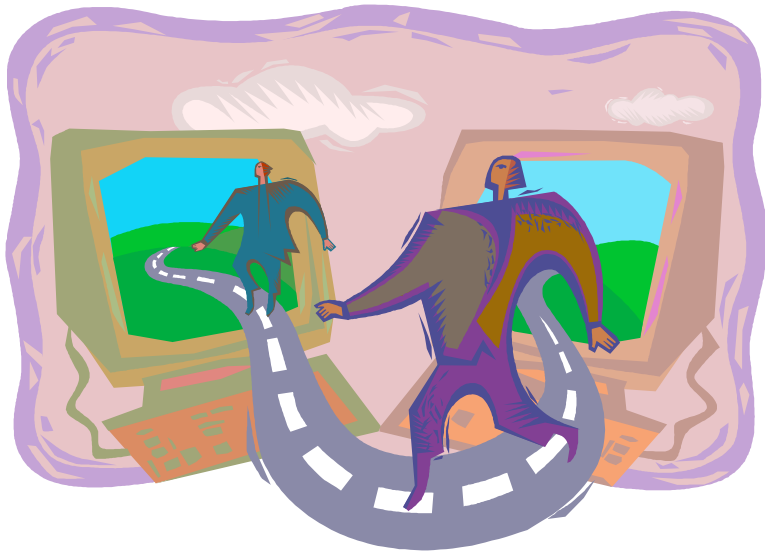
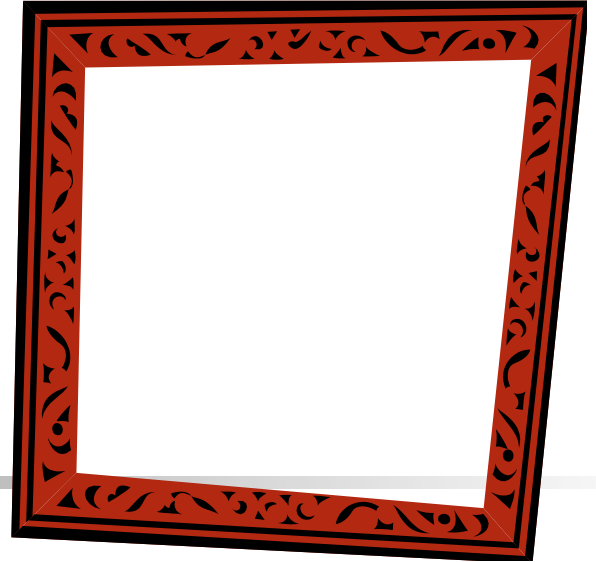


# Discussion #11

## EE450



- IP Fragmentation
- Addressing and Subnetting



# Problem#1: Description

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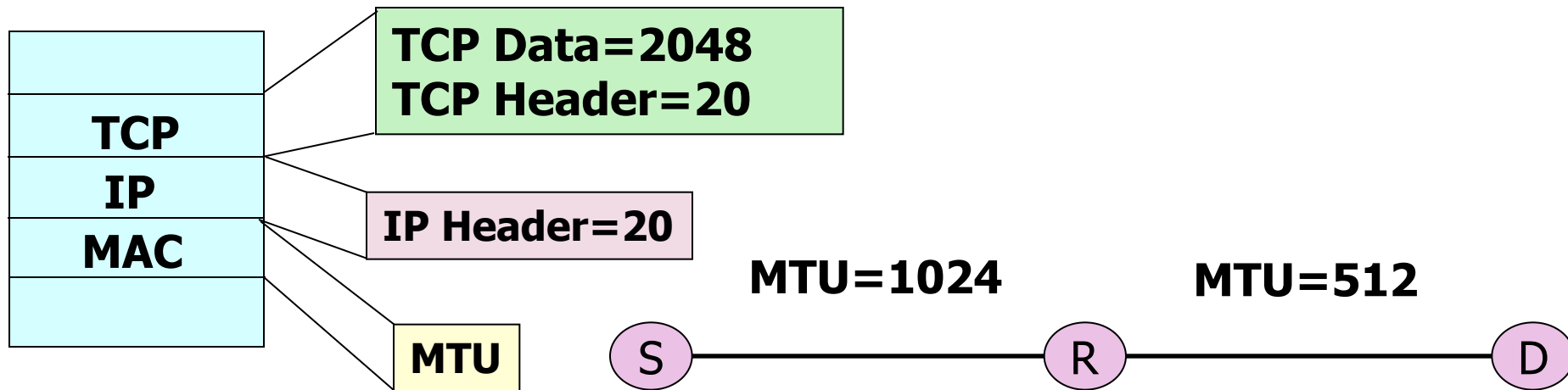


- Suppose that a TCP message that contains 2048 bytes of data and 20 bytes of TCP header is passed to IP for delivery across two networks of the Internet (i.e. from the source host to a router to the destination host ).
- The first network has an MTU of 1024 bytes and the second network has an MTU of 512 bytes.
- Each network's MTU gives the total packet size that may be sent including the network header.

# Problem#1: Question



- Give the sizes of the fragments delivered to the network layer at the destination host, assuming all IP headers are 20 bytes.





# Problem#1: Solution

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Across the first network:

- Packets have room for  $1024-20=1004$  bytes of IP-level data.
- Since 1004 is not multiple of 8, each fragment can contain at most  $8 \times \lfloor 1004/8 \rfloor = 1000$  bytes.
- We need to transfer  $2048 + 20$  bytes of such data.
- This would be fragmented into fragments of size 1000, 1000 and 68 bytes.
- **For Packet sizes across the first network , add 20 bytes to each fragment.**

# Problem#1: Solution

## Unfragmented and fragmented datagrams



Start of Header			
Ident=x		0	Offset=0
Rest of Header			
2068 data bytes			

The M bit and the offset field in the header are used for IP fragmentation as illustrated.

Start of Header			
Ident=x		1	<i>Offset=0</i>
Rest of Header			
<b>1000 data bytes</b>			

Start of Header			
Ident=x		1	<i>Offset=125</i>
Rest of Header			
<b>1000 data bytes</b>			

Start of Header			
Ident=x		0	<i>Offset=250</i>
Rest of Header			
<b>68 data bytes</b>			



# Problem#1: Solution

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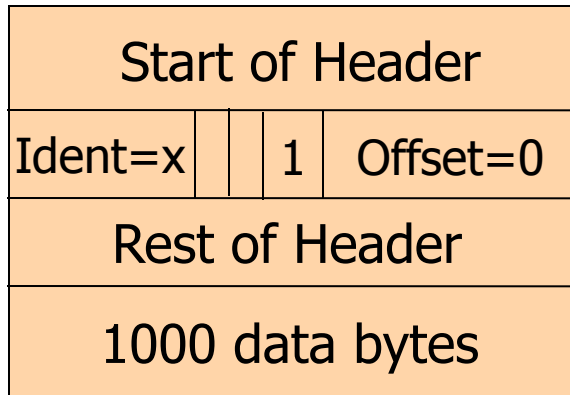


Across the second network:

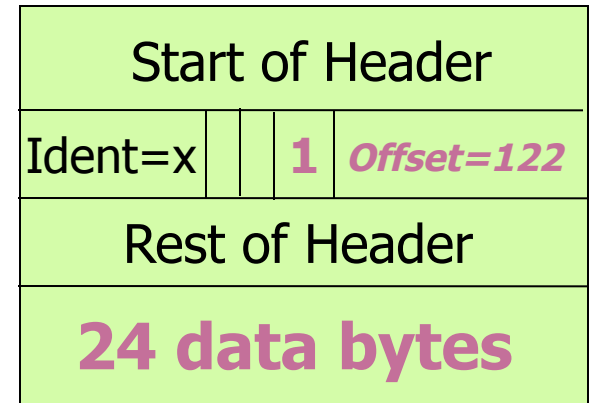
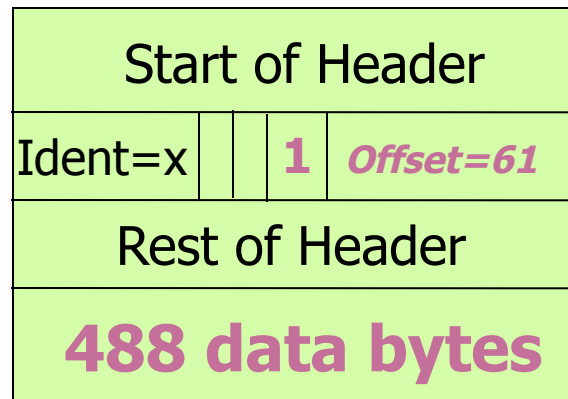
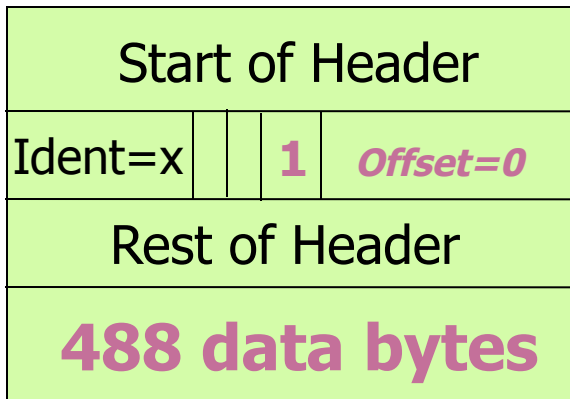
- Packets have room for  $512-20=492$  bytes of IP-level data.
- So the 68-byte packet will not be fragmented but the other two 1000-byte packets will be fragmented.
- Since 492 is not multiple of 8, each fragment can contain at most  $8 \times \lfloor 492/8 \rfloor = 488$  bytes.
- Each 1000-byte fragment would be fragmented into fragments of size 488, 488 and 24 bytes.
- **For Packet sizes across the second network, add 20 bytes to each fragment.**

# Problem#1: Solution

## Unfragmented and fragmented datagrams

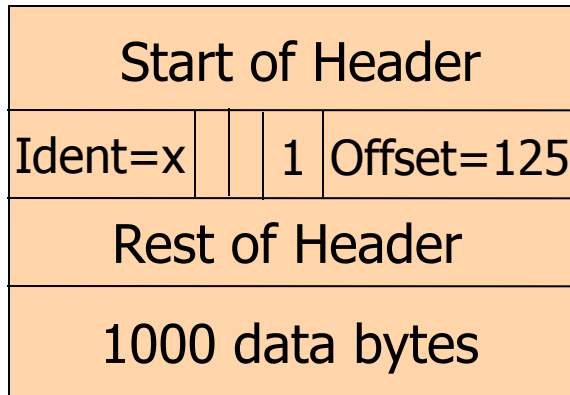


The M bit and the offset field in the header are used for IP fragmentation as illustrated.

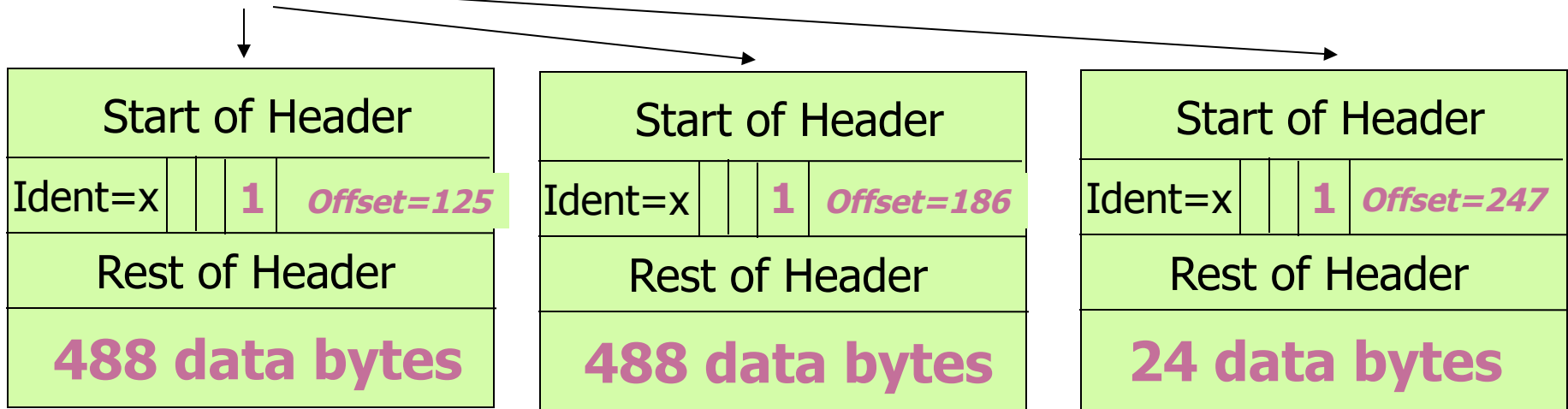


# Problem#1: Solution

## Unfragmented and fragmented datagrams



The M bit and the offset field in the header are used for IP fragmentation as illustrated.



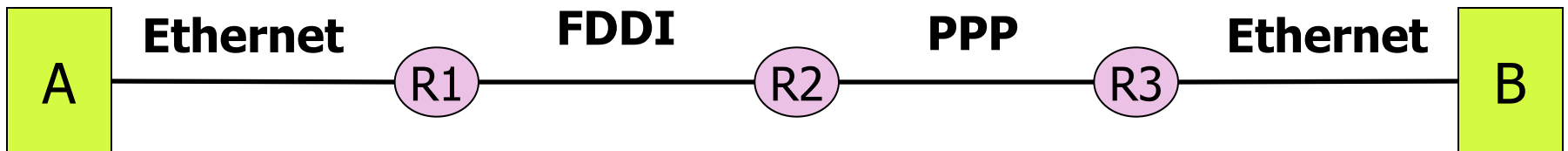




## Problem#2: Description



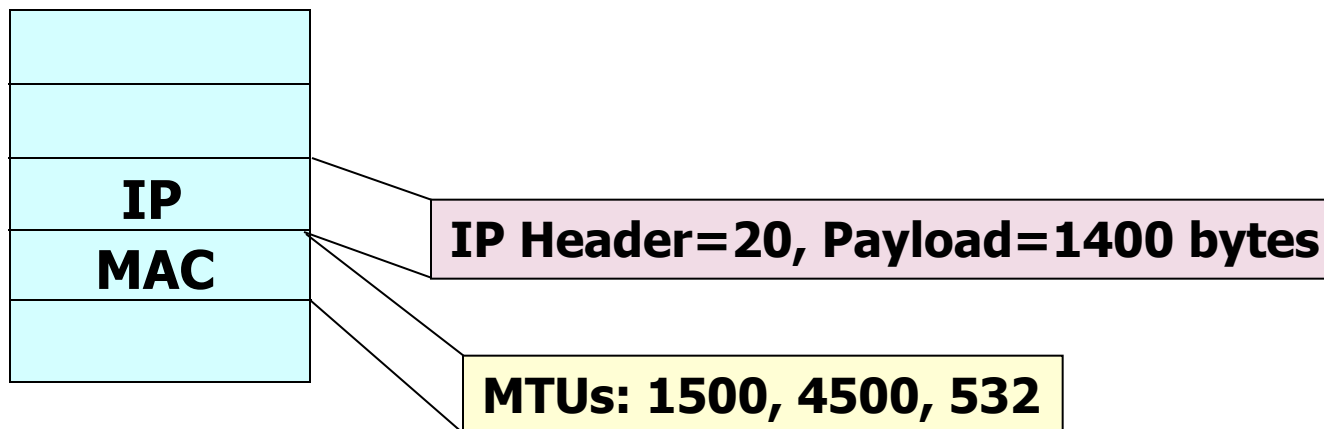
- We have an IP datagram of size 1420 bytes (including the IP header) traversing the sequence of physical networks with different MTUs as follow:
  - Ethernet : MTU = 1500 bytes
  - FDDI : MTU = 4500 bytes
  - PPP : MTU = 532 bytes



## Problem#2: Question



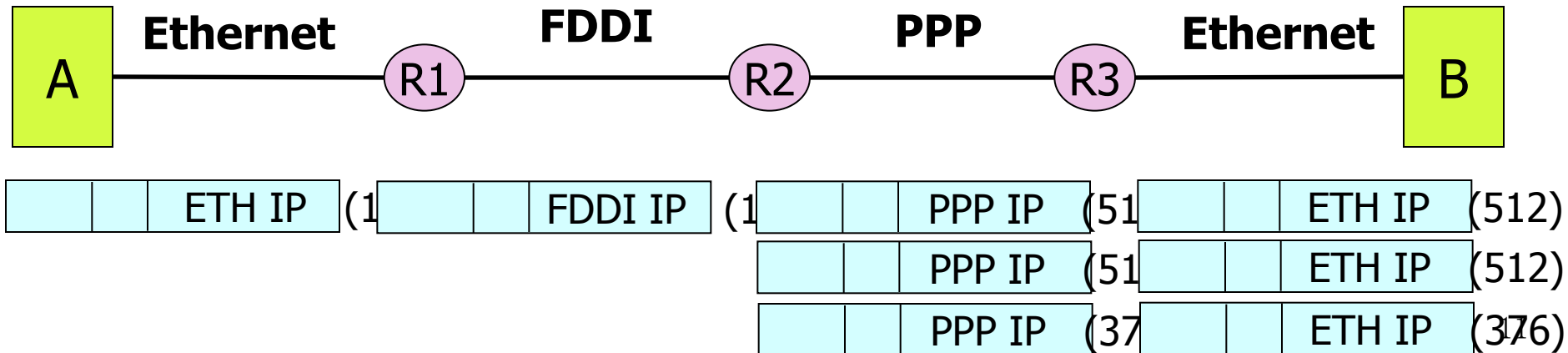
- Show the unfragmented datagram as well as the fragmented datagrams and clearly identify the Header fields used in IP fragmentation.



## Problem#2: Solution

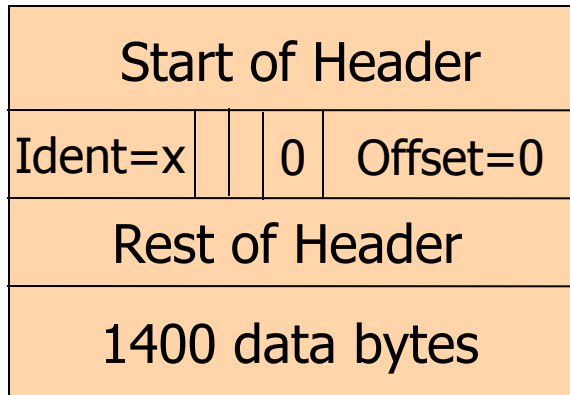


- The datagram will not be fragmented across the first two networks.
- Since the MTU of the PPP network is less than the size of the datagram (without the IP header), it will be fragmented to 3 datagrams.
- The fragments of the original datagram travel across the 4<sup>th</sup> network with no further fragmentation and they will be reassembled at the endpoint.

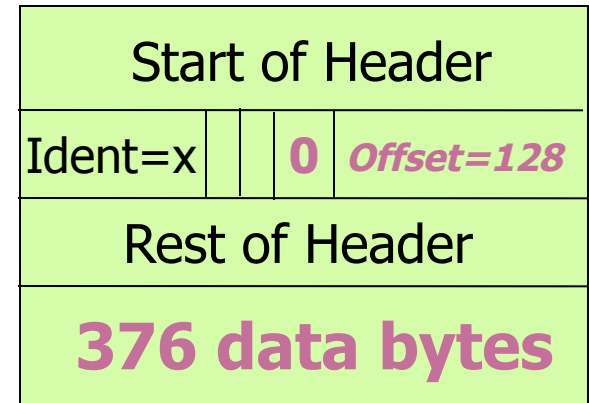
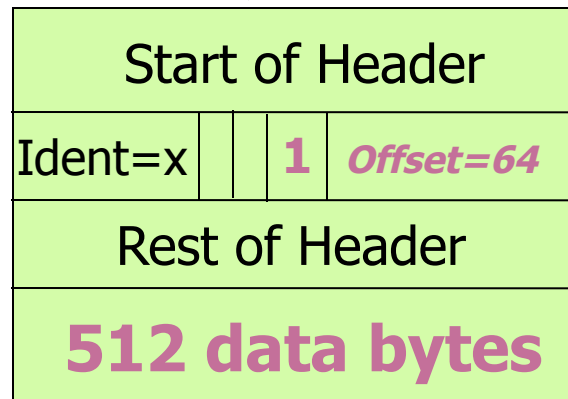
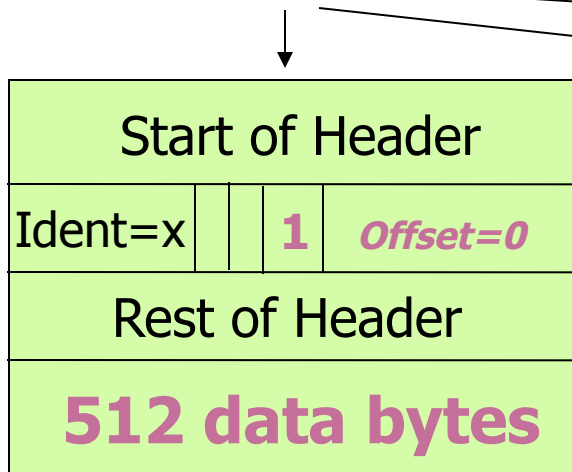


## Problem#2: Solution

### Unfragmented and fragmented datagrams



The M bit and the offset field in the header are used for IP fragmentation as illustrated.





## Problem#4: Description

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- Suppose a router has built up its routing table. The router can deliver packets directly over interfaces 0 and 1, or it can forward packets to routers R2, R3, or R4. Describe what the router does with a packet addressed to each of the following destinations:
  - (a) 128.96.39.10
  - (b) 128.96.40.12
  - (c) 128.96.40.151
  - (d) 192.4.153.17
  - (e) 192.4.153.90



## Problem#4: Routing Table

SubnetNumber	SubnetMask	NextHop
128.96.39.0	255.255.255.128	Interface 0
128.96.39.128	255.255.255.128	Interface 1
128.96.40.0	255.255.255.128	R2
192.4.153.0	255.255.255.192	R3
(default)		R4

Apply each subnet mask to the given destination IP address and if the corresponding subnet number matches the entry in the SubnetNumber column, use the entry in the Next-hop column. (In these tables there is always a unique match.)

## Problem#4: Solution



SubnetNumber	SubnetMask	NextHop
128.96.39.0	255.255.255.128	Interface 0
128.96.39.128	255.255.255.128	Interface 1
128.96.40.0	255.255.255.128	R2
192.4.153.0	255.255.255.192	R3
(default)		R4

- (a) **128.96.39.10**. Applying the subnet mask **255.255.255.128**, we get 128.96.39.0. Use **interface0** as the next hop.
- (b) **128.96.40.12**. Applying the subnet mask **255.255.255.128**, we get 128.96.40.0. Use **R2** as the next hop.



## Problem#4: Solution

SubnetNumber	SubnetMask	NextHop
128.96.39.0	255.255.255.128	Interface 0
128.96.39.128	255.255.255.128	Interface 1
128.96.40.0	255.255.255.128	R2
192.4.153.0	255.255.255.192	R3
(default)		R4

- (c) **128.96.40.151**. All subnet masks give **128.96.40.128** as the subnet number. Since there is no match, use the default entry. Next hop is **R4**.
- (d) **192.4.153.17**. Applying the subnet mask **255.255.255.192**, we get 192.4.153.0. Next hop is **R3**.
- (e) **192.4.153.90**. None of the subnet entries match, hence use default router **R4**.





# Problem#5: Description

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- An organization has a class C network 200.1.1 and wants to form subnets for four departments, with hosts as follows:

A 72 Hosts

B 35 Hosts

C 20 Hosts

D 18 Hosts

There are 145 hosts in all.

- a) Give a possible arrangement of subnet masks to make this possible.
- b) Suggest what the organization might do if department D grows to 34 hosts.



## Problem#5: Solution, part (a)

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A possible arrangement of subnet numbers is as follows.

- A with 72 hosts requires  $\log_2 72 = 7$  host bits  
Subnet number: 0/
- B with 35 hosts requires  $\log_2 35 = 6$  host bits  
Subnet number: 10/
- C with 20 hosts requires  $\log_2 20 = 5$  host bits  
Subnet number: 110/
- D with 18 hosts requires  $\log_2 18 = 5$  host bits  
Subnet number: 111/



## Problem#5: Solution, part (a)

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- Giving each department a single subnet, the nominal subnet sizes are  $2^7$ ,  $2^6$ ,  $2^5$ ,  $2^5$  respectively (rounding up to the nearest power of 2).
- Subnet numbers are in binary and represent an initial segment of the bits of the last byte of the IP address, anything to the right of the / represents host bits.
- The / thus represents the subnet mask.
- Any individual bit can, by symmetry, be flipped throughout.
- There are several possible bit assignments.
- The essential requirement is that any two distinct subnet numbers remain distinct when the longer one is truncated to the length of the shorter.



## Problem#5: Solution, Part (b)

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- We have two choices: either assign multiple subnets to single departments or abandon subnets and buy a bridge.
- Here is a solution giving A two subnets of sizes 64 and 32, every other department gets a single subnet of size the next highest power of 2.

A 01/

001/

B 10/

C 000/

D 11/