DMET602 – Networks and Media Lab

[Spring 2025]

Lecture 6 – IPv4 Packet Header Fields & subnetting Examples

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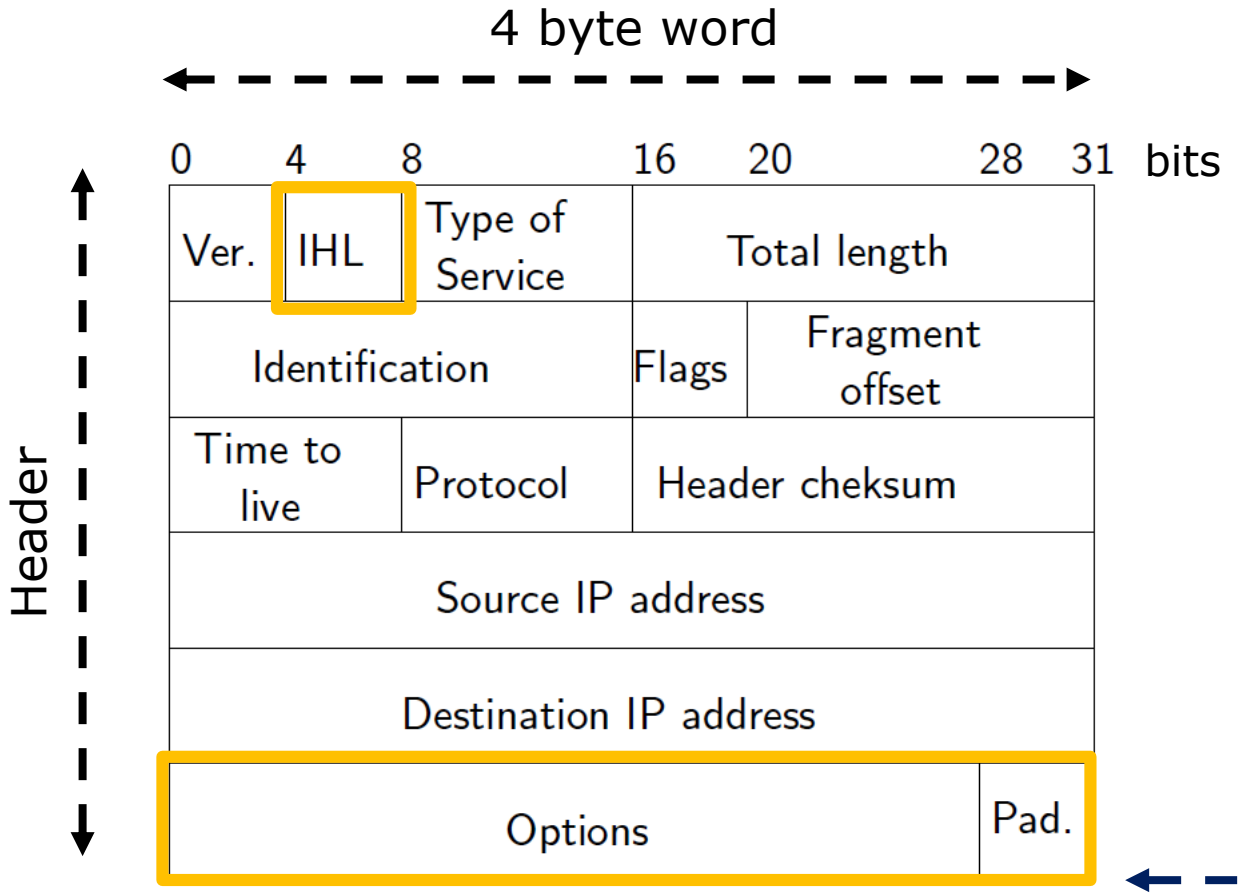
IPv4 Packet – Header
IP Header Length (IHL) Field



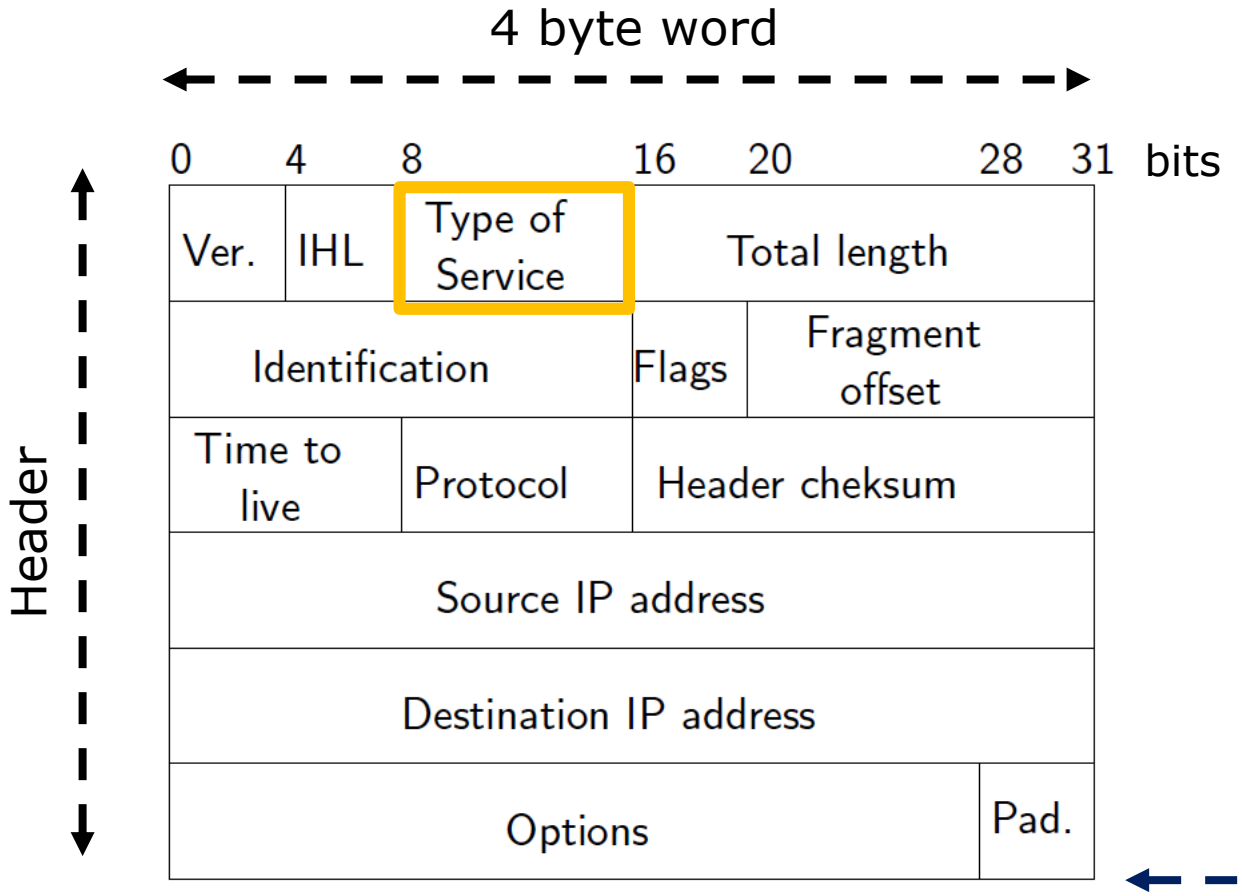
Example:
If IPv4, IHL = $(0101)_2 = 5_{10}$
What is the header length?

Header length is 5 words,
i.e., 5 x 4 = 20 Bytes

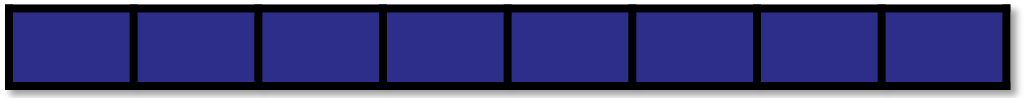
If IHL is $(0101)_2 = 5_{10}$ → no Options field
If IHL is $(1111)_2 = 15_{10}$ → Options field present
So Header Length varies: (20-60) Bytes

Header length also indicates where the packet payload begins.

IPv4 Packet – Header
Type of Service Field



Type of Service → 8 bits

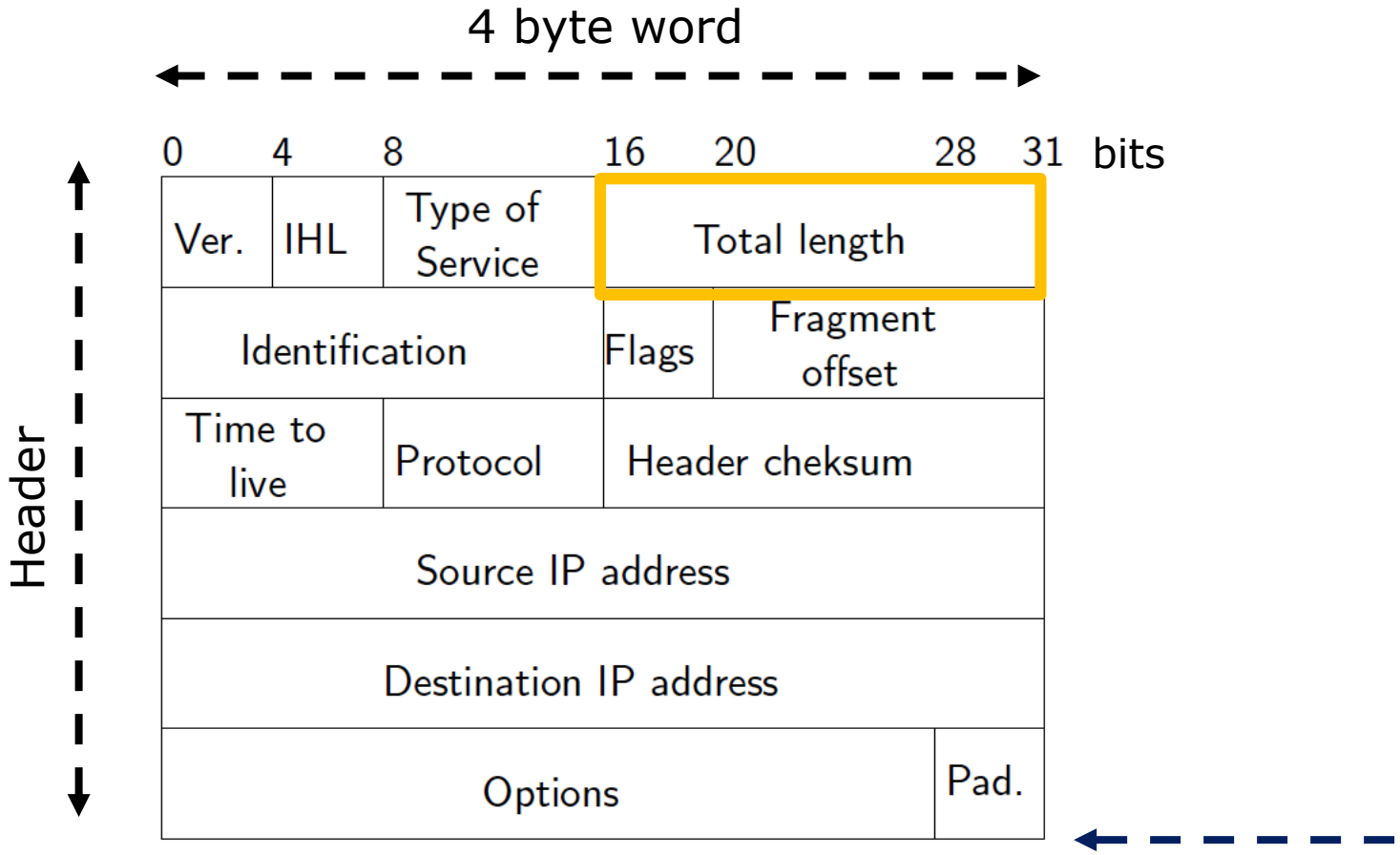


DSPC (Differentiated Services Point Codes)

ECN **(Explicit Congestion Notification)**

6 bits → 2^6 bit combination to classify IP packets

IPv4 Packet – Header
Total Length Field

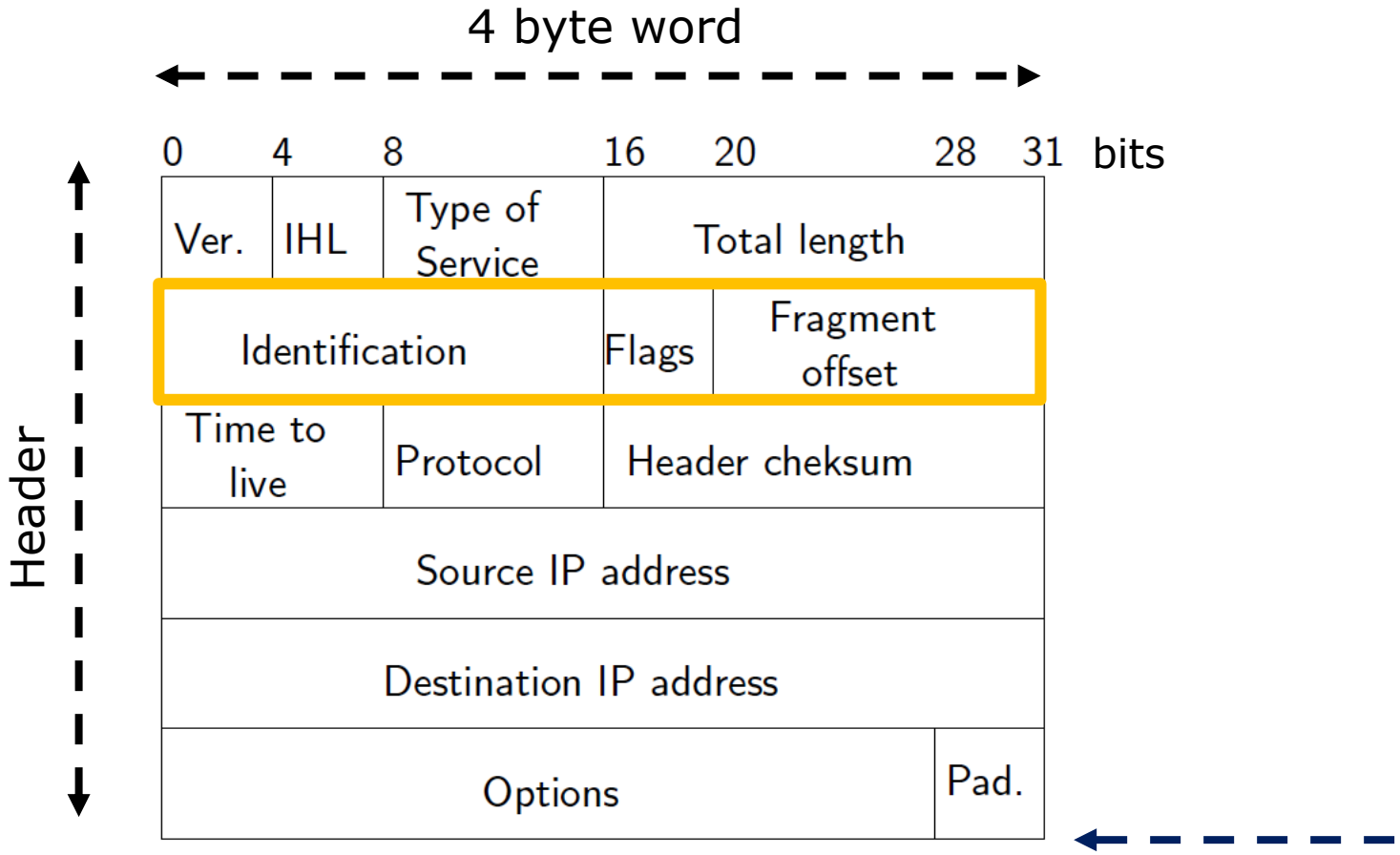


Total Length Field → 16 bits

Theoretically:
Maximum packet length
$= 2^{16} - 1 = 65535$ Bytes

Practically:
Packet size rarely larger than 1500 Byte (to allow IP packet fit in the payload of data link/frame) aka: Ethernet Maximum Transmission Unit

IPv4 Packet – Header
Identification, Flags and Fragment Offset



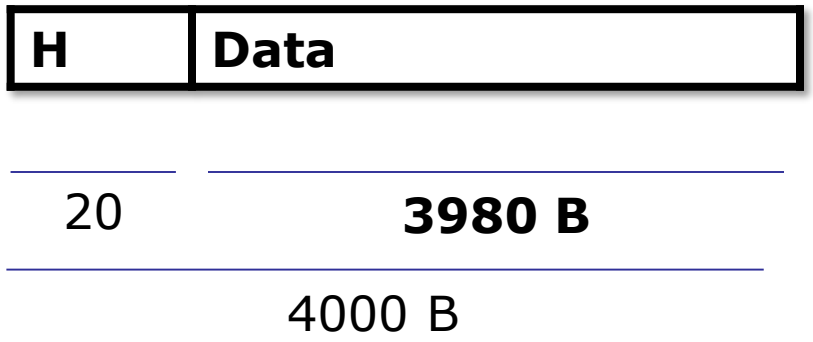
- Identification (16 bits)
- Flags (3 bits)
- Fragment Offset (13 bits)

Used for IP Fragmentation and Reassembly

N.B.: IP Fragments must be in multiple of 8

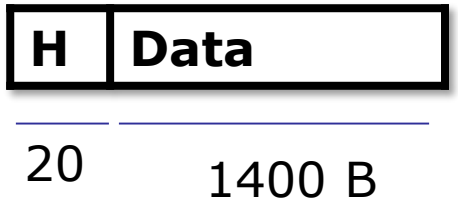
IPv4 Fragmentation Example

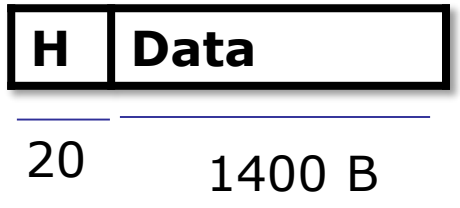
- Suppose a router receives a packet of 4000 Bytes with 20 Bytes header. The maximum transmission unit on an Ethernet link is 1500 Byte

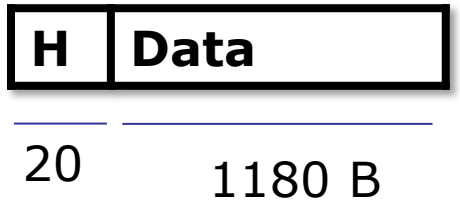


- **No. of IP fragments = 3980/1500 = 3**

N.B.: IP Fragments must be in multiple of 8

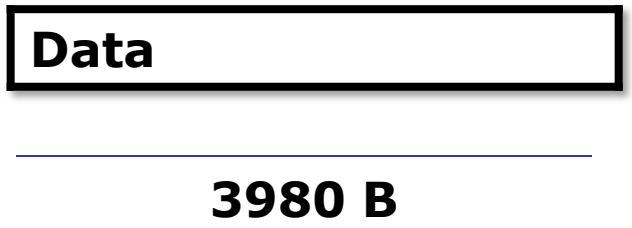




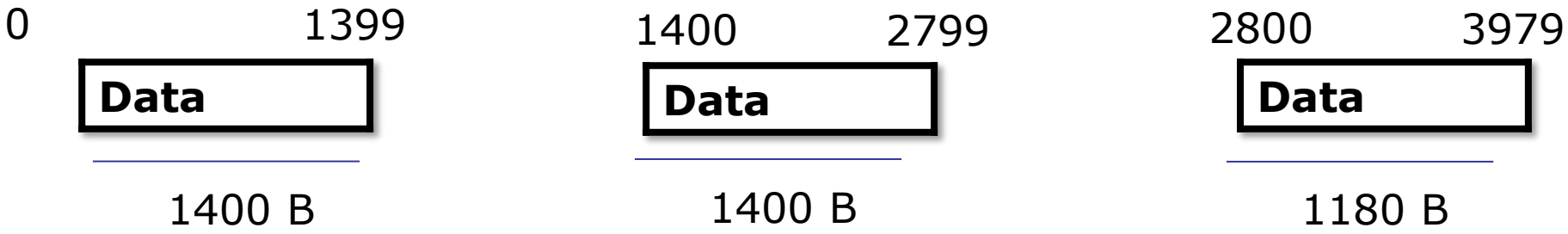


IPv4 Reassembly Example cont'd

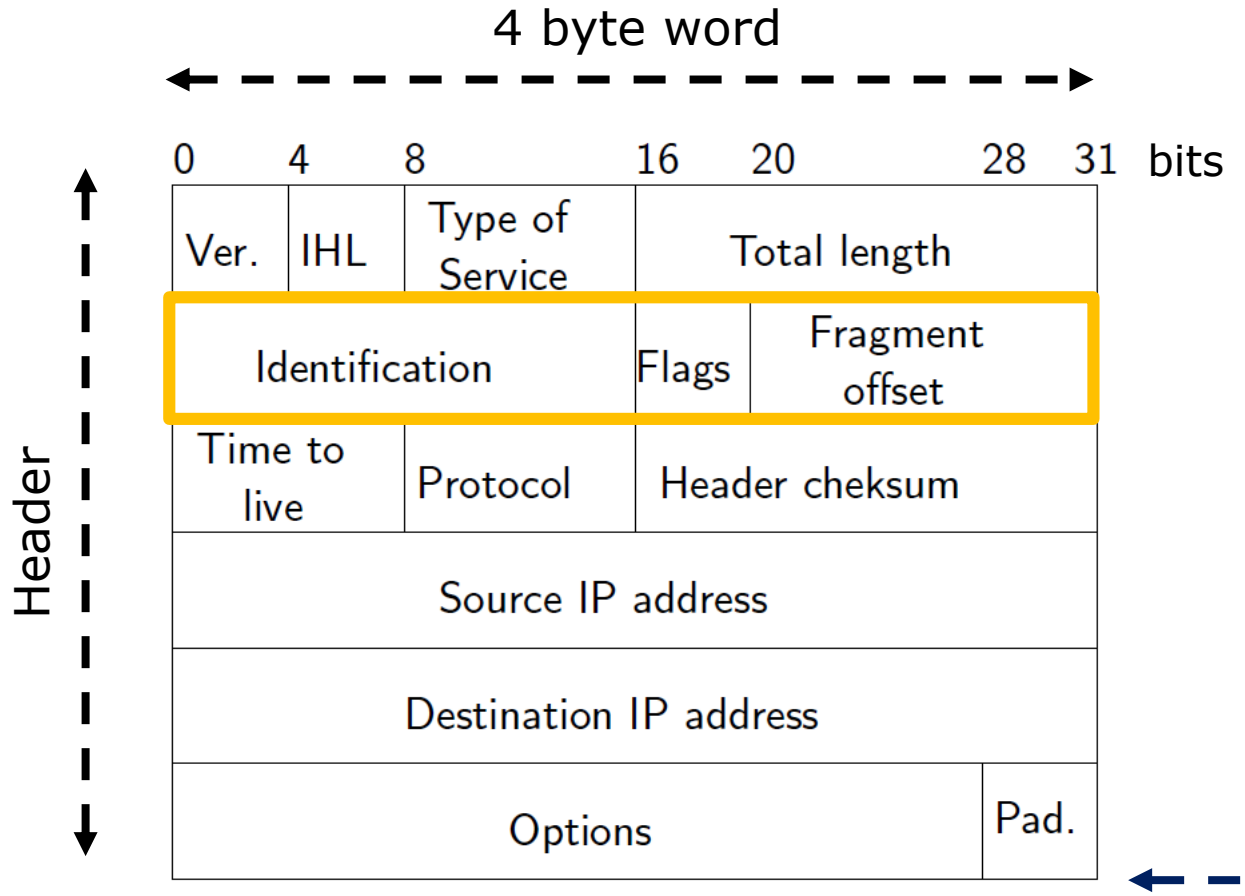
- Suppose a router receives a packet of 4000 Bytes with 20 Bytes header. The maximum transmission unit on an Ethernet link is 1500 Byte



Fragment1:offset=0.
Fragment2:offset=1400/8=175.
Fragment3:size=(1400+1400)/8=350.



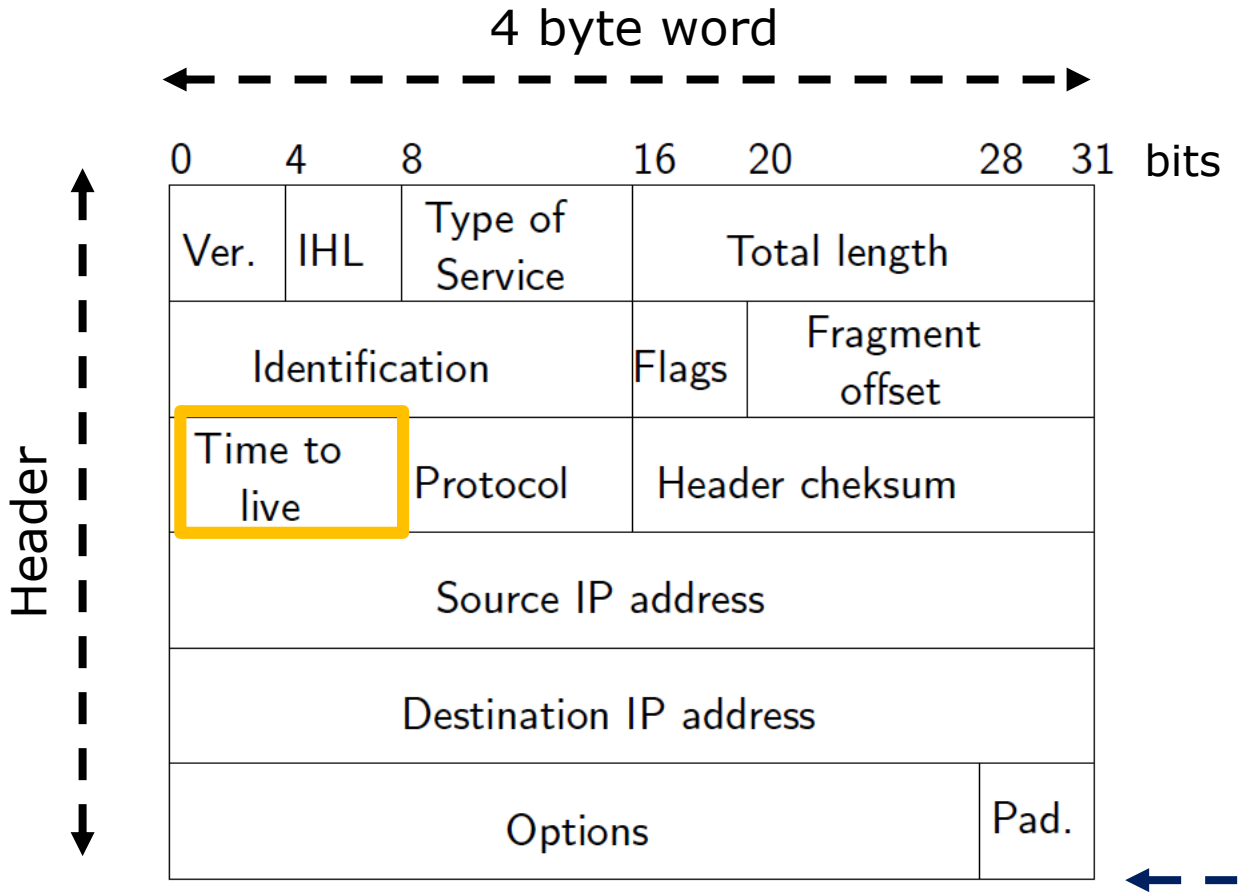
IPv4 Packet – Header
Identification, Flags and Fragment Offset



- Identification (16 bits): hold the same value for all IP fragments
- Flags (3 bits): only 2 are used

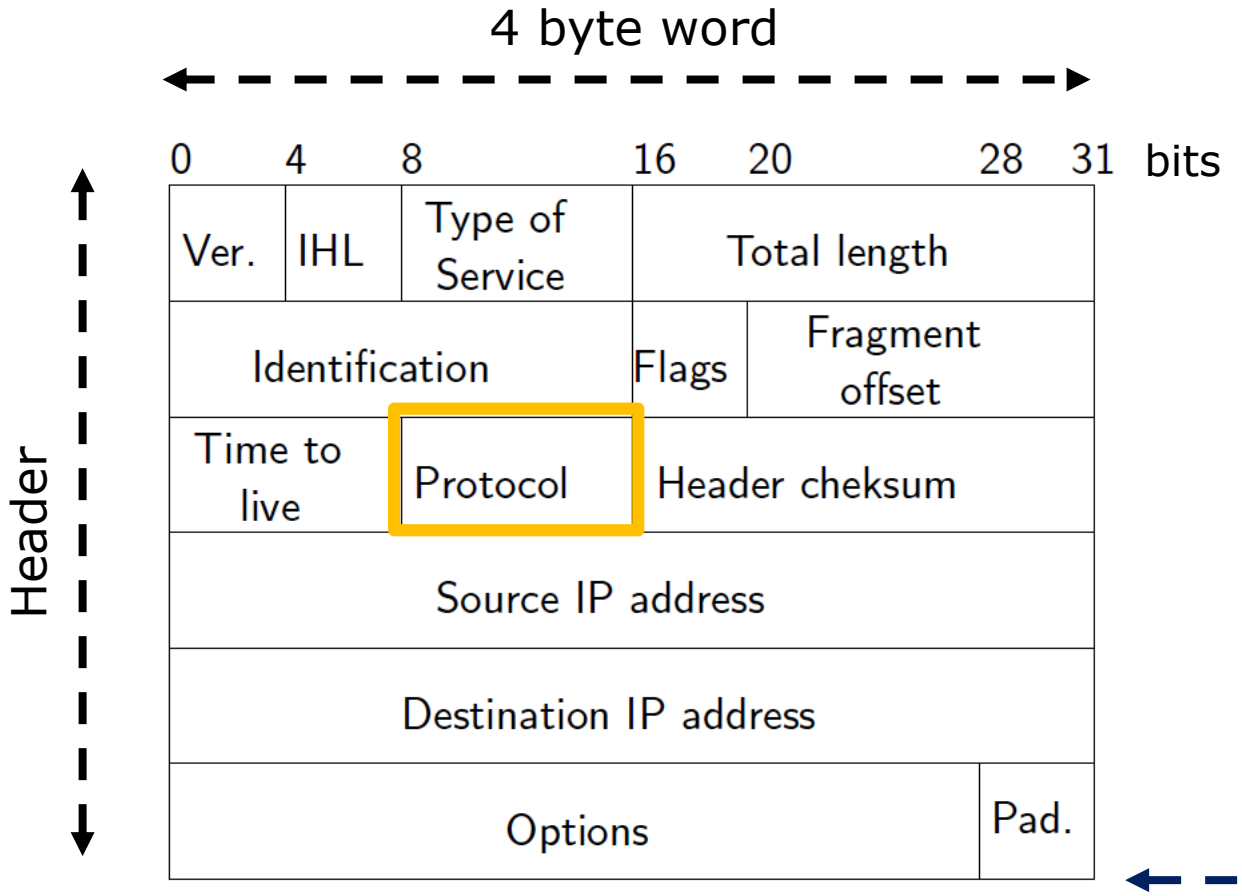
Do not Fragment More Fragments

IPv4 Packet – Header
Time to Live Field



- Initially set to a value
- Decremented at each hop

IPv4 Packet – Header Protocol Field



Time to Live Field → 8 bits

Examples:
6: TCP
17: UDP
1: ICMP
2:IGMP
89:OSPF

Structured Design
IPv4 Network Address Planning

- IP network planning is crucial to develop a scalable solution to an enterprise network.
  - To develop an IPv4 network wide addressing scheme, you need to know how many subnets are needed, how many hosts a particular subnet requires, what devices are part of the subnet, which parts of your network use private addresses, and which use public, and many other determining factors.

- Examine the needs of an organization's network usage and how the subnets will be structured.
  - Perform a network requirement study by looking at the entire network to determining how each area will be segmented.
  - Determine how many subnets are needed and how many hosts per subnet.
  - Determine DHCP address pools and Layer 2 VLAN pools.

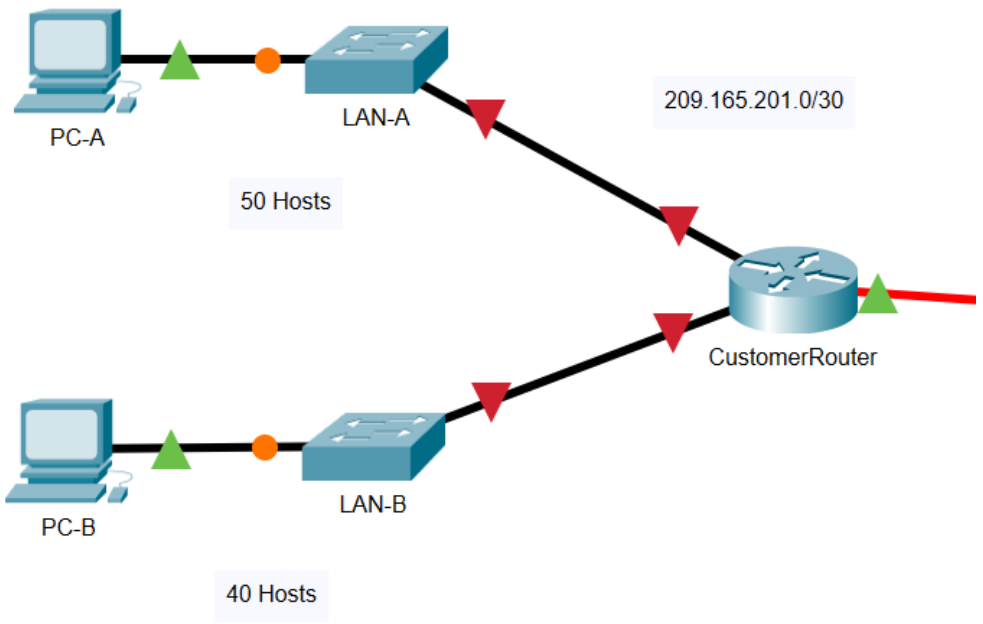
Structured Design
IPv4 Network Address Planning

- 1. Determine network and Host requirements
- 2. Satisfy Net and Host Requirements
- 3. Subnet Mask
- 4.Determine Network, Broadcast and Usable Host IP Addresses

IPv4 Subnetting – Example 1

•The subnet scheme should be based on the number of host computers required in each subnet, as well as other network considerations, like future network host expansion.

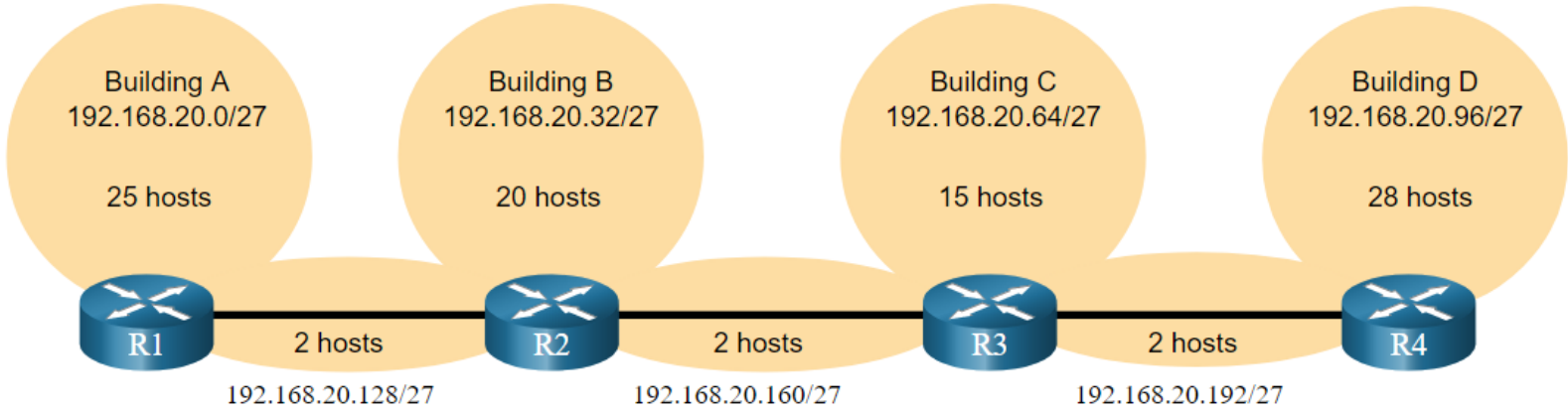
- In this scenario, you are a network technician assigned to install a new network for a customer. You must create multiple subnets out of the **192.168.0.0/24** network address space to meet the following requirements:
  - a. The first subnet is the LAN-A network. You need a minimum of 50 host IP addresses.
  - b. The second subnet is the LAN-B network. You need a minimum of 40 host IP addresses.
  - c. You also need at least two additional unused subnets for future network expansion.



VLSM
IPv4 Address Conservation

•Given the topology, 7 subnets are required (i.e, four LANs and three WAN links) and the largest number of host is in Building D with 28 hosts.

- A /27 mask would provide 8 subnets of 30 host IP addresses and therefore support this topology.



VLSM

IPv4 Address Conservation (Cont'd)

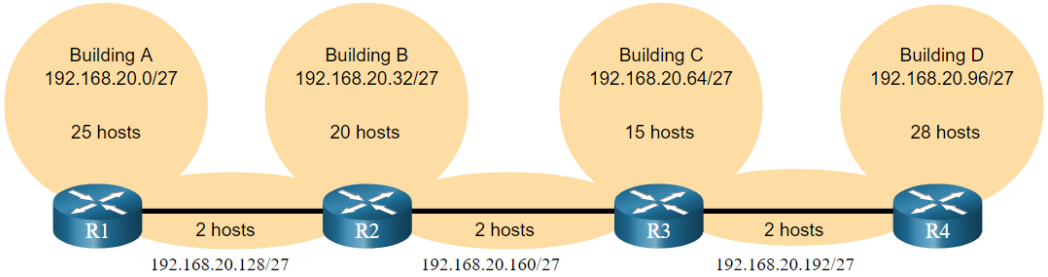
Host portion
2^5 – 2 = 30 host IP addresses per subnet

30 – 2 = 28
Each WAN subnet wastes 28 addresses

28 x 3 = 84
84 addresses are unused

However, the point-to-point WAN links only require two addresses and therefore waste 28 addresses each for a total of 84 unused addresses.

- Applying a traditional subnetting scheme to this scenario is not very efficient and is wasteful.
- VLSM was developed to avoid wasting addresses by enabling us to subnet a subnet.



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VLSM

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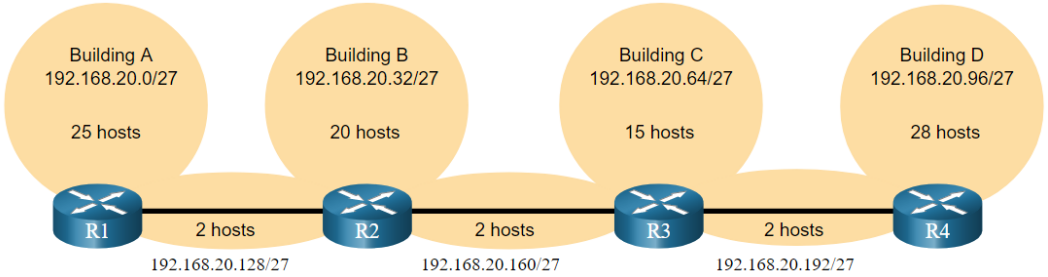

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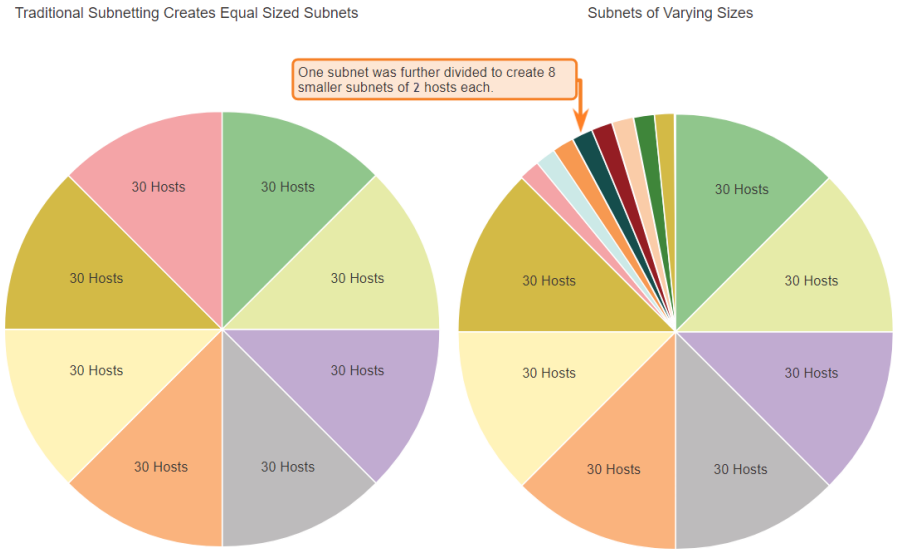
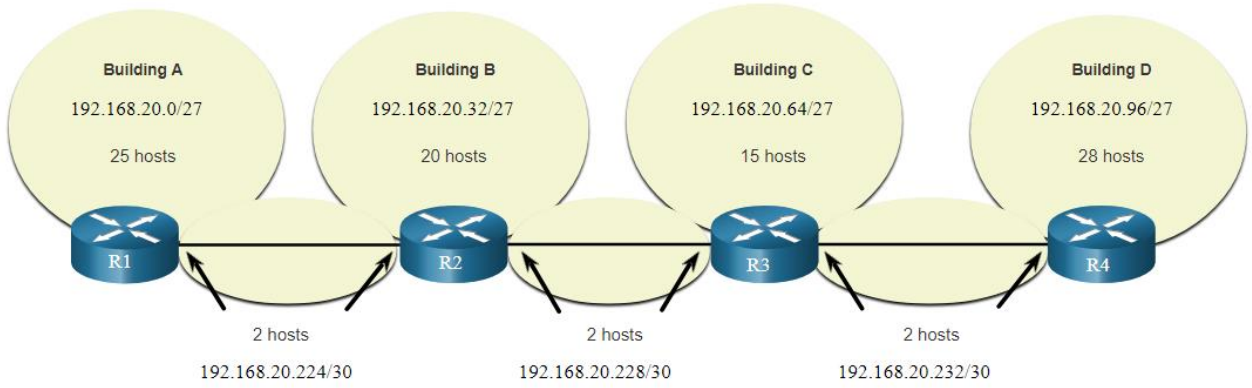
VLSM

- The left side displays the traditional subnetting scheme (i.e., the same subnet mask) while the right side illustrates how VLSM can be used to subnet a subnet and divided the last subnet into eight /30 subnets.

- When using VLSM, always begin by satisfying the host requirements of the largest subnet and continue subnetting until the host requirements of the smallest subnet are satisfied.

- The resulting topology with VLSM applied.

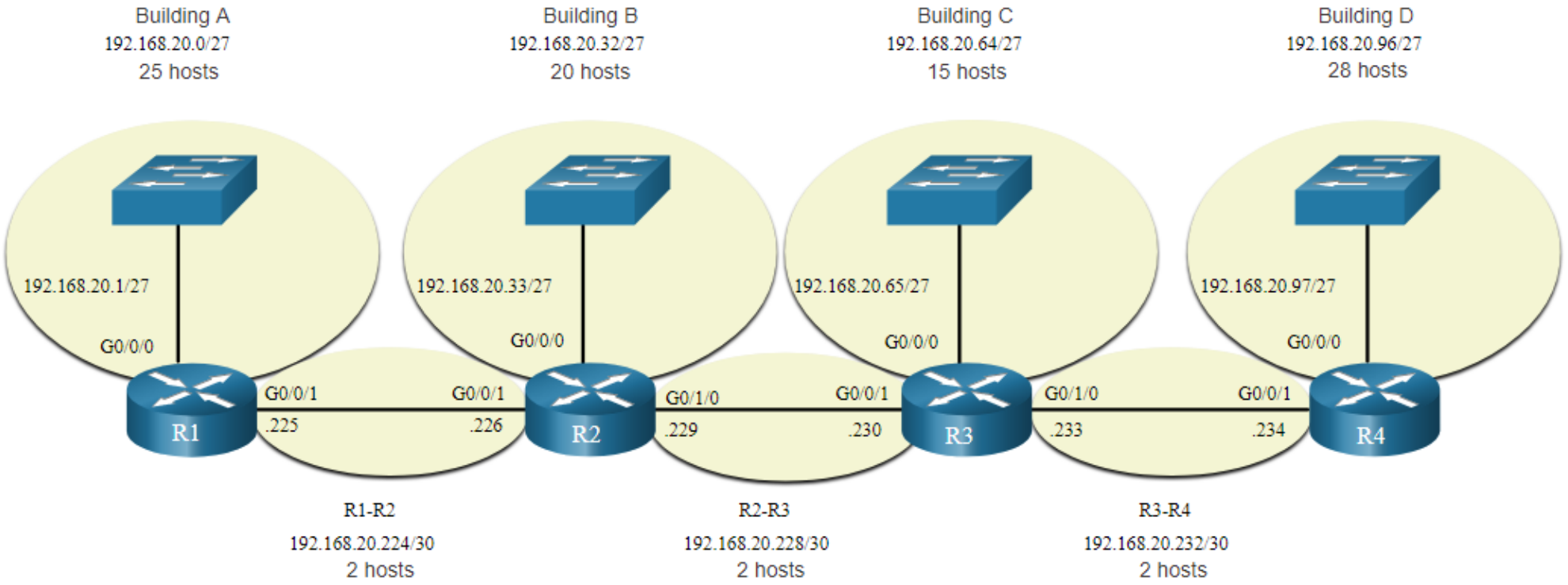




VLSM

VLSM Topology Address Assignment

- Using VLSM subnets, the LAN and inter-router networks can be addressed without unnecessary waste as shown in the logical topology diagram.



IPv4 VLSM – EXAMPLE 2

•The subnet scheme should be based on the number of host computers required in each subnet, as well as other network considerations, like future network host expansion.

- You will subnet the network address **10.11.48.0/24**. The network has the following requirements:
  - **ASW-1** LAN will require **14** host IP addresses
  - **ASW-2** LAN will require 8 host IP addresses
  - **ASW-3** LAN will require 25 host IP addresses
  - **ASW-4** LAN will require 27 host IP addresses