CS3873: Final Review

Final Exam

- Schedule
  - https://es.unb.ca/apps/exam-schedule/?page=FR
  - Mar. 17, 2019, 9AM, Currie Centre
- Format
  - Two-hour, closed-book, calculator is allowed, no other electronics
  - 50% of overall marks
  - Cover all the materials of this course

Format

- Two parts (totally 50 points)
  - Part A: 20 multi-choice questions (10 points)
  - Part B: numerical and discussion questions (5 points each)
    - Best 8 among 9 questions of Part B are counted

References for Preparation

- Lecture slides
  - Posted at Desire2Learn
- Textbook
  - Check the sections related to the slides
- Assignments
  - Understand the corrections if you didn't get right answers
  - More self-testing questions in the problem set at the end of each chapter of the textbook

Topics

1. Network overview
2. Application layer
3. Transport layer
4. Network layer
5. Network security
6. Link layer

Topic 1: Network Overview

Topic 1: Network Overview (1)

- Computer network, distributed system, Internet
- What is the Internet?
  - End systems, communication links, and routers/switches
- Network architecture
  - End systems (network edge), access networks, network core
- Access options
  - Dial-up, DSL, coax cable, fibre optics (pros and cons)
  - Wireless access

Topic 1: Network Overview (2)

- Switching technologies in network core
  - Circuit switching vs. packet switching (pros and cons)
  - Throughput
  - Delay
- Layered architecture
  - Why layering?
  - Five-layer protocol stack
  - Peers and protocols

Topic 2: Network Applications

Topic 2: Network Applications (1)

- Client/server and peer-to-peer models
  - What are the advantages and disadvantages?
- C/S example: HTTP
  - How does the HTTP protocol work for Web service?
    - **`Request`** and **`Response`** messages
  - Non-Persistent vs. persistent HTTP connections
  - Conditional GET
- P2P example: File sharing
  - How does the distribution time differ in C/S and P2P architecture?
  - What are strengths of P2P applications?

Topic 2: Network Applications (2)

- DNS
  - Hierarchy of DNS servers
  - Name resolution with DNS: Iterative vs. Recursive
  - DNS records
  - DNS messages: Query vs. Response
  - Attacks to DNS

Topic 3: Transport Layer

Topic 3: Transport Protocols (1)

- Why is the transport layer needed?
  - End-to-end reliable and in-order delivery without duplicates
- UDP
  - Segment structure
  - UDP checksum algorithm
  - UDP socket: Identified by two-tuple

Topic 3: Transport Protocols (2)

- TCP
  - Segment structure
    - A few very important control fields:
      Seq#, ACK#, Receive Window Size, control bits ACK/SYN/FIN
  - TCP socket: Identified by four-tuple
- TCP connection management
  - Three-way handshake for connection
  - SYN flood attack and SYN cookies

Topic 3: Transport Protocols (3)

- TCP error/flow control
  - Flow control concepts
    - Stop-and-Wait: Low utilization
    - Pipelining, utilization, window size
  - TCP: Pipelined sliding window protocol
    - Cumulative ACK
    - How does TCP generate ACKs and deal with in-order, out-of-order, missing, and duplicate segments?
    - Fast retransmit

Topic 3: Transport Protocols (4)

- TCP congestion control
  - Flow control vs. congestion control
  - Philosophy: Take a loss event (timeout or tripe duplicate ACKs) as an indicator of congestion
  - Three phases:
    - Slow start → Exponentially increase CWND
    - Congestion avoidance →Additively increase CWND linearly
    - Congestion detection → Multiplicatively decrease CWND

Topic 4: Network Layer

Topic 4: Network Layer (1)

- Services provided by network layer
  - Store-and-forward packet switching
- IPv4 datagram
- IPv4 addressing
  - 32-bit IPv4 address, dotted-decimal notation
    - Split into subnet part and host part
  - Subnet mask
  - Network prefix: a.b.c.d/x: The x most significant bits constitute the subnet portion of IP address

Topic 4: Routing and IP (2)

- Allocation of IP addresses
  - How to allocate blocks of addresses to subnets based on requirements and specify network prefixes for subnets?
  - Dynamic host configuration protocol (DHCP)
    - Dynamically and automatically obtain its IP address from a network server when it connects to a network
  - Network address translation (NAT) with private address
    - How to configure NAT translation table for incoming and outgoing IP datagrams

Topic 4: Routing and IP (3)

- Forwarding
  - Forwarding table
  - Longest prefix matching and route aggregation
- Routing
  - Routing table → derive forwarding table
  - Routing algorithms
    - Distance vector algorithms
    - Link state algorithms

Topic 5: Network Security

Topic 5: Network Security (1)

- Security requirements
  - CIA triad: Confidentiality, integrity, availability
  - Kerckhoff's principle
- Private-key cryptography
  - Traditional ciphers: substitution, transposition
  - Modern ciphers: DES, 3DES, AES
- Public-key cryptography
  - RSA algorithms
    - Key generation, encryption, and decryption
  - Private-key cryptography vs. public-key cryptography

Topic 5: Network Security (2)

- Data integrity: Hash/message digest
  - Properties of hash function: One-way many-to-one function
  - Un-keyed or keyed hash (message authentication code)
- Digital signature
  - Sender authentication, data integrity, non-repudiation
- How to use public-key cipher for confidentiality, sender authentication, and digital signature

Topic 5: Network Security (3)

- Internet security protocols
  - Application-layer security: PGP
  - Transport-layer security: TLS/SSL
    - Website certificate
  - Network-layer security: IPsec
    - Application to VPN

Topic 6: Link Layer and LANs

Topic 5: Link Layer and LANs (1)

- Data link layer introduction
  - Link: wired, wireless
  - Where is the link layer implemented?
- Functions of data link layer
  - Different scope compared to transport layer
  - Framing, error control, flow control, medium access control

Topic 5: Link Layer and LANs (2)

- Error detection and correction
  - Parity check
  - Cyclic redundancy check (CRC)
- LANs
  - Ethernet: Ethernet frame, MAC address
  - Wi-Fi: Wi-Fi MAC protocol

Example Questions

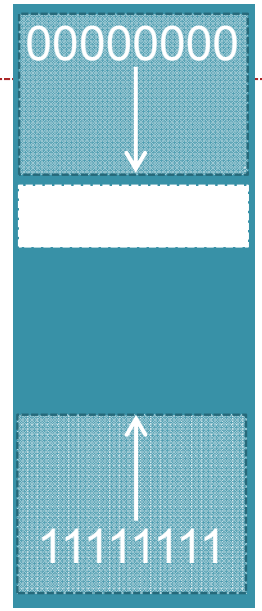
Example Question (1)

- Consider a router that interconnects three subnets: Subnet 1, Subnet 2, and Subnet 3. Suppose all of the interfaces in each of these three subnets are required to have the prefix 223.1.17.0/24.
- Also suppose that Subnet 1 is required to support up to 63 interfaces, Subnet 2 is to support up to 95 interfaces, and Subnet 3 is to support up to 16 interfaces. Provide three network prefixes (of the form a.b.c.d/x) that satisfy these constraints.

Example Question (1)

- Block with network prefix 223.1.17.0/24
  - Subnet 1: 63 interfaces → 64
  - Subnet 2: 95 interfaces → 128
  - Subnet 3: 16 interfaces → 16

} $208 < 2^8 = 256$



Subnet	Last byte of address	Network prefix	Address range
1	**00** 000000 – **00** 111111: 64 addr	223.1.17.0/26	223.1.17.0 -- 223.1.17.63
2	**1** 0000000 – **1** 1111111: 128 addr	223.1.17.128/25	223.1.17.128 --223.1.17.255
3	**0100** 0000 – **0100** 1111: 16 addr	223.1.17.64/28	223.1.17.64 -- 223.1.17.79
3	**0101** 0000 – **0101** 1111: 16 addr	223.1.17.80/28	223.1.17.80 -- 223.1.17.95
3	**0110** 0000 – **0110** 1111: 16 addr	223.1.17.96/28	223.1.17.96 -- 223.1.17.111
3	**0111** 0000 – **0111** 1111: 16 addr	223.1.17.112/28	223.1.17.112 -- 223.1.17.127

Example Question (2)

Consider a datagram network using 32-bit host addresses. Suppose a router has 4 links, numbered 0 to 3, and packets are to be forwarded to the link interfaces as follows:

Destination Address Range	Interface
11100000 **00**000000 00000000 00000000 **11100000** **00**111111 11111111 11111111	0
11100000 **01000000** 00000000 00000000 **11100000** **01000000** 11111111 11111111	1
11100000 **01**000001 00000000 00000000 **11100001** **01**111111 11111111 11111111	2
otherwise	3

Example Question (2)

Destination Address Range	Interface
11100000 00000000 00000000 00000000	0
11100000 00111111 11111111 11111111	
11100000 01000000 00000000 00000000	1
11100000 01000000 11111111 11111111	
11100000 01000001 00000000 00000000	2
11100001 01111111 11111111 11111111	
otherwise	3

224.0.0.0/10

224.64.0.0/16

224.0.0.0/8

225.0.0.0/9

Destination Address Range	Interface
11100000 00xxxxxx xxxxxxxx xxxxxxxx	0
11100000 01000000 xxxxxxxx xxxxxxxx	1
11100000 00000000 00000000 00000000	2
11100000 11111111 11111111 11111111	
11100001 00000000 00000000 00000000	2
11100001 01111111 11111111 11111111	
Otherwise	3

Example Question (2)

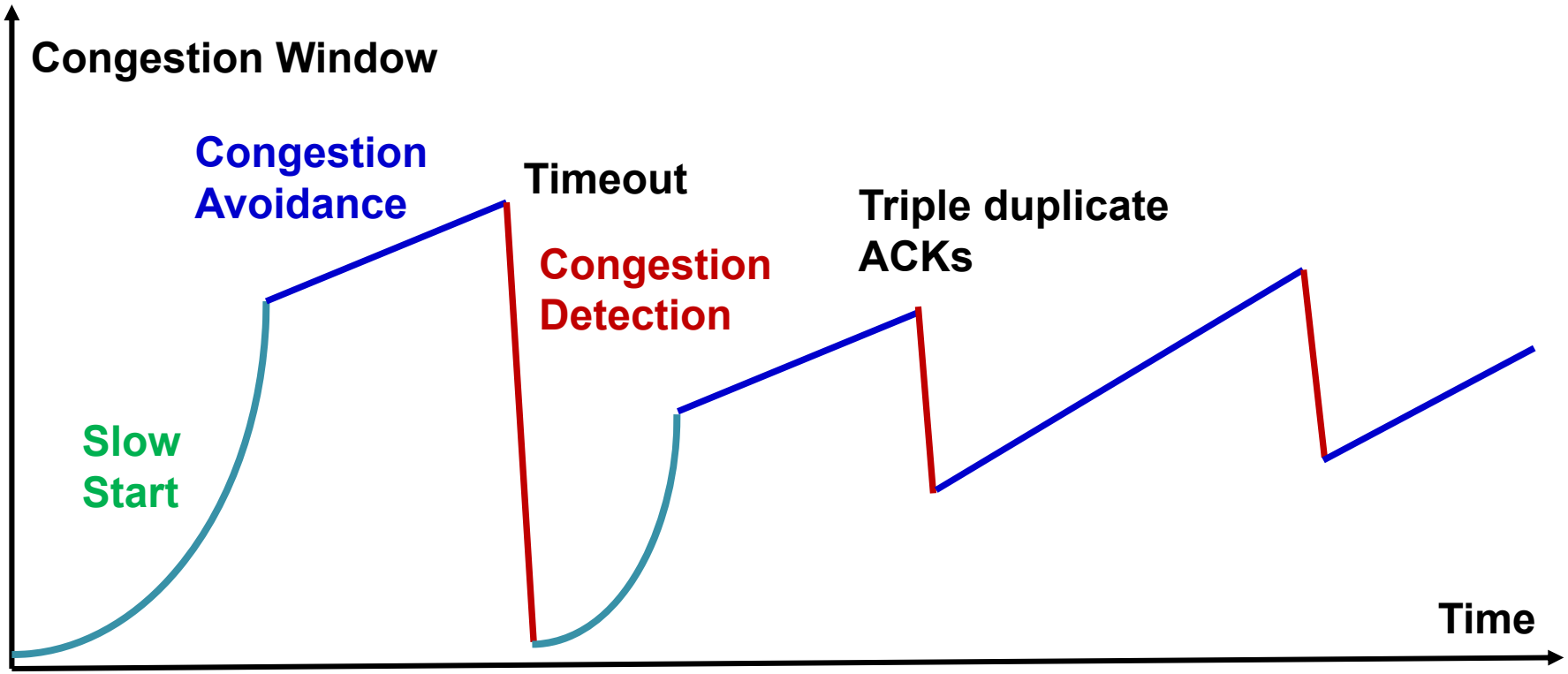
Determine interface for datagrams with destination addresses:

- 11001000 10010001 01010001 01010101 → Interface 3
- 11100001 00000000 11000011 00111100 → Interface 2
- 11100001 10000000 00010001 01110111 → Interface 3

Net Prefix	Destination Address Range	Intf
224.0.0.0/10	11100000 00xxxxxx xxxxxxxx xxxxxxxx	0
224.64.0.0/16	11100000 01000000 xxxxxxxx xxxxxxxx	1
224.0.0.0/8	11100000 xxxxxxxx xxxxxxxx xxxxxxxx	2
225.0.0.0/9	11100001 0xxxxxxx xxxxxxxx xxxxxxxx	2
Otherwise		3

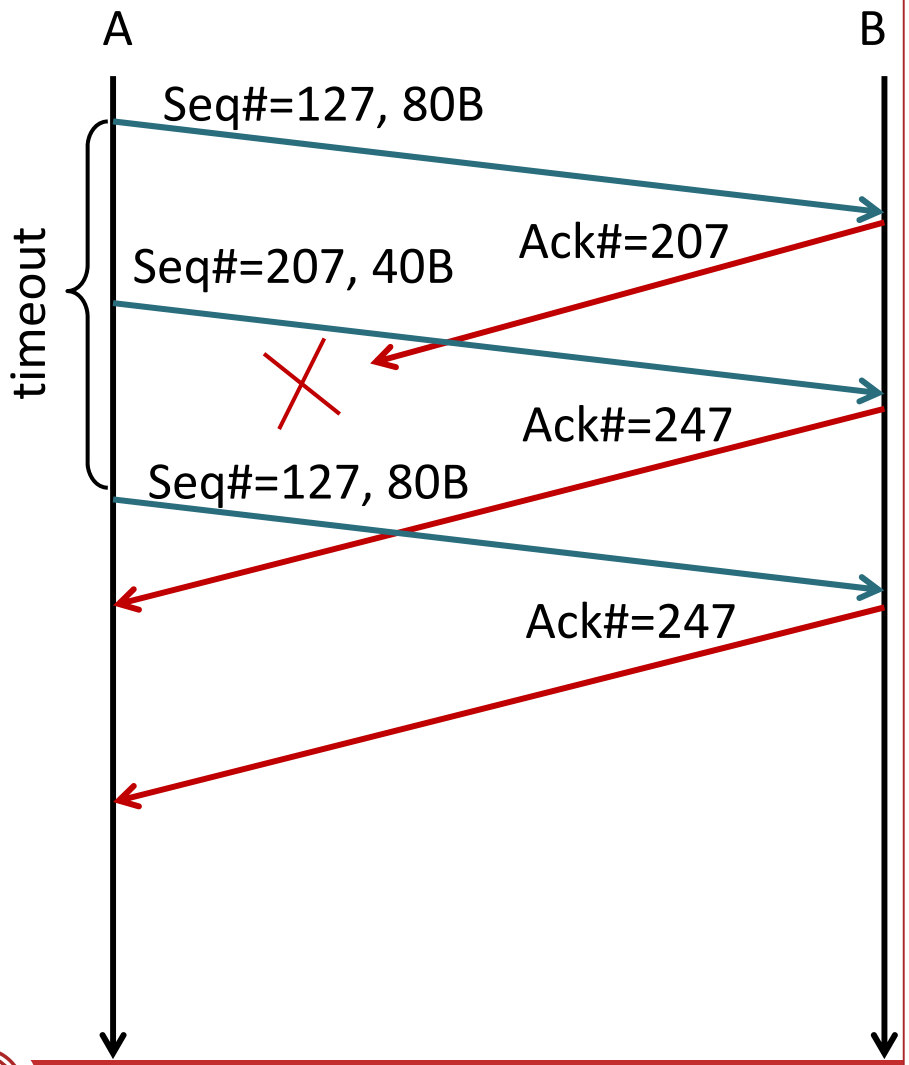
Example Question (3)

- Identify the three phases o TCP congestion control
  - Slow start, congestion avoidance, congestion detection



Example Question (4)

- A and B are communicating over a TCP connection, and B has already received from A all bytes up through byte 126.
- Suppose A then sends two segments to B back-to-back. The first and second segments contain 80 and 40 bytes of data, respectively. Host B sends an ACK whenever it receives a segment from A.
- Suppose the two segments sent by A arrive in order at B. The 1st ACK is lost and the 2nd ACK arrives after the 1st timeout interval.
- Then Host A retransmits accordingly. Suppose any retransmission is successful.
- Provide the missing sequence numbers and ACK numbers.



Good Luck!