
Lecture 9

Computer Networks

Full information

<http://www.stanford.edu/class/cs101/network-1-introduction.html>

<http://www.stanford.edu/class/cs101/network-2-internet.html>

Outline

- How to send data?
 - Dividing into packets
 - Protocols (HTTP, FTP, SMTP)
 - Error correction
- Types of network
 - LAN, WAN, MAN
- How to send data to correct address?
 - Ethernet, and MAC-address
 - TCP-IP protocol, IP-address
 - IPv4, IPv6
 - DNS, domain names
- How to send data faster?
 - P2P, Torrents

Basics of network

The computer network is like a phone system

When a user enters sdu.edu.kz in browser:

- the browser sends a request to sdu.edu.kz (request is small, weights 1 KB)

- sdu.edu.kz server responses to the browser

- (response is bigger can weights 200 KB).

LAN, WAN, MAN

A LAN (local area network) is a group of computers and network devices connected together, usually within the same building. By definition, the connections must be high speed and relatively inexpensive (e.g., token ring or Ethernet). Most Indiana University Bloomington departments are on LANs.

A MAN (metropolitan area network) is a larger network that usually spans several buildings in the same city or town. The IUB network is an example of a MAN.

A WAN (wide area network), in comparison to a MAN, is not restricted to a geographical location, although it might be confined within the bounds of a state or country. A WAN connects several LANs, and may be limited to an enterprise (a corporation or an organization) or accessible to the public. The technology is high speed and relatively expensive. The Internet is an example of a worldwide public WAN.

BASIS OF COMPARISON	LAN	MAN	WAN
Stands For	Local Area Network	Metropolitan Area Network	Wide Area Network
Covers	Local areas only (e.g., homes, offices, schools)	covers the area inside a town or a city.	Large geographic areas (e.g., cities, states, nations)
Ownership of Network	Private	Private or Public	Private or Public
Speed	High speed (1000 Mbps)	moderate speed(44 to 155 Mbps)	Less speed (150 Mbps)

Packets data from here to there

Problem:

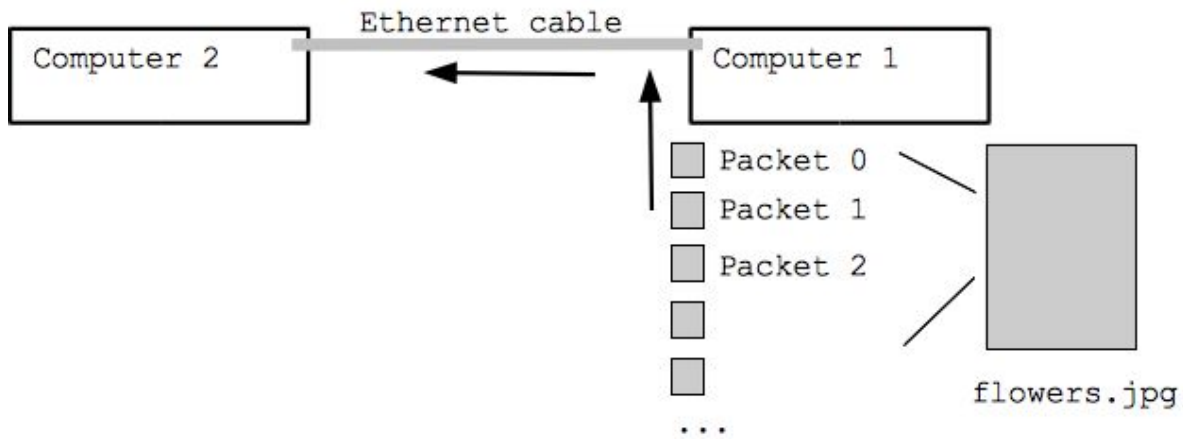
Send image from one computer to another on ethernet

e.g. 50KB image.jpg (50,000 bytes)

How to send the image.jpg on the wire? (on right side)

Packets

- Divide bytes of image.jpg into packets
- Say each packet is 1500 bytes (varies)
- Then image.jpg divides into about 32 packets
- Ethernet: transmit one packet between computers



dividing file into packets

Error control

Problem:

While sending packets through errors may occur

Solution:

We must check if received packet is same as it was sent

checksum vs errors

Each packet has extra checksum bytes, to detect if some bits were corrupted while transporting to receiver

Simple checksum can be:

- last two digits of the sum of all bytes

Receiver sums all bytes and checks if sums are equal

packet	checksum
105, 220, 5, 30, 21, 110	91

bytes sum to 491

checksum example

What is Ethernet?

Ethernet is the type of computer network:

- One wire shared by all the computers
- No central control -- distributed, collaborative
- Like talking at a party

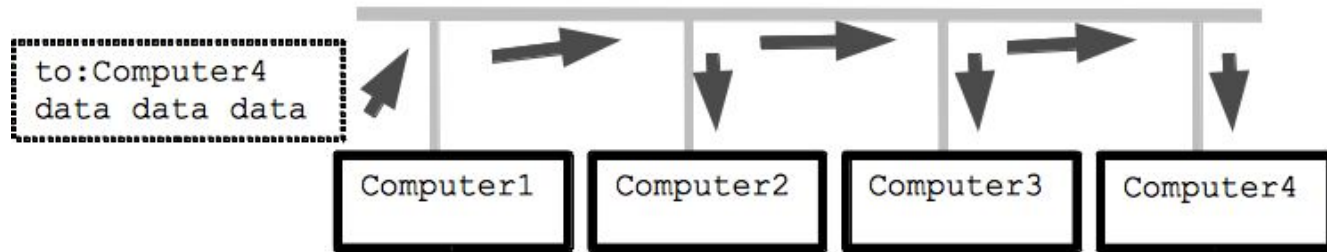
How to send:

- Every computer has a unique address on the wire
- Packet includes to:addr of recipient
- Sender waits for period of silence on the wire, sends packet
- Packet spreads out on wire, reaching all computers
- More "broadcast" than "send"

Receive:

- All computers listen to the wire all the time
- Pick out packets addressed to them, ignore other packets

Computer1 sends packet to Computer4 (broadcasts)



ethernet data sending

MAC address (Physical Address)

MAC (Media Access Control)

MAC address is burned at the factory

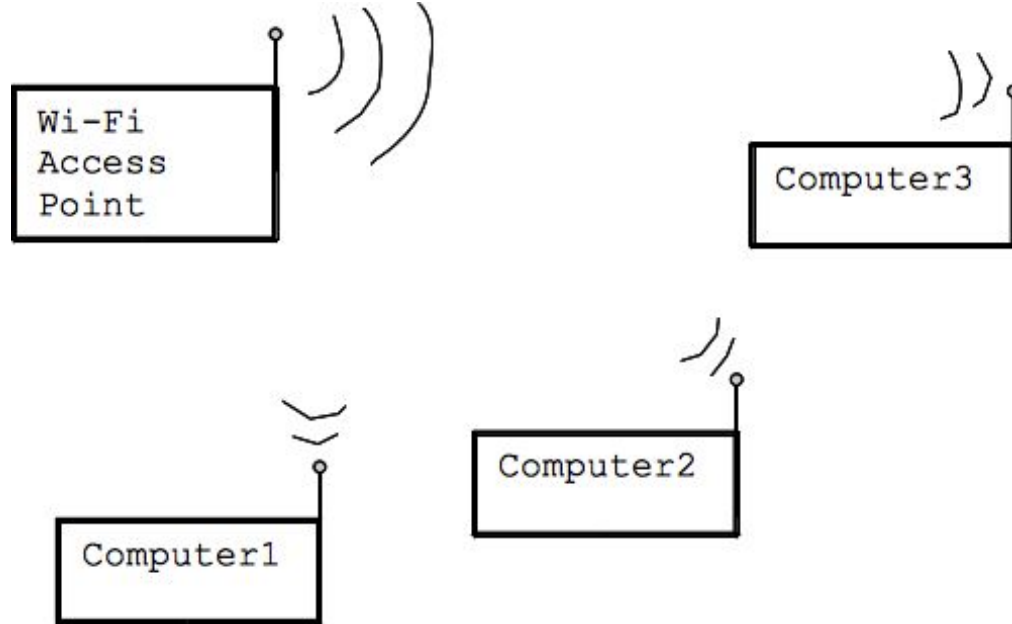
Every computer (phone, desktop, laptop) has its own globally unique address

On Linux MAC address can be changed

example: ab:cc:dd:12:34:56

Wi-Fi

- Wi-Fi wireless networking
- Similar strategy to Ethernet (simplifying)
 - Every computer has a radio
 - The radio-channel used is the shared medium
- One computer transmits at a time
- Everyone listens



wifi example

What is protocols

'Protocol' is a fancy word for simply saying "an agreed way to do something". You might have heard it in a cheesy cop show -- "argh Jim, that's against protocol!!!" -- or heard it used in a procedural sense, such as how to file a tax return or sit a driving test. We all use protocols, every day. Think of when you're in class. The protocol for asking a question may be as follows: raise your hand, wait for a nod from the teacher then begin asking your question.

HTTP

The HyperText Transfer Protocol (HTTP) is the most common protocol in use on the internet. The protocol's job is to transfer HyperText (such as HTML) from a server to your computer. It's doing that right now. You just loaded the Field Guide from the servers where it is hosted. Hit refresh and you'll see it in action.

HTTP uses a request/response pattern for solving the problem of reliable communication between client and server. The “ask for” is known as a request and the reply is known as a response. Both requests and responses can also have other data or resources sent along with it.



TCP-IP standard

- Previously .. LAN, e.g. ethernet, Wi-Fi, one house
- Internet - world-wide network built on open standards
- Internet is like a phone system for computers
 - Every computer has a unique address
 - Every computer can try to "call" any other computer

IP address

- Every computer on the internet has an "IP address" that identifies it (like a phone number)
- The IP address is 4 bytes, written between dots, like "171.64.2.3". The left part of the address encodes in part where that IP address is in the whole internet -- for example any 171.64.(anything) is part of Stanford (like the area code of a phone number). More specifically, in my part of the Gates building, all the IP addresses begin 171.64.64.XX varying only in that last byte.

IPv4 vs IPv6

IPv4 can contain $2^8^4 = 2^{32}$ = about 4.3 billion addresses

IPv6 can contain 2^{128} addresses (about $3.4 * 10^{38}$ addresses)

Example of IPv6:

2001:0db8:85a3:0042:1000:8a2e:0370:7334

IPv6 addresses are represented as eight groups of four hexadecimal digits separated by colons

IPv4

vs.

IPv6

Deployed 1981

32-bit IP address

4.3 billion addresses

Addresses must be reused and masked

Numeric dot-decimal notation

192.168.5.18

DHCP or manual configuration

Deployed 1998

128-bit IP address

7.9×10^{28} addresses

Every device can have a unique address

Alphanumeric hexadecimal notation

50b2:6400:0000:0000:6c3a:b17d:0000:10a9

(Simplified - 50b2:6400::6c3a:b17d:0:10a9)

Supports autoconfiguration

Internet of Things

The Internet of Things (IoT) is the network of physical objects or "things" embedded with electronics, software, sensors, and network connectivity, which enables these objects to collect and exchange data.

So your refrigerator, and kettle will be online and you can send them commands.

Experts estimate that the IoT will consist of almost 50 billion objects by 2020.

What is web-site

Web-site is some resource located on web-server

Web-server is computer:

- always turned on
- accessible through internet
- have fixed IP address. *Why ?*

Domain names

- Basically human-readable synonyms for IP addresses
- codingbat.com (synonym for 173.255.219.70)
- Domain names are easy for people to remember and type
- Domain system can look up an IP addr from a domain name
- So when you use a domain name, it is looked up to get an IP addr for the actual packets

DNS, hosts.txt

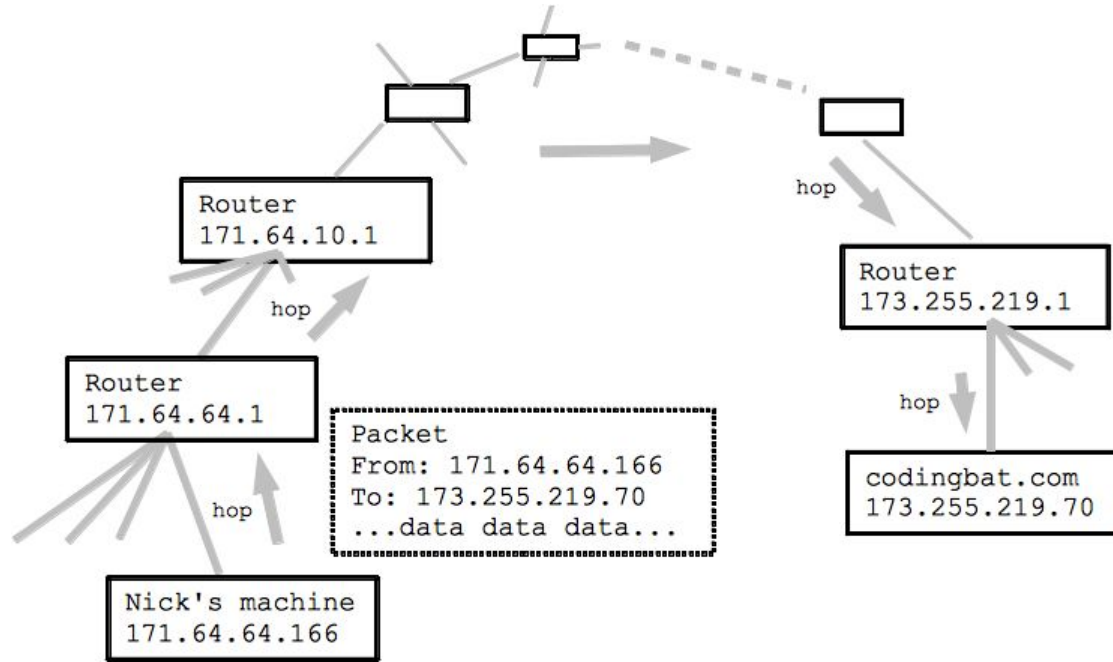
When you enter vk.com it sends request to DNS
DNS looks up in its database and responds IP address of entered domain, and request is sent to specified IP address.

On operating systems there is a file which is called hosts.txt file.
In hosts.txt on each line IP address and corresponding domain name are stored.

You can match any pair of domain address IP address

Router

- Router has multiple connections, copies/routes packets between them
- My office computer is at 171.64.64.16
- That computer connects "upstream" to router 171.64.64.1
- That router handles traffic for a few local computers
- Left side of computer and router IP addresses typically the same -- same neighborhood



the way by which request goes from browser to site

Local IP address

- Note that 10.x.x.x , 172.16.x.x and 192.168.x.x addresses are special "local" IP addresses
- These addresses are not valid out on the internet at large
- These are translated to a real IP addr as a packet makes its way
- Frequently given out by Wi-Fi routers .. why I mention them
- 127.0.0.1 (IPv4) is own address of computer
- ::1 (IPv6) is own address of computer

Ping and traceroute

Ping is command to check computer on some address is working

Traceroute to find which routers were visited by packet before reaching destination

Switch

A switch connects multiple computers together in a LAN. After the first data transfer, it creates a “switch table” which matches ports to connected devices by their MAC addresses.

Switches, unlike hubs, are able to differentiate between computers as the first time data passes through the switch, it looks to see which MAC addresses are connected to which ports and remembers the layout.

<http://www.makeuseof.com/tag/whats-difference-routers-hubs-switches/>

Hub

A hub connects multiple computers together in a Local Area Network (LAN). All information sent to the hub is then sent through each port to every device in the network.

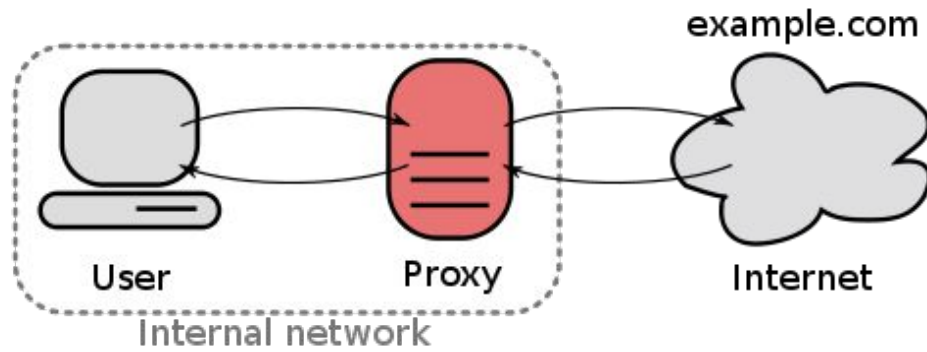
Hubs are unable to tell one computer from another, so they receive information on one port and then blindly forward it to all other ports — whether it was intended for those computers or not.

So even though you may only want to send information to one other computer, if you have five total computers on your network, then there will be four other computers receiving data that wasn't intended for them.

Proxy server

Server software which is located between server and client. So that all requests from computers of network go through proxy, and proxy requests to servers.

Proxy can save all requests and filter the requests to Internet

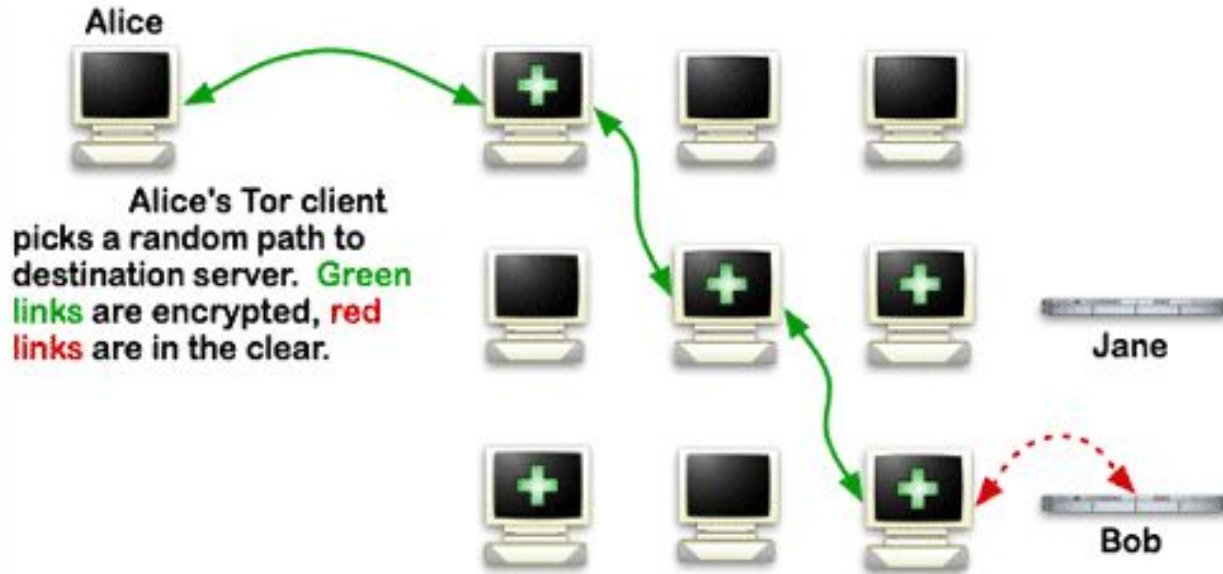


Proxy server

TOR - The Onion Router

- Tor is a network that keeps users anonymous on the Internet.
- It works by moving data across many Tor servers, called "hops".
- The role of each server is to only move that data to another server.
- With the final hop moving data to the end site.
- Information is transmitted in way so it is hard to trace.

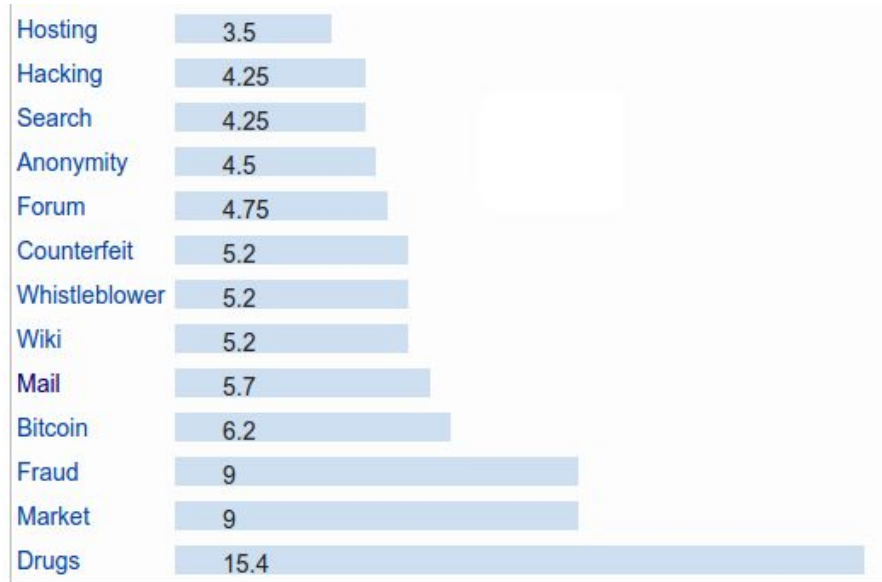
How Tor Works



Tor network

TOR is used for?

Because TOR don't track users, it is mostly used for illegal uses



Darknet

Darknet is located inside TOR network

TOR network recognizes .onion domain requests and sends it to specified servers

Darknet mostly contains web-sites that are illegal

Server-client network

On a client-server network, resources are located on and controlled by a central computer known as a server

client-server networks are often more expensive to set up than their peer-to-peer equivalents, as server hardware and software is more expensive than regular desktop computers

P2P network

In contrast to server-client network, P2P doesn't have server.

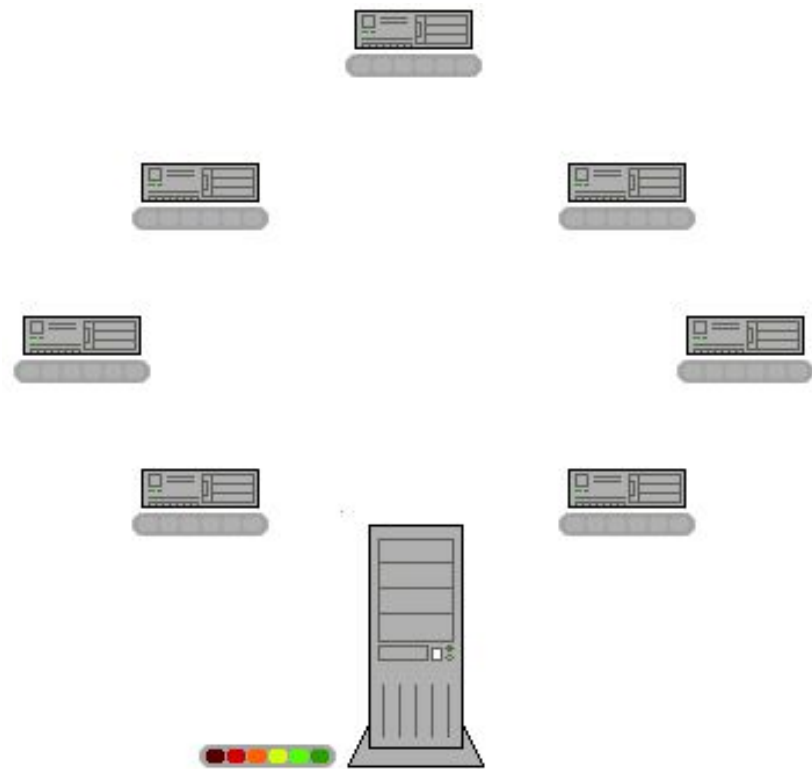
All computers in P2P network contain parts of resources, and can work as client or server.

BitTorrent

BitTorrent protocol for peer-to-peer file sharing.

File is located not in one server, but on different peers.

So to download file, pieces of it are requested from different peers. After downloading piece of file, peer can immediately share it to other peers.



Why loading by Torrent is usually faster than loading from server?

Because in server-client network there is only one server, and many clients.

Server has limited bandwidth, and it will be divided to many clients.

In p2p network there are many peers that share file, so bandwidth is much more.

Firechat



Mobile application that creates network from nearby devices, sends messages without using Internet, and cellular connection, using only WiFi or Bluetooth.

Skype

Skype (Sky peer to peer) was originally hybrid of client-server and peer-to-peer technology.

Now it uses Microsoft's supernode servers.



Watch video about MAC address and IP addresses
<https://www.youtube.com/watch?v=iGPXkxeOfdk>