# Distributed Operating Systems

COMP755

> *"A distributed system is one where you can't get your work done because a computer you didn't even know existed, has crashed."*
>
> - Leslie Lamport

## Spectrum of Multiprocessor OS

- Some distributed OS only share files. Accessing data on another computer is very visible to the user. The textbook calls this a Network Operating System.
- Other distributed OS try to make a collection of computers look like one large single computer. The textbook calls this a Distributed Operating System.
- There are many systems in between.

## Types of Multiprocessor Systems

- SMP or dual core computer
- Hypercube, separate memory multiprocessor
- Beowulf Cluster
- Cluster of Workstations
- Ad Hoc collection of computers
- Client/Server systems

## Beowulf Cluster

- A Beowulf cluster is a group of usually identical PC computers running an Open Source Unix-like operating system. They are networked into a small LAN.
- Usually consists of one server node and several client nodes connected together via Ethernet
- Server node controls the whole cluster and serves files to the client nodes

## Beowulf Programming

- Beowulf appears to the user like a multi-processor computer instead of a bunch of PCs.
- Beowulf clusters often use Parallel Virtual Machine (PVM) or Message Passing Interface (MPI) for parallel programming



## Beowulf in Literature



- Epic poem written about 800 – 1000 CE
- Earliest surviving English literature
- The hero, Beowulf, battles monsters and dragons.
- More about *"wurd"* than *"worm"*

## Why distributed systems?

- People are distributed, data are distributed
- Performance / Cost
- Scalability
- Modularity
- Availability & Reliability

## Characteristics of a Distributed System

- Resource sharing
  - Hardware like printers, disks, scanners
  - Data
    - Web pages
    - software libraries
    - corporate data
    - cooperative work
- Openness
  - interfaces are published
  - uniform communication mechanism
  - possibly heterogeneous

## Characteristics

- Concurrency
- Scalability
- Message Passing
- Lack of global information
- Fault Tolerance
  - availability

## A distributed system can be built from

1. Microsoft Windows PCs
2. Linux computers
3. Sun Sparc workstations
4. All of the above
5. None of the above



20%  20%  20%  20%  20%

Microsoft Wind…  Linux computer…  Sun Sparc work…  All of the abo…  None of the ab…
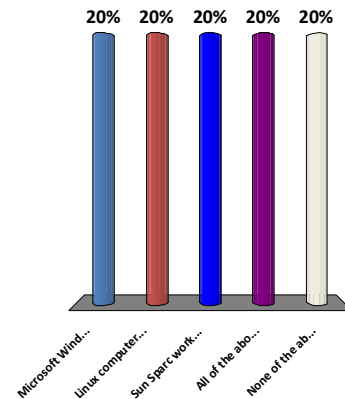
## Transparency

- **access** - local and remote objects accessed by identical operations
- **location** - do not have to know location of objects or processes
- **concurrency** - multiple access without interference
- **replication** - multiple copies without user or application knowledge

## Transparency (cont.)

- **failure** - continue despite hardware or software failure
- **migration** - objects can move without user knowledge
- **reconfiguration** - system can be changed without user knowledge
- **scaling** - increasing the system size does not effect structure or applications

## Goals

- Efficiency
  - Minimize communications
  - load balancing
- Flexibility
  - friendliness
  - ability to evolve.
- Consistency
  - transparency
- Robustness
  - equipped to handle exceptional situations and errors.

## Robustness

- Failure detection

- Reconfiguration

## Failure Detection

- Detecting hardware failure is difficult
- To detect a link failure, a handshaking protocol can be used
- If Site A does not receive a reply, it can repeat the message or try an alternate route to Site B

## Failure Detection (cont)

- If Site A does not ultimately receive a reply from Site B, it concludes some type of failure has occurred

- Types of failures:
  - Site B is down
  - The direct link between A and B is down
  - The alternate link from A to B is down
  - The message has been lost

- However, Site A cannot determine exactly **why** the failure has occurred

## Reconfiguration

- When Site A determines a failure has occurred, it must reconfigure the system:

  1. If the link from A to B has failed, this must be broadcast to every site in the system

  2. If a site has failed, every other site must also be notified indicating that the services offered by the failed site are no longer available

- When the link or the site becomes available again, this information must again be broadcast to all other sites