CPSC 441
COMPUTER COMMUNICATIONS

FINAL EXAM SOLUTION

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

It is a 120 minute exam, with a total of 80 marks. There are 18 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: _____

Student ID: _____

Score: _____ / 80 = _____ %

Multiple Choice

Choose the best answer for each of the following 12 questions, for a total of 12 marks.

1 1. The "big three" network applications in the early days of the Internet were:

(a) remote login, file transfer, and electronic mail

(b) remote login, file transfer, and network news

(c) remote login, file transfer, and World Wide Web

(d) remote login, file transfer, and BitTorrent

(e) none of the above

1 2. The two key algorithms in TCP congestion control are:

(a) slow start and fast retransmit

(b) slow start and fast recovery

(c) slow start and dynamic RTT estimation

(d) slow start and congestion avoidance

(e) none of the above

1 3. Why is "bufferbloat" such a big problem for TCP on the Internet?

(a) It creates large queues, which inflate RTT and reduce TCP throughput.

(b) It delays the feedback that TCP needs in order to adjust its behaviour.

(c) It defers, but does not solve, the congestion problem.

(d) TCP's congestion control algorithm can only "learn" by losing packets.

(e) all of the above

1 4. The Internet Control Message Protocol (ICMP) provides:

(a) end-to-end flow control

(b) end-to-end congestion control

(c) a means to diagnose and report network-related errors

(d) a viable alternative to TCP

(e) none of the above

1 5. Asynchronous Transfer Mode (ATM) is an example of:

(a) a datagram network service model with fixed-size packets

(b) a datagram network service model with variable-size packets

(c) a virtual circuit network service model with fixed-size packets

(d) a virtual circuit network service model with variable-size packets

(e) none of the above

1 6. Some of the key improvements in IPv6 compared to IPv4 are:

(a) streamlined header for simplified datagram processing

(b) removing IP fragmentation entirely

(c) significantly expanded IP address space

(d) better support for quality of service (QoS), mobility, and security

(e) all of the above

1 7. The datalink layer service model offered by IEEE 802.3 Ethernet is:

(a) connection-less unacknowledged

(b) connection-less acknowledged

(c) connection-oriented unacknowledged

(d) connection-oriented acknowledged

(e) all of the above

1 8. The datalink layer service model offered by IEEE 802.11 WiFi is:

(a) connection-less unacknowledged

(b) connection-less acknowledged

(c) connection-oriented unacknowledged

(d) connection-oriented acknowledged

(e) all of the above

1 9. Within the data link layer, the two sub-layers from top to bottom are:

(a) UDP and TCP

(b) TCP and IP

(c) IP and TCP

(d) Logical Link Control and Medium Access Control

(e) Medium Access Control and Logical Link Control

1 10. The minimum legal frame size on a classic Ethernet LAN is:

(a) 64 bytes

(b) 1000 bytes

(c) 1024 bytes

(d) 1500 bytes

(e) none of the above

1 11. The typical MTU (Maximum Transmission Unit) size for IP on an Ethernet LAN is:

(a) 64 bytes

(b) 1000 bytes

(c) 1024 bytes

(d) 1500 bytes

(e) none of the above

1 12. Wireless ad hoc networks differ from typical IEEE 802.11 WiFi usage in that:

(a) there is no external Internet required

(b) there is no need for wireless Access Points

(c) the wireless nodes use each other as intermediate routers as required

(d) it uses an extra address field in the IEEE 802.11 header

(e) all of the above

Protocol Stack Operations

12 13. Imagine a scenario in which you bring your wireless laptop to MacEwan Hall, and are checking your CPSC 441 grades in D2L while you have lunch there. This seemingly simple activity triggers a number of events reflecting different aspects of the Internet protocol stack. Among the rather mixed up set of events listed below, use consecutive small integers from 1 (first) to 12 (last) to **indicate the relative order** in which these events would occur.

_10_ Your laptop terminates its TCP connection with the D2L server.
__6_ Your laptop uses DNS to determine the IP address of the D2L server.
__2_ You open up your laptop, turn it on, and launch a Web browser.
__9_ Your laptop issues an HTTP request to the D2L server for the CPSC 441 page.
__4_ You provide CAS your user credentials to authenticate to the AirUC WLAN.
__5_ Your laptop uses DHCP to acquire a valid IP address from the DHCP server.
__1_ The manufacturer assigns the MAC address for the wireless NIC in your laptop.
__7_ Your laptop initiates a TCP connection to the D2L server.
_12_ You do your "happy dance", close your browser, and shut off your laptop.
__8_ You provide your user credentials and password to authenticate to D2L.
__3_ Your laptop associates with a nearby AP for the AirUC WLAN.
_11_ You view your CPSC 441 grades in D2L using your Web browser.

Here are some of the relevant acronyms for the question above, just in case you need them:

- AP (Access Point)
- CAS (Central Authentication Service)
- D2L (Desire to Learn)
- DHCP (Dynamic Host Configuration Protocol)
- DNS (Domain Name Service)
- HTTP (Hyper-Text Transfer Protocol)
- IP (Internet Protocol)
- MAC (Medium Access Control)
- NIC (Network Interface Card)
- TCP (Transmission Control Protocol)
- UDP (User Datagram Protocol)
- WLAN (Wireless Local Area Network)

Networking Concepts and Definitions

12 14. For each of the following pairs of terms, **explain each term**, making sure to identify the similarities (if any) and the **key differences** between the two terms.

(a) (3 marks) "Internet checksum" and "Cyclic Redundancy Code (CRC)"

```
These are both error detection mechanisms to ensure data integrity.
IC: covers part of IP header (NL),   CRC: used in many DLL protocols,
as well as TCP/UDP data (TL).        such as Ethernet and WiFi.
16-bit modulo 2 arithmetic.          Typically 32-bit, sent as trailer.
Done in software. Very weak.         Done in hardware. Very powerful.
```

(b) (3 marks) "subnet" and "Autonomous System (AS)"

```
SN: set of hosts that can communicate   AS: a logical subset of the
directly with each other without        Internet routers under the control
having to traverse a router.            of a single organization.
All have same network ID (prefix)       Has an AS number. Does intra-AS
in the IPv4 address structure.          routing inside, plus inter-AS routing.
```

(c) (3 marks) "DNS (Domain Name Service)" and "ARP (Address Resolution Protocol)"

```
Both are special protocols to support Internet "infrastructure".
DNS: application-layer protocol.       ARP: protocol to support DLL delivery.
Uses UDP (or TCP) on port 53.          Does queries using MAC broadcast.
Maps domain name to IP address.        Maps IP address to MAC address.
```

(d) (3 marks) "twisted pair" and "optical fiber"

```
Both are physical layer transmission technologies used in networks.
TP: two strands of copper wire,      fiber: ultra-thin, refined glass.
twisted around each other.           Light pulses. Total internal reflection.
Used in access networks.             Used in long-haul networks.
Limited bandwidth and distance.      Immense bandwidth, long distance.
```

Medium Access Control (MAC) Protocols

12 15. Within the Data Link Layer, we studied a variety of Medium Access Control (MAC) protocols to regulate access to a broadcast channel shared by many stations. For each of the MAC protocols listed below, give a brief description of the protocol, and summarize the key strengths and weaknesses of the protocol relative to the other MAC protocols listed here.

(a) (3 marks) TDMA (Time Division Multiple Access)

```
Static channel allocation among N stations. All of channel, part of time.
Time slot for each station in turn (e.g., round robin).
Perfect if every station always has data to send (else wastes empty slots).
Collision free, but have to wait for your turn to send.
```

(b) (3 marks) Pure Aloha

```
Random channel access protocol.
Good for large number of stations with bursty and unpredictable traffic.
Very low channel access delay. Works best at light load. Prone to collisions.
Max achievable successful transmissions is about 18%.
```

(c) (3 marks) Persistent CSMA (Carrier Sense Multiple Access)

```
Listen to the channel before transmitting. Look before you leap!
Requires carrier sense capability. Reduces number of collisions.
Successful utilization well over 50%.
Still has collisions, which can waste entire frames.
```

(d) (3 marks) CSMA/CD (CSMA with Collision Detection)

```
Used in classic Ethernet LANs.
Has collision detection capability.
When collision occurs, abort transmission of current frame.
Can achieve successful utilization of over 90%.
```

Routing Protocols

12 16. The current Internet uses several different routing protocols at the Network Layer to deliver IP datagrams from a source host to a destination host. Three of these that we discussed in class are RIP, OSPF, and BGP. **Compare and contrast** these three protocols, based on their design, roles, properties, scalability, or implementation details. Point form is sufficient, but please give **at least 4 relevant points** for each routing protocol.

RIP (Routing Information Protocol)	OSPF (Open Shortest Path First)	BGP (Border Gateway Protocol)
Distance Vector (DV)	Link State (LS)	Hybrid (DV+LS)
Intra-AS	Intra-AS	Inter-AS
Hop based	Settable metrics	AS hops
Flat AS	Hierarchical AS	Policy-based
Simple	Complicated	Very complicated
Single path	Multipath	Path vector
routed (AL, UDP)	Uses IP	Uses TCP
RFC 1058	RFC 2328	RFC 4271

Networking Trends

10 17. One of the words that came up several times during the semester was "middlebox". In fact, we encountered this term 3 or 4 times, at different layers of the protocol stack.

(a) (4 marks) What is a "middlebox"? Give two examples of middlebox devices that we encountered, and indicate the layer(s) of the protocol stack where they are involved.

```
defn: an intermediate device that is neither an end system nor a router.
Has partial protocol stack. Performs some special network function.
Example 1: NAT for Network Address Translation
Example 2: CDN for accelerating content delivery
Example 3: Web proxy for caching content or restricting access
Example 4: HA/FA for supporting Mobile IP
```

(b) (3 marks) Why are middleboxes a **good** thing to have in a network? Give an example to help make your point clearly.

```
Improves functionality and/or performance of the network.
Example 1: NAT protects home network, and economizes on IP addresses.
Example 2: Web proxy cache or CDN provides faster access to popular content
```

(c) (3 marks) Why are middleboxes a **bad** thing to have in a network? Give an example to help make your point clearly.

```
Violates layered model of protocol stack.
Breaks the rules or assumptions behind protocol operation.
Example 1: NAT messes with NL and TL information.
Example 2: traffic shaper alters TCP flow/congestion control behaviour
```

Internet of Things

10 18. One of the growing trends in networking is towards the "Internet of Things", which refers to an era in which a vast multitude of devices are interconnected, accessed, controlled, and operated via Internet-like protocols. In the *Warriors of the Net* video in January, one example of these devices was a refrigerator. In a recent TV commercial by Cisco, it includes not only refrigerators, but homes, cars, wind turbines, farms, retail outlets, and more. In short, the "Internet of Things" could be transformative for our future as humankind.

(a) (3 marks) What does the "Internet of Things" mean to you? Specifically, what are some of the exciting **opportunities** that you foresee as ways for Internet technology to improve quality of life for you or others?

```
Many possible answers here. All acceptable if well articulated/justified.
Example follows:
Everything is connected. A wealth of information available at your
fingertips, from anywhere at any time. Smart highways, with weather
conditions, speed warnings, accident reports, emergency dispatch...
```

(b) (3 marks) What are some of the key **challenges** (e.g., technological, philosophical, economic, societal, legal) associated with the "Internet of Things"?

```
Many possible answers here. All acceptable if well articulated/justified.
Example follows:
Scalability of protocols (e.g., IPv4 address space versus IPv6).
Wireless spectrum use.
Privacy and security issues (the "Big Brother" effect)
Growing dependence on Internet as critical infrastructure.
```

(c) (4 marks) If you were to design and build a new "network app" for the "Internet of Things", what would it do, and how would you build it? Specifically, what services would it offer, what protocols would it use, and why? (And no, I am not planning to steal your idea!)

```
Many possible answers here. All acceptable if well articulated/justified.
Example follows:
Home security monitoring. Watch your pets. Watch your kids. Check on
your babysitter. Keep in touch while traveling.
Needs UDP (streaming) and TCP (reliable data delivery).
Needs lots of Web cams, remote access, authentication, and more...
```

*** THE END ***