# Class Notes

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Welcome to Computer Networks (CS3001)

Fundamental problem addressed by "computer" networks:

(a) **[High Level]** How two computational entities communicate with each other to share useful information?

(b) **[More Nuanced]** How to efficiently, reliably, economically, and securely [...] make any two computational entities, anywhere in the world (anywhere in the universe??) communicate with each other?

   a. **Challenges to communication:**

      i. No of parties needing communication
      ii. Distance between the communicating parties
      iii. Diverse application needs: high throughput, low latency etc.
      iv. How to deal with failures of links and nodes.
      v. How to deal with eavesdropping and data integrity
      vi. How to use potentially many types of hardware technologies
      vii. (This list of challenges is not exhaustive!)

(c) It will take us the whole semester to deal with above mentioned challenges.

Why do we want to communicate?

(a) Communication (to speak and to express) is one of the fundamental human traits differentiating humans from other species
(b) To solve computational problems (say in the cloud or at some remote supercomputer) and to get the results back
(c) To facilitate scientific research (Example: MARS Rover conducting experiments as per the commands sent by the Earth station and providing the new findings and results back.)
(d) Many more reasons (this list is by no means exhaustive!)

Why this course (and the concepts it teaches) is important?

(Or why university has forced this course on you by making it a core course ☺ )

Little trivia: The “i” in many Apple products was originally meant to say that “out devices can work with the Internet”. Believe it or not it was a big deal back then! Its just like folks say today “My app is AI enabled”.

(a) Let’s do a little thought experiment. Assume you suddenly lose all of your ability to communicate with anyone remotely (no mobile phones, no Internet). You can only talk with people around you and that is it! Which of your daily chores will be impacted?

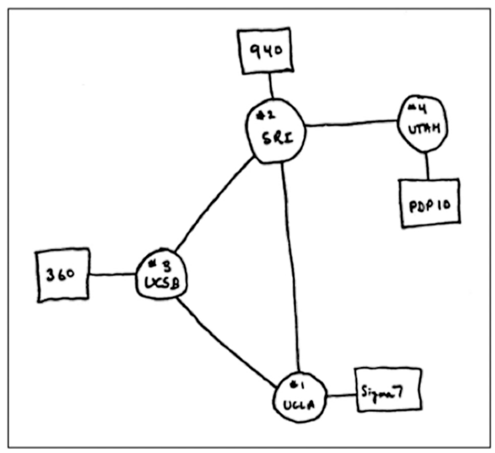
(b) If you have a brand-new mobile phone (or a computer) with the latest technology but your network is not delivering you your bits at all (or in a timely manner), how do you feel? Don’t you feel as if your shiny new gadget is totally useless without its ability to communicate over the network?

(c) In this course we will study many of the important concepts using the Internet (a collection of many, many networks) because arguably the global Internet is one of the most sophisticated artifact humans have ever created!

(d) Internet then and now!

Then:

- Well, technically, the ARPANET
- Circa 1969
- 4 nodes




Routers
End host
Links

Image Credit: Tom Coffeen, Oreilly Books, Intro to IPv6

~ Now:

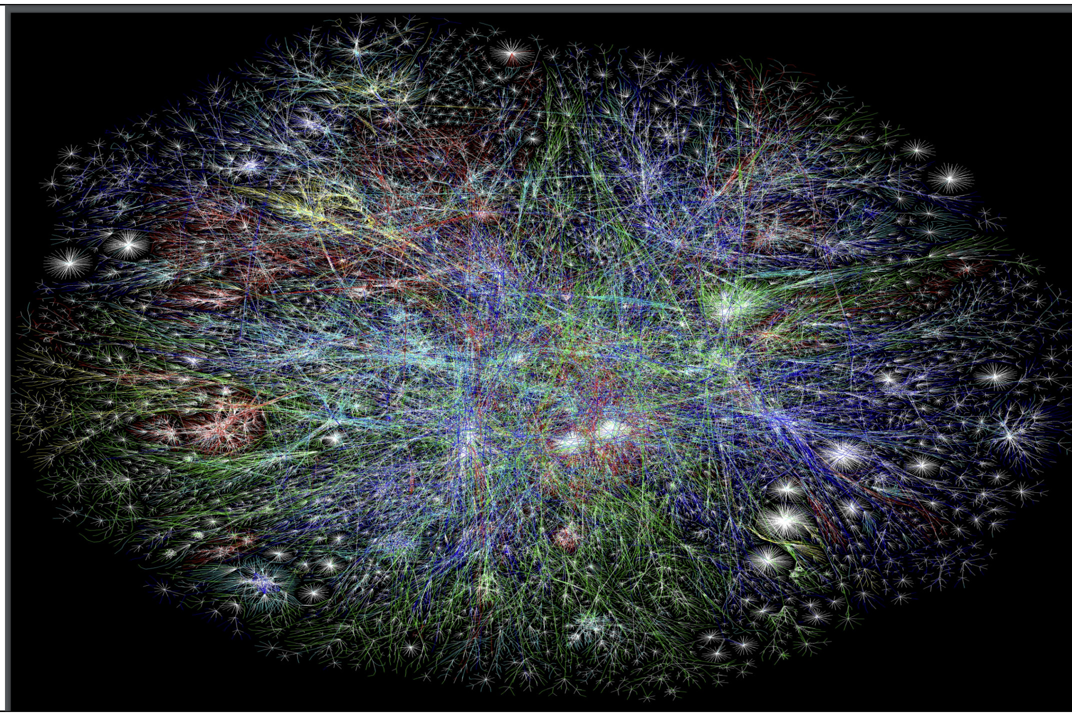
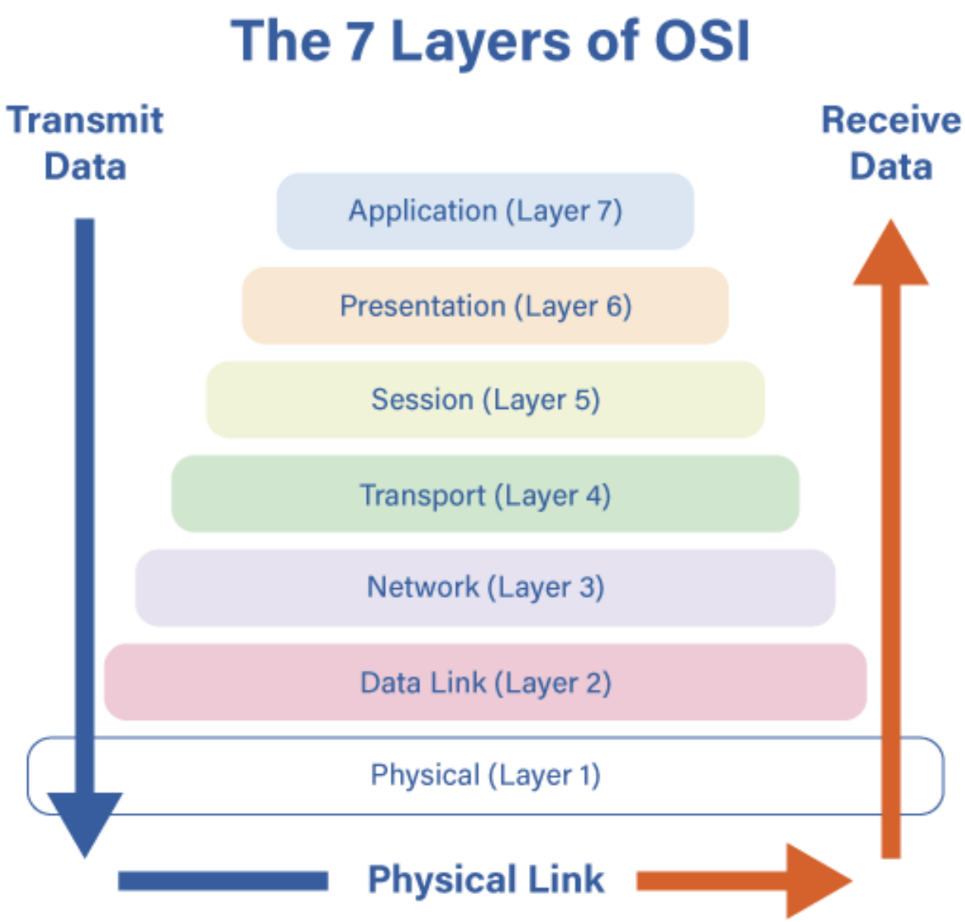


Image Credit: Keith Winstein, CS144 at Stanford

(e) To learn how does it (the Internet) all work?
(f) To learn how it (The Internet) was designed the way it is
(g) To understand how networked program work, and to write such software

Do we have any hope to understand a complex architecture of the Internet in just about 15 weeks?

(a) Yes! The architecture of the Internet is based on a few remarkable, time-tested ideas.
(b) To tame the complexity (for us for learning purposes, and for the designers and implementors of the Internet protocols), the network stack is divided up into layers:
(c) OSI (Open Systems Interface by ISO, International Standards Organization). Often referred to as: OSI 7-layer model




Memory Mnemonic: **P**lease **D**o **N**ot **T**ouch **S**am's **P**et **A**lligator

Image credit: https://insights.profitap.com/osi-7-layers-explained-the-easy-way

Now let's see what happens when we type [www.google.com](www.google.com) in our browser and how we get the response back.

(a) DNS name resolution
(b) Some preliminary discussion of Wireshark
(c) Demonstrate traceroute (tracert for Windows) (ICMP protocol)
(d) Demonstrate how encapsulation and de-capsulation happens and why

Read the blog post that summarizes above discussion:
https://systemspotpourri.substack.com/p/computer-networks

Read the blog why computer networks is a very useful subject for you:
https://systemspotpourri.substack.com/p/why-computer-networks

Now over to the course overview document to discuss mechanics of the course!

Start chapter 1, use slides of the book

About units in networking:

## How big is a "mega"?

There are several pitfalls you need to be aware of when working with the common units of networking, such as MB and Mbps. The first is to distinguish carefully between bits and bytes. Throughout this book, we always use a lowercase *b* for bits and a capital *B* for bytes. The second is to be sure you are using the appropriate definition of giga (G), mega (M), and kilo (K). *Mega,* for example, can mean either $2^{20}$ or $10^6$. Similarly, *kilo* can mean either $2^{10}$ or $10^3$, and *giga* can mean either $2^{30}$ or $10^9$. What is worse, in networking, we typically use both definitions. Here is why.

Network bandwidth, which is often specified in terms of Mbps, is typically governed by the speed of the clock that paces the transmission of the bits. A clock that is running at 10 MHz is used to transmit bits at 10 Mbps. Because the *mega* in MHz means $10^6$ hertz, Mbps is usually also defined as $10^6$ bits per second. (Similarly, Gbps is $10^9$ bits per second.) On the other hand, when we talk about a message that we want to transmit, we often give its size in bytes. Because messages are stored in the computer's memory, and memory is typically measured in powers of two, the *K* in kB is usually taken to mean $2^{10}$. (Similarly, MB usually means $2^{20}$ and GB usually means $2^{30}$.) When you put the two together, it is not uncommon to talk about sending a 64-kB message over a 100-Mbps channel, which should be interpreted to mean $64 \times 2^{10} \times 8$ bits are being transmitted at a rate of $100 \times 10^6$ bits per second. This is the interpretation we use throughout the book, unless explicitly stated otherwise.

The good news is that many times, we are satisfied with a back-of-the-envelope calculation, in which case it is perfectly reasonable to make the approximation that $10^6$ is really equal to $2^{20}$ (making it easy to convert between the two definitions of mega). This approximation introduces only a 5% error. We can even make the approximation in some cases that a byte has 10 bits, a 20% error but good enough for order-of-magnitude estimates.

While we are making quick-and-dirty calculations, 100 ms is a reasonable number to use for a cross-country round-trip time—at least when the country in question is the United States—and 1 ms is a good approximation of an RTT across a local area network. In the case of the former, we increase the 48-ms round-trip time implied by the speed of light over a fiber to 100 ms, because there are, as we have said, other sources of delay, such as the processing time in the switches inside the network. You can also be sure that the path taken by the fiber between two points will not be a straight line.

Source credit: Computer Networks by Peterson and Davie

If time permits, we will discuss the paper:

**[The design philosophy of the DARPA internet protocols](#) by David Clark**


Source: Wikipedia, https://en.wikipedia.org/wiki/David_D._Clark

Read blog entry about Internet's design philosophy:
https://systemspotpourri.substack.com/p/commentary-on-the-paper-the-design