Multiplayer Game Programming

Lecture 2: The Layer Cake

ITP 484

The Layer Cakes

TCP/IP (IN OUR BOOK)

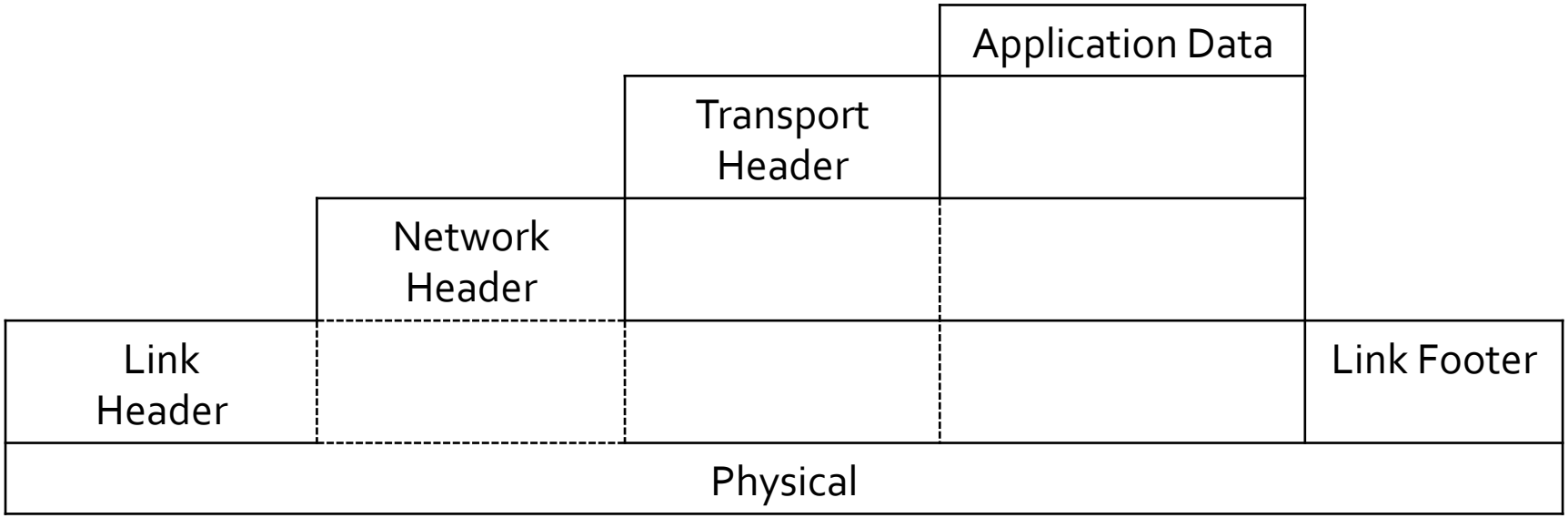
Application
Transport
Network
Link
Physical

OSI

- Application
- Presentation
- Session
- Transport
- Network
- Data Link
- Physical

Layer Cake Responsibilities

- Each layer wraps and attempts to deliver data for the layer above it



Endianness

- Network Byte Order is Big Endian
- You are probably programming for a Little Endian Processor (unless building for a previous gen console)
- htons, ntohs, ntohl, htonl are your friends

Physical Layer

- Provides path for electrons
  - Ethernet Cable (4 pairs of copper wire)
  - Fiber
  - Radio transmission
- Unreliable

Link Layer

- Provides a transmission channel along the physical layer
  - Ethernet
  - 802.11a/b/g/n/ac
  - FDDI
- Data Unit = Frame
- Unreliable

Link Layer

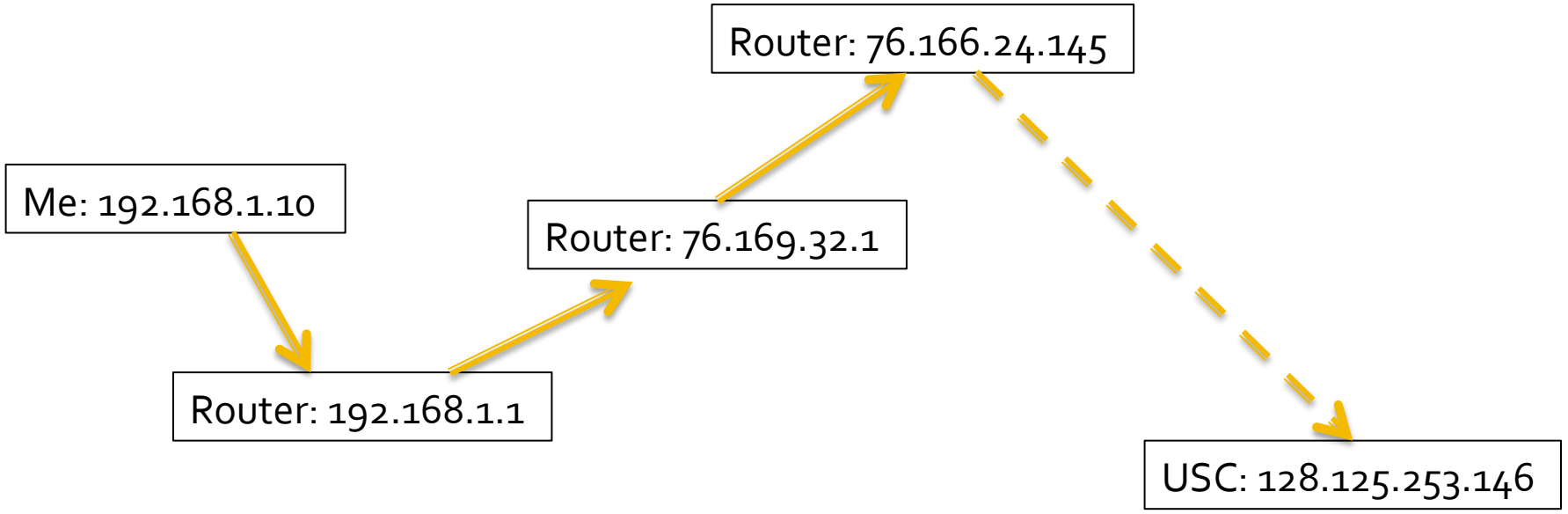
- Maximum Transmission Unit (MTU)
  - The maximum amount of payload the Link Layer can send as a unit (not counting Link Layer header)
  - Ethernet v2 1500 bytes (most common Ethernet)
  - FDDI 4352
  - 802.11 7981 bytes
  - IPv4 standard requires >= 68

Network Layer

- Routes data from Host To Host
- Data units = Packets
- IP (IPv4 / IPv6), ICMP, et al.
- Unreliable
- Each host has:
  - IP address
    - 128.125.253.146 is www.usc.edu in IPv4
  - Gateway
  - Subnet Mask

Routing at the Network Layer

- Hosts are connected through a series of routers that "know" how to get to other hosts



Subnet

- A group of hosts that can communicate without sending packets through a router
- Netmask defines subnet
  - 255.255.0.0 = 11111111 11111111 00000000 00000000
  - isSameSubnet = ((ip1 & netmask) == (ip2 & netmask))
  - 192.168.1.10, 192.168.2.20 same subnet, 192.169.1.10 not
  - Classless interdomain routing notation (CIDR)
    - IP/X where X is number of significant bits in IP address that match

IPv4 Header

```
struct IPv4Header
{
    unsigned int  mVersion : 4;           //4
    unsigned int  mHeaderLength : 4;      //in 32bit words
    uint8_t       mTypeOfService;         //QoS related
    uint16_t      mTotalLength;           //in bytes
    uint16_t      mIdentification;
    unsigned int  mFlags : 3;
    unsigned int  mFragmentOffset : 13;   //in 64bit words
    uint8_t       mTimeToLive;
    uint8_t       mProtocol;
    uint16_t      mHeaderChecksum;
    uint32_t      mSourceAddress;
    uint32_t      mDestinationAddress;
    uint32_t      mOptionalOptions[];
};
```

- Total Size?
  - 20 bytes

Fragmentation

- MTU at Link Layer. Ethernet v2 1500 bytes.
- Max packet size is 65535 bytes though!
- Each Fragment gets:
  - Identification: Unique id for packet
  - More Fragments flag (0x4) (except the last)
  - Fragment Offset into packet
- Example

Fragmentation

- Why is fragmentation bad?
  - Must buffer incoming fragments to reassemble
  - Must spend time reassembling
  - If one fragment is lost, whole packet is lost
  - Must spend bandwidth on one header per fragment
- Why is fragmentation good?
  - Higher layers can send more data at once and not worry about underlying MTUs

More Header Fields

- Time To live (TTL)
  - decremented by 1 each time packet goes through a router
  - Prevents Internet clogging up due to bad routing
- Protocol
  - Tells host which protocol to use at the the Transport Layer to interpret the packet

Transport Layer

- Implements End-To-End communication between two processes
- Data units = Segments
- TCP (6)
- UDP (17)
- SCTP(132)

UDP: User Datagram Protocol

- Introduces Ports
  - Solves problem of where data goes when it arrives
- Adds checksum to detect corruption of entire segment

```
struct UDPHeader
{
    uint16_t  mSourcePort;
    uint16_t  mDestinationPort;
    uint16_t  mLength;
    uint16_t  mCheckSum;
};
```

Ports

- 0-1023 are System Ports
- 1024-49151 are User Ports
- 49152-65535 are Dynamic Ports
- www.iana.org/assignments/service-names-port-numbers/

Problems with UDP

- Offers no guarantees over the underlying network layer, which means it too is Unreliable
  - Segments might arrive out of order
  - Segments aren't guaranteed to arrive at all