NETWORKS

What is a network?

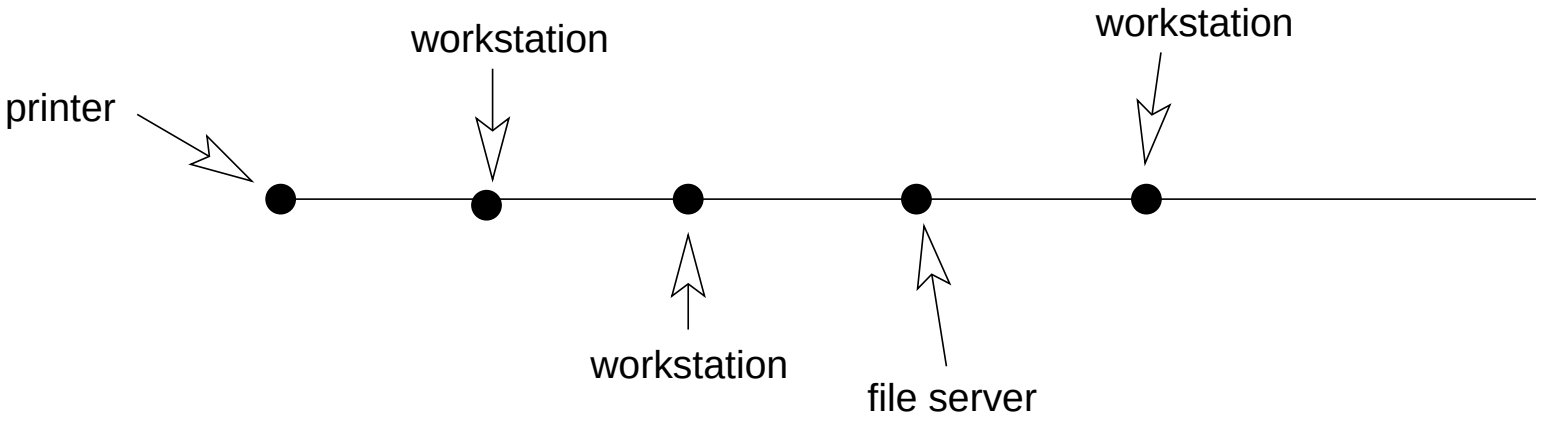
- When computers talk to each other, this is called a **network**
- *Open system* = "a system whose architecture is not a secret"
- The network can have different kinds of computers and peripherals attached to it
- The way in which the computers are connected to each other is called the network's *topology*

Network concepts

- Networks in which computers are physically connected to each other in the close geographical proximity are called *local area networks*.
  - LAN
- Other networks are called *wide area networks*
  - WAN
- The *internet* is a wide area network

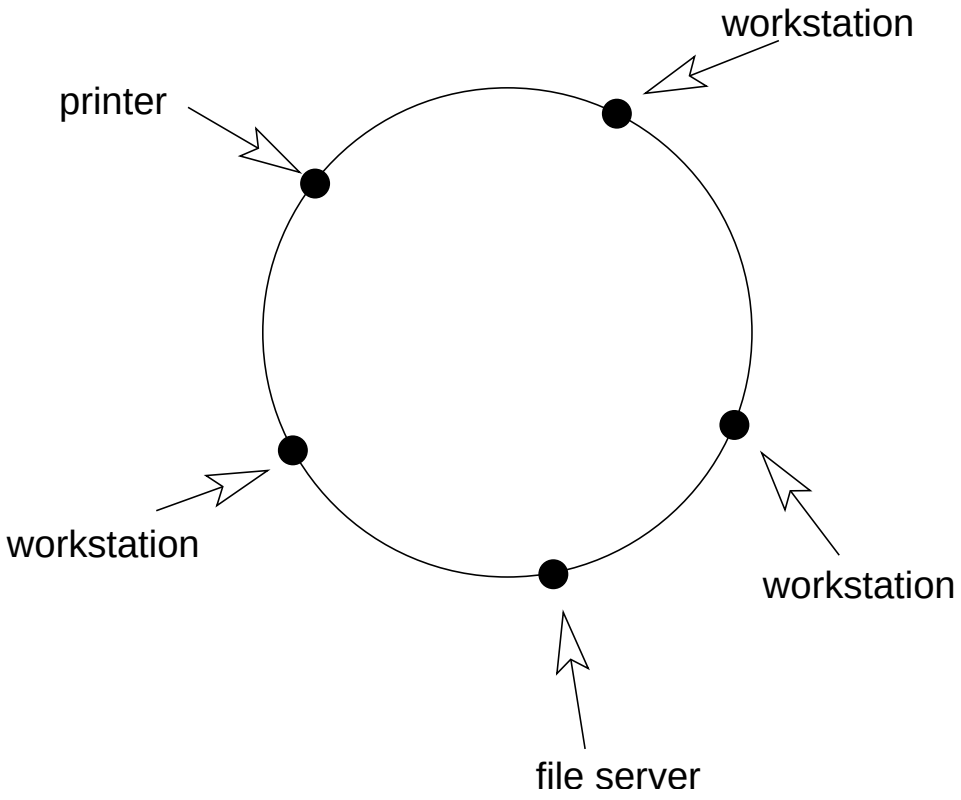
Network topologies

- Bus (linear model; inexpensive to run cables, but not robust to node failure)

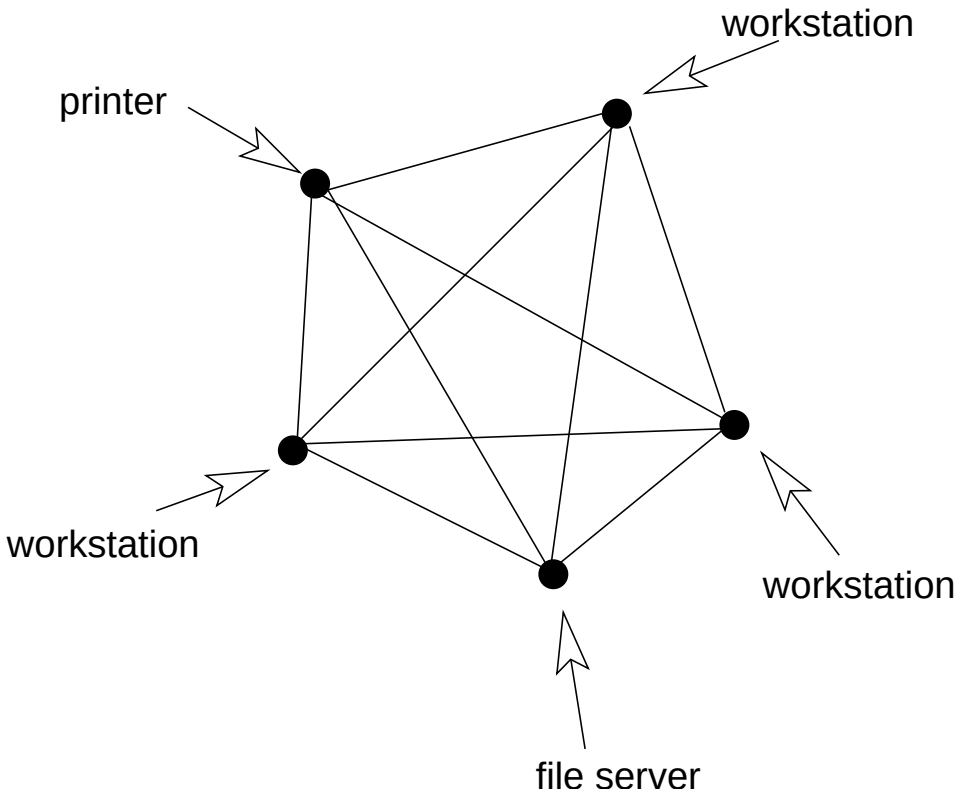


- This is basically the way that the campus network is wired (though the bus branches).

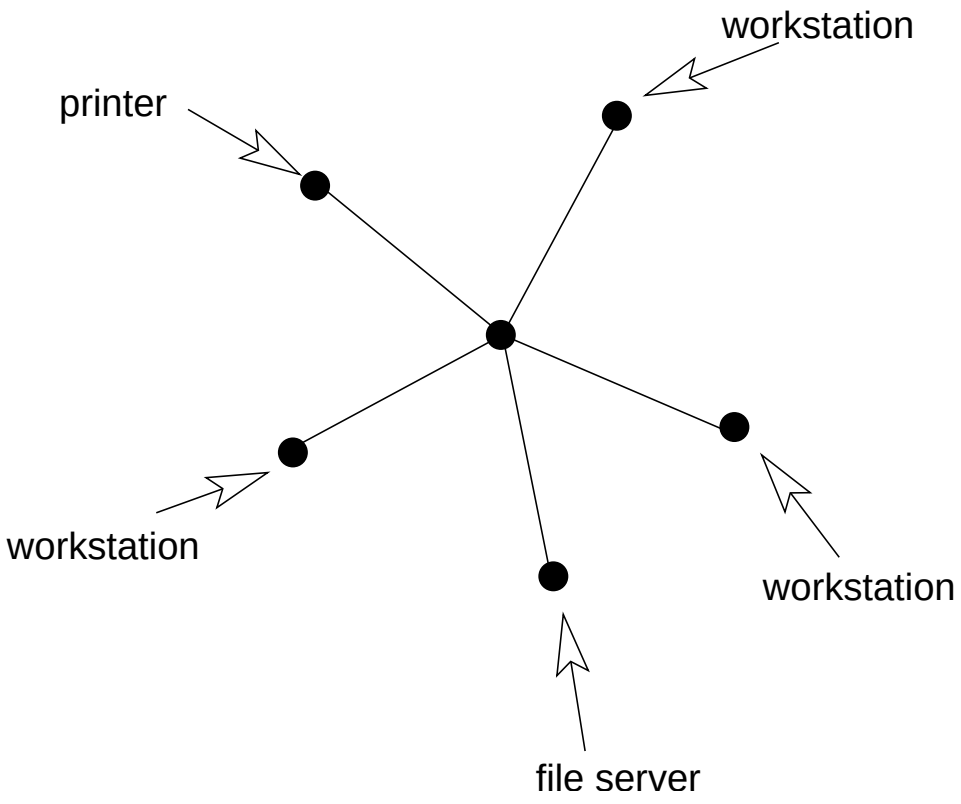
- Ring (example: IBM token ring)



- Star (can be expensive to run cables, but robust to node failure)

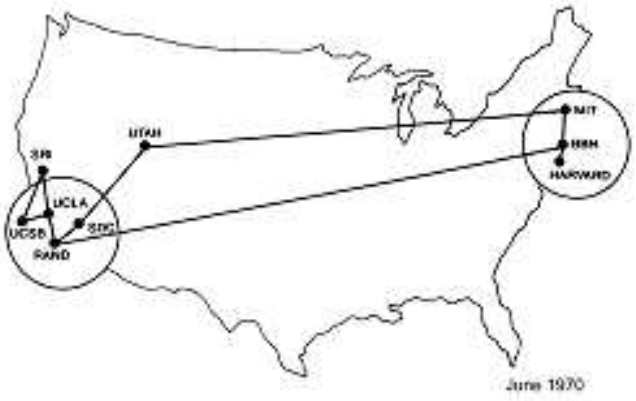


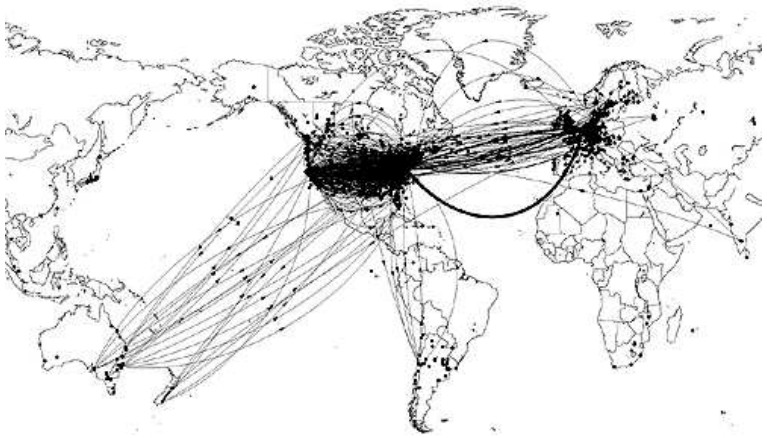
- Hub (efficient; internet model)



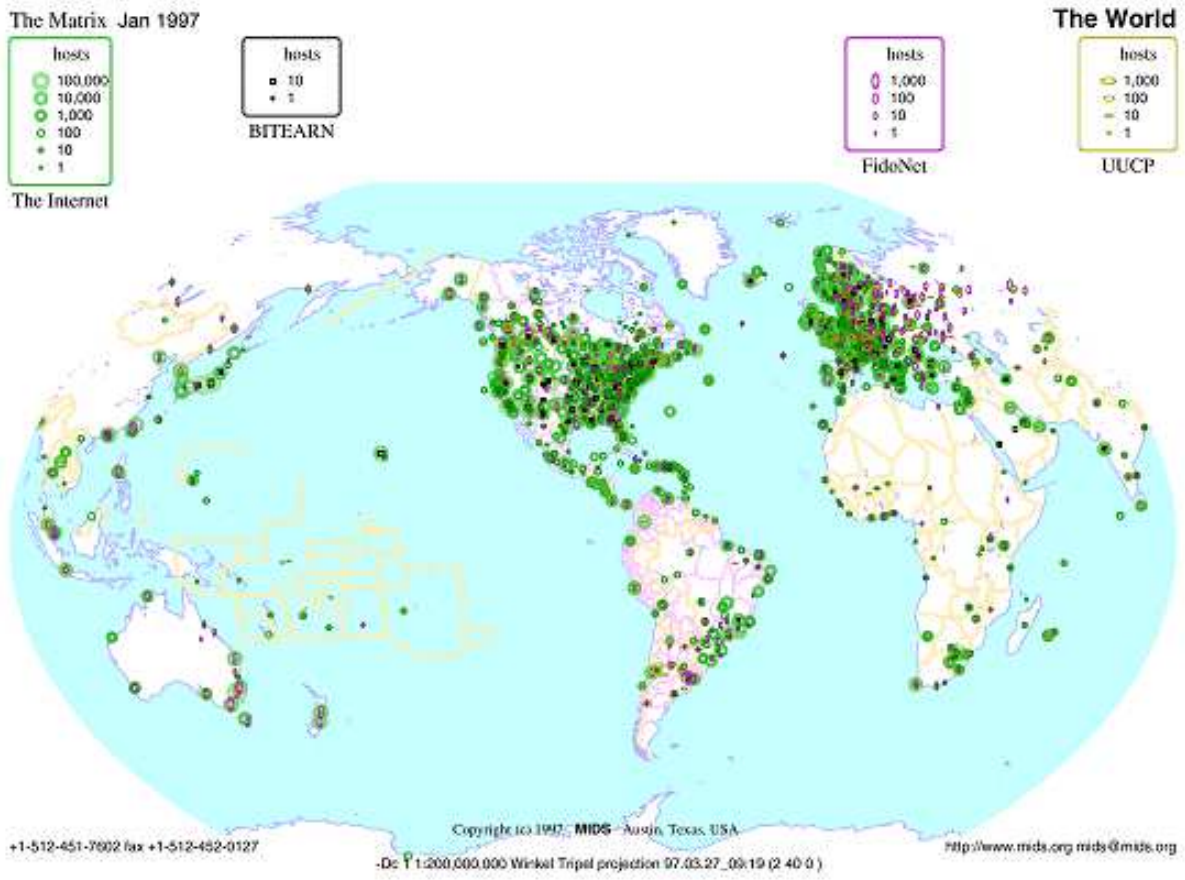
What is the internet?

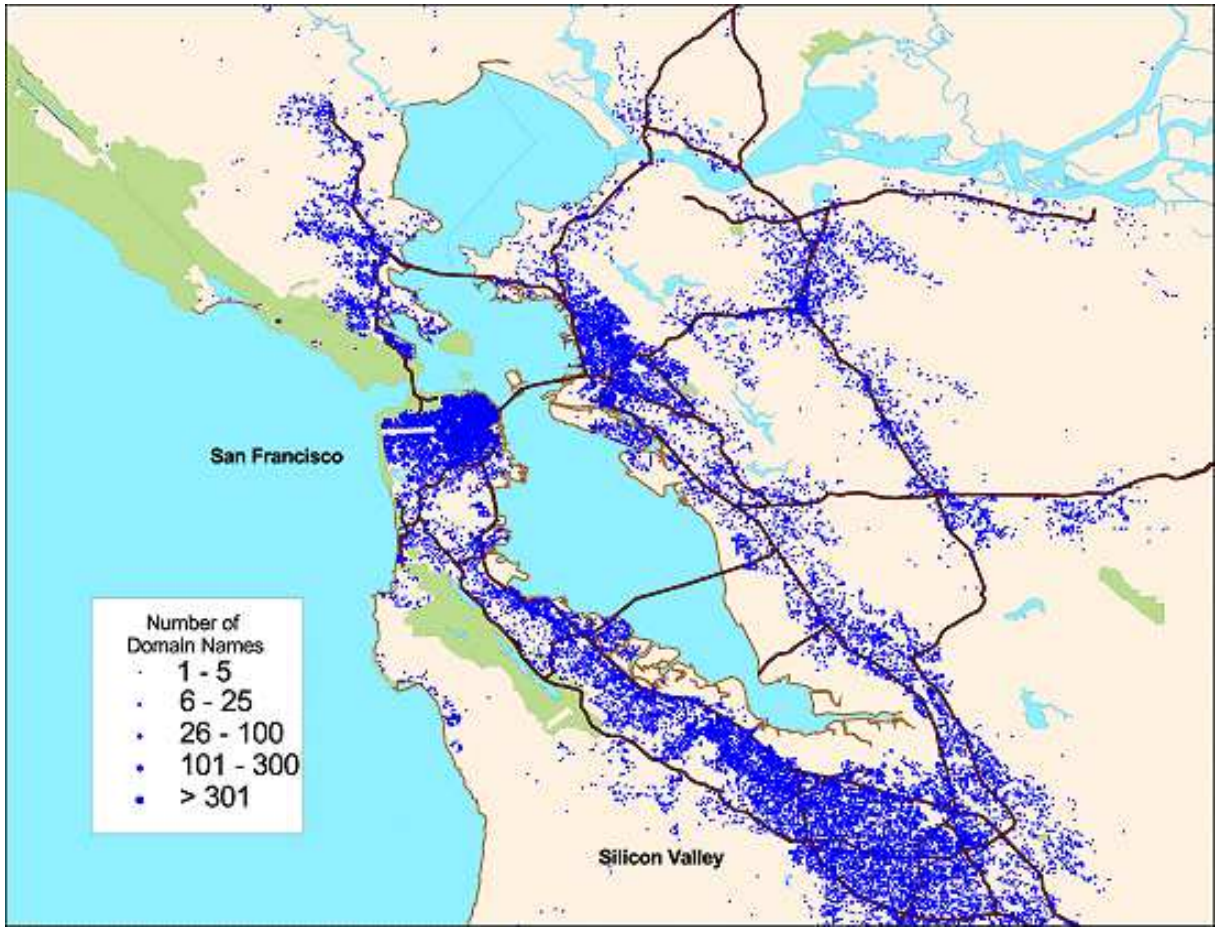
- ARPAnet (circa 1970): used "NCP"
- TCP (1974): hardware independent, open
- Internet was standardized in September 1981.
- It grew :-)





Internet growth




San Francisco
Silicon Valley
Number of
Domain Names
1 - 5
6 - 25
26 - 100
101 - 300
> 301

Internet architecture

- Layered structure
- (Open System Interconnection (OSI) or "7-layer" model)

1. application layer
   (displays data, communicates with lower layers via presentation layer)
2. presentation layer
   (converts application layer data to forms understandable by other layers, and back; translates the "meaning" of the bits)
3. session layer
   (exchange of data between applications – "dialog" – and synchronization between applications)

4. transport layer
   (transfer of data through network; effects flow control; provides some error recovery)
5. network layer
   (physical routing of data from one computer to another; facilitates sender finding receiver)
6. data link layer
   (manages transmissions of low-level data; detects and corrects transmission errors)
7. physical layer
   (sends electronic signals, or "bits" – 0's and 1's) (usually linked to above)

- **A**ll **P**eople **S**eem **T**o **N**eed **D**ata **P**rocessing

Network information units and formats

- "Information units" are passed from one layer to another.
- "Headers" are added as information passes from upper to lower layer.
- The information passed in layer N, is the information unit passed down from layer $N - 1$, plus the header for layer N.

- Terminology is defined below (it is often not used clearly or precisely):
  - *frame* = information unit whose source and destination are the *data link* layer
  - *packet* = information unit whose source and destination are the *network* layer
  - *segment* = information unit whose source and destination are the *transport* layer
  - *message* = information unit whose source and destination are the *application*, *presentation* or *session* layers
  - *datagram* = information unit in a "connectionless" network

Internet protocols

- *protocol* = set of rules for how computers communicate with each other.
- IP: internet protocol, moving data via TCP or UDP.
- TCP: transmission control protocol (computer $\leftrightarrow$ computer), can retransmit if errors are detected.
- UDP: user datagram protocol, no error checking, fast messaging.
- HTTP: hypertext transfer protocol (computer $\leftrightarrow$ browser)
- FTP: file transfer protocol
- SMTP: simple mail transfer protocol
- TFTP: trivial file transfer protocol (fast file transfer, lacks security)

Internet facilities

- World wide web
  - HTML = hypertext markup language
  - *hyperlink*
  - *browser*
  - *web page*, *web site*, *web server*
- Email

- ftp (file transfer protocol)
  - *download*
  - *upload*
- Newsgroups
  - *posting*
  - *thread*
- Mailing lists

Internet addresses

- *IP address* = Internet Protocol address
- every computer on the internet has a unique address
- *dotted quad notation* = four numbers separated by dots (.); e.g., 146.245.201.20 (which is the address of the BC web server...)
- address can be stored in 32 bits; there are four formats, depending on the size of the network (i.e., the size of each of the numbers in the dotted quad notation is defined by the format...)
- "subnetting" is a standard (defined in 1985) to divide a large network into a number of smaller networks (this is what a *router* does)
- example:

	network prefix	subnet number	host number
IP address 130.5.5.25 →	130.5.	.5	.25

Domain names

- provides a more convenient way to address a computer on the internet than the numeric IP address
- structured hierarchically
- example: `www.sci.brooklyn.cuny.edu` instead of `146.245.250.131`
- common *domain names*: `com`, `edu`, `gov`, `uk` and other country-based domains
- *name server*: maintains correspondance between numeric IP address and domain names;
- DNS = internet domain name system = group of domain name servers

Clients and servers

- *server*:
  - computer on a network which carries out some service for another computer
- *client*:
  - the other computer for whom the server is carrying out the service

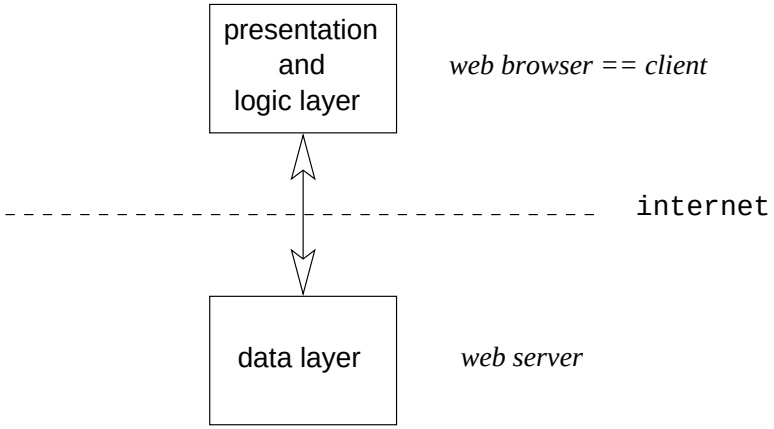
Types of servers

- file servers (provides files for clients)
- database servers (specialized file server: provides databases – structured files – for clients)
  - what is a *database*?
  - key concepts: SQL (structured query language), hierarchy, *records*, *fields*
- web servers (specialized file server: provides files that make up the components of a web site, e.g., html documents, video clips, etc)

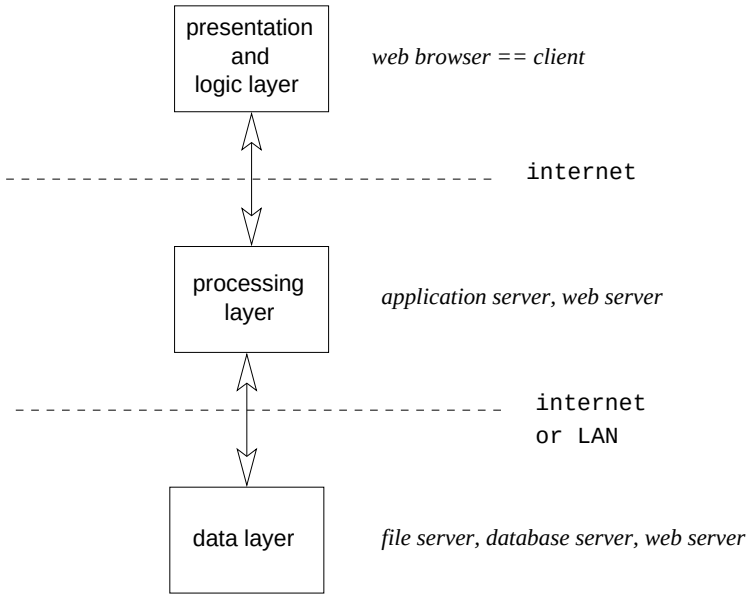
- groupware
  - manages scheduling for individuals and groups of co-workers/collaborators
  - provides reports (e.g., billing) for collaborators
  - supports mailing lists for collaborators
  - e.g. Lotus Notes
- mail servers (provides mail sending, receiving, storage)
- object servers (provides access to “distributed objects”)

- print servers (manages a print *queue*)
  - adds requests to the queue
  - schedules requests
  - instructs printer regarding requests
  - provides status on requests to clients
- application servers (provides access to particular applications, e.g., game servers)

Client-server architectures



two-tier architecture



three-tier architecture

- advantages:
  - isolates data storage technology
  - places more burden on server (instead of client) and distributes tasks amongst server(s)
  - follows object-oriented and modular paradigms

Why do we use networks in medical computing?

Summary

- This lecture has discussed the basics of networks (including the internet).
- Amongst other things, we discussed network topologies, client server architectures, and the OSI seven layer model.
- While there is lots of other work on networks and networking, this material should be enough to be going on with.