


# Chapter 9: Distributed Systems




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## Chapter 9: Distributed Systems

- ▣ Advantages of Distributed Systems
- ▣ Network Structure
- ▣ Communication Protocols
- ▣ Network and Distributed Operating Systems
- ▣ Design Issues of Distributed Systems




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## Chapter Objectives

- ▣ Explain the advantages of networked and distributed systems
- ▣ Define the roles and types of distributed systems in use today

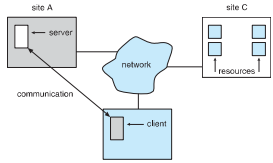


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## Overview

- ▣ A **distributed system** is a collection of loosely coupled nodes interconnected by a communications network
- ▣ Nodes variously called **processors, computers, machines, hosts**
  - ▣ **Site** is location of the machine, **node** refers to specific system
  - ▣ Generally a **server** has a resource a **client** node at a different site wants to use




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## Overview (cont.)

- ▣ Nodes may exist in a **client-server, peer-to-peer, or hybrid** configuration.
  - ▣ In client-server configuration, server has a resource that a client would like to use
  - ▣ In peer-to-peer configuration, each node shares equal responsibilities and can act as both clients and servers
- ▣ Communication over a network occurs through **message passing**
- ▣ All higher-level functions of a standalone system can be expanded to encompass a distributed system




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## Reasons for Distributed Systems

- ▣ **Resource sharing**
  - ▣ Sharing files or printing at remote sites
  - ▣ Processing information in a distributed database
  - ▣ Using remote specialized hardware devices such as **graphics processing units (GPUs)**
- ▣ **Computation speedup**
  - ▣ Distribute subcomputations among various sites to run concurrently
  - ▣ **Load balancing** – moving jobs to more lightly-loaded sites
- ▣ **Reliability**
  - ▣ Detect and recover from site failure, function transfer, reintegrate failed site



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## Network Structure

- **Local-Area Network (LAN)** – designed to cover small geographical area
- Consists of multiple computers (workstations, laptops, mobile devices), peripherals (printers, storage arrays), and routers providing access to other networks
- Ethernet and/or Wireless (**WiFi**) most common way to construct LANs
  - ▶ Ethernet defined by standard IEEE 802.3 with speeds typically varying from 10Mbps to over 10Gbps
  - ▶ WiFi defined by standard IEEE 802.11 with speeds typically varying from 11Mbps to over 400Mbps.
  - ▶ Both standards constantly evolving

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## Local-Area Network (LAN)

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## Network Structure (Cont.)

- **Wide-Area Network (WAN)** – links geographically separated sites
- Point-to-point connections via links
  - ▶ Telephone lines, leased (dedicated data) lines, optical cable, microwave links, radio waves, and satellite channels
- Implemented via **routers** to direct traffic from one network to another
- Internet (World Wide Web) WAN enables hosts world wide to communicate
- Speeds vary
  - ▶ Many backbone providers have speeds at 40-100Gbps
  - ▶ Local **Internet Service Providers (ISPs)** may be slower
  - ▶ WAN links constantly being upgraded
- WANs and LANs interconnect, similar to cell phone network:
  - ▶ Cell phones use radio waves to cell towers
  - ▶ Towers connect to other towers and hubs

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## Wide-Area Network (WAN)

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## Naming and Name Resolution

- Each computer system in the network has a unique name
- Each process in a given system has a unique name (process-id)
- Identify processes on remote systems by **<host-name, identifier>** pair
- **Domain name system (DNS)** – specifies the naming structure of the hosts, as well as name to address **resolution** (Internet)

```

/**
 * Image: java.DNSLookup <IP name>
 * s.s.s - java.DNSLookup www.vijay.com
 */
public class DNSLookup {
    public static void main(String[] args) {
        InetAddress hostAddress;

        try {
            hostAddress = InetAddress.getByName(args[0]);
            System.out.println(hostAddress.getHostAddress());
        } catch (UnknownHostException e) {
            System.err.println("Unknown host: " + args[0]);
        }
    }
}
    
```


Figure 19.4 Java program illustrating a DNS lookup.

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## Communication Protocol

- Communication via OSI model ( 7 Layers)
- Transport Protocols:
  - TCP (Transmission Control Protocol)
    - ▶ Reliable and Connection-oriented
  - UDP (User Datagram Protocol)
    - ▶ Unreliable and Connectionless


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## Network-oriented Operating Systems


- Two main types
- Network Operating Systems**
  - Users are aware of multiplicity of machines
- Distributed Operating Systems**
  - Users not aware of multiplicity of machines

multiplicity : ความหลากหลายหลายรูปแบบ




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## Network Operating Systems

- Users are aware of multiplicity of machines
- Access to resources of various machines is done explicitly by:
  - Remote logging into the appropriate remote machine (ssh)
    - ssh kristen.cs.yale.edu
  - Transferring data from remote machines to local machines, via the File Transfer Protocol (FTP) mechanism
  - Upload, download, access, or share files through cloud storage
- Users must change paradigms – establish a **session**, give network-based commands, use a web browser
  - More difficult for users



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## Distributed Operating Systems


- Users not aware of multiplicity of machines
  - Access to remote resources similar to access to local resources
- Data Migration** – transfer data by transferring entire file, or transferring only those portions of the file necessary for the immediate task
- Computation Migration** – transfer the computation, rather than the data, across the system
  - Via remote procedure calls (RPCs)
  - Via messaging system

migration : การเคลื่อนย้ายจากที่หนึ่งไปยังอีกที่หนึ่ง




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## Distributed-Operating Systems (Cont.)

- Process Migration** – execute an entire process, or parts of it, at different sites
  - Load balancing** – distribute processes across network to even the workload
  - Computation speedup** – subprocesses can run concurrently on different sites
  - Hardware preference** – process execution may require specialized processor
  - Software preference** – required software may be available at only a particular site
  - Data access** – run process remotely, rather than transfer all data locally
- Consider the World Wide Web




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## Design Issues of Distributed Systems

- We investigate three design questions:
  - Robustness** – Can the distributed system withstand failures?
  - Transparency** – Can the distributed system be transparent to the user both in terms of where files are stored and user mobility?
  - Scalability** – Can the distributed system be scalable to allow addition of more computation power, storage, or users?




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## Robustness

- Hardware failures can include failure of a link, failure of a site, and loss of a message.
- A **fault-tolerant system** can tolerate a certain level of failure
  - Degree of fault tolerance depends on design of system and the specific fault
  - The more fault tolerance, the better!
- Involves **failure detection**, **reconfiguration**, and **recovery**




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## Failure Detection

- Detecting hardware failure is difficult
- To detect a link failure, a **heartbeat** protocol can be used
- Assume Site A and Site B have established a link
  - At fixed intervals, each site will exchange an *I-am-up* message indicating that they are up and running
- If Site A does not receive a message within the fixed interval, it assumes either (a) the other site is not up or (b) the message was lost
- Site A can now send an *Are-you-up?* message to Site B
- If Site A does not receive a reply, it can repeat the message or try an alternate route to Site B




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## 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




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## Reconfiguration and Recovery

- When Site A determines a failure has occurred, it must reconfigure the system:
  - If the link from A to B has failed, this must be broadcast to every site in the system
  - 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



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## Transparency


- The distributed system should appear as a conventional, centralized system to the user
  - User interface should not distinguish between local and remote resources
    - ▶ Example: NFS
  - User mobility allows users to log into any machine in the environment and see his/her environment
    - ▶ Example: LDAP plus desktop virtualization

NFS: Network File System (เป็นกลไกในการเก็บไฟล์ข้อมูลในระบบเครือข่ายเซิร์ฟเวอร์)  
 LDAP: Lightweight Directory Access Protocol (ใช้กลไกที่ใช้ในการเข้าถึงไคลเอนต์ในระบบเครือข่ายเซิร์ฟเวอร์)




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## Scalability

- As demands increase, the system should easily accept the addition of new resources to accommodate the increased demand
  - Reacts gracefully to increased load
  - Adding more resources may generate additional indirect load on other resources if not careful
  - Data **compression** or **deduplication** can cut down on storage and network resources used




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## End of Chapter 9

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