THE UNIVERSITY OF
MELBOURNE

Week8 Network Layer

COMP90007 Internet Technology

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Your Tutor

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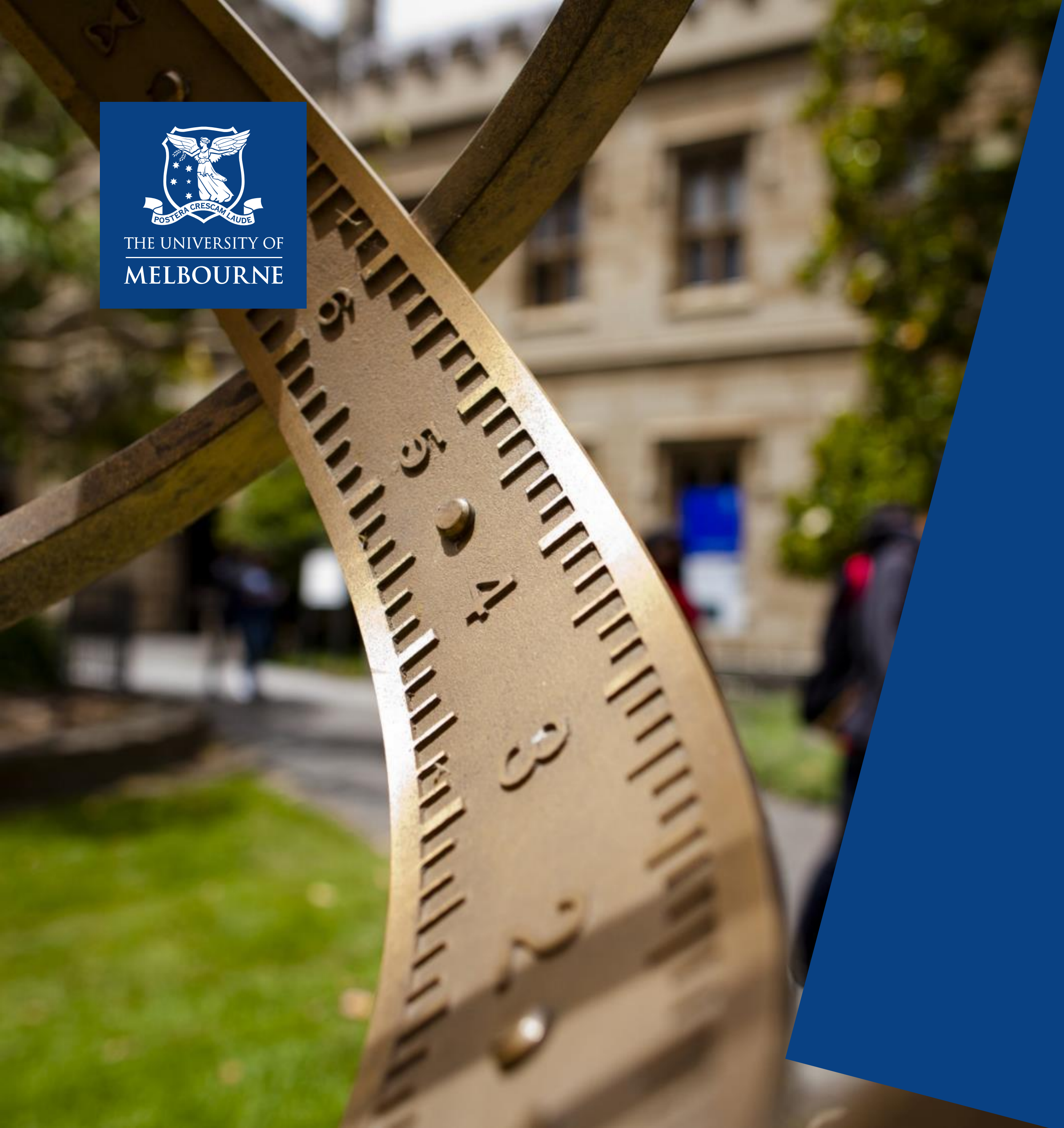
- Workshop Slides: https://github.com/LuChenyang3842/Internet-technology-teaching-material

Day	Time	Location
Tue	18:15	Bouverie st –B114
Wed	10:00	Elec Engineering -122
Wed	17:15	Bouverie-sr 132



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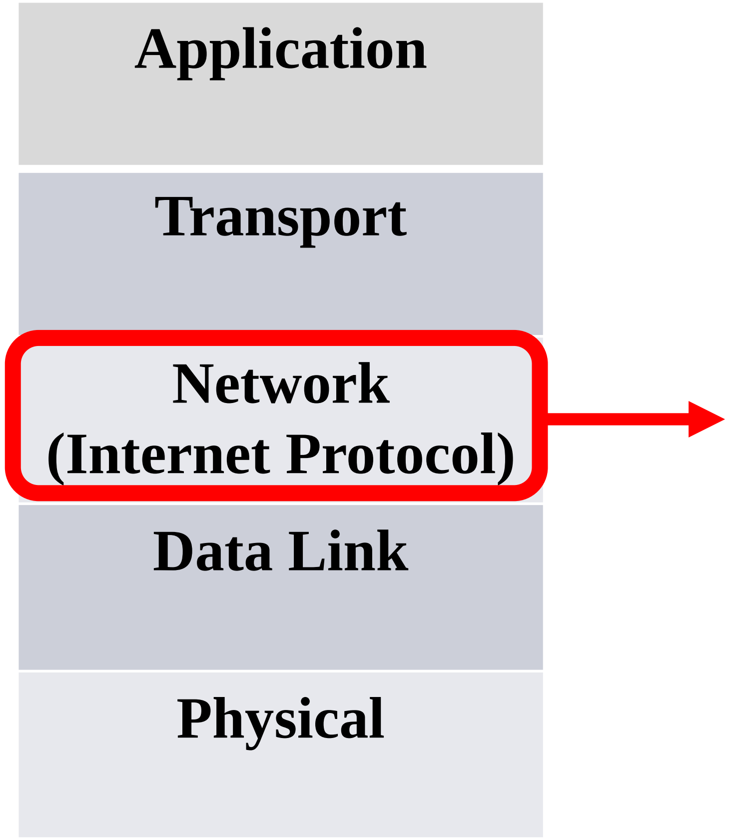
Network Layer

Network Layer



1. Routing Method
   - Virtual-Circuit subnet (Connection Oriented)
   - Datagram subnet (Connectionless)
2. IPV4
   - Datagram
   - IP address and subnetting (important!)
3. Fragmentation
4. ★ Routing algorithm (Manage Routing Table)
   - Non-adaptive
     - Shortest Path routing
     - Flooding
   - Adaptive
     - Distance Vector Routing
     - Links state routing
   - Hierarchical Routing
   - Broadcasting Routing
   - Multicasting Routing

IP address and subnetting

- **IP address = Network portion + Host portion**

	Binary Form	Dot-decimal
IP address	?	118.217.110.149/10
Subnet mask	?	?
Network prefix	?	?
Number of hosts	?	

Q1

	Binary Form	Dot-decimal
IP address	?	?
Subnet mask	?	?
Network prefix	?	192.0.2.0/23
Number of hosts	?	

Q2

	Binary Form	Dot-decimal
IP address	?	?
Subnet mask	11111111.11111111.11111111.00000000	?
Network prefix	?	?
Number of hosts	?	

Q3

If the network portion of Ip address is 15, what is the subnet mask? What is the number of host?

Q4

	Binary Form	Dot-decimal
IP address	01110110.11011001.01101110.10010101	118.217.110.149/10
Subnet mask	11111111.11000000.00000000.00000000	255.192.0.0
Network prefix	01110110.11000000.00000000.00000000	118.192.0.0/10
Number of hosts	2^22	

Q1

	Binary Form	Dot-decimal
IP address	N/A	N/A
Subnet mask	11111111.11111111.11111110.00000000	255.255.254.0
Network prefix	11000000.00000000.00000010.00000000	192.0.2.0/23
Number of hosts	2^9	

Q2

	Binary Form	Dot-decimal
IP address	N/A	N/A
Subnet mask	11111111.11111111.11111111.00000000	255.255.255.0
Network prefix	N/A	N/A
Number of hosts	2^8	

Q3

If the network portion of Ip address is 15, subnet mask: 255.254.0.0, number of host: 2^17

Q4

Aggregation

- **Aggregation:** process of joining multiple IP prefixes into a single prefix to reduce size of routing table
- Based on the **longest prefix match**

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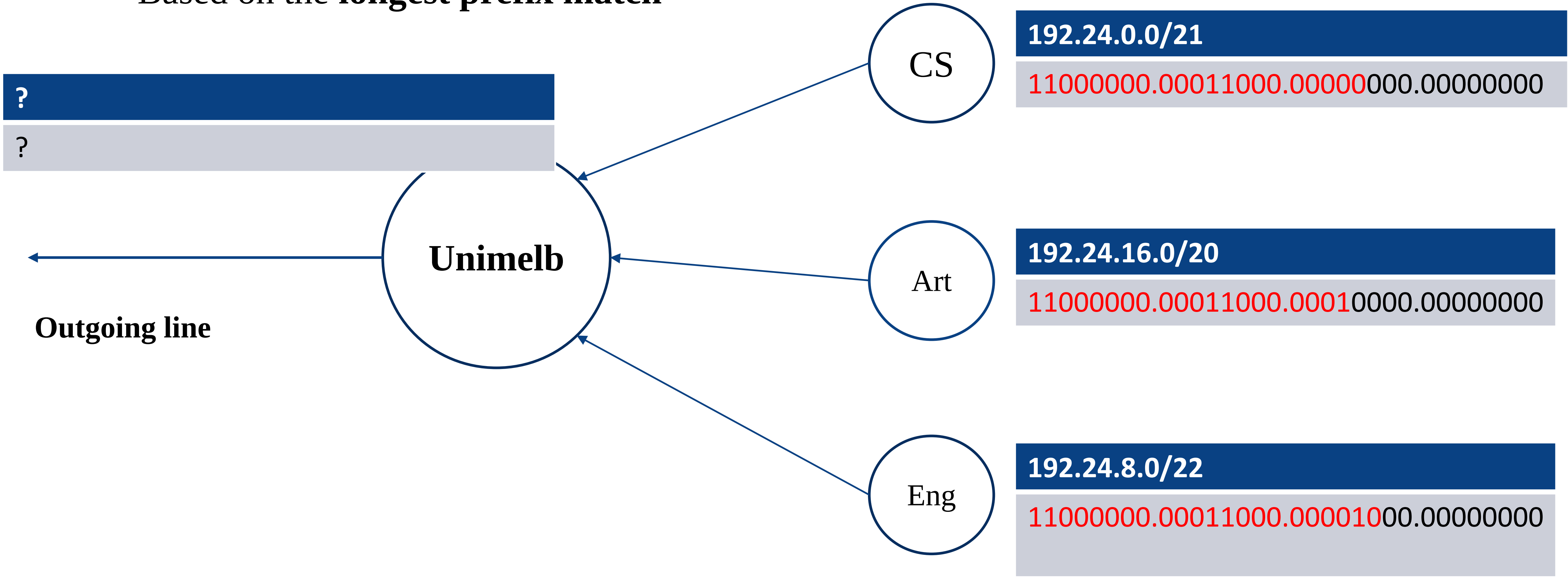

Aggregation

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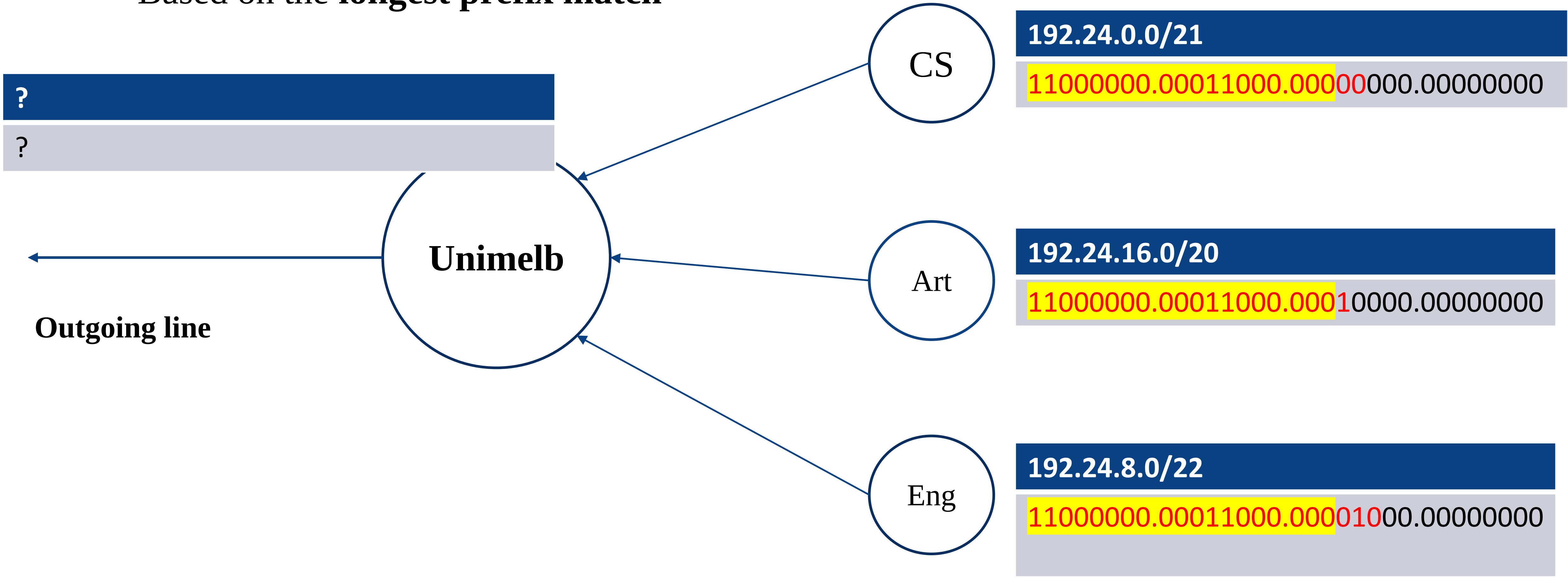

Aggregation

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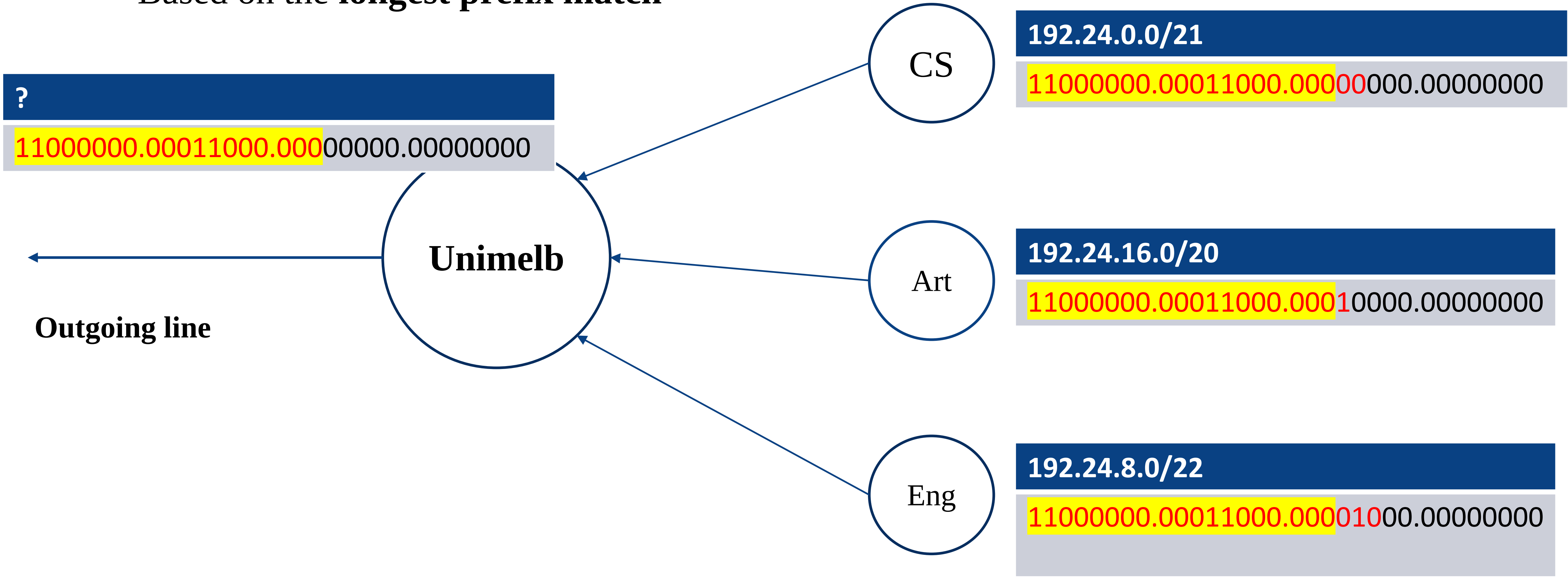

Aggregation

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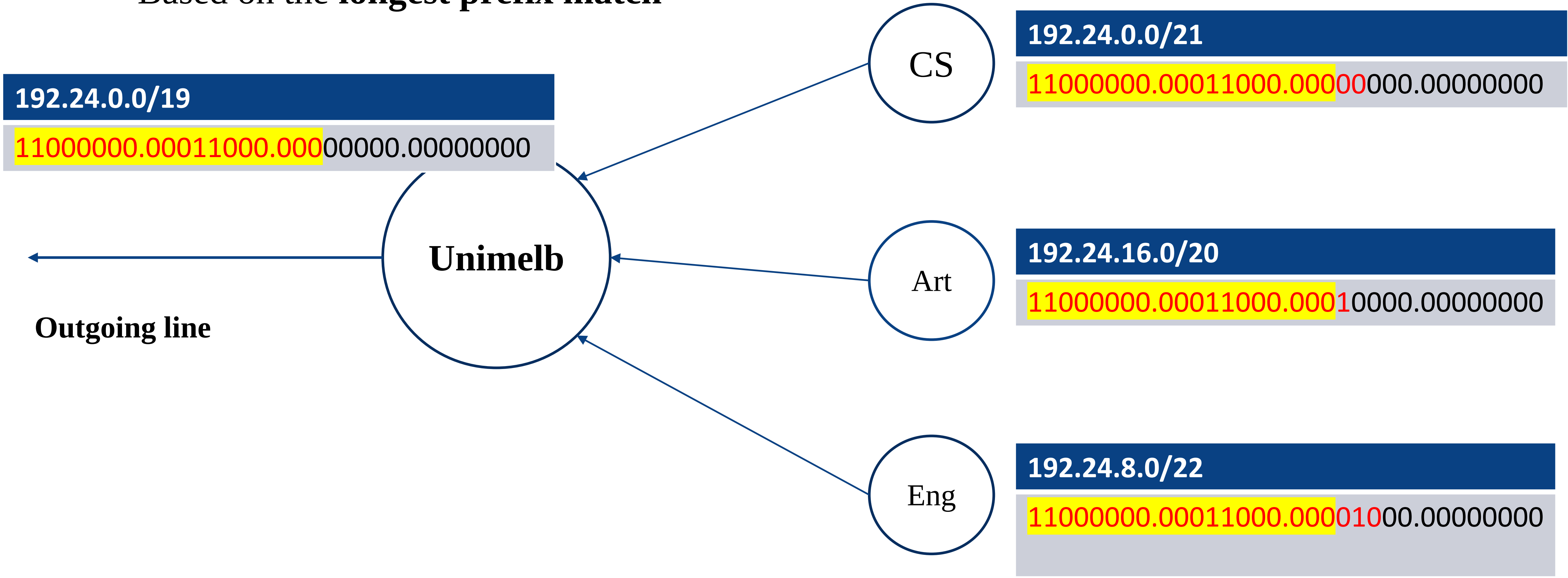
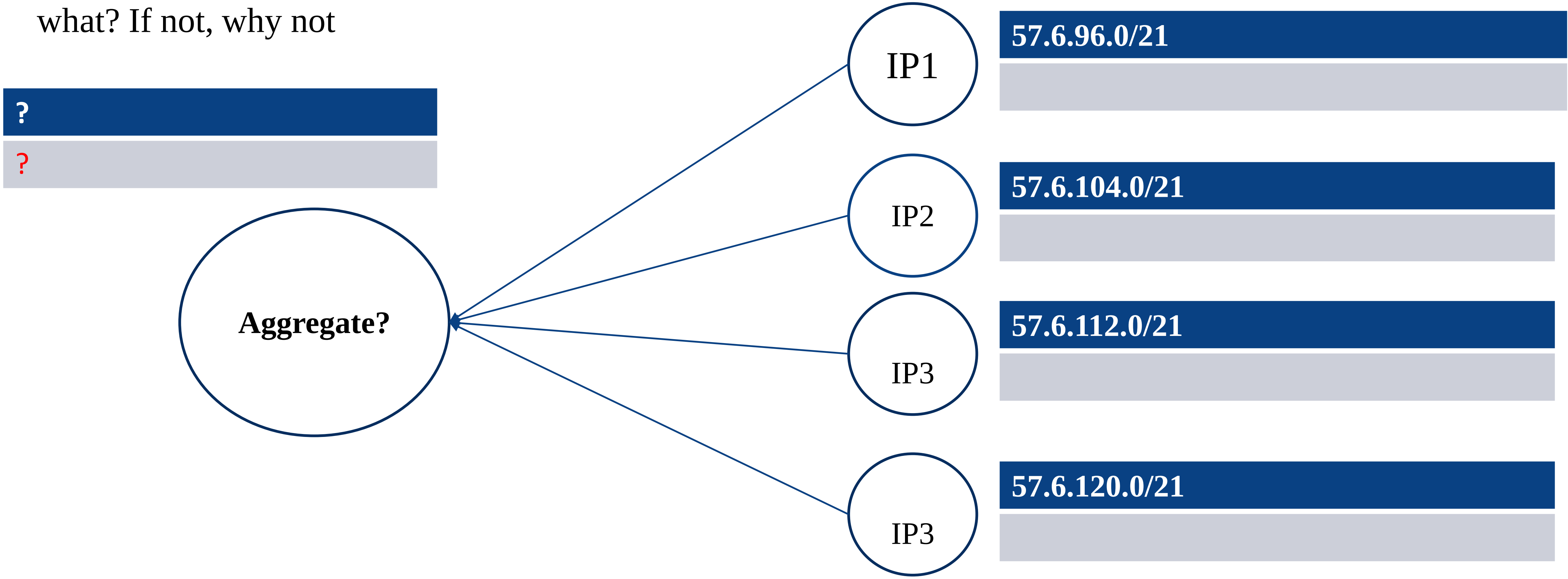
- Based on the **longest prefix match**

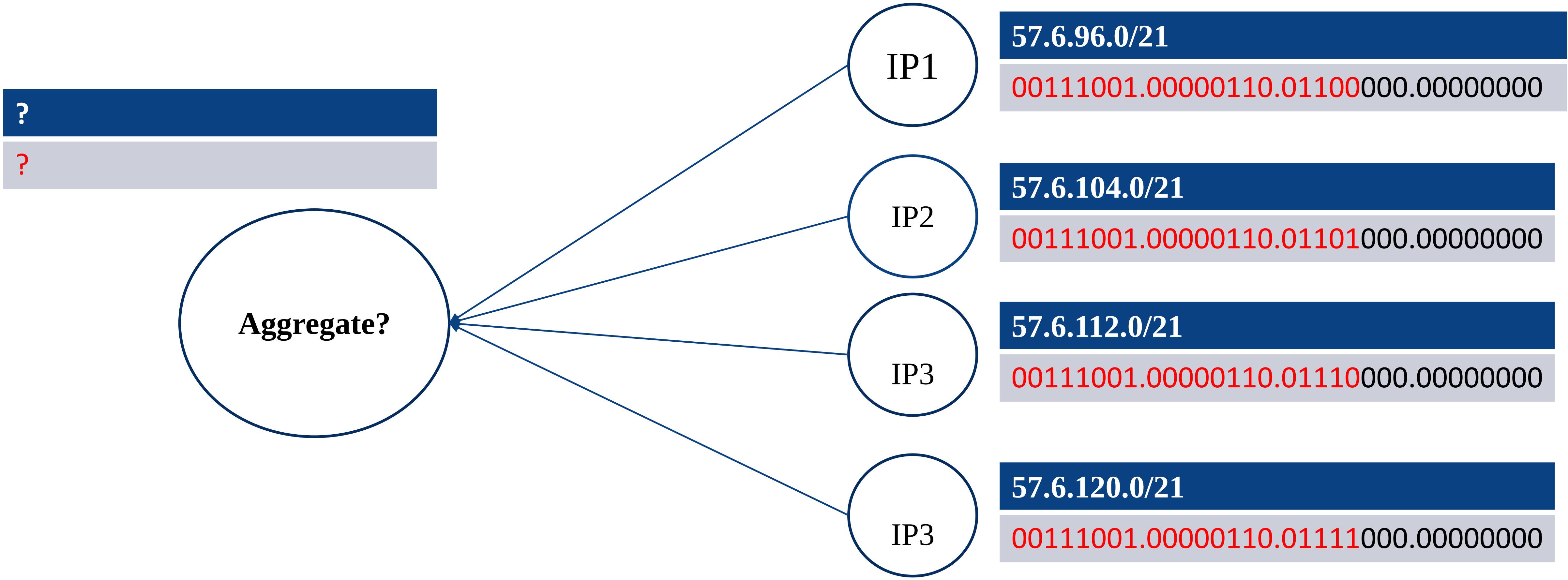


Question 1 Aggregation

A router has just received the following IP addresses: 57.6.96.0/21, 57.6.104.0/21, 57.6.112.0/21 and 57.6.120.0/21. If all of them use the same outgoing line, can they be aggregated? If so, to what? If not, why not



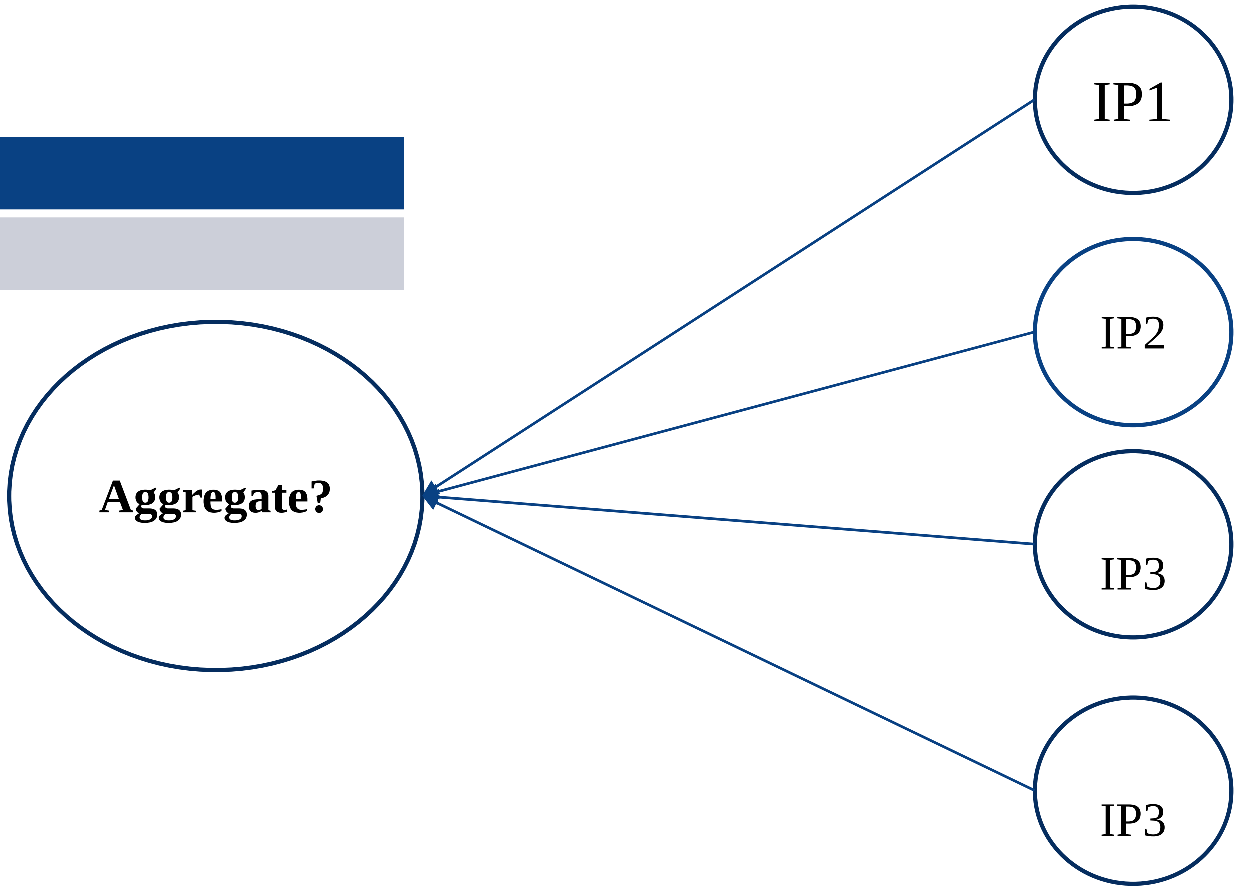
Step1: Convert to binary



Step2: Find the longest matched prefix: first 19 bits

?

?



57.6.96.0/21

00111001.00000110.01100000.00000000

57.6.104.0/21

00111001.00000110.01101000.00000000

57.6.112.0/21

00111001.00000110.01110000.00000000

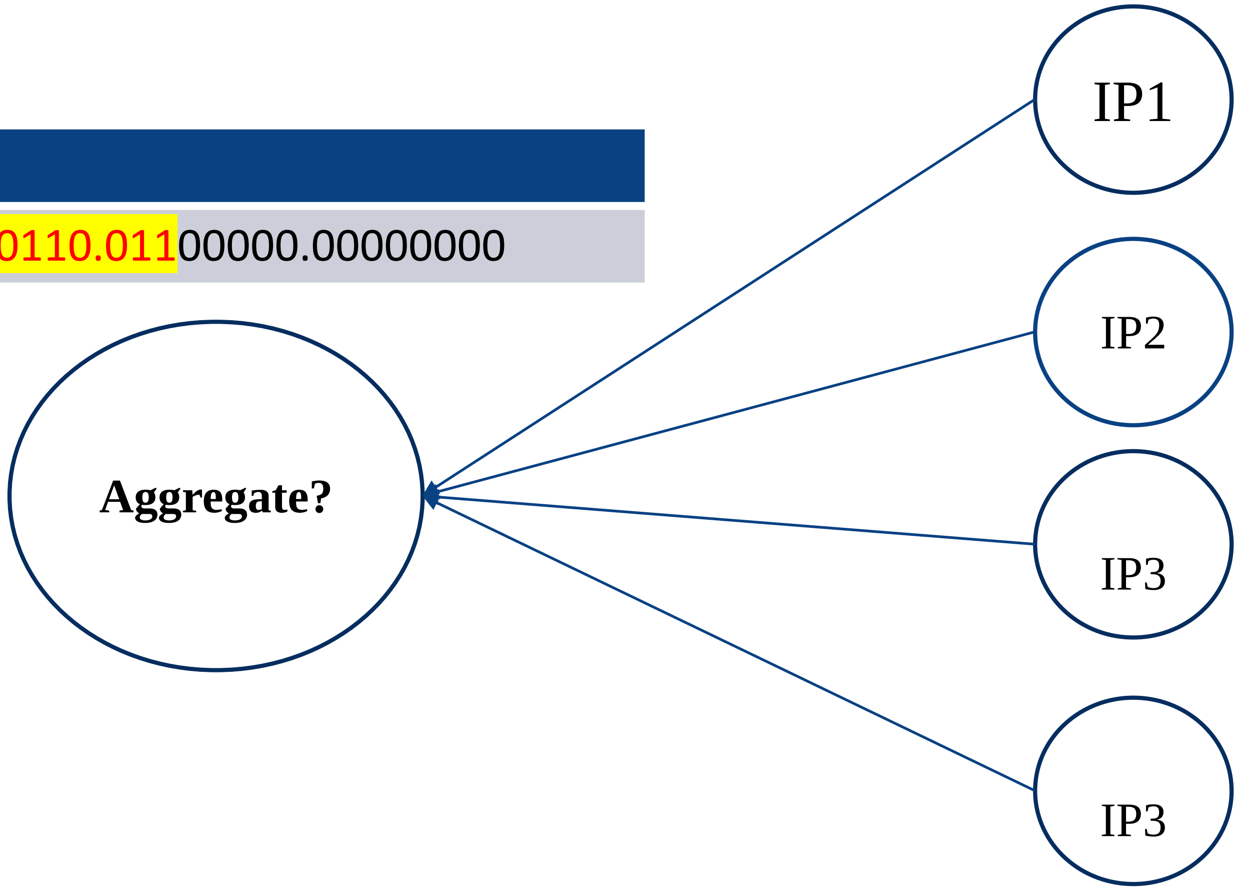
57.6.120.0/21

00111001.00000110.01111000.00000000

Step3: Extract the first 19 bits as the network portion, and all zeros for host portion which is : 00111001.00000110.01100000.00000000

?

00111001.00000110.01100000.00000000



57.6.96.0/21

00111001.00000110.01100000.00000000

57.6.104.0/21

00111001.00000110.01101000.00000000

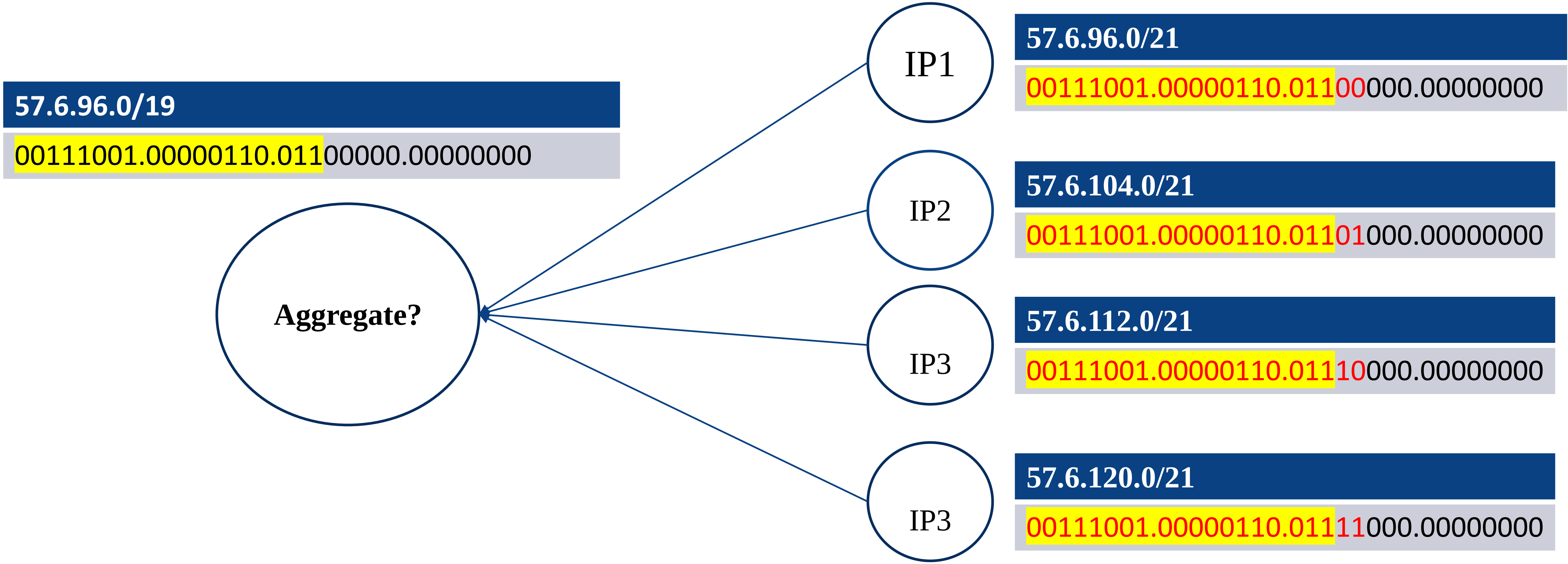
57.6.112.0/21

00111001.00000110.01110000.00000000

57.6.120.0/21

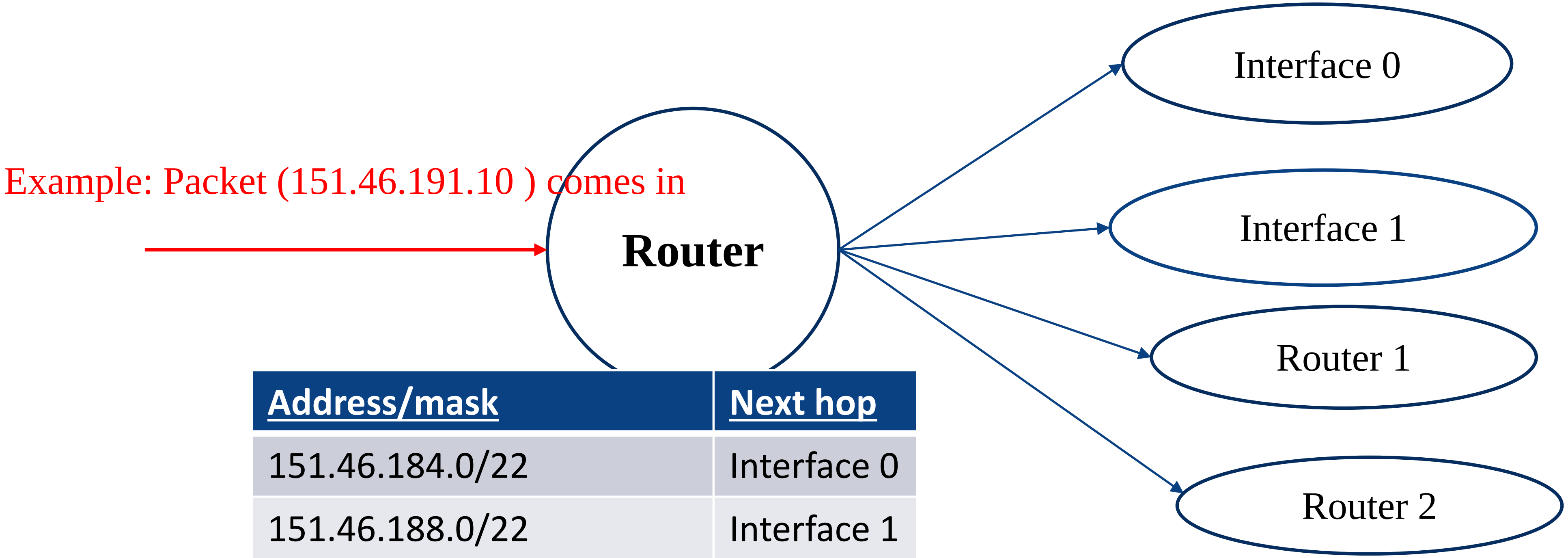
00111001.00000110.01111000.00000000

Step4: Convert to decimal: the result is 57.6.96.0/19



Rules of packet forward

- A router maintains a routing table
- Packets are forwarded to the entry with the **longest matching prefix (binary)**

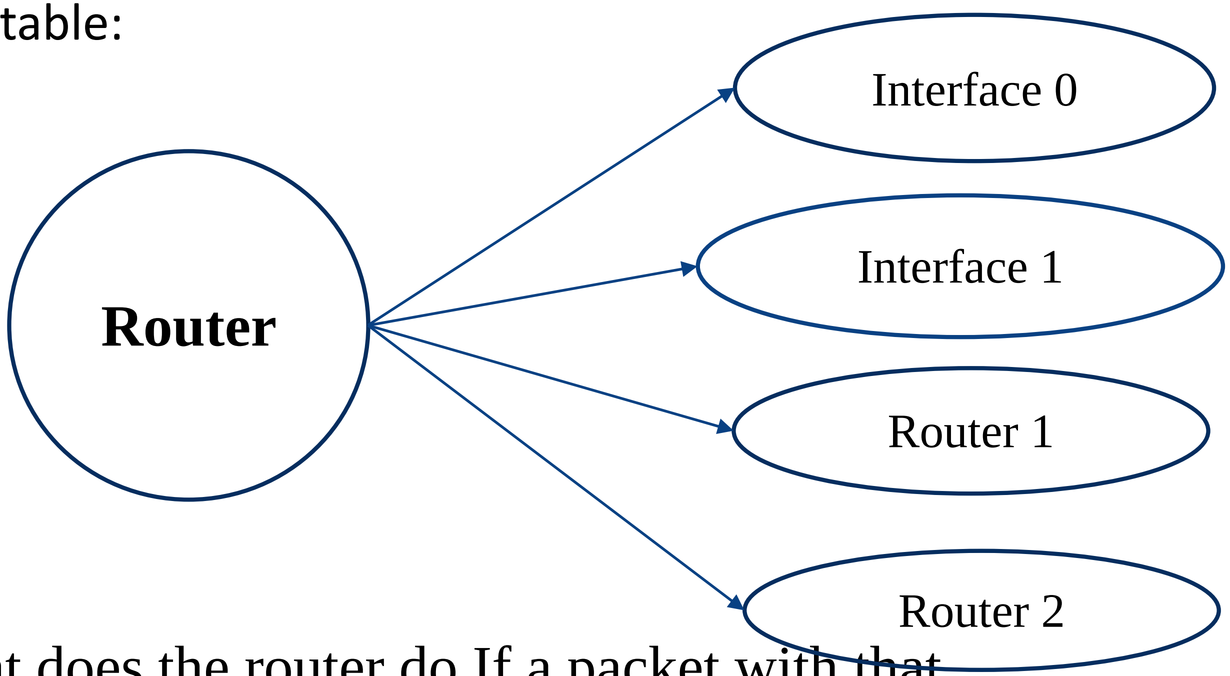


Address/mask	Next hop
151.46.184.0/22	Interface 0
151.46.188.0/22	Interface 1
151.53.40.0/23	Router 1
Default	Router 2

Question 2 Packet forward

A router has the following entries in its routing table:

Address/mask	Next hop
151.46.184.0/22	Interface 0
151.46.188.0/22	Interface 1
151.53.40.0/23	Router 1
Default	Router 2



For each of the following IP addresses, what does the router do If a packet with that address arrives?

(a) 151.46.191.10

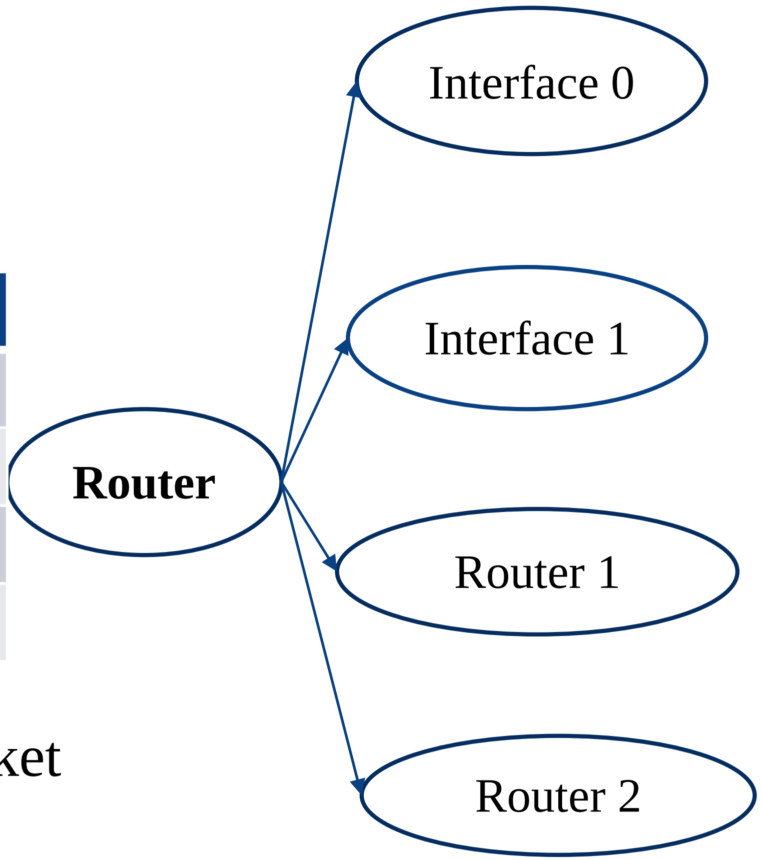
(b) 151.46.187.2

Step1: Convert to binary

Step2: Find out the longest matched prefix

Question 2 Packet forward

Address/mask	Binary format	Next hop
151.46.184.0/22	10010111.00101110.10111000.00000000	Interface 0
151.46.188.0/22	10010111.00101110.10111100.00000000	Interface 1
151.53.40.0/23	10010111.00110101.00101000.00000000	Router 1
Default		Router 2



For each of the following IP addresses, what does the router do If a packet with that address arrives?

(a) 151.46.191.10

1. Convert to Binary : 10010111.00101110.10111111.00001010
2. Find longest matched prefix is interface1 , so route to interface 1.

(b) 151.46.187.2

1. Convert to binary: 10010111.00101110.10111011.00000010
2. Find the longest matched prefix is interface 0, so route to interface 0.

Network Layer

Application

Transport

Network
(Internet Protocol)

Data Link

Physical

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3. Fragmentation
4. Routing algorithm (Manage Routing Table)

★
   - Non-adaptive
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Question 3 Routing algorithm

Why do we need routing algorithms in the Network layer?
What are the key categories of routing algorithms?

Answer:

Routing algorithms are needed to help decide on which output line an incoming packet should be transmitted.

Key Categories:

- Non-Adaptive Algorithms
- Adaptive Algorithms

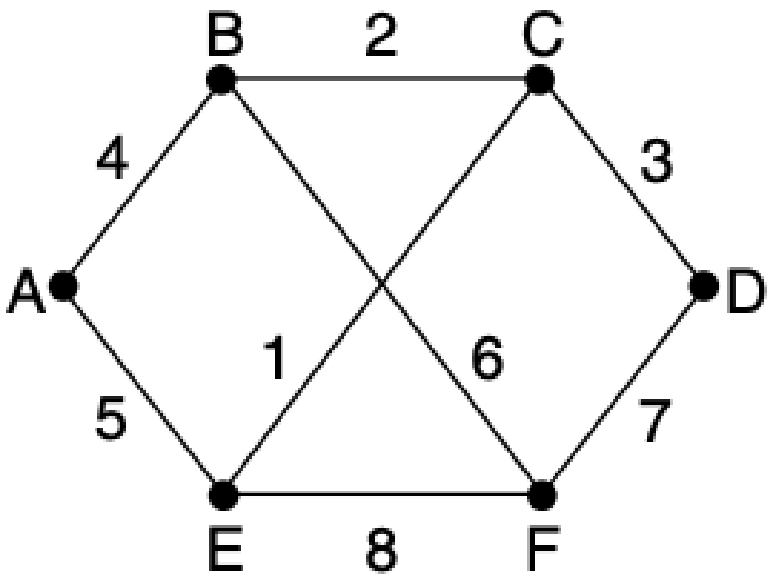
Routing algorithm

- Non-adaptive (Static)
  - Shortest Path routing (use to Dijkstra's algorithm to build sink tree)
  - Flooding

- Adaptive (Dynamic)
  - Distance Vector Routing
  - Links state routing

Question 4 Routing algorithm (Shortest Path)

Compute the sink tree for Node F in the graph below:



Use Dijkstra's algorithm to determine tree

Procedures :

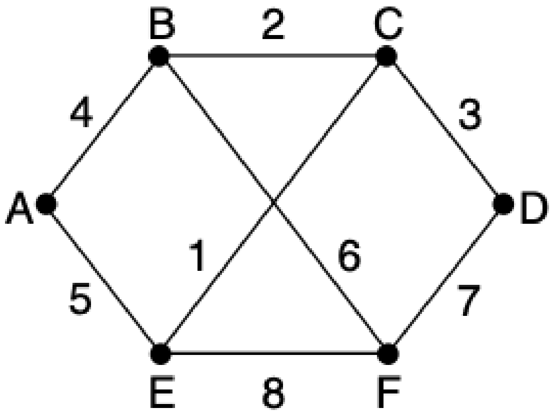
1. Create **a set *P*, *tracking* the nodes added in the tree**. Initialize it as empty.

2. For each node, assign a **distance value *d* from the node to sink**. Initialize the distance for all nodes as infinity.

3. Start from the sink node, assign distance as 0.

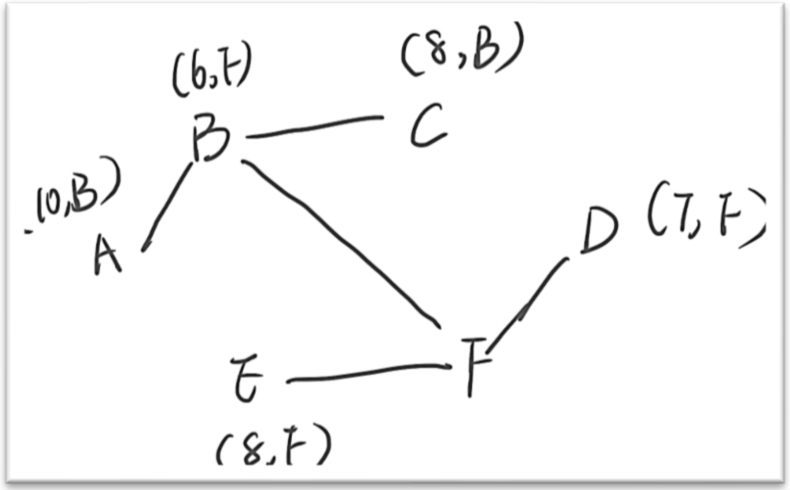
4. Repeat when *P* doesn't include all nodes:
   - For all the nodes not in *P*, pick a node *v* with min distance and add it to *P*
   - Update *d* for all the adjacent nodes of *v* *(only if the d is smaller)*

Refer to Dijkstra's algorithm on the Slide 8 of Week 6's Lecture



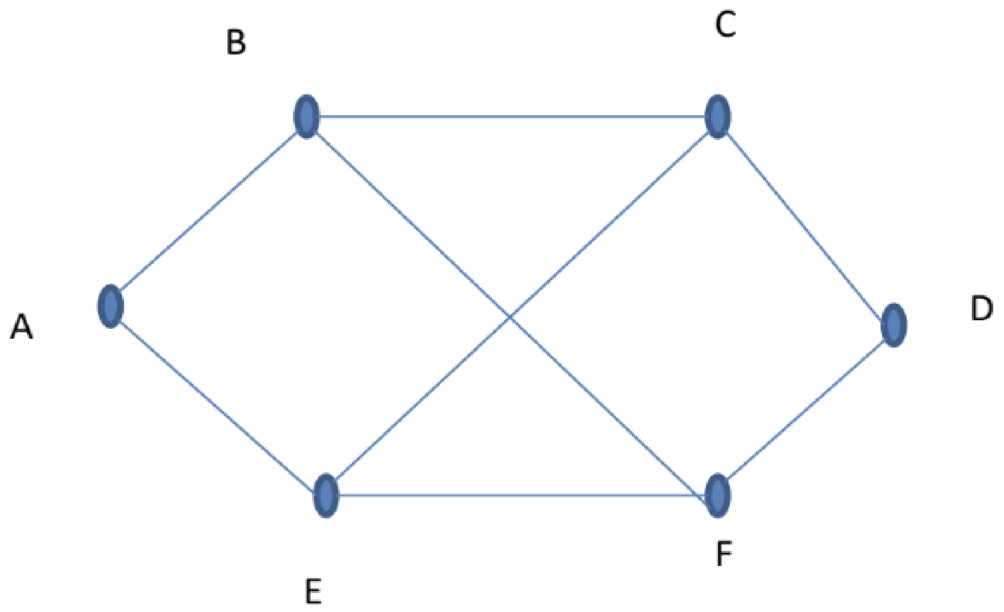
N	A	B	C	D	E	F	Set P
1	∞	∞	∞	∞	∞	0	{F}
2	∞	6	∞	7	8	--	{F, B}
3	10	--	8	7	8	--	{F, B,D}
4	10	--	8	--	8	--	{F, B,D,E}
5	10	--	8	--	--	--	{F, B,D,E,C}
6	10	--	--	--	--	--	{F, B,D,E,C, A}

Sink Tree:



Question 5 Routing algorithm (Distance Vector Routing)

Distance vector routing is used for the diagram shown below, and the following vectors have just come in to router C: from B: (5, 0, 8, 12, 6, 2); from D: (16, 12, 6, 0, 9, 10); and from E: (7, 6, 3, 9, 0, 4). The cost of the links from C to B, D, and E, are 6, 3, and 5, respectively. What is C's new routing table? Give both the outgoing line to use and the expected delay.



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All Routers	From B	From D	From E
To A	5	16	7
To B	0	12	6
To C	8	6	3
To D	12	0	9
To E	6	9	0
To F	2	10	4

C to B: 6 **C to D: 3** **C to E: 5**

→

From C

All Routers	Via B	Via D	Via E
To A	11	19	12
To B	6	15	11
To C	14	9	8
To D	18	3	14
To E	12	12	5
To F	8	13	9

→

All Routers	Outgoing Line	Expected Delay from C
To A	B	11
To B	B	6
To C	-	0
To D	D	3
To E	E	5
To F	B	8