This submission template is a convenient document for you to provide your work and your answers for Assignment 6. This submission template is intended to be used in conjunction with the Assignment 6 Instructions document. The instructions document illustrates how to correctly derive the answers, explains important theoretical and practical details, and contains the complete set of instructions for this lab.

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Section One – Foundational Routing Concepts

Scenario 1

1. Identify which adapter(s) would receive a data-link layer broadcast transmitted by Computer B and which would not (if any). Provide an explanation of why each adapter present in the preceding figure would or would not receive the broadcast.

- Network adapter R2 would receive a data-link layer broadcast transmitted by Computer B because they are in the same network B (When the sender and receiver are on the same network, the sender directly transmits the IPv4 packet to the receiver via the data-link layer).
- Network adapter R1 and network adapter A would not receive a data-link layer broadcast transmitted by computer B because they are not in the same network B, and Router do not broadcast, it simply drops the packet as soon as it notices a broadcast address. The primary role of router is to separate broadcast domains

2. Can Computer B directly address Computer A at the data-link layer? Explain why or why not.

No, Computer B cannot directly address Computer A at the data-link layer because Computer A and Computer B are on the different network. Computer B forwards the IPv4 packet to the router's network adapter R2 via data-link layer (because they are in the same network B), and then the router sends a new frame out of its network adapter R1 (configured for network A) to Computer A via data-link layer.

3. Imagine that Computer B successfully transmits an IPv4 packet to Computer A, that there are no errors on any frame or packet, and that the ARP cache on all computers and the router is already fully populated. Identify any data-link layer frame(s) that are created for this transmission. For each frame, identify the adapter it originates from and the adapter it is addressed to, explain why it was created, and provide its source and destination MAC address and source and destination IPv4 address.

- ***Two frames are created when an IPv4 packet is sent from Computer B to Computer A:***
  - ❑ Frame 1, or source frame, from Computer B to Router (Network adapter B to network adapter R2)
  - ❑ Frame 2, or destination frame, from Router to Computer A (Network adapter R1 to network adapter A)

- When Computer B needs to send an IPv4 packet to Computer A which is in different network (Network A), it embeds the packet into a data-link layer frame, and addresses the frame to the router's network adapter R2 that is configured to participate on network B. When a router receives a data-link layer frame, it expects that the embedded IPv4 packet may not be addressed to it directly but may be intended for another host (which is computer A in network A). It therefore extracts the IPv4 packet from the frame and inspects the IPv4 destination

address (IPv4 address of Computer A). Because the packet is indeed destined for Computer A on a different network which is network A, the router creates a new data-link layer frame with the Computer A's MAC address as the destination address, embeds the IPv4 packet in it, and then sends the frame out of the network adapter R1 (which is configured for network A) to Computer A. In this way, the router bridges network A and network B.

- **Source and destination MAC address and source and destination IPv4 address:**

  Frame 1: Source frame
  Source MAC Address: Computer B's MAC address (C4-04-32-81-A2-98)
  Destination MAC Address: Adapter R2's MAC address (Router) (FA-AF-93-28-7C-31)

  Source IPv4 Address: Computer B's IPv4 address (15.152.13.98/25)
  Destination IPv4 Address: Computer A's IPv4 address (90.118.32.132/24)

  Frame 2: Destination frame
  Source MAC Address: Adapter R1's MAC address (Router) (93-0B-05-B4-2E-59)
  Destination MAC Address: Computer A's MAC address (3C-22-39-A1-1A-32)

  Source IPv4 Address: Computer B's Ipv4 address (15.152.13.98/25)
  Destination Ipv4 Address: Computer A's Ipv4 address (90.118.32.132/24)

4. What function does the router serve for the transmission in #3?

- **The router bridges network A and network B** (Router is acting as a gateway for Computer B. When computer B wants to transmit an IPv4 packet to Computer A, it has to encapsulate the IPv4 packet into a data-link layer frame) because When Computer B needs to send an IPv4 packet to Computer A which is in different network (Network A), it embeds the packet into a data-link layer frame, and addresses the frame to the router's network adapter R2 that is configured to participate on network B. When a router receives a data-link layer frame, it expects that the embedded IPv4 packet may not be addressed to it directly, but may be intended for another host (which is computer A in network A). It therefore extracts the IPv4 packet from the frame and inspects the IPv4 destination address (IPv4 address of Computer A). Because the packet is indeed destined for Computer A on a different network which is network A, the router creates a new data-link layer frame with the Computer A's MAC address as the destination address, embeds the IPv4 packet in it, and then sends the frame out of the network adapter R1 (which is configured for network A) to Computer A.

Scenario 2

5. Imagine that Computer C successfully sends an IPv4 packet to Computer A, that there are no errors on any frame or packet during the transmission, and that the ARP cache on all computers and routers has been fully populated before the packet is sent. Identify any data-link layer frame(s) that are created in this scenario. For each frame, identify the adapter it originates from and the adapter it is addressed to, explain why it was created, and provide its source and destination MAC address and source and destination IPv4 address.

Three frames are created when an IPv4 packet is sent from Computer C to Computer A:

- ❑ Frame 1, or source frame, from Computer C to Router BC (Network adapter C to Network adapter BC2)
- ❑ Frame 2 or intermediate frame, from Router BC to Router AB (Network adapter BC1 to Network adapter AB2)
- ❑ Frame 3, or destination frame, from Router AB to Computer A (Network adapter AB1 to Network adapter A)

According to theory, A sender and receiver are not always on adjacent networks. In such a case, the first router to receive the IPv4 packet routes it to another router, which in turn routes it to another, until the router on the destination network receives the packet. The router then forwards the packet to the receiver by addressing the receiver directly at the data-link layer. If a router has a network adapter configured to be on the same network as the receiver, the router sends it to the receiver directly; otherwise, the router routes the packet to another router. Thus, the IPv4 packet is routed from network to network until it arrives at the destination network.

→ **Frames were created** because a sender (Computer C) and receiver (computer A) are not on adjacent networks. In such a case, the first router (router BC) to receive the IPv4 packet from computer C by network adapter BC2 and then routes packet to another router which is router AB by sending packet from network adapter BC1 to network adapter AB2, The router AB then forwards the packet (from network adapter AB1) to the receiver (computer A) by addressing the receiver (network adapter A of computer A) directly at the data-link layer. Because Network adapter AB1 of Router AB (which is configured to same network A) are on the same network with receiver (Computer A), so the router AB sends packet to the receiver (Computer A) directly.

- **Source and destination MAC address and source and destination IPv4 address:**

Frame 1: Source frame
Source MAC Address: Computer C's MAC address (12-34-01-9A-FF-FE)
Destination MAC Address: Adapter BC2's MAC address (Router BC) (9B-D1-82-13-AB-CD)
Source IPv4 Address: Computer C's IPv4 address (210.99.45.137/24)
Destination IPv4 Address: Computer A's IPv4 address (43.19.238.195/22)

Frame 2: Intermediate frame
Source MAC Address: Adapter BC1's MAC address (Router BC) (47-E2-FE-77-11-23)

Destination MAC Address: Adapter AB2's MAC address (Router AB) (DD-01-23-45-9A-BC)
Source IPv4 Address: Computer C's IPv4 address (210.99.45.137/24)
Destination IPv4 Address: Computer A's IPv4 address (43.19.238.195/22)

Frame 3: Final frame
Source MAC Address: Adapter AB1's MAC address (Router AB) (94-59-4B-88-00-01)
Destination MAC Address: Computer A's MAC address (23-9E-77-10-09-4C)
Source IPv4 Address: Computer C's IPv4 address (210.99.45.137/24)
Destination IPv4 Address: Computer A's IPv4 address (43.19.238.195/22)

6. Across all frames in the transmission in #5, contrast the number of different destination IP addresses with the number of different MAC addresses. Why these are numbers different, and what does this tell us about the routing process?

Although IPv4 routing is a network layer function, the data- link layer also plays a role in routing. In particular, the data-link layer is always used to transmit an IPv4 packet, whether the packet is being sent directly to the receiver or is being sent to a router. When the sender and receiver are on the same network, the sender directly transmits the IPv4 packet to the receiver via the data-link layer. When the sender and receiver are on a different network, the sender forwards the IPv4 packet to the router via the data-link layer, and ultimately the router on the receiver's network transmits the IPv4 packet to the receiver via the data-link layer.

The sender sends the frame to the router's network adapter configured for its own network, and that the router sends out a new frame out of its network adapter configured for the destination network, which is addressed to the receiver. The IPv4 packet embedded inside of each frame starts out and remains addressed to the receiver. Data-link layer only makes use of the data-link address, most commonly a MAC address, and the network layer only makes use of the network address, most commonly an IPv4 address.

The source and destination IPv4 addresses remain constant as the packet makes its way through the network from a source computer to a destination computer.

Section Two - Routing Tables

Scenario 3

7. To get started, calculate the network address and subnet mask of all three networks in this scenario. You will need these values to create rules for the computer's routing table.

- **Network A:**
  - ***Calculate network address***: We have IPv4 of network adapter A: **43.19.238.195/22**
    Because network identifier fully spans on the first and second octets, partially spans on third octet, it does not span on fourth octet, using shortcut by copy first 2 octets and zero last octet and calculate third octet, We have: **43.19.X.0**
    Calculate X, we have: **238 → 11101110** We keep first 6 bits and zero last 2 bits → **11101100** → 236 in decimal notation
    → ***Network address of network A:*** **43.19.236.0**
  - ***Calculate subnet mask***: We have IPv4 of network adapter A: **43.19.238.195/22** from this CIDR, we know that the network identifier spans 22 bits (we have 22 1s follow by 10 0s), and the corresponding subnet mask can be represented as follows in binary: **11111111 11111111 11111100 00000000** which is **255.255.252.0** in decimal notation.

- **Network B:**
  - ***Calculate network address:*** We have IPv4 of network adapter AB2: **19.107.16.120/23**
    Because network identifier fully spans on the first and second octets, partially spans on third octet it does not span on fourth octet, using shortcut by copy first 2 octets and zero last octet and calculate third octet, we have **19.107.X.0**
    Calculate X, we have: **16 → 00010000** We keep first 7 bits and zero last 1 bit → **00010000** → 16 in decimal notation
    → ***Network address of network B:*** **19.107.16.0**
  - ***Calculate subnet mask:*** We have IPv4 of network adapter AB2: **19.107.16.120/23** from this CIDR, we know that the network identifier spans 23 bits (we have 23 1s follow by 9 0s), and the corresponding subnet mask can be represented as follows in binary: **11111111 11111111 11111110 00000000** which is **255.255.254.0** in decimal notation.

- **Network C:**
  - ***Calculate network address:*** We have IPv4 of network adapter BC2: **210.99.45.1/24**
    Because network identifier fully spans on the first, second and third octets it does not span on fourth octet, using shortcut by copy first 3 octets and zero last octet, we have **210.99.45.0**
    → ***Network address of network C:*** **210.99.45.0**
  - ***Calculate subnet mask:*** We have IPv4 of network adapter BC2: **210.99.45.1/24** from this CIDR, we know that the network identifier spans 24 bits (we have 24 1s follow by 8 0s), and the corresponding subnet mask can be represented as follows in binary: **11111111 11111111 11111111 00000000** which is **255.255.255.0** in decimal notation.

8. Create a routing table for Computer C that has no default route, and that supports sending packets to all hosts (directly or indirectly) on Network A, Network B, and Network C. A hint is that this routing table will contain three rules.

Network Destination	Netmask	Gateway	Interface	Metric
210.99.45.0	255.255.255.0	210.99.45.137 or "On-link"	Adapter C	
19.107.16.0	255.255.254.0	210.99.45.1	Adapter C	
43.19.236.0	255.255.252.0	210.99.45.1	Adapter C	

9. Create a routing table for Computer C that has a default route, and that supports sending packets to all hosts (directly or indirectly) on Network A, Network B, and Network C. Make sure to remove redundant routes that are not necessary with the presence of a default route.

Network Destination	Netmask	Gateway	Interface	Metric
0.0.0.0	0.0.0.0	210.99.45.1	Adapter C	
210.99.45.0	255.255.255.0	210.99.45.137 or "On-link"	Adapter C	

10. Would you recommend using the routing table in #8 or in #9, for Computer C? Explain why.

I would recommend using the routing table in # 9 for computer C because the first rule is the default route, which indicates that if any other rules do not match, the IPv4 packet is to be forward to the router with IPv4 address 210.99.45.1. The default route will help Computer C reach Network B and Network A (which indicates that if any other rules do not match, the IPv4 packet is to be forward to the router with IPv4 address 210.99.45.1 over its first network adapter C), It helps to optimize the process. The second rule indicates the next hop is on the same network as the host and can therefore be addressed directly Because the gateway column of the second rule indicates the same address as the host, or some other indicator such as "On-link"

11. Create a routing table for Router AB which has no default route, which supports communications to all hosts (directly or indirectly) on Network A, Network B, and Network C. A hint is that this routing table will contain three rules.

Network Destination	Netmask	Gateway	Interface	Metric
19.107.16.0	255.255.254.0	19.107.16.120 or "On-link"	Adapter AB2	
43.19.236.0	255.255.252.0	43.19.238.4 or "On-link"	Adapter AB1	
210.99.45.0	255.255.255.0	19.107.16.220	Adapter AB2	

Your assignment will be evaluated according to the following rubric..

	Grade	Qualities Demonstrated by the Assignment Submission	Grade Assigned
Content (70%) Measures the quality of the content in the assignment	A+ ➔ 100	The content demonstrates exceptional understanding of all relevant subject matter and its inter-relationships. All major relevant issues are thoroughly covered, and all content is very focused and on-topic. There is no known way to improve the content, and there are absolutely no technical or coverage errors present.	
	A ➔ 96	The content demonstrates exceptional understanding of all relevant subject matter and its inter-relationships. All major relevant issues are thoroughly covered, and all content is very focused and on-topic. At most one insignificant technical or coverage error may be present	
	A- ➔ 92	The content demonstrates deep understanding of all relevant subject matter and its inter-relationships. All major relevant issues are covered, and all content is on-topic.	
	B+ ➔ 88	The content demonstrates understanding of all relevant subject matter and its inter-relationships. Almost all major relevant issues are covered, and the content is at least reasonably on-topic.	
	B ➔ 85	The content demonstrates understanding of most relevant subject matter and its inter-relationships. Almost all major relevant issues are covered, and all content is at least reasonably on-topic.	
	B- ➔ 82	The content demonstrates moderate understanding of much relevant subject matter and its inter-relationships. There is reasonable coverage of major relevant issues, and the content is at least reasonably on-topic.	
	C+ ➔ 78	The content demonstrates some understanding of relevant subject matter and its inter-relationships. Some major relevant issues are covered, and at least some content is on-topic.	
	C ➔ 75	The content demonstrates understanding of a small portion of the relevant subject matter and its inter-relationships. Some major relevant issues are covered, and at least a small portion of the content is on-topic.	
	C- ➔ 72	The content demonstrates little understanding of and insight into the relevant subject matter and its inter-relationships. A small portion of the major relevant issues are covered. The focus of the content may be off topic or on insubstantial or secondary topics	

	D ➔ 67	The content demonstrates almost no understanding of or insight into the relevant subject matter and its inter-relationships. Almost none of the major relevant issues are covered, and the content may be almost entirely off-topic.	
	F ➔ 0	The content demonstrates no understanding of or insight into the relevant subject matter and its inter-relationships. No major relevant issues are covered, and the content is entirely off-topic.	
Exposition (30%) Measures how well the content is expressed	A+ ➔ 100	The presentation of all ideas and designs is exceptionally clear and persuasive; the entire submission is exceptionally organized. There is no known way to improve the clarity or organization of the submission.	
	A ➔ 96	The presentation of all ideas and designs is exceptionally clear and persuasive; the entire submission is exceptionally organized. There may be at most one insignificant way to improve the clarity or organization of the submission.	
	A- ➔ 92	The presentation of all ideas and designs is very clear and persuasive; the entire submission is very organized.	
	B+ ➔ 88	The presentation of all ideas and designs is clear and persuasive; the entire submission is organized.	
	B ➔ 85	The presentation of most ideas and designs is clear and persuasive; most of the submission is organized.	
	B- ➔ 82	The presentation of most ideas and designs is generally clear; most of the submission is reasonably organized.	
	C+ ➔ 78	Some parts of the submission are hard to understand; some parts are disorganized.	
	C ➔ 75	About half of the submission is hard to understand; about half is disorganized.	
	C- ➔ 72	Most parts of the submission are hard to understand; most parts are disorganized.	
	D ➔ 67	Almost all of the submission is hard to understand and disorganized.	
	F ➔ 0	The entire submission is hard to understand and disorganized.	
Overall Assignment Grade:			

Use the **Ask the Teaching Team** discussion board if you have any questions regarding how to approach this assignment.

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