49202 Communication Protocols

Summary and Final Theory Exam

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The complete TCP/IP stack

- The nature of the Internet: a distributed, hierarchical network of networks
- The purpose of the 5 layers of the stack:
  - Application (layer 5);
  - Transport (Layer 4);
  - Network (Layer 3);
  - Data link (Layer 2); and
  - Physical (Layer 1).
- **Encapsulation** and **decapsulation**

Layer 5: the application layer

- Defining application requirements - loss-sensitive vs. delay-sensitive / real-time applications
- Application architectures - client-server, peer-to-peer
- Connection-oriented vs. connectionless applications
- Glue/infrastructure applications - DNS, authentication, VPNs etc.
- System calls, sockets - a file-like interface for networking
- Server-side and client-side functions and behaviour

The application layer

- Calculating the efficiency or overhead of an application layer protocol - if asked to do this, the question will be as specific as possible:
  - *Expressed as a fraction of XXX* - e.g. of the total layer 2 frame size
  - Calculate the
    - Efficiency - what fraction (as a percentage) of the total is useful payload?
    - Overhead - what fraction (as a percentage) of the total is headers?

The application layer

- Example: an Ethernet frame carrying HTTP traffic over TCP/IP (IPv4) has a Layer 2 header size of 26 bytes, Layer 3 header size of 20 bytes and Layer 4 header size of 20 bytes. If the http packet is 1200 bytes long, what is the efficiency of the transmission expressed as a percentage of the total frame size (to the nearest 1%)?
- Answer: $\eta = 1200/(1200 + 20 + 20 + 26) * \times 100\% = 95\%$
- The overhead in this case would be 5%.
- You may need to calculate one of the header sizes given the other header sizes, overall efficiency (or overhead) and the payload size - in this case you would need to rearrange the efficiency formula to solve for the unknown header size

Layer 4: the transport layer

- Provides a range of services to applications, including
  - Application multiplexing/demultiplexing (getting data to the right application)
  - Error control, flow control, congestion control (some or all of which are optional...)
- TCP and UDP service loss-sensitive and delay-sensitive applications, respectively - both may be used for different types of data in the one application
- The address at Layer 4 is known as a **port**

Layer 4: the transport layer

- TCP provides reliable data transfer
- It includes mechanisms for
  - **Connection management**, including connection establishment, maintenance and teardown
  - **Error control**, including error or loss detection, and retransmission of lost/damaged segments
  - **Flow control**, to avoid overwhelming the receiver, by telling the sender how much capacity there is to store received data
  - **Congestion control**, to avoid overwhelming the network, by adaptively controlling the rate at which data is being sent over the network
- Make sure you understand the TCP state machine!

Layer 4: the transport layer

- How does TCP estimate a sensible value for segment timeouts?
- How does TCP congestion control work - how does it respond to lost packets?
- Additive increase / multiplicative decrease, fairness
- Slow start and transition to AIMD
- Additional improvements such as fast retransmit and recovery
- UDP and its interaction with TCP
- Interactions between TCP and underlying data link layer - what would be the effect of non-congestion packet loss? Why do Layer 2 protocols in lossy environments try so hard to avoid this?

Layer 4: the transport layer

- TCP timing calculations - timing of connection establishment, slow start, steady-state and connection termination phases; insertion time and propagation time
- TCP state machine - state transitions during various phases of operation
- CongestionWindow and AdvertisedWindow

Layer 3: the network layer - internetworking, routing

- Internetworking - getting datagrams from a host in one network to a host in another via intermediate networks
- Routing decisions - where are they made? **NOT by the sender** - rather, hop-by-hop using only **destination address** and **routing table** (list of destination prefixes and netmasks)
- Purpose of TTL field - avoiding routing loops
- IP addressing - **NOT EXAMINABLE** in the final exam. You should still know how it works, so don't skip this part when studying!
- What changes with every hop? (MAC addresses; a new frame is constructed for every hop)
- What stays the same? (IP source / destination address, EXCEPT if we are using NAT)

Layer 3: the network layer

- Fragmentation and reassembly, MTU path discovery
- ICMP - conveying error messages for control and management
- Private IP addressing and network address translation (yes this is examinable...)
- DHCP - automatic distribution of IP addresses (and other information) in an IP network
- IPv6

The network layer - routing protocols

- How do we populate the routing tables in our routers?
- Static routing - useful in simple networks, but inflexible, prone to mistakes, no automatic repair
- Distance vector routing - routing by rumour - periodic updates, indirect knowledge of network topology - slow convergence
- Bellman-Ford algorithm (only briefly discussed)
- Link state routing - routing by explicit knowledge - event-driven updates, direct knowledge of entire network topology - fast convergence
- Dijkstra's algorithm

The network layer - routing protocols

- Autonomous systems, interior vs. exterior routing protocols
- OSPF - a link state interior routing protocols
- BGP - a largely policy-driven, path (distance) vector exterior routing protocol
- iBGP, eBPG - BGP import/export policies & interaction with OSPF

Layers 2 and 1: The data link and physical layers

- L2: Framing, host addressing within a single network, error detection/control - adds metadata to L3 payload and formats into bit sequence for transmission over L1
- L1: transmits a bit sequence using symbols carried via a physical property of the medium - e.g. electrical voltage or current, optical pulses, radio pulses
- L2 and L1 are closely connected together and usually defined in pairs (e.g. Ethernet; WiFi; Bluetooth; many others)
- L2: critical features of the frame - optional features needed for some media
  - Preamble - synchronisation of receiver
  - Addressing - MAC addresses, and how to discover which MAC address is associated with IP addresses via Address Resolution Protocol (ARP)
  - Broadcast addresses
  - Frame check sequence - error detection (and in some L2 protocols, retransmission)

Layers 2 and 1: The data link and physical layers

- Medium access control - arbitrating between multiple hosts connected to a shared medium
- Collision domains vs. broadcast domains:
  - Collision domains are separated by switches (each port on a switch is a separate collision domain) - collisions may occur with shared media such as Ethernet hubs (very old technology) or WiFi networks
  - Broadcast domains are separated by routers - a broadcast will reach every host in a single Layer 2 network, but no further
- Example Layer2/Layer1 protocols:
  - Ethernet
    - Cut-through vs. store-and-forward switches
    - Learning port/MAC association
  - WiFi (802.11)

Local/onshore students: final exam format and structure

- Students who are physically in Sydney **MUST** attend in person unless you have already explained to me why this is not possible (medical reasons only)
- Students who are in Sydney but who have enrolled in the online lab option (because the class was flagged as full) should attend the exam during one of the exam periods (9:00 AM is better as there will probably be more capacity).
- It will be a **supervised online exam** with **restricted open book** conditions
- Similar format to previous quizzes - runs on Canvas
- Two hours; approximately 60 questions covering ALL material **except for IP addressing calculations**
- Mix of multiple-choice, match correct answer, identify true or false statements etc. plus some calculations
- **NO IP ADDRESSING CALCULATIONS**. You've all done enough of those!

Local/onshore students: exam conditions and permitted materials

- The exam is **restricted open book**
- You may bring into the exam the following materials:
  - No more than **TWO A4 sheets of paper** with whatever you want written or typed on both sides of each sheet.
  - **Your own device (laptop/tablet)** for taking the test - you can use one of the lab machines if you want but it is safest to use your own machine
  - **Translation dictionary** if needed.
  - **Calculator** (you MAY use a **calculator application** if you want)
- You must only have **ONE** browser window open and only **ONE** tab open in that window (to Canvas). Please ensure that all other windows/tabs are closed before you start.
- **Translation browser plugins/extensions** ARE permitted, but please let me know BEFOREHAND which one you plan to use if you will be using one.

Local/onshore students: exam conditions and permitted materials

- During the exam, your laptop may be inspected by myself or one of my teaching assistants
- **Anyone in possession of prohibited materials, or with unauthorised extra browser tabs open, will be asked to leave immediately and their exam will be submitted as-is**
- If you think there is a mistake with any question, either **ask one of the exam supervisors** or make a note of the question and **email me after the exam**. I will check - but please still answer the question as best you can.
- Remember - for multiple choice questions, select the **best** answer.

Remote/offshore students: Zoom interview schedule

- This option is **ONLY** for students who are not physically in Sydney OR who are medically unable to be present for an in-person exam
- I'm planning to do the Zoom interviews on either Friday this week or Monday next week
- Please add your name to the spreadsheet in the Files section of the 49202 Team (see link in the General discussion section)
- If we run out of slots I can schedule some for Tuesday or Wednesday but only once Friday and Monday are full
- If the timezone is not convenient for you please advise and I'll work out a better time

Remote/offshore students: Zoom interview format

- Treat the interview like a job application - prepare for it seriously!
- It will run for about 20 minutes
- Expect questions covering all layers of the TCP/IP protocol stack. You will need to explain certain concepts, protocols, why is XYZ done this way etc.
- No calculations as such but you may need to explain **how you would calculate** something (that is, I want to see if you understand the method)
- Depending on your responses, we may explore some topics in more depth
- While you may refer to your notes or other materials during the test, if you have to look things up on the Internet during the interview, your score will be very low (again: how would this look to a potential employer?)

For all students

- Good luck and don't stress - it is only an exam.
- There will be **no surprises**. My aim is to evaluate how much you have learned, as fairly as possible.