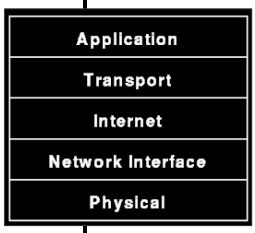
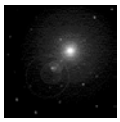
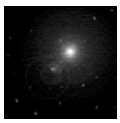
- IP- Internet Protocol
  - Addressing Scheme
  - Address Resolution
  - Datagram Forwarding
  - Encapsulation, Fragmentation & Reassembly
- TCP- Transmission Control Protocol
  - Connection startup & shutdown
  - Reliability: ordering, missing data handling





TCP/IP Packets

- Physical Networks differ in the format, size, transmission mechanism of packets. If applications have to be aware of these diversities than application developed for one physical network technology will not work for other.
- TCP/IP therefore creates a definition of virtual packets which all applications can use. TCP/IP software takes the responsibility of adapting to specific underlying network technology.
- TCP/IP packets are virtual. They never travel across a network intact.
- TCP/IP offers communication mechanism for both connectionless and connection-based services.

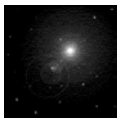


IP Datagram

- TCP/IP packets are called IP datagram.

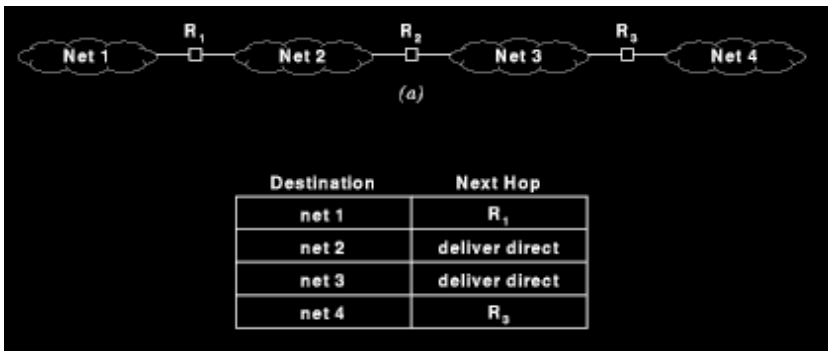
- IP datagrams can be of variable size 1-64K octates.
- IP datagram header contains information to route the packet across internet.
- IP datagrams are encapsulated in frames before they are transmitted over any Network.

The address that appears in datagram header is different from the address that appears in frame header.

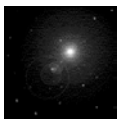


COMPUTER COMMUNICATION NETWORK

IP Datagram Forwarding: Concept



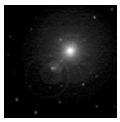
- R2's routing table



COMPUTER COMMUNICATION NETWORK

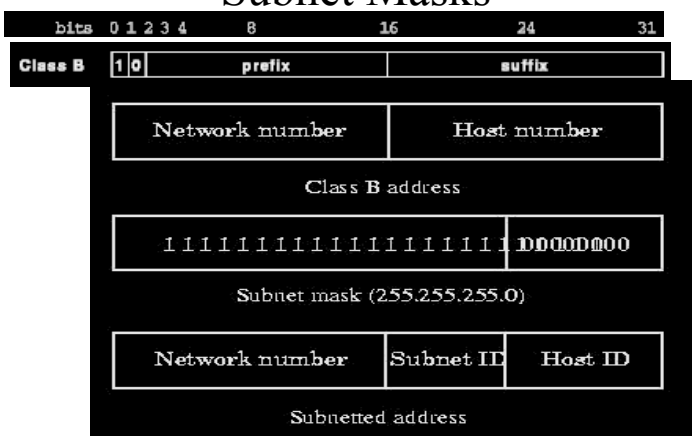
IP address Depletion & Subnetting

- IP address is depleting faster than expected:
  - All network, even one with 2 hosts, need at least class C address.
  - A network with 256 hosts need class B address.
- Also, the more there is networks, the bigger the routing table gets.
- Solution is *subnetting*.
  - A network can be divided into subnets.
  - Outside routers still view them as one large network.
  - Only, the local routers see them as separate networks.

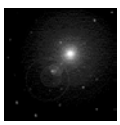


COMPUTER COMMUNICATION NETWORK

Subnet Masks

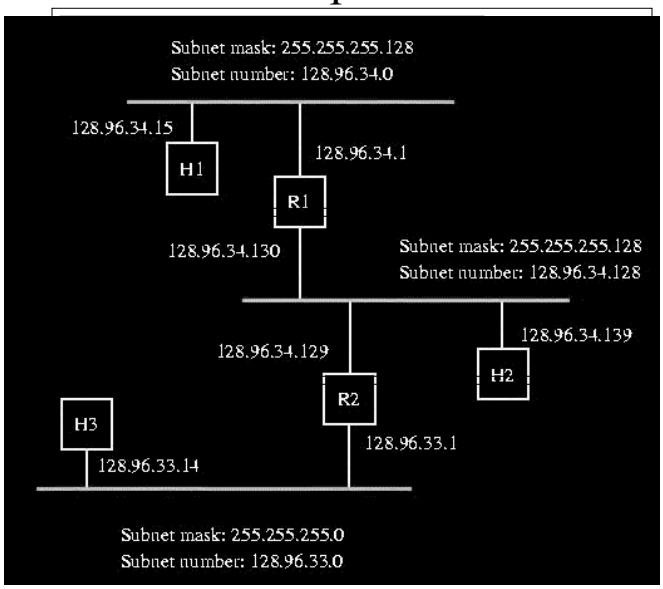


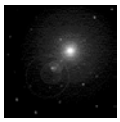
•Now in each routing table both the network number and the mask is stored.
•An AND operation is performed before looking up for the next hop.
•For distant networks, the mask is of type A, B, or C. But for local network, the mask is longer.



COMPUTER COMMUNICATION NETWORK

Example of Subnets



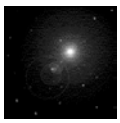


COMPUTER COMMUNICATION NETWORK

- But the administrator of 128.96.33.0 has divided its network into two physical networks 128.96.34.0 and 128.96.34.0 and 128.96.34.128 with mask 255.255.255.128
- Network 128.96.34.0 is class B address and can have about 256 hosts in one large network.
- H3 in 128.96.33.0 sees everything in 128.96.34.0 as one single network.

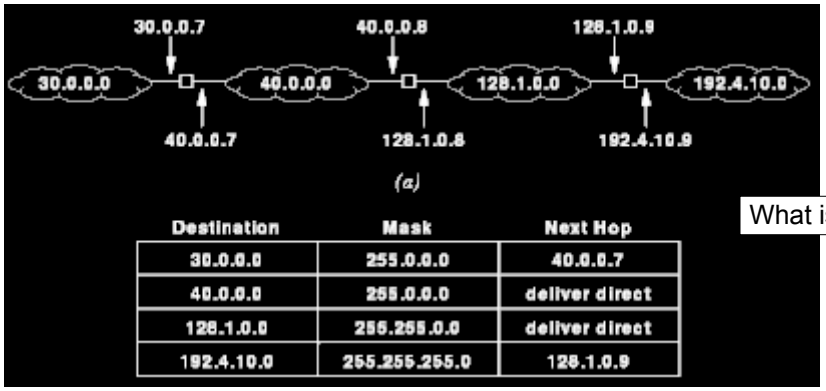
Quiz

- Quiz 501: We would like to divide a class C network 128.123.10.0 at BRAC University into four sub networks to create four computer labs with 34 computers in each. Determine the network addresses and corresponding masks for each to be used by a BRAC University router.
- Quiz 502: What will be the network address(es) and mask(s) to be used for these networks by a distant router in England?



COMPUTER COMMUNICATION NETWORK

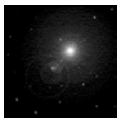
IP Datagram Forwarding: with IP



Destination	Mask	Next Hop
30.0.0.0	255.0.0.0	40.0.0.7
40.0.0.0	255.0.0.0	deliver direct
128.1.0.0	255.255.0.0	deliver direct
192.4.10.0	255.255.255.0	128.1.0.9

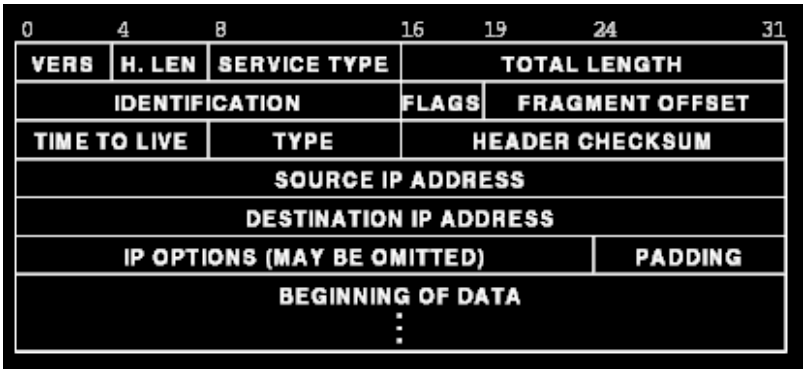
What is Bit Mask?

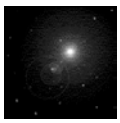
- R2's routing table



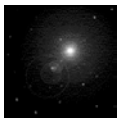
COMPUTER COMMUNICATION NETWORK

IP Datagram Header

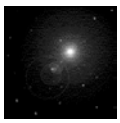




COMPUTER COMMUNICATION NETWORK



- Quiz: 504: what are the four address fields found in an ARP message?
- Quiz: 505: An application is sending data which requires 10 IP packets. Average number of transmission needed to receive one frame in an Ethernet segment is 2 due to collision. How many attempts have to be made for Ethernet frames if the sender requires ARP resolution?



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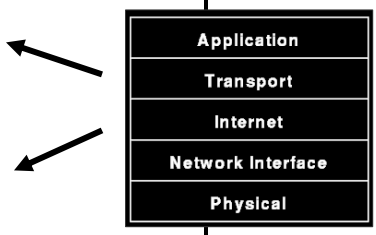


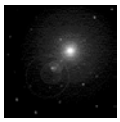
CLASS MECHANICS

•A network has a diameter of 300. It uses Link-state routing. But the TTL of LSP has 8 bits, and the sequence number field has only 10 bits. (50 points).

•TTL WILL RUN OUT FOR SOME LINKS WHICH REQUIRE MORE THAN 255 HOPS..

•A transmission algorithm uses 2-dimensional parity by arranging data in 8x10 bit blocks for error check. But, its transmission unit uses a defective buffer to compute the parity. It always flips bits (2,2), (2,8), (9,8) and (9,2). (50 points)

•THIS ERROR WILL GO UNDETECTED.

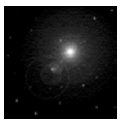


COMPUTER COMMUNICATION NETWORK

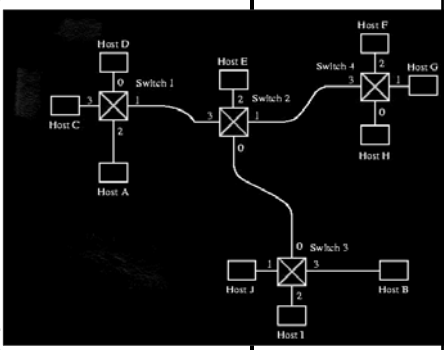
CLASS MECHANICS

•There is a very popular web server at Host A of Fig-4.29 (page 205). There are 3 users in each of the hosts at B,E,F,G,H, I and J. All of them are starting Web Browser applications to access a live presentation at A. Each requires a separate virtual circuit. All links have capacity of 100 Mbits/sec. The virtual circuit identifier field for this network has 3 bits, and each packet carries 1000 bits of data. Each circuit generates 100 packets per second. (50 points).

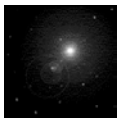
•VIRTUAL CIRCUIT IDENTIFIED CAN SUPPORT ONLY 8 VCS, WHILE ATLEAST ONE LINK WILL REQUIRE 21 VCS IN THE ABOVE SCENARIO.



COMPUTER COMMUNICATION NETWORK



CLASS MECHANICS

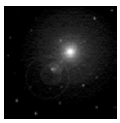


COMPUTER COMMUNICATION NETWORK

•An 10 MB slotted ALOHA network has 1000 stations. Each requires 5 Kbps/sec bandwidth. (50 points).

•NO PROBLEM FOR 10 MBYTES CHANNEL. BUT FOR 10Mbps CHANNEL BANDWIDTH WILL RUN OUT AT 30% EFFICIENCY OF SLOTTED ALOHA.

CLASS MECHANICS

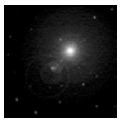


COMPUTER COMMUNICATION NETWORK

Suppose we want to transmit the message 11001101 and protect it from errors using the CRC polynomial . What will be the transmitted code?

CRC-POLY = 1011, COMPUTE 11001101000/1011
REMINDER IS 110
XCODE=11001101000 + 110 = 11001101110

CLASS MECHANICS

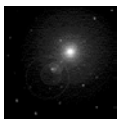


COMPUTER COMMUNICATION NETWORK

Suppose you are designing a sliding window protocol for a 10-Mbps point-to-point link to the moon, which has RTT of 2.5 seconds. Assume that each frame carries 2 KB of data, how many bits do you need for the sequence number?

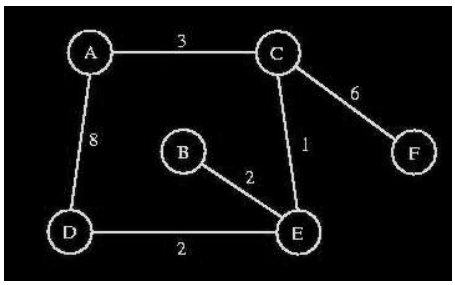
(10 X 1000,000 X 2.5)/(2,000X8 BITS)=1562.5 OUTSTANDING PACKETS. SO SERIAL NUMBER SHOULD BE 11 BITS, 11 BITS.

CLASS MECHANICS



COMPUTER COMMUNICATION NETWORK

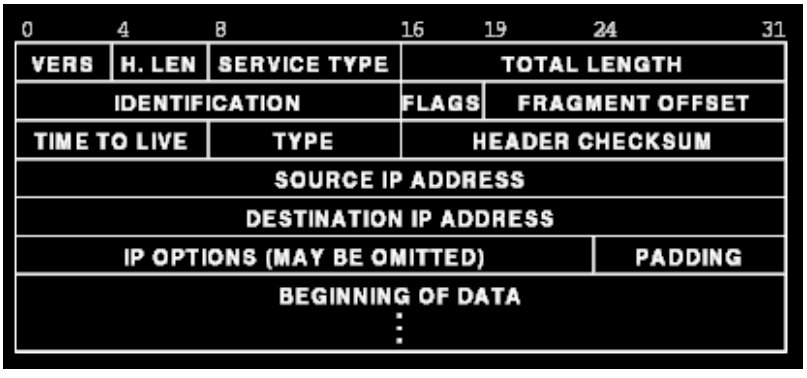
For Fig-4.30 show how the link-state algorithm builds the routing table for node A, (by drawing a table like Fig-4.6).

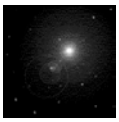


ANS IS: A,C,E,D,B,E, OR A,C,E,B,D,F

ENCAPSULATION FRAGMENTATION & REASSEMBLY

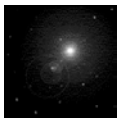
IP Datagram Header





COMPUTER COMMUNICATION NETWORK

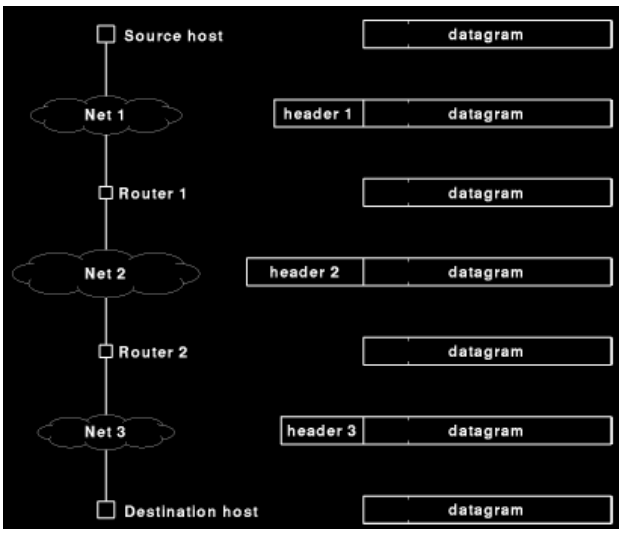
Encapsulation

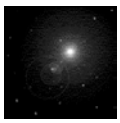


- Datagrams have to travel via a physical network. But, a physical network has its own Frame format. A Datagram, therefore must be encapsulated.

- The destination address in the Frame header is the address of the next hop.

Transmission across Internet

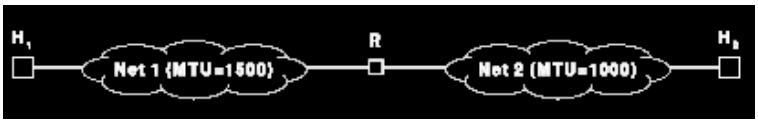




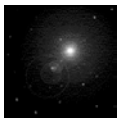
Encapsulation applies to one network at a time. However, in Internet the journey requires series of transmission over many different Networks.

MTU and Datagram Size

- Each Network on its way generally has their own maximum transmission unit size (MTU). How can IP routers can overcome this obstacle?



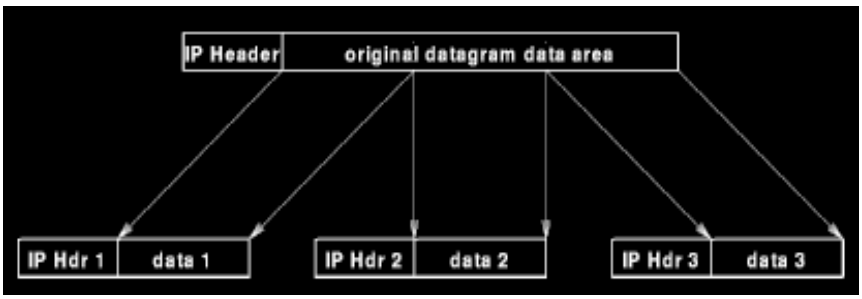
Ethernet MTU=1500B, while FDDI has MTU=4500B

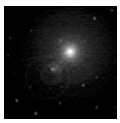


COMPUTER COMMUNICATION NETWORK

Fragmentation

- Datagrams are fragmented into multiple segments, if it faces a Network with MTU smaller than the datagram size.
- Each fragment has the same format as the datagram, except a bit flag which indicates that it is a fragment, not the entire datagram (length field changes too.)
- FRAGMENTOFFSET field indicates where in the orginal datagram the fragment data belongs.





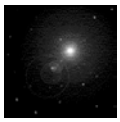
COMPUTER COMMUNICATION NETWORK

Reassembly

- Because each fragment has a copy of the original header, and an indication flag that it is a fragment, the original datagram can be reassembled at the end.

H1 sends 1500B, but it is fragmented by R1. But, R2 does not reassemble them although Net3 MTU is 1500!

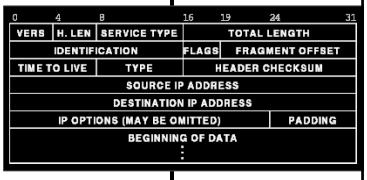
Only the destination reassumbles fragments.

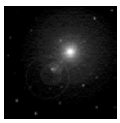


COMPUTER COMMUNICATION NETWORK

Datagram Identification

- individual fragments can arrive out of order. How IP reassembles out of order fragments?
  - FRAGMENT OFFSET helps in restoring out of order fragments.
  - Sender inserts an unique number in INDENTIFICATION field to identity a group.
- IP does not guarantee delivery. Fragments can be lost. How IP handles such loss?
  - The same two fields helps in identifying a missing fragment.
  - After receiving the first FRAGMENT, receiver starts a timer. If the entire datagram does not arrive with in a specified time, it discards all fragments.
  - But, it does no notify the sender!

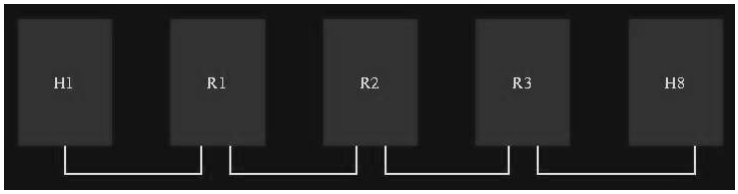




COMPUTER COMMUNICATION NETWORK

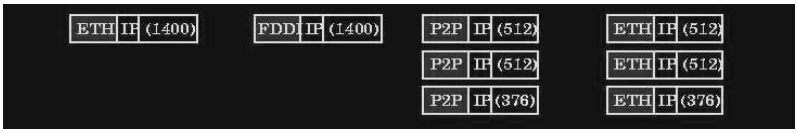
Example

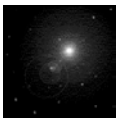
- Ethernet MTU is 1500, while FDDI has MTU=4500



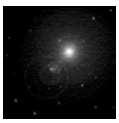
ETH (1500) **FDDI((4500)** **P2P((532)** **ETH(1500)**

- One Solution:

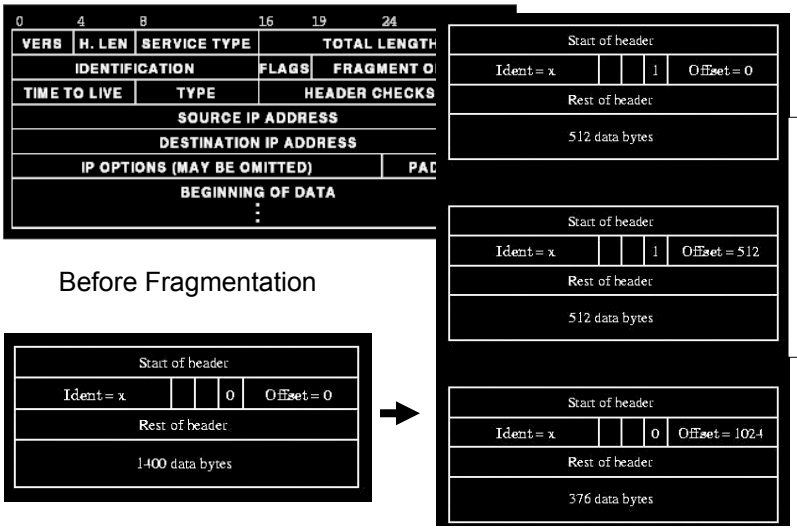


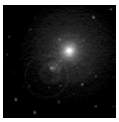


- Quiz 503: List two issues because of which fragments are not reassembled at routers?



Example of TCP Fragements

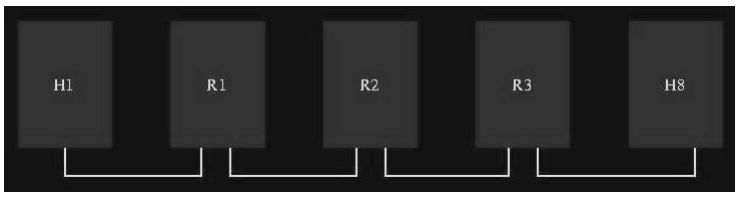




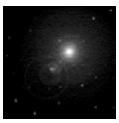
COMPUTER COMMUNICATION NETWORK

Minor detail: Offset field count in units of 8 bytes. Fragmentation have to be performed in units of 8 bytes.

What if a fragment needs to be fragmented again?



ETH (1500) **FDDI((1400)** **P2P((532)** **ETH(256)**

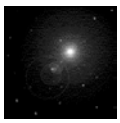


COMPUTER COMMUNICATION NETWORK

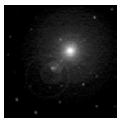
ICMP

ICMP: An Error Control/Reporting Message Protocol

- IP is a best effort mechanism. But provides no guarantee of delivery.
- However, it is not careless!
- ICMP is a mechanism by which network elements can pass information about the source/cause of errors.
- ICMP defines 5 error messages and 4 information messages.



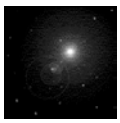
ICMP: Error Messages



COMPUTER COMMUNICATION NETWORK

- SOURCE QUENCE
  - send by overworked routers to the sources of discarded datagrams.
- TIME EXCEEDED
  - send by router for packets whose TIME TO LIVE filed has expired.
- DESTINATION UNREACHABLE
  - send by routers who could not find forwarding address.
- REDIRECT
  - if a router thinks, not him, but some other router should have received the packet.
- FRAGMENTATION REQUIRED
  - if the fragment as regiired permission is not given to a router, it can request source to send fragmented datagrams

ICMP: Informational Messages



COMPUTER COMMUNICATION NETWORK

- ECHO/ REQUEST/REPLY
  - An echo request message can be sent to any ICMP host in a network. It sends replies.
  - Ping!
- ADDRESS MASK REQUEST/REPLY
  - A host, when boots can request for the correct address mask for the network. The router in the network send the correct 32 bit address mask.

BOOTP & DHCP