CSE 451: Operating Systems
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Module 21
Distributed Systems

Ed Lazowska
lazowska@cs.washington.edu
Allen Center 570

What is a "distributed system"?

- Very broad definition
  - loosely-coupled to tightly-coupled
- Nearly all systems today are distributed in some way
  - they use email
  - they access files over a network
  - they access printers over a network
  - they're backed up over a network
  - they share other physical or logical resources
  - they cooperate with other people on other machines
  - they access the web
  - they receive video, audio, etc.

Distributed systems are now a requirement

- Economics dictate that we buy small computers
- Everyone needs to communicate
- We need to share physical devices (printers) as well as information (files, etc.)
- Many applications are by their nature distributed (bank teller machines, airline reservations, ticket purchasing)
- To solve the largest problems, we will need to get large collections of small machines to cooperate together (parallel programming)

Loosely-coupled systems

- Earliest systems used simple explicit network programs
  - FTP (rcp): file transfer program
  - telnet (rlogin/rsh): remote login program
  - mail (SMTP)
- Each system was a completely autonomous independent system, connected to others on the network

- Even today, most distributed systems are loosely-coupled
  - each CPU runs an independent autonomous OS
  - computers don't really trust each other
  - some resources are shared, but most are not
  - the system may look differently from different hosts
  - typically, communication times are long

Closely-coupled systems

- A distributed system becomes more "closely-coupled" as it
  - appears more uniform in nature
  - runs a "single" operating system
  - has a single security domain
  - shares all logical resources (e.g., files)
  - shares all physical resources (CPUs, memory, disks, printers, etc.)
- In the limit, a distributed system looks to the user as if it were a centralized timesharing system, except that it's constructed out of a distributed collection of hardware and software components

Tightly-coupled systems

- A “tightly-coupled” system usually refers to a multiprocessor
  - runs a single copy of the OS with a single job queue
  - has a single address space
  - usually has a single bus or backplane to which all processors and memories are connected
  - has very low communication latency
  - processors communicate through shared memory

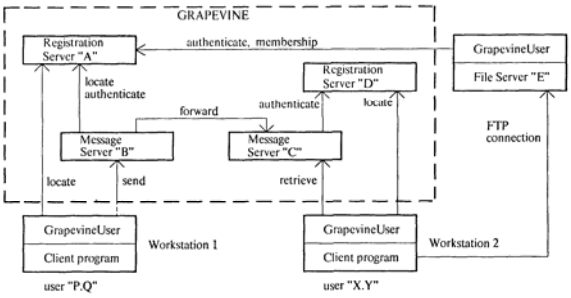
Some issues in distributed systems

- Transparency (how visible is the distribution)
- Security
- Reliability
- Performance
- Scalability
- Programming models
- Communication models

Grapevine distributed mail service

- Xerox PARC, 1980
  - cf. Microsoft Outlook/Exchange today!!!!!
- Goals
  - cannot rely on integrity of client
  - once the system accepts mail, it will be delivered
  - no single Grapevine computer failure will make the system unavailable to any client either for sending or for receiving mail
- Components
  - GrapevineUser package on each client workstation
  - Registration Servers
  - Message Servers
- Implementation: Remote Procedure Call

Grapevine: Functional diagram



Grapevine: Sending a message

- User prepares message using mail client
- Mail client contacts GrapevineUser package on same workstation to actually send message
- GrapevineUser package
  - contacts any Registration Server to get a list of Message Servers
  - contacts any Message Server to transmit message
    - presents source and destination userids, and source password, for authentication
      - Message Server uses any Registration Server to authenticate
    - sends message body to Message Server
      - Message Server places it in stable storage and acknowledges receipt

Grapevine: Transport and buffering

- For each recipient of the message, Message Server contacts any Registration Server to obtain list of Message Servers holding mail for that recipient
- Sends a copy of the message to one of those Message Servers for that recipient

Grapevine: Retrieving mail

- User uses mail client to contact GrapevineUser package on same workstation to retrieve mail
- GrapevineUser package
  - contacts any Registration Server to get a list of each Message Server holding mail for the user ("inbox site")
  - contacts each of these Message Servers to retrieve mail
    - presents user credentials
      - Message Server uses any Registration Server to authenticate
    - acknowledges receipt of messages so that the server can delete them from its storage

Grapevine: Scalability

- Can add more Registration Servers
- Can add more Message Servers
- Only thing that didn't scale was handling of distribution lists
  - the accepting Message Server was responsible for expanding the list (recursively if necessary) and delivering to an appropriate Message Server for each recipient
  - some distribution lists contained essentially the entire user community
- Jeff Dean (Google) told us they don't even think about more than two decimal orders of magnitude
  - fundamental design decisions will need to change
  - advances in technology will make it possible