CPSC 441
COMPUTER NETWORKS

FINAL EXAM SOLUTION

Department of Computer Science
University of Calgary

December 16, 2021

This is a CLOSED BOOK exam. Textbooks, notes, laptops, personal digital assistants, tablets, and cell phones are NOT allowed. However, **calculators are permitted**.

It is a two-hour exam, with a total of 80 marks. There are 25 questions, and 9 pages (including this cover page). Please read each question carefully, and write your answers legibly in the space provided. You may do the questions in any order you wish, but please USE YOUR TIME WISELY.

When you are finished, please hand in your exam paper and sign out. Good luck!

Student Name: _____

Score: _____ / 80 = _____ %

Optional Privacy Fold Here

Student ID: _____

True or False

Circle either **True** or **False** for each of the following 10 questions, for a total of 10 marks.

1 1. An input port on a router performs the physical layer function of line termination.

TRUE False

1 2. One weakness in Link State (LS) routing algorithms is the "count-to-infinity" problem.

True FALSE

1 3. Every datalink layer protocol requires a MAC channel access protocol.

True FALSE

1 4. One new feature supported in IPv6, but not IPv4, is IP fragmentation.

True FALSE

1 5. BGP is the "glue" that holds Internet routing together.

TRUE False

1 6. An Ethernet switch is a link-layer (layer 2) device.

TRUE False

1 7. Cyclic Redundancy Check (CRC) is a powerful error correction code.

True FALSE

1 8. The link-layer service model in IEEE 802.11 WLANs is connectionless and unACKed.

True FALSE

1 9. DHCP is an application-layer protocol.

TRUE False

1 10. Intra-AS routing is also known as Inter-Domain routing.

True FALSE

Multiple Choice

Choose the best answer for each of the following 8 questions, for a total of 8 marks.

1 11. The Internet Control Message Protocol (ICMP) is used by:

(a) Web and email applications

(b) FTP and email applications

(c) **ping and traceroute**

(d) DNS and ARP

(e) all of the above

1 12. Which one of the following IP addresses is a **private** IP address?

(a) **10.13.159.125**

(b) 172.186.11.21

(c) 244.244.244.244

(d) 11.189.11.21

(e) 192.166.125.221

1 13. The allocation of IP addresses on the Internet is managed by:

(a) **ICANN**

(b) IEEE

(c) IETF

(d) Internet Society

(e) Professor Williamson

1 14. The "tunneling" technique of IP-in-IP encapsulation can be used to support:

(a) mobile hosts who want to retain their IP-level identity while roaming

(b) sending IPv6 packets within a predominantly IPv4 network

(c) multicast datagram delivery in an application-layer overlay network

(d) **all of the above**

(e) none of the above

1 15. Which of the following algorithms was used in the Routing Information Protocol (RIP)?

(a) Dijkstra algorithm

(b) **Bellman–Ford algorithm**

(c) Prim's algorithm

(d) Floyd–Warshall algorithm

(e) Kruskal's algorithm

1 16. On the Internet, each Autonomous System (AS) communicates with other ASes using:

(a) IS-IS

(b) OSPF

(c) RIP

(d) **BGP**

(e) none of the above

1 17. In a classic bus-based Ethernet LAN, all the stations on a LAN segment share the same:

(a) IP address

(b) MAC address

(c) operating system

(d) **broadcast channel**

(e) network interface card

1 18. The MAC-layer retry mechanism in IEEE 802.3 Ethernet is known as:

(a) slow start

(b) congestion avoidance

(c) contention avoidance

(d) collision avoidance

(e) **none of the above**

Networking Concepts and Definitions

12 19. For each of the following pairs of technical terms, **define** each term, and **clarify** the key difference(s) between the two terms. Be clear and concise. If in doubt about your definition, feel free to supplement with a relevant example.

(a) (3 marks) "data plane" and "control plane"

```
DP: deals with forwarding                CP: deals with routing
Choose which outgoing link to use        Choose end-to-end path to dest host
Simple fast hardware lookup              Software computation (routing algorithm)
Nanoseconds to microseconds              Seconds to minutes time scale
```

(b) (3 marks) "IPv4 address" and "MAC Address"

```
IP: network layer address                MAC: datalink layer address
32 bits; network ID and host ID          48 bits; flat address space
Dotted decimal notation                  Hexadecimal notation
Locally unique                           Globally unique
Set via software                         Set via hardware
```

(c) (3 marks) "DHCP" and "NAT"

```
DHCP: for leasing an IP for a while      NAT: translates internal/external IP
AL protocol that uses UDP                NL info plus TL info (middlebox)
Common in WLAN environments              Common in home Internet (firewall)
Discovery and request steps              Rewrites packet headers in/out
```

(d) (3 marks) "destination-based forwarding" and "generalized forwarding"

```
Dest: traditional Internet routing       Gen: SDN-based approach to routing
Only look at dest IP address             Look at any fields of header
Only action is to forward on a link      Many possible actions to use
```

IP Subnets, Forwarding, and Routing

5 20. Recall that hosts in the same **subnet** can communicate directly with each other without traversing any routers. The table below shows examples of source IP addresses, destination IP addresses, and subnet masks. On each row, which pairs of source and destination IPv4 addresses are in the **same subnet**? Circle either Yes or No. (1 mark each)

Source	**Destination**	**Netmask**	**Same Subnet?**
171.64.1.65	171.19.201.2	255.0.0.0	YES / No
10.0.1.4	10.0.1.5	255.255.255.0	YES / No
171.313.15.133	171.313.15.5	255.255.255.224	Yes / NO
128.34.1.15	128.35.1.15	255.255.0.0	Yes / NO
10.0.1.4	10.0.1.5	255.255.255.192	YES / No

5 21. Given the forwarding table on the left, over which outgoing link would a traditional router using longest-prefix-match send the IP datagrams A, B, C, D, and E, with destination IPv4 addresses as indicated below? (1 mark each)

Forwarding Table	
CIDR Prefix	**Link**
18.0.0.0/8	5
55.128.0.0/10	6
63.19.5.0/28	3
171.0.0.0/8	2
171.0.0.0/10	4
171.0.15.0/24	7
0.0.0.0/0 (default)	1

Router's Forwarding Decisions	
IP Destination Address	**Outgoing Link**
A. 63.19.5.3	3
B. 171.15.15.0	4
C. 63.19.5.32	1
D. 44.199.230.1	1
E. 171.128.16.0	2

8 22. In class, we discussed three different network-layer routing protocols used on the Internet, namely RIP (Routing Information Protocol), OSPF (Open Shortest Path First), and BGP (Border Gateway Protocol). Pick **any two** of these three routing protocols, and **compare and contrast** them. Make sure to identify their role, what they do and how, as well as similarities/differences in functionality and/or implementation details. (4 marks each x 2)

RIP	OSPF	BGP
Intra-AS	Intra-AS	Inter-AS
Distance vector	Link state	Path vector
Hops only	Link weights	AS hops
Small flat AS	Large hierarchical AS	Between ASes
Single best path	Multiple best paths	Policy > performance
UDP	IP	TCP

Medium Access Control Protocols

12 23. For each of the following MAC-layer protocols, write a clear, concise synopsis of how the protocol operates. Also indicate in what type of network environment it is used (if any).

(a) (4 marks) Pure ALOHA

```
Random access MAC protocol; packet radio network (Abramson, U.Hawaii)
When a station has a frame to send, just send it!
If a collision occurs, then wait a random time and try again.
Effective at low load; low channel access delay
Many collisions at high load; max success = 1/2e = 18%
```

(b) (4 marks) CSMA/CA

```
Random access MAC protocol; used in IEEE 802.11 WLANs
When a station has a frame to send, listen to the channel.
If busy, then defer, else transmit.
If a collision occurs, then wait a random time and try again.
CA: Collision Avoidance; stations use NAV to stay off channel.
Can also use RTS/CTS to solve the hidden node problem.
```

(c) (4 marks) Token Ring

```
Turn-taking protocol; used in IBM networks in 1980's
LAN has fiber loop connecting through all stations.
Single token circulaton on LAN.
If a station has a frame to send, then wait for token, grab, send.
Return token when done. Collision-free protocol.
```

Home Networking

8 24. Suppose that you have just graduated from your degree program, and are starting your first real job ($$$), possibly in a new city, with a new house or apartment there.

Using the knowledge that you have gained in CPSC 441 this semester, describe the choices that you would make about the specific technologies (e.g., hardware, software, networking gear) that you would use in setting up your new home network. Give **four specific examples** (2 marks each) of technologies that you would consider, whether you would use them or not, and why. If in doubt about your choices, think about your current home network environment, and what you might want to do differently next time to make it newer, better, and easier to use. State any relevant assumptions that you make (e.g., roommates, family members, devices, gaming, telecommuting, IoT, ISP, availability, cost).

```
Many possible answers here; most students got full marks. Examples below:

1. ISP: choose one with high data rate, low monthly fee, unlimited data,
and no policy restrictions on content (e.g., Netflix, BitTorrent, gaming)

2. Wireless vs wired: choose wireless for easy mobility and access from
any room in the house, but perhaps a wired desktop for critical work stuff.

3. NAT: multiple in-home devices share single public IP; use middlebox as
a firewall to protect internal home network from external attacks

4. DHCP: easy to add new devices or have guests using WiFi

5. Proxy: to regulate Web browsing; limit kids access to undesirable content

6. Streaming: Netflix, Crave, Disney, Amazon Prime, etc, with CDN support

7. VoIP: Internet telephony rather than landline phone service

8. Gaming: high-end computer and graphics support for gaming

9. FTTH: fiber to the home (yay!)

10. Web cam for Zoom online meetings.
```

Internet and Society

12 25. During the global COVID-19 pandemic, the Internet has been both a **blessing** (i.e., beneficial) and a **curse** (i.e., detrimental) to modern society.

(a) (6 marks) Give **at least 3 examples** (and at most 5 examples) of how the Internet has been a good thing during the pandemic. Explain and justify each.

```
Global sharing of knowledge and best practices for health and safety
(e.g., pandemic regulations, medical stats, travel advisories, etc)

Remote work and learning from home via Zoom or Teams or Meet
(not the best, but better than nothing)

Online social networks for maintaining contact with family/friends

Entertainment: gaming, streaming, music to do while isolated

Virtual conferences for research and education (cheap, global)

Online services: food, shopping, e-government, etc
```

(b) (4 marks) Give **at least 2 examples** (and at most 3 examples) of how the Internet has been a bad thing during the pandemic. Explain and justify each.

```
Misinformation: fake news, vax hoax, etc

Malware: increasing number and severity of attacks on home/corporate nets

Mental health: isolation, stress, anxiety, depression, doom scrolling, etc

Unhealthy lifestyles; urban/rural divide; cyber-bullying; social isolation
```

(c) (2 marks) If you could travel back to pre-pandemic times, and change **one network-related item** to make things better now, what would it be, and why?

```
Many ideas here: screen time limits; govt Web sites; better security;
ubiquitous high-speed Internet (including rural); home office upgrade;
neutrality; censorship; unbiased OSN algorithms; new e-businesses, etc
```

*** THE END ***