Distributed Processing, Client/Server, and Clusters

Chapter 13

Client/Server Computing

- Client machines are generally single-user PCs or workstations that provide a highly user-friendly interface to the end user
- Each server provides a set of shared user services to the clients
- The server enables many clients to share access to the same database and enables the use of a high-performance computer system to manage the database

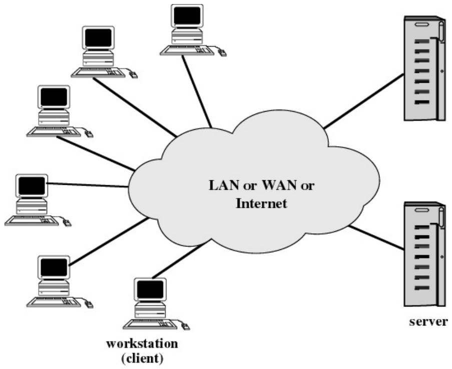


Figure 13.1 Generic Client/Server Environment

Client/Server Applications

- Basic software is an operating system running on the hardware platform
- Platforms and the operating systems of client and server may differ
- These lower-level differences are irrelevant as long as a client and server share the same communications protocols and support the same applications

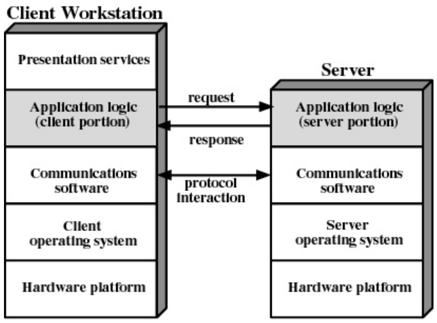


Figure 13.2 Generic Client/Server Architecture

Client/Server Applications

- Actual functions performed by the application can be split up between client and server
- Optimize platform and network resources
- Optimize the ability of users to perform various tasks
- Optimize the ability to cooperate with one another using shared resources

Database Applications

- The server is a database server
- Interaction between client and server is in the form of transactions
  - the client makes a database request and receives a database response
- Server is responsible for maintaining the database

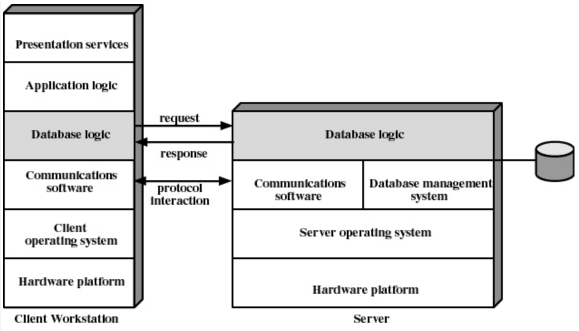
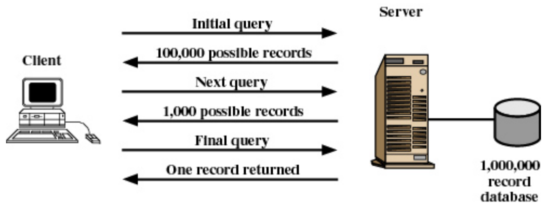
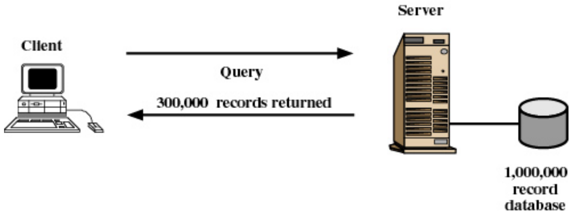


Figure 13.3 Client/Server Architecture for Database Applications



(a) Desirable client/server use

Figure 13.4 Client/Server Database Usage

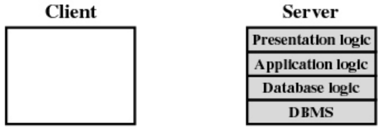


(b) Misused client/server

Figure 13.4 Client/Server Database Usage

Classes of Client/Server Applications

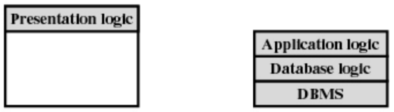
- Host-based processing
  - not true client/server computing
  - traditional mainframe environment



(a) Host-based processing

Classes of Client/Server Applications

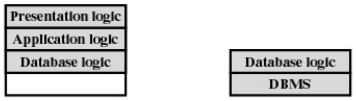
- Server-based processing
  - server does all the processing
  - user workstation provides a graphical user interface



(b) Server-based processing

Classes of Client/Server Applications

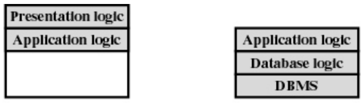
- Client-based processing
  - all application processing done at the client
  - data validation routines and other database logic function are done at the server



(d) Client-based processing

Classes of Client/Server Applications

- Cooperative processing
  - application processing is performed in an optimized fashion
  - complex to set up and maintain



(c) Cooperative processing

Three-Tier Client/Server Architecture

- Application software distributed among three types of machines
  - User machine
    - thin client
  - Middle-tier server
    - Gateway
    - Convert protocols
    - Merge/integrate results from different data sources
  - Backend server

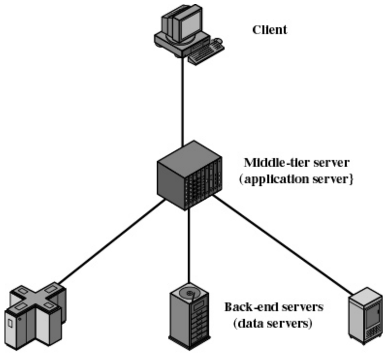


Figure 13.6 Three-tier Client/Server Architecture

File Cache Consistency

- File caches hold recently accessed file records
- Caches are consistent when they contain exact copies for remote data
- File-locking prevents simultaneous access to a file

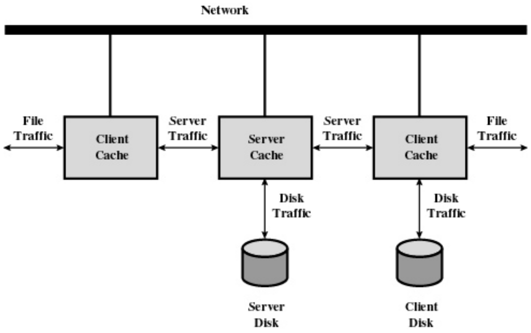


Figure 13.7 Distributed File Cacheing in Sprite

Middleware

- Set of tools that provide a uniform means and style of access to system resources across all platforms
- Enable programmers to build applications that look and feel the same
- Enable programmers to use the same method to access data

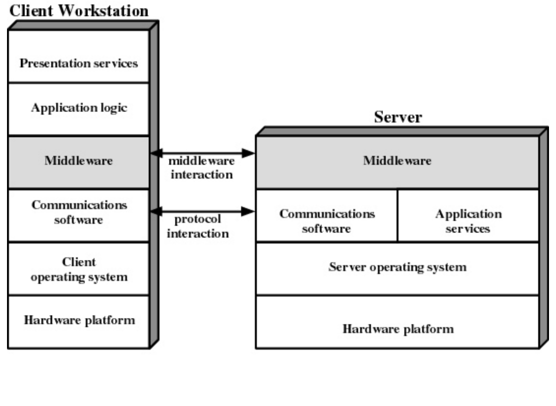


Figure 13.8 The Role of Middleware in Client/Server Architecture

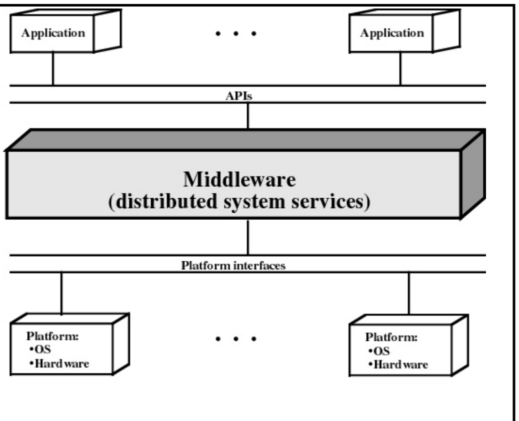


Figure 13.9 Logical View of Middleware [BERN96]

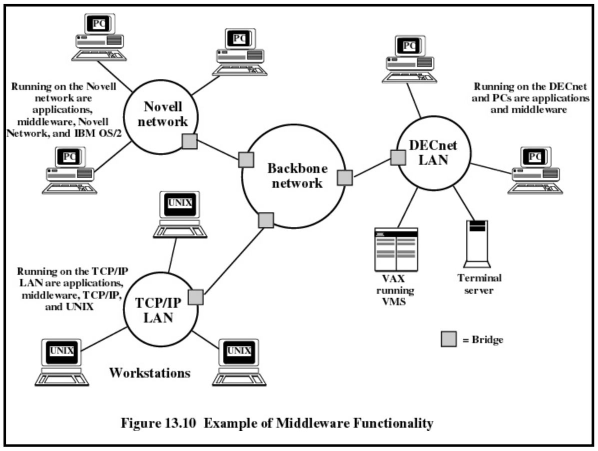

PC
Running on the Novell network are applications, middleware, Novell Network, and IBM OS/2
Novell network
Backbone network
DECnet LAN
Running on the DECnet and PCs are applications and middleware
UNIX
Running on the TCP/IP LAN are applications, middleware, TCP/IP, and UNIX
TCP/IP LAN
Workstations
VAX running VMS
Terminal server
= Bridge

Figure 13.10 Example of Middleware Functionality

Distributed Message Passing

- Message passed used to communicate among processes
- Send and receive messages as used in a single system OR
- Remote procedure calls

Basic Message-Passing Primitives

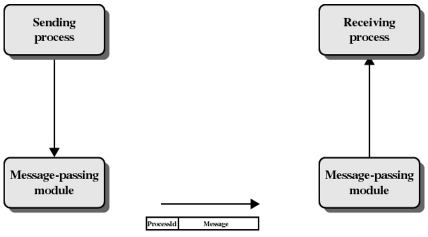


Figure 13.12 Basic Message-Passing Primitives

Reliability Versus Unreliability

- Reliable message-passing guarantees delivery if possible
  - Not necessary to let the sending process know that the message was delivered
- Send the message out into the communication network without reporting success or failure
  - Reduces complexity and overhead

Blocking Versus Nonblocking

- Nonblocking
  - Process is not suspended as a result of issuing a Send or Receive
  - Efficient and flexible
  - Difficult to debug
- Blocking
  - Send does not return control to the sending process until the message has been transmitted
  - OR does not return control until an acknowledgment is received
  - Receive does not return until a message has been placed in the allocated buffer

Remote Procedure Calls

- Allow programs on different machines to interact using simple procedure call/return semantics
- Widely accepted
- Standardized
  - Client and server modules can be moved among computers and operating systems easily

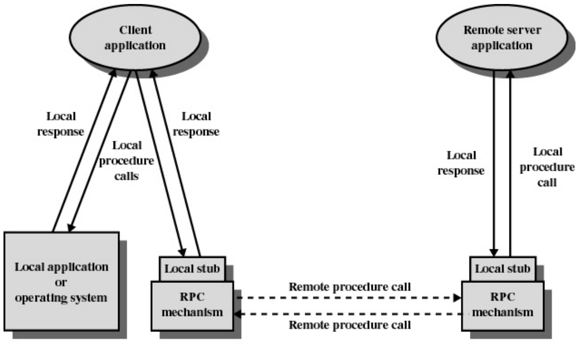


Figure 13.13 Remote Procedure Call Mechanism

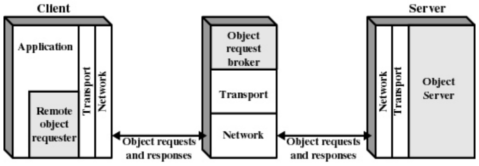
Client/Server Binding

- Binding specifies the relationship between remote procedure and calling program
- Nonpersistent binding
  - logical connection established during remote procedure call
- Persistent binding
  - connection is sustained after the procedure returns

Synchronous versus Asynchronous

- Synchronous RPC
  - Behaves must like a subroutine call
- Asynchronous RPC
  - Does not block the caller
  - Enable a client to invoke a server repeatedly so that it has a number of requests in the pipeline at one time

Object-Oriented Mechanisms



(c) Object request broker

Figure 13.11 Middleware Mechanisms

Clusters

- Alternative to symmetric multiprocessing (SMP)
- Group of interconnected, whole computers working together as a unified computing resource
  - illusion is one machine
  - system can run on its own

Benefits of Clusters

- Absolute scalability
  - Can have dozens of machines each of which is a multiprocessor
- Incremental scalability
  - Add new systems in small increments
- High availability
  - Failure of one node does not mean loss of service
- Superior price/performance
  - Cluster can be equal or greater computing power than a single large machine at a much lower cost

Clusters

- Separate server
  - Each computer is a separate server
  - No shared disks
  - Need management or scheduling software
  - Data must be constantly copied among systems so each is current

Clusters

- Shared nothing
  - Reduces communication overhead
  - Several servers connected to common disks
  - Disks partitioned into volumes
  - Each volume owned by a computer
  - If computer fails another computer gets ownership of the volume

Clusters

- Shared disk
  - Multiple computers share the same disks at the same time
  - Each computer has access to all of the volumes on all of the disks

Operating System Design Issues

- Failure management
  - Highly available cluster offers a high probability that al resources will be in service
    - No guarantee about the state of partially executed transactions if failure occurs
  - Fault-tolerant cluster ensures that all resources are always available

Operating System Design Issues

- Load balancing
  - When new computer added to the cluster, the load-balancing facility should automatically include this computer in scheduling applications
- Parallelizing Computation
  - Parallelizing compiler
  - Parallelized application
  - Parametric computing

Cluster Computer Architecture

- Cluster middleware services and functions
  - Single entry point
  - Single file hierarchy
  - Single control point
  - Single virtual networking
  - Single memory space
  - Single job-management system

Cluster Computer Architecture

- Cluster middleware services and functions
  - Single user interface
  - Single I/O space
  - Single process space
  - Checkpointing
  - Process migration

Clusters Compared to SMP

- SMP is easier to manage and configure
- SMP takes up less space and draws less power
- Clusters are better for incremental and absolute scalability
- Clusters are superior in terms of availability

Windows 2000 Cluster Service

- Cluster Service
  - Collection of software on each node that manages all cluster-specific activity
- Resource
  - Item managed by the cluster service
- Online
  - Online at node when it is providing service on that specific node
- Group
  - Collection of resources managed as a single unit

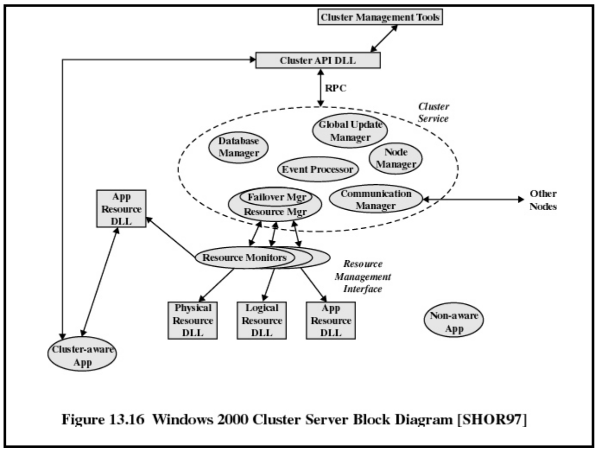
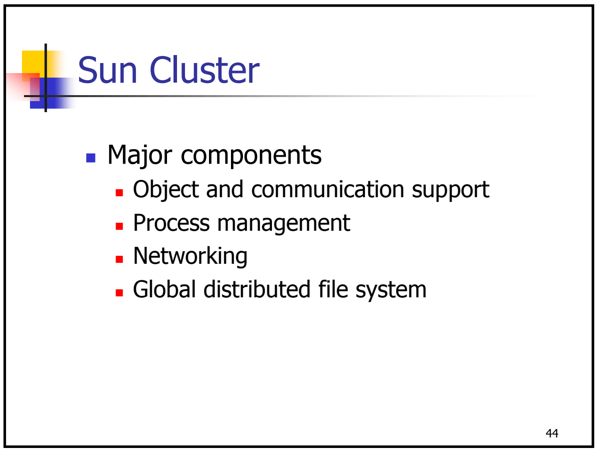


Figure 13.16 Windows 2000 Cluster Server Block Diagram [SHOR97]



Sun Cluster

- Major components
  - Object and communication support
  - Process management
  - Networking
  - Global distributed file system

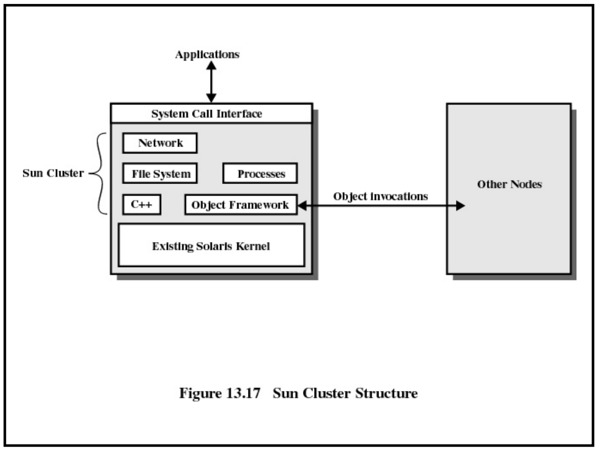
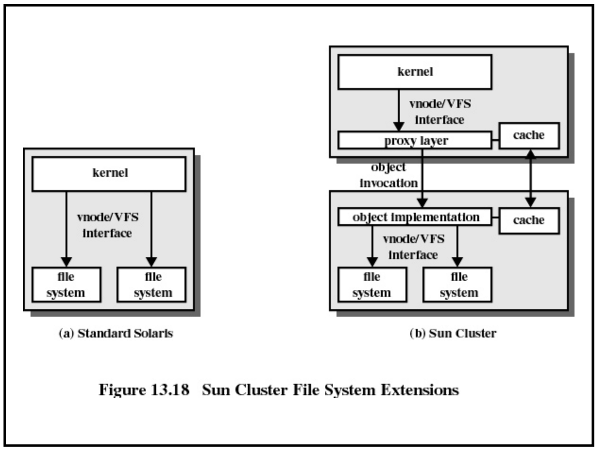


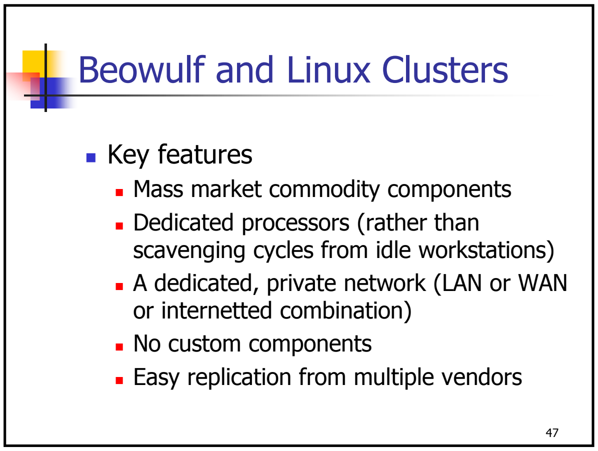
Figure 13.17 Sun Cluster Structure



(a) Standard Solaris

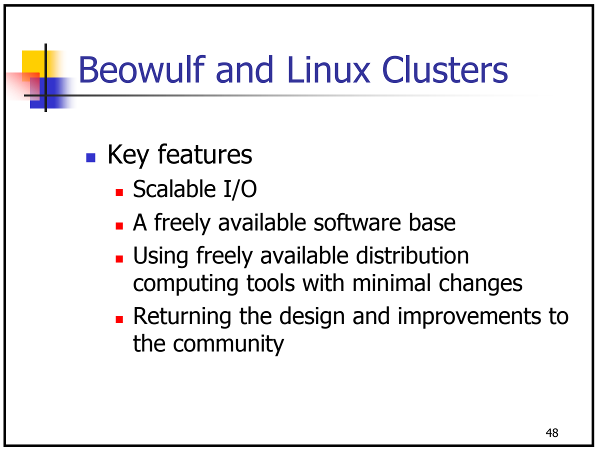
(b) Sun Cluster

Figure 13.18 Sun Cluster File System Extensions



Beowulf and Linux Clusters

- Key features
  - Mass market commodity components
  - Dedicated processors (rather than scavenging cycles from idle workstations)
  - A dedicated, private network (LAN or WAN or internetted combination)
  - No custom components
  - Easy replication from multiple vendors



Beowulf and Linux Clusters

- Key features
  - Scalable I/O
  - A freely available software base
  - Using freely available distribution computing tools with minimal changes
  - Returning the design and improvements to the community

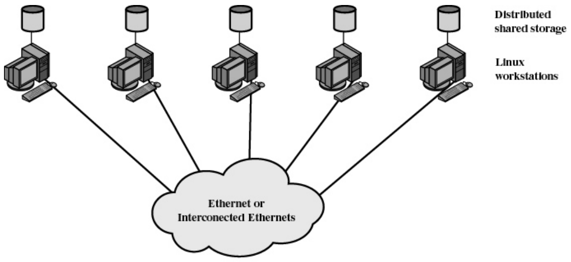


Figure 13.19 Generic Beowulf Configuration