CprE 450/550x
Distributed Systems and Middleware

Introduction

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Definition of a Distributed System

A distributed system is:

A collection of independent computers that appears to its users as a single coherent system.

Questions?

- Why we need distributed systems?
- What properties should a distributed systems have?
- What problems/issues should be addressed?

Why we need distributed systems?

- Centralized System
- Network Operating Systems
- Distributed Operating Systems
- Middleware
- Computer Networks

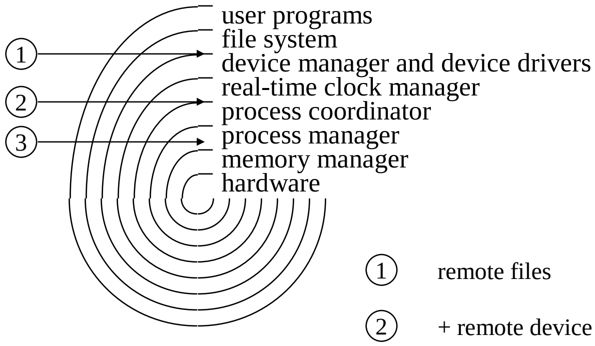
Definition of a Distributed System

- Requirements:
  - – Provide user with convenient virtual computer.
  - – Hide distribution of resources.
  - – Mechanisms for protecting resources.
  - – Secure communication.
- Definition

- **Distributed system looks to user like ordinary centralized OS, but runs on multiple, independent CPUs.**
  - – Use of multiple processors is invisible.
  - – User views system as virtual uniprocessor.

The insider's view of a Centralized OS

- The insider's view of a centralized OS.
- (Roughly patterned after XINU [Comer 1984])



user programs
file system
device manager and device drivers
real-time clock manager
process coordinator
process manager
memory manager
hardware

1 remote files

2 + remote device access

3 + remote process management

Distributed *vs.* Centralized Systems

- Advantages of Distributed Systems:
  - Reliability.
  - Sharing of resources.
  - Aggregate computing power.
  - Openness/Scalability

- Disadvantages of distributed systems:
  - Security.
  - Physical distribution of resources *vs.* demand.
  - Computing power per node is limited.

Distributed *vs.* Networked OS

Transparency:

- How aware are users of the fact that multiple computers are being used?

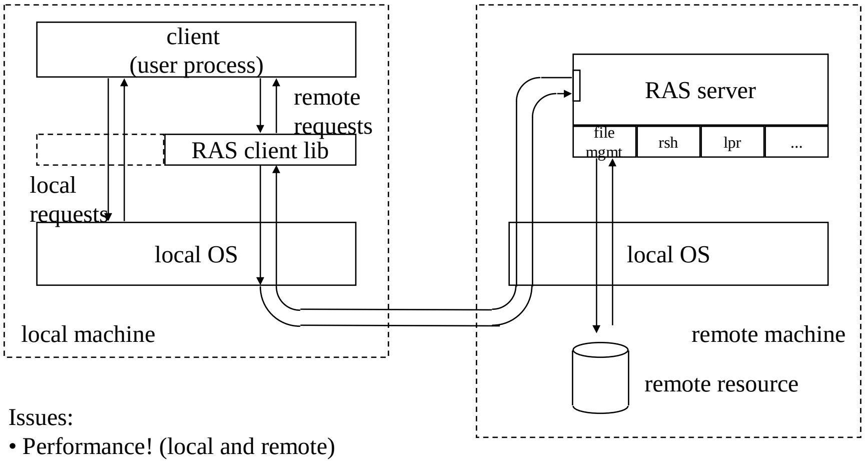
- Network OS:
  - Users are aware where resources are located
  - Network OS is built on top of centralized OS.
  - Handles interfacing and coordination between local OSs.
- Distributed OS:
  - Designed to control and optimize operations and resources in distributed system.

Network Operating Systems

- Definition:
  - A network OS is a collection of OSs of computers connected through a network incorporating modules to provide access to remote resources.
- Characteristics:
  - Each computer has private OS.
  - User works on his own machine and remotely logs in to other computers.
  - Users are aware of location of files.
  - Limited fault tolerance.

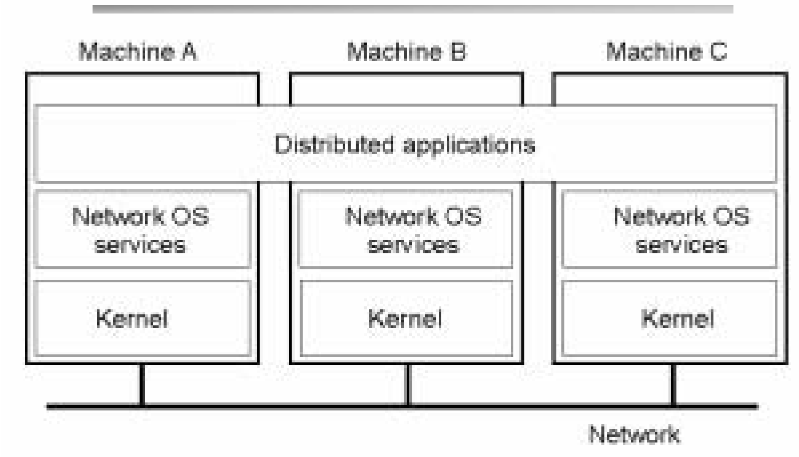
A Vanilla Network OS

(Remote Access System [Goscinsky '83])



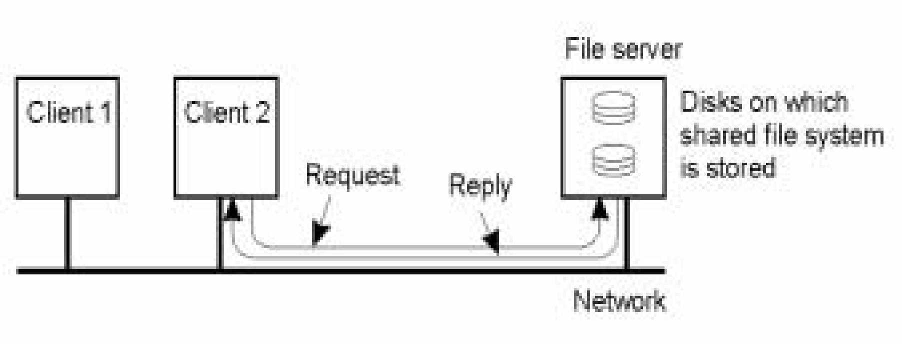
Issues:
- Performance! (local and remote)
- Where is the state?
- Serialization of operations.
- Blocking operations

Network Operating System (1)



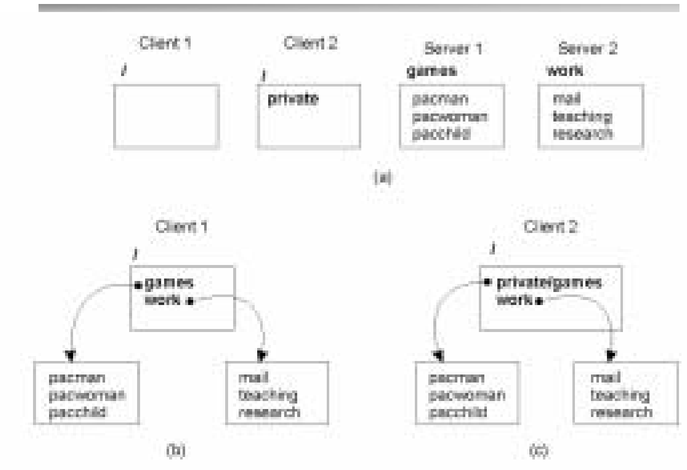
General structure of a network operating system.

Network Operating System (2)



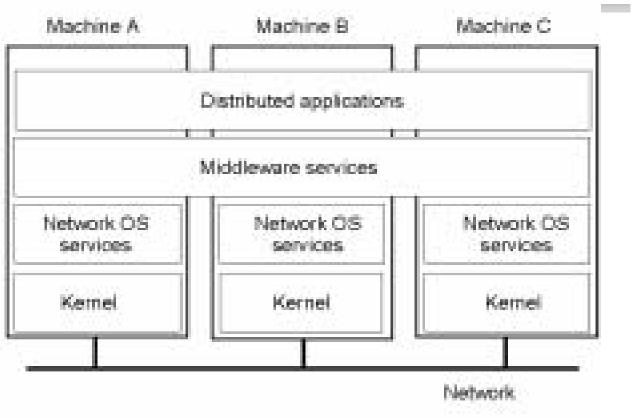
Two clients and a server in a network operating system.

Network Operating System (3)



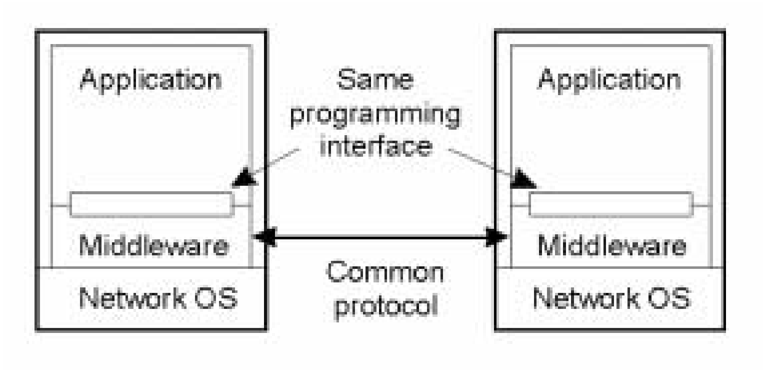
Different clients may mount the servers in different places.

Positioning Middleware



General structure of a distributed system as middleware.

Middleware and Openness



In an open middleware-based distributed system, the protocols used by each middleware layer should be the same, as well as the interfaces they offer to applications.

Comparison between Systems

Item	Distributed OS		Network OS	Middleware-based OS
	Multiproc.	Multicomp.		
Degree of transparency	Very High	High	Low	High
Same OS on all nodes	Yes	Yes	No	No
Number of copies of OS	1	N	N	N
Basis for communication	Shared memory	Messages	Files	Model specific
Resource management	Global, central	Global, distributed	Per node	Per node
Scalability	No	Moderately	Yes	Varies
Openness	Closed	Closed	Open	Open

A comparison between multiprocessor operating systems, multicomputer operating systems, network operating systems, and middleware based distributed systems.

Research and Design Issues

- Communication model
- Paradigms for process interaction
- Transparency
- Heterogeneity
- Autonomy and/or interdependence
- Reliable distributed computing
- Replication

Communication Model

- ISO/OSI Model
  - Physical
  - Datalink
  - Network
  - Transport
  - Session
  - Presentation
  - Application

- An alternative, e.g. *Functional,* Model
  - Physical
    - same as ISO/OSI
  - Datagram
    - connectionless service between source and destination process
    - location of services
  - Transport
    - reliable transport between client and server
    - “transaction level”
  - Binding
    - location of resources within the server
    - logical connection between client and server
  - User
    - request semantics

Process Interaction: Client/Server

- **Server: A** subsystem that provides a particular type of service to *a priori* unknown clients.

- Control functionally distributed among the various servers in the system.
- Control of *individual* resources is centralized in a server. (localized?)
- Problems:
  - Reliability/Availability
  - Scalability
  - Replication?

Process Interaction: Pipe Model

- **Pipe**: Communication facility to transfer data between processes in FIFO order. Can be used for synchronization purposes.

- Named/unnamed pipes

- Pipes for secure IPC

- Pipes across network?

- Multicast pipes?

Transparency in a Distributed System

Transparency	Description
Access	Hide differences in data representation and how a resource is accessed
Location	Hide where a resource is located
Migration	Hide that a resource may move to another location
Relocation	Hide that a resource may be moved to another location while in use
Replication	Hide that a resource may be shared by several competitive users
Concurrency	Hide that a resource may be shared by several competitive users
Failure	Hide the failure and recovery of a resource
Persistence	Hide whether a (software) resource is in memory or on disk

Different forms of transparency in a distributed system.

Autonomy and Interdependence

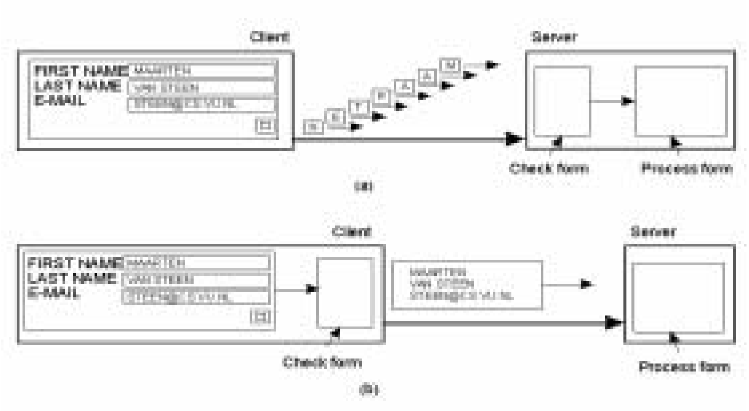
- Disadvantage generated by interdependence:
  - cannot work stand-alone
  - globally controlled
  - difficult to identify source of authority and responsability
  - what about mutual suspicion?
- Reasons for autonomy:
  - policy freedom
  - robustness
  - cooperation between mutually suspicious users

Scalability Problems

Concept	Example
Centralized services	A single server for all users
Centralized data	A single on-line telephone book
Centralized algorithms	Doing routing based on complete information

Examples of scalability limitations.

Scaling Techniques (1)

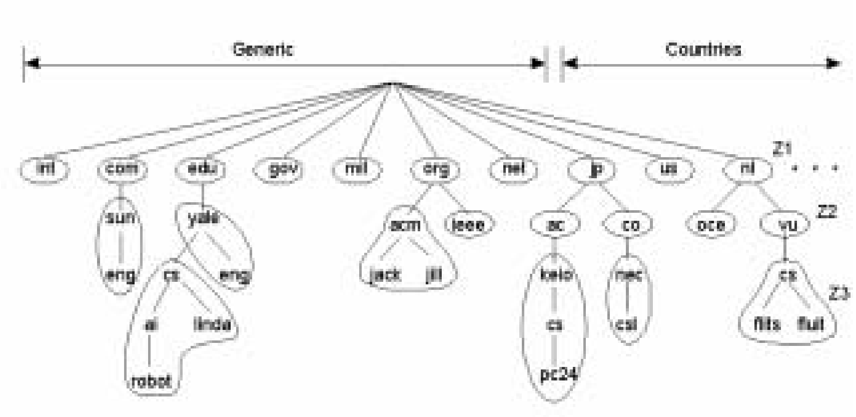


The difference between letting:

a) a server or

b) a client check forms as they are being filled

Scaling Techniques (2)



An example of dividing the DNS name space into zones.

Any Questions?