**CMPSCI 377 Operating Systems** **Fall 2005**

# Lecture 20: December 01

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Today:

- Distributed Systems
- Page Eviction
- Network Topologies
- Network Communication
- Packets

## 20.1 Distributed Systems

### 20.1.1 General Information

- A distributed system is a set of physically separate processors connected by one or more communication links.
  - contains no shared clock or memory.
  - this systems are in broad use today.

### 20.1.2 Parallel vs. Distributed Systems

- Tightly-coupled systems or "parallel processing"
  - Systems share clocks, memory, etc.
  - Systems frequent communication
- Loosely-coupled systems or "distributed computing"
  - Each system/processor has its own memory and runs independent of the OS.
  - Systems have infrequent communication

### 20.1.3 Advantages of Distributed Systems

- Resource Sharing
  - Resources do not need to be replicated because they are shared.
  - Expensive resources can be shared
  - Processors present the same environment to users.

- Computational Speedup
  - n processors, n times the computational power
  - Problems must be decomposable into subproblems
  - Coordination and communication is required between operating processes.
- Reliability
  - Replication of resource produces fault tolerance. This cannot happen with only one machine.
  - If one node crashes the user can work on another.
  - Systems must be available for all but five minutes per year.
  - Must avoid single point of failure
- Communication
  - Users, or processors, on different systems can communicate. Examples of this are mail servers and transaction processing systems.

### 20.1.4 Issues with Distributed Systems

- Issues:
  1. Communication
  2. Transparency
  3. Security
  4. Reliability
  5. Performance
  6. Programming modules

## 20.2 Networks

### 20.2.1 General Information

- Networks should provide efficient, correct, and robust message passing between two separate nodes.
- Local area networks are connected in a singled building. This networks are extremely fast and reliable.
- Wide area networks are connected across a large geographical area.

### 20.2.2 Network Topologies

- Connection of the nodes impact the fault tolerance and cost of a network.
- There are two basic topologies:
  1. Point-to-Point
  2. Bus

### 20.2.3 Point-to-Point Networks

- Fully Connected
  - This is not used in common day practice
  - Each message takes one hop.
  - Node failure will not bring this network down, but it is very expensive.
- Partially Connected
  - Links between some but not all nodes.
  - Sending messages requires several hops.
  - This setup is not ideal because one node failure can result in the entire network going down.
- Tree Structure
  - Network is connected in a tree structure. This is where every node is connected through a child or parent node.
  - Messages are fast between descendants. They are of order logn time.
  - Network is vulnerable to failure especially at nodes located at a higher position within the tree.
- Star Network
  - All nodes are connected to a central node.
  - Each message takes two hops.
  - Central node is critical, need to take action to make that node very reliable
  - Not fault tolerant.
- One-directional Ring
  - Nodes are connected in the same fashion as a token ring. With max hops being n-1.
  - This system is very inexpensive, but it only takes one node failure to bring down the entire network.
- Bi-directional Ring
  - Nodes are connected like a one-direction ring, but with nodes being able to communicate forwards and backwards. This network gives n/2 max hops.
  - This network is inexpensive but is still not fault tolerant as it would only take two node failures to take down this network.
- Double-connected Ring
  - Nodes are connected as in the bi-directional ring plus one additional node. This network give n/4 max hops.
  - This network is more expensive, but it is fault tolerant as it would take four node failures to take down this network.

### 20.2.4 Bus Network Topology

- Bus nodes are connected to a common network. While this is very fast and reliable, it is not commonly utilized because of the poor scalability.
  - Linear Bus
    - Single shared link.
    - Nodes connect directly to each other via bus.
    - Network is inexpensive and fault tolerant.
  - Ring Bus
    - Single shared circular link.
    - Same pros and cons as Linear Bus.

### 20.2.5 Principles of Network Communication

- Data is broken down into packets. The packets are then sent through networks. These protocols are based on agreed communication standards.

### 20.2.6 Network Layers

- Application: Data is used by applications.
- Presentation: Data format conversion.
- Session: Implement communication strategy.
- Transport: Reliable end-to-end communication.
- Network: Routing and congestion control.
- Data Link Control: Reliable point-to-point communication over reliable channel.
- Physical: Electrical signaling across wire.

### 20.2.7 TCP/IP Protocal Stack

- TCP: Reliable protocol that ensures that packets are received in order.
- UDP: Unreliable protocol that is fast, but does not ensure that packets are received in order.

### 20.2.8 Packets

- Contain all information needed to recreate original message.
- Packets may arrive out of order but can be put back in order through the sequence numbers of the packets.
- Data segment contains header for higher protocol layers.