BUS 175 Networking Basics Course Guide

Hi everyone. I have decided to make a tutorial for the students in BUS 175 with Professor Satpathy to offer supplemental information to the terms and concepts you may not understand immediately in class. This course is very very technical and you may have trouble understanding Dr. Satpathy every once in a while when he goes on a tangent about how whatever is on his mind that day. I hope this guide will offer you a basic and simple understanding of the topic. I'll try to explain it the best I can in layman terms but please do understand that I am not an expert in this field. Just trying to help out ya know?

Let's get started.

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The Fundamentals

In networking there are a few things you need to absolutely know before we continue.

1. All networks deal with computers. It doesn't matter if it's Mac, Windows, Linux, iPhone, etc. It needs computers.

2. Networks are created through connecting one computer to another. This can be done with and without internet or Wi-Fi or just by connecting a cable from one computer to another.
3. The internet is not just Google Chrome and the webpages it loads. If you think that is the case, please drop the class since you probably won't get very far.

If you understand this so far, read on.

Client / Server Relationship

There are two types of computers that are in networks. There are clients (that's you) and there are servers (the webpage). Your computer and the webpage talk to each when requested. The talk is exchanged by **packets**. Packets are packaged **bits** of information that are encoded to transport over a network. They can't be sent all at once so the information on the webpages are sent bit by bit. Same concept goes for the return of information requested from the webpage (the server).

Database Servers

Most of the time servers are going to be computers where databases are held. You can access the databases with a DBMS – database management systems. You can create, modify, and delete information, also known as records, in the system. Some DBMS's are MySQL, Microsoft Access, & Oracle. There are more but those are the more popular ones.

Data Center

A center where databases and/or servers are held. It can be on-site, offsite, in any size room across multiple floors or buildings.

Different Types of Networks (Infrastructure)

1. Personal Area Network (PAN)
   a. Your iWatch to your iPhone to your iMac to you iRack...oops.
2. Small Office Home Office Network (SOHO)
   a. This is pretty much a LAN but generally with fewer than 10 computers connected.
3. Local Area Network (LAN)
   a. This network is local. This can include your computer, wired & Wi-Fi devices across many floors if need be. Typically connected together through 1 router. If not part of a WAN, the LAN connects directly to Internet Service Provider (ISP).

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4. Metropolitan Area Network (MAN)
   a. This practically encompasses a city or a specific geographic region. Usually corresponds with one area which is why when Charter has an outage at the apartments at UCR, everyone's pissed…though it doesn't always have to be Charter.
5. Wide Area Network (WAN)
   a. This network covers more than one LAN. This network can span across many buildings at UCR and is usually the direct contact to the MAN which is generally the ISP.
   b. Normally used with sharing information between departments. Ex – Info between FBI, CIA, NSA, Donald Trump…Russians……etc.

Types of Connectors

1. HUB
   a. Common connector between computer to computer. It usually copies the information (bits & packets) so it can be accessible to other computers on the same network. This is considered ancient hardware since there are newer connectors that do the job better.
2. Switch
   a. A switch is an upgraded hub where rather than just copies and makes info available, it also can forward information to a specific computer on a network. Think of the old days when telephone operators used to be the intermediary for phone calls. They would use a 'switchboard'. Same concept.
3. Router
   a. The big one for all connectors. A router is also known as an access point / gateway and this device connects to or more networks together. Ex: your LAN to your ISP (located in the MAN). This thing also sends, receives, and forwards information across networks. The difference between this and a switch and hub is that a router will use the TCP/IP protocol and encode the information and send it to its location. A router finds the best 'route' to take to get your information to you quickly. More advanced topic for later.

Internet Protocol

1. IP (Internet Protocol)
   a. Literally stands for Internet Protocol.
   b. Every computing device that can be connected to a network has an IP address. This address serves as the identity of your computer. Each IP address is unique and cannot be the same as another computer's. If you don't understand this, think of how every citizen in the U.S. has a social security number and it can't be the same as another person's. The IP address can also be used by servers to send the appropriate information to your computer and not someone else's.

2. IPv4 (Internet Protocol version 4)
   a. Internet Protocol version 4
   b. IPv4 gets its name by having 4 bytes of 8 bits. (1 byte = 8 bits). Add it all up, its 32 bits.
      i. Decimal notation goes 00000000.00000000.00000000.00000000 ← that's 32 0's for those that don't want to count them all.
      ii. The bytes are measured in 1's and 0's. You can actually calculate your IP address given the bytes.
      iii. You can have an example like 10101100.11000101.11111111.00000001.
         1. You can calculate what your IP is by knowing your times table. Starting from the last number all the way to the right (8th place from left), you multiple it by 1. The next number (7th place from the left), multiple that by 2. The next, (6th place), multiple that by 4. Then (5th place), x 8. And so on. Here's a chart.
         2.

Nth decimal from the left	Multiply that by
8th	x 1
7th	X 2
6th	X 4
5th	X 8
4th	X 16
3rd	X 32
2nd	X 64
1st	X 128

         3. After you multiply those 1's and 0's, add them all up (the non-zero numbers) to get your IP address.
         4. 10101100.11000101.11111111.00000001 = 172.197.255.1
            a. ^^ Currently that IP address traces to someplace in Sydney, Australia.
   c. This is the standard IP address that is used today, however there is more devices connected to the internet now than ever before. They're running out of permutations so they created IPv6. More on that later.

3. IPv6 (Internet Protocol version 6)
   a. Similar to IPv4 in the way they are used to identify computers but because there are more and more computers, they're running out of permutations for the 32 bit IP addresses.
   b. IPv6 instead is almost entirely different where it uses hexadecimal inputs rather than just numerals like in IPv4.

            i.   Aka – They have letters in them too.

  c. Not all systems support IPv6 yet but a lot of companies are making ipv4 and ipv6 in the same computers as a default.

  d. For what we're required of for BUS 175, just know that IPv6 is different than IPv4.

Client/Server IP Addressing

As previous mentioned, every computing device has a unique IP address. Clients (you) have a different IP address than with servers (the webpage/database/cloud/Russian military). However, because we're human and not robots, we tend to remember cnn.com rather than 151.101.0.73. ←Actually points to CNN's server…lol. When working locally though, your router will assign your IP address a different IP address to help protect your computer from the outside world.

This concept is through DHCP.

1. DHCP (Dynamic Host Configuration Protocol)
    a. The protocol that pre-configures dynamic IP addresses for a router through a scope. Think of this as the rental car agency. You go in and say you need a car. That is a DHCP request. They respond back to you and say, OK, this is what we have (DHCP offer). In that offer, you get your car (dynamic IP), the information where the car is from (subnet mask), and how long you can lease it for before having to rent it again (lease time).

2. Dynamic IP Address
    a. When working locally, your router wants to protect you and it will assign you a short term IP address that changes. This is called a dynamic IP address. I guess an example of this will be renting a car. You'd be able to hold on to the car for a day, week, month, etc. until your lease is up. Then you'd have to return it. Dynamic IP addresses can be assigned to more than one computer, but only once at a time.

3. Subnet
    a. A sub network (smaller network) within a larger network. Concept only used in IPv4. Primarily used for network management and origination within a closed campus. Aka, UCR and its different departments.
4. Subnetting
    a. Subnetting is where you take many IP addresses in a LAN through a gateway in order to look for the real website you're trying to get to. To explain further, think about each one of us (students) is/are an IP address. To get to SoBA from OLMS

421, we all would need to go through the door (gateway) in order to find where SoBA (the real website) is. That's my best explanation. Ask Satpathy for further clarification or learn from YouTube.

5. Subnet Masking
    a. Subnet masking is a tricky concept that even the most well versed technical guys have difficulty with. In the 'real world' outside of textbook, subnet masking is determined by which network pathways can be used in accordance to the hosts and records. I don't even really understand it tbh. Still learning ~

6. Network Address Translation (NAT):
    a. Normally found and used in routers, NAT converts your computer's public IP address (your 10.23.45.1234) to a 192.162.2.38 number to a private IP address. Translates local IP to global IP.

Domain Name Servers (DNS)

To understand Domain name server, first you need to know what a domain is. Google.com is a domain. Facebook.com is a domain. Jonathanng.xyz is a domain. Ok, you get the point.

1. DNS – Domain Name System
    a. The internet equivalent to a phone book. The DNS server is pretty much a lookup table of the domain names and associates the domains to IP addresses. For instance, the domain CNN.com is 71.53.22.2222 (or something like that).
    b. **From lecture notes**
        i.   DNS gives us IP mapping
        ii. Provides aliasing
2. Name servers
    a. DNS points to name servers which in turn forwards you to the domain's IP address you wanted to go to.
        i.   Ex – I want to go to www.target.com. First, it would go from browser → dns servers → name servers → real target.com.
3. Cache Files
    a. "Catch files" 'caught files'. Automatically catches your web browsing history and stores little bits of cookies there so that the hungry web browsers will find it faster. This is all done on your personal computer.

Data Center Computing

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If you've read up to this far, congrats. I don't even know how I did it. I just want to watch Netflix.

Ok, data center computing.

1. Data Center Computing
    a. Essentially, a data center is the brain of the company where most of the computing needs of the corporation is being processed. It normally is the center of the most important things in a corporation because all business typically run through a data center nowadays.
2. Tiers of Data Center Computing
    a. The data center tiers are measured from Tier 1 – Tier 4.
    b. Classified by how probable the server is to failure or downtime and the amount of backup computers they have to handle the failure.
        i. Tier 1 has the highest rate of failure because they only have 1 computer running the server = 99.671% uptime
        ii. Tier 2 has 2nd highest failure rate since they have the server and 1 backup = 99.741% uptime
        iii. Tier 3 has 1 server and 2 backups. = 99.982% uptime
        iv. Tier 4 has 1 server and 3 backups leading to a 99.995% uptime guarantee.

3. Datacenter: Horizontal Partitioning
    a. Splitting the database records / ***rows*** to make it easier and more efficient to find.
    b. This can be conceptualized through taking a set of 50,000 addresses and dividing them into 2 or more tables by zip codes.
    c. This way the information is the same but just organized differently.

4. Datacenter: Vertical Partitioning
    a. Splitting the database records / columns to make the tables more organized; efficient.
    b. Conceptualized through 'normalization' and 'row splitting'
        i. Normalization
            1. Making the table 'normal' by cleaning up unnecessary and redundant information and putting them into another table where it belongs.
        ii. Row Splitting
            1. If you're taking 173, this applies. This concept is when the columns are organized, it can take the organized rows and match them with another data set from another database using unique keys. In a way, this is the concept of a password.

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Methods of Database Processing

There is more than one method for data processing. Data servers can be in one location and locked up like a jail cell onsite in a closet somewhere or they can be dispersed across many places. These include centralized data processing, decentralized data processing, and distributed data processing.

1. Centralized Data Processing
   a. It is exactly as what it's titled as. Centralized. This method is where all processes happen onsite. There can be pros and cons for this but that's up for debate. Consider this concept a consolidation of tech resources. Typically, this is based around mainframes. (large supercomputers)
2. Decentralized Data Processing
   a. Not in one location. (Thanks Sherlock). Is dispersed across many servers and/or locations and departments. Data servers can benefit from decentralized datacenters since it would allow the businesses to choose hardware and software based on their needs. Ex – you wouldn't want accounting software on a datacenter dedicated to rocket science.
3. Distributed Data Processing (DDP)
   a. Computers & servers are dispersed across an organization where information is copied on all computers once something is changed.
   b. It is scalable meaning that the company can increase the size or decrease the size of what they need.
   c. Goal is to process the information that is most effective use of their resources.
   d. Usually done with smaller computers and not mainframes.
   e. All connected to each other with access to each other's data. (I still need a bit more clarification on this too).
   f. Hadoop clusters are part of a DDP but only exist to decrease the time it takes for information to pass through. Apparently they're also called 'shared nothing' systems since if it fails, no information is lost because changes are copied to all servers.

Virtualization

1. Setting up a computer for it to host multiple virtual (cloud) servers on a single physical server at once.
   a. Satpathy said that this can be done by 'slicing' the physical server into one with Windows, one with Linux, one with Apple. ← This one Is operating system virtualization. It can be done with servers, client, software, etc.
   b. If you don't understand, think of it as a multi-use server. You can do a lot with it.

2. Every time something is installed on it, the software is called 'instances'.
3. There are more than one type of virtualization.
    a. Operating System Virtualization
        i. Running Windows/Mac in the cloud.
    b. Server Systems Virtualization
        i. Running Linux / Windows servers in the cloud.
        ii. Don't know if Mac's are generally used as servers….
    c. Storage System Virtualization
        i. Meaning a place to keep all your files and stuff…but this can also be accomplished by the first two listed.

Internet

- To get onto the internet, your computer must go through an Internet Service Provider (ISP) that connects you to another ISP. They are the middle man between you and the website you're trying to get to.
- Internet is when computers are connected to each other OUTSIDE of the internal network.

Intranet

- An intranet is different than an internet. Be very careful not to get these two mixed up.
- Intranets are generally computers that are connected to other computers WITHIN a network or general area/vicinity.
    o Think Internal safeguards. That's what an intranet is.
        ▪ Example: If you're not a UCR student/ on campus, you can't access those Mergent database that UCR library offers. That database is part of an intranet.
- Intranets, although connected to other computers within a network, they also use Internet based protocols – TCP/IP for local networking and Wide area networking (WAN) and sometimes even MAN's. Sometimes bigger.
- Intranets, like subnet masking, can easily be managed within a network but once you go out to the internet…it's like going into the ocean. Good luck with that.

Extranet

- Extranet's are similar to Intranets but they do have differences in the way that they are designed.
    1. Despite intranets being internalized, extranets provide side doors to let other people / vendors access the network as well.
    2. This can be for many reasons including, but not limited to,
        a. Financial audits
        b. Security

     i. Aka – police sharing their files with the FBI.
    c. Accounting
    d. Etc.

Storage Area Networks (SAN's)

- Storage Area Networks are networks that are dedicated to, well… storage.
- It is considered to be a separate network to handle storage needs.
    - Its also important to note that a SAN, although is its own network, is still connected locally to a LAN.
- SAN's can also be compared to data centers in the sense that SAN's have lots of servers there. Not for processing like data centers, but just for storage.
    - The typical LAN of a SAN is generally below:
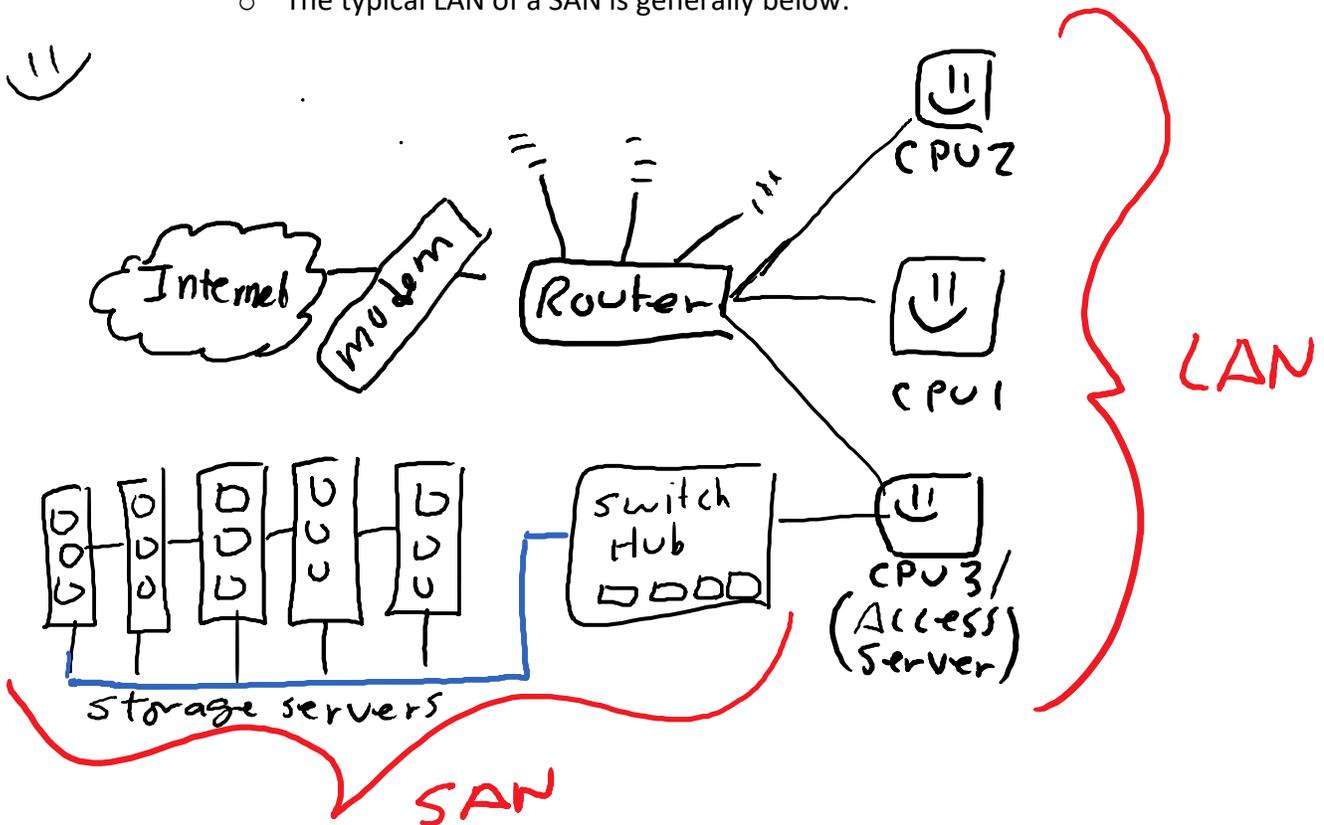
- Please forgive my drawings. I know, its ugly.):

OSI Model (Open Systems Interconnection)

- According to the book, the OSI model is a model of communications between cooperating devices. ← that sounds pretty boring.

- o In my terms, the OSI model is the model that highlights the entire process of data travel. I think my definition sounds better.
- o Note that the OSI model is only a concept and is not really used in practice.
    - ▪ The ones that are used in practice today is the TCP/IP model. It's similar but it has its differences.
- o To better understand this, you'd need to know that there are 7 Layers (aka steps) to the OSI model.

    - ▪ Starting from the very first layer (the origin layer) is the Application layer, then it goes to Presentation, Session, Transport, Network, Data Link, Physical link.
    - ▪ You may find the mnemonic device "Please Do Not Teach Students Pointless Acronyms" useful if you think of it from Layer 1 to Layer 7.
- o **Layer 7 (Application Layer) – Open envelop**
    - ▪ This is where you interact with the data whenever you request/receive webpages or whatever. Think of it as being named application because you're using an Application (your web browser) to see the data.
- o **Layer 6 (Presentation Layer) – The pretty envelop in your hand**
    - ▪ This layer is when your computer wants to present itself and the data in the best way possible. In this layer the webpages will make itself pretty for you to look at before you interact with it.
- o **Layer 5 (Session Layer) – When mailman is handing you the mail / you giving mailman mail.**
    - ▪ In this layer, the data packets talk with your computer to let that data in. Once its in, it's in session. Like at an airport when the air traffic controller tells the planes that they can land. Once those pilots land the plane, the session is on to get passengers on/off board.
- o **Layer 4 (Transport Layer) – In the truck to be delivered to/from post office.**
    - ▪ When the data packets are en route to your computer.
- o **Layer 3 (Network / Internet Layer) – Post office**
    - ▪ This is where most of the behind the scenes networking concepts are. In this layer, data packets are being routed in the right direction before its en route to you.
- o **Layer 2 (Data Link) – Mailman's collection bag /delivery bag**
    - ▪ An example of this is when data is ready to be on its way. Similar to your snail mail is in the truck and almost out for delivery.
- o **Layer 1 (Physical Link) – Your mailbox**
    - ▪ This is where the requests are made / received.

The OSI model is pretty easy to understand assuming you can follow the steps on how a post office system works...conceptually speaking.

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Protocol Data Unit (PDU)

- There is not a good definition of what a PDU is anywhere so here's my best shot at explaining it.
- A PDU is a name for the data at each layer of the OSI model.
    - In Layer 4 Transport, the data is called "Segments". The PDU for layer 4 is "Segments.
    - In Layer 3 the data is defined as packets. The PDU for Layer 3 is "Packets".
   - Layer 2, Frame. Layer 1, Bits. Layer 5 and above, it's just called data.

User Datagram Protocol (UDP)

- The OSI model offers two different networking protocols in Layer 3 – TCP and UDP.
- With UDP, the protocol was established before TCP/IP and it boasted a lot of problems.
    - For starters,
        - UDP does not guarantee delivery, does not preserve sequence order, or protects against duplication.
- UDP is not common but there are applications that do actually use it…still. The book states that one application Simple Network Management Protocol (SNMP) uses it but other than that, it is archaic and is not efficient.

TCP/IP (Transmission Control Protocol / Internet Protocol)

- TCP/IP was developed after UDP has failed to do what those CS guys back in the day wanted it to do. Although UDP has some pretty good functions, TCP included UDP features while developing TCP/IP.
- TCP/IP is similar to the OSI model but in this model, it consolidates the OSI layers into 4 layers…that and it renames it too.
- One thing to note is that TCP/IP model works almost entirely in Layer 3, Network/Internet layer.

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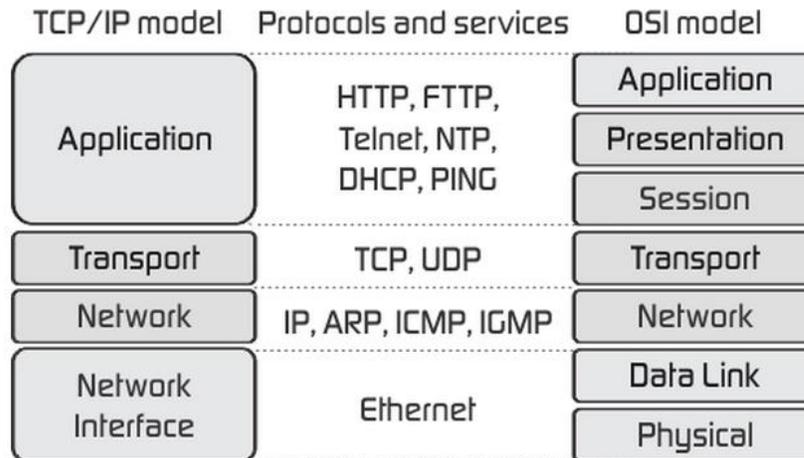
-
- Be careful to also note that TCP / IP model uses a 3 tier/ 3 layer model.
    - Networks
        - This includes the Network Access layer where all information goes in/out of computers
    - Computers:
        - We need computers to even host this scenario.
        - This layer would also play hosts in transporting data packets from one computer to another.
    - Applications
        - Similar to the OSI model, applications are specific software that are used to access the network / programs you are running.

Connectionless

- According to technopedia, connectionless is when there is no structure in the data when computers are exchanging information with each other. On top of that, connectionless data transfers are when computers would be receiving data whether they like it or not. This is generally practiced in UDP and IP transmissions but because it is unorganized and unstructured It is not commonly used anymore without the presence of TCP.

Connection-Oriented

- Like connectionless and my research on technopedia, connection-oriented means that prior to any data being sent or received, a connection must be established. Additionally, Connection-oriented practices follow a structure (similar to the OSI / 3 layer concept) when establishing communications between computers. With connection oriented methods, data packets are able to be traced within each layer of data transmission/receipt. It is important to know that in connection oriented concept, both computers / hosts/ clients would have to be able to send and receive data transmissions. If they can't, the practice would be connectionless.

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Wireshark Legacy / Wireshark Network Analyzer

- In lecture, Professor Satpathy introduced Wireshark to us to analyze packets and data.
- In the event that he asks us what Wireshark is/was used for, it is to analyze packet data that we can use to monitor bandwidth, detect network intrustions, and diagnose problems at the network level (Layer 3 – Internet / Network).

Am I missing anything?

- Let me know if there's something that I may have missed or if you need clarification on my writing. Thanks guys!

The End so far:

This is how much we've covered in class so far. I will continue to update with my explanations on the topic should you guys need more clarification on the concepts. If you need extra help, feel free to shoot me an e-mail at jonathanngw@gmail.com or FB messenger me. FB messenger would probably be the fastest way to get a hold of me. Study hard everyone!

-Jonathan