

# Problems in Computer Networking

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DIC1 Guest Lecture  
Jan 17th, 2023

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Submit any term you know, related to  
Computer Networking

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Please wear your  
thinking hats!

Please participate

*This is not a 'lecture'*

Today, in class:  
Series of questions and  
problems to show you  
the kind of 'puzzles' one  
needs to solve to make  
'The Internet' work, and  
key ideas of solutions  
that clicked.

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Please wear your  
thinking hats!

Please participate

*This is not a 'lecture'*

Later, At home

Few videos, which you  
will understand if you  
stay engaged today.  
Quiz and endsem  
questions will be based  
on the videos + class.

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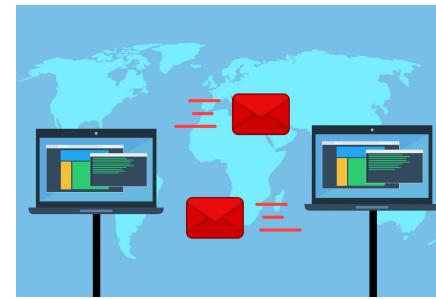
# Warm Up!

Consider any two communicating entities  
(e.g. persons, animals, machines!)

What is the most basic thing needed for communication?

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Enter code: 8474 6896



# Most basic requirement for communication

For communication, first and foremost, we need:

A **medium** on which the sender entity can send **something** : matter, energy (a “signal”) that will **reach** the receiver entity

Problem 1: What can be a medium?

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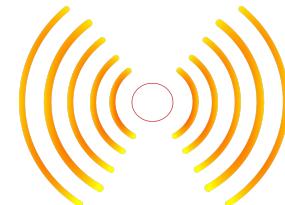
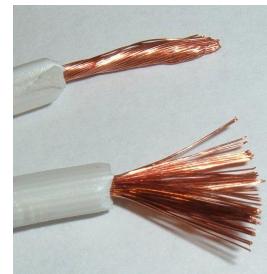


# Examples of media (“links”)

In general: paper (written message), air (speech)...

For computers:

- Metal Wires (carry electricity)
- Optical Fiber - glass (carry light)
- Anything/nothing (carry radio waves)



# Sending a message on a medium

How exactly does one send a message?

Puzzle: suppose two spies are on a secret mission. They know that at one point the only way they can communicate is through a pair of sunglasses that they can leave on a table. Suppose there are three possible messages that need to be communicated:

1. Go ahead with the next task right away.
2. Abort your mission, wait for new mission
3. Your cover is blown, run for your life!

How can the spies use the sunglasses to send one of these 3 messages?

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# Encoding

What you just did was *encoding* using the ‘medium’ of sunglasses (and light, which enabled viewing of the sunglasses)

Problem 2:

In computers, on Directly connected entities - how can messages be *encoded*?

Encoding on a wire on which electrical current flows??

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# Encoding

Problem 2: Encoding on a metal wire on which electrical current flows??

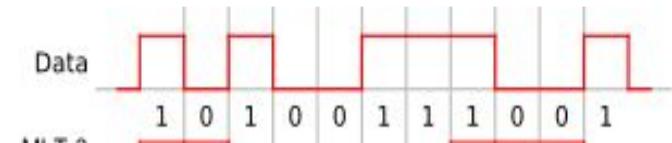
(One) Solution: Encoding is using 'bits', 1 and 0 is distinguished by voltage levels.

High: 1, Low: 0

Problem 2.1: What if series of 1s? Voltage just stays high...? Is it One 1 or Many 1s?

Solution: CLOCK. Agree on a BIT RATE.

E.g. one bit per ms. If voltage stays high for 10ms - you got 10 ones

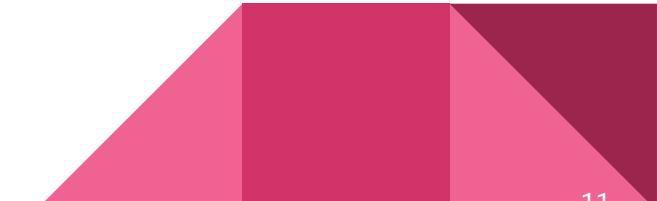
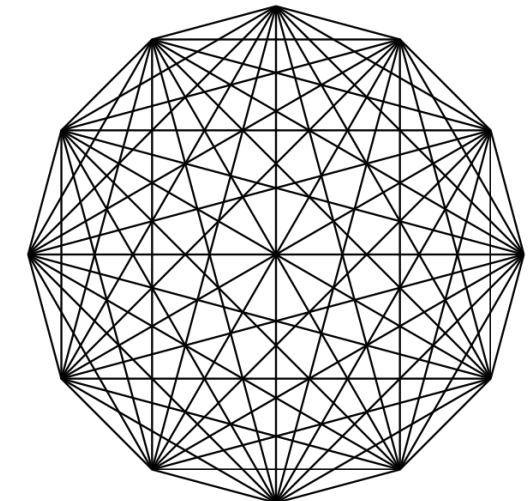


## Next: Connectivity

Now: two “nodes” are directly connected, and they know how to exchange messages using their medium.

But... do all nodes in the world need to be directly connected?????

Obviously...No.



# Connectivity Puzzle

Problem 3:

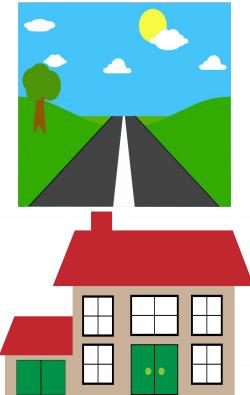
3a) Consider 5 Houses within a radius of 100 meters or so. Persons from each house should be able to walk to any other house.

3b) Consider 20 houses each in a cluster of 5 houses, in an overall radius of 1-2 km. Persons from each house should be walk/ride a cycle or drive a car to every other house.

You are the architect in charge of planning a road network for these houses. Think about some possible road networks. Draw two pictures in your notebook, for 3a and 3b, take a photo and upload here:

<https://tinyurl.com/dic1road>

(Google Form: you can click on 'browse' and then use 'Camera' to take a picture and upload)



# Connectivity between Devices

1. Similar to dedicated “driveways”, shared roads:

**Wired Cables, Wireless Media**



2. Similar to junctions, “circles”,

**SWITCHES**

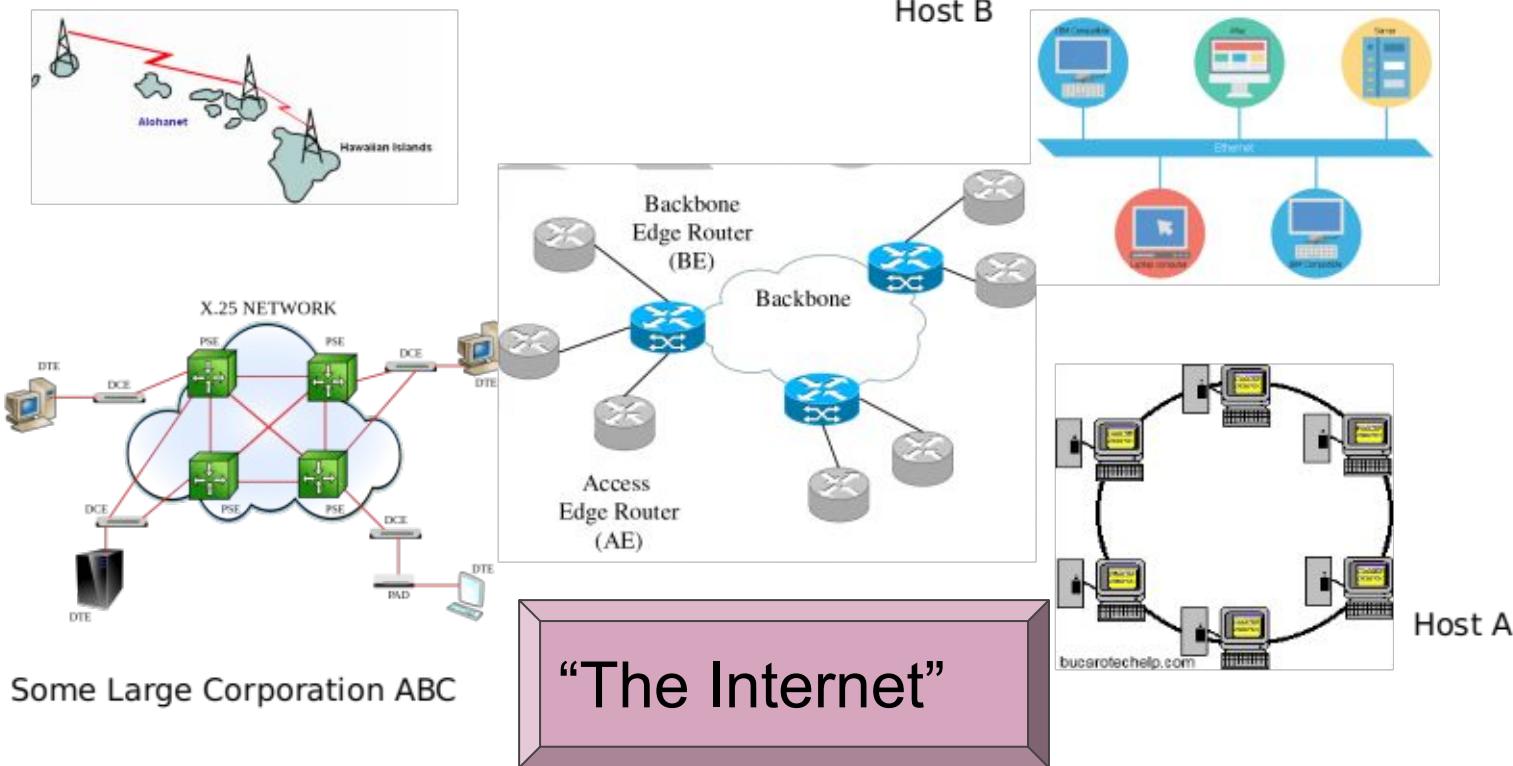


3. Similar to bus station, train stations, airports (where people come in using one type of transport, but go out using another type of transport)

**ROUTERS**



# All together...make one big Global Network!



# Addressing

Communication between more than 2 entities requires addresses.

E.g. Physical locations have addresses.

What are some essential qualities of postal addresses that makes them work on a global scale? How is it that a letter from small village in USA can reach a small village in India? (Does the postman in this US know where this village in India is??)

(Problem 4) Submit, preferably in just one word, the most important quality that makes it work.

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J. Sender  
456 Everywhere Blvd  
Johnstown St 45678

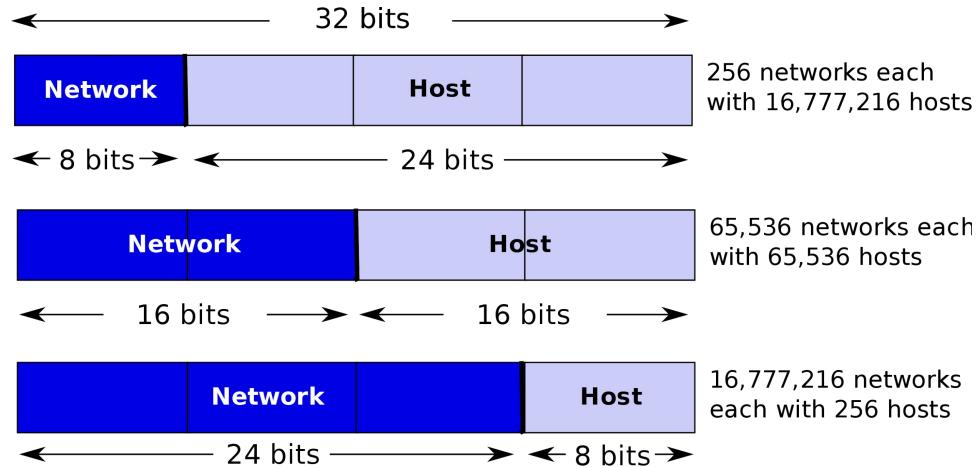


Favored Recipient  
123 Somewhere Place  
Worcestershireville, ST  
32133-5555



# Addresses in “The Internet”

Are HIERARCHICAL

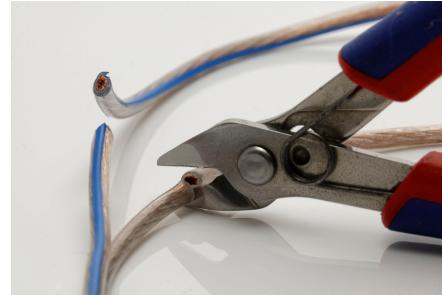


*More on this in the videos you will see.*

# Reliable, dependable communication

Everything in the world can break. In a computer network: wires, switches, routers, can break or malfunction.

(Problem 5) How can we ensure a message reaches a destination even if some intermediate wire/switch/router has failed?



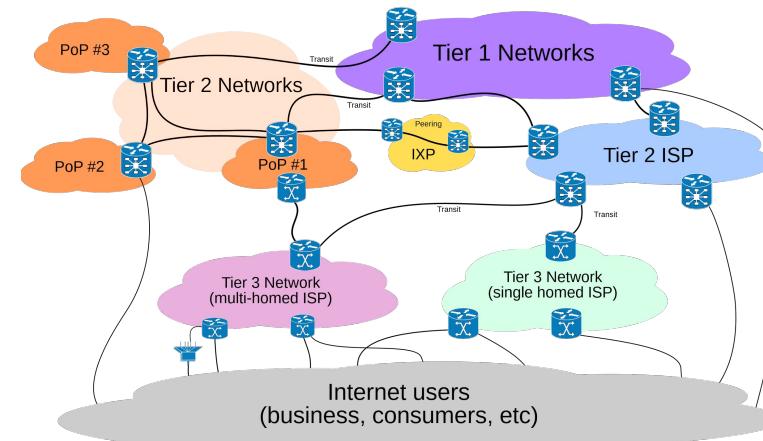
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# Reliable, dependable communication

The foundational design rules ('protocols') of  
'The Internet'

## Internet Protocol (IP) and Transmission Control Protocol (TCP)

Are both designed to function even if network components fail or change. TCP 'owns' the responsibility of making communication reliable, but it uses the flexibility of IP to do so.



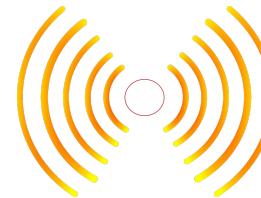
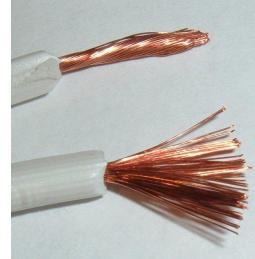
*More on this in the videos you will see.*

# Future Proofing network design

TCP and IP do not assume anything about the media they work on, the encoding used by media, etc.

They have survived for almost 50 years because of a brilliant, *resilient*, adaptable design that made it “future-proof” (Problem 6)

***More on this in the videos you will see.***



# Application Communication

In real life: postal service just carries your messages. You may write letters in your own language.

Similarly: applications communicate using their own languages, or ‘application level protocol’. (Problem 7)

***More on this in the videos you will see.***

**HTTP (Web)**

**SMTP (Outgoing mail)**

**IMAP (Incoming mail)**

**SNMP (Network Management)**

**FTP (File transfer)**

# Summarizing Problems

Finding media (material, signal)  
Encoding on the media  
Connecting a large number of devices  
Addressing  
Making it all work reliably  
Future proofing the design  
Application Communication

Problem We Did Not Discuss:  
Efficiency!

Making cost-effective use of the media

**PACKET SWITCHING**  
*(Revolutionary idea without which internet would not work)*

**See it in the videos**

# Follow up videos

1. **Four** videos (1-4, ~ 26 mins in all) from Khan Academy Internet 101 [playlist](#)
2. **One IIT Bombay Techfest video** (38 mins): [Interview of Vincent Cerf](#).

Practice quiz and endsem questions will be based on this class + above videos. **Watch with captions on.**

One doubts session can be done later, if required, **for students who have sincerely watched above videos and did practice questions.**



# Thank you for listening and *participating*

All concepts discussed today were highly simplified, some liberties taken, and we did not discuss many many nuances. Some of the 'solutions' discussed have problems of their own. Modern networks have evolved by fixing these issues over time, and will continue to evolve.

You will learn the 'complex' and 'actual' version of these problems if you CHOOSE to do CS 224, taught by one of the following Professors...

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# Networking teachers@IITB



Kameswari



Bhaskaran



Vinay



Varsha



Puru



Mythili

# Future Outlook of Computer Networking (including work at CSE, IIT Bombay)

Data networks ('5G core') built of 'cheap' 'commodity' machines, using *software* (Prof Mythili)

Squeezing more and more out of Wireless Media (Radio, Audio!!)  
(Prof Bhaskar)

Blazingly fast routers (Prof. Ashwin)

Smarter, AI-powered network management

Access to every corner of the earth (satellite)

Interplanetary Internet!

