header checksum
  - Ensures some degree of header integrity

Fragmentation

- Forwarding costs per packet
  - Nice if we can send large chunks of data
- Different link-layers have different MTUs
- Fragmentation
  - Intra-network
  - Inter-network

Fragmentation Is Harmful

- Uses resources poorly
  - Example of packet just bigger than MTU
- Poor end-to-end performance
  - Loss of a fragment
- Reassembly is hard
  - Buffering constraints

Path MTU Discovery

- Hosts dynamically discover MTU of path
  - Send message with don't fragment bit
  - Get ICMP message indicating size
- What happens if path changes?
  - Increasing/decreasing path MTU
- Usually implemented by the *transport* layer
  - Expected that future routing protocols will provide MTU information

Path MTU

- Algorithm:
  - Initialize MTU to MTU to next hop
  - Send datagrams with DF bit set
  - If *"datagram too big"*, decrease MTU
  - Periodically (>5mins, or >1min after previous increase), increase MTU
- Some routers will return proper MTU
- MTU values cached in routing table