2

Driving Forces Behind Client/ Server Computing

2.1 INTRODUCTION

A rapidly changing business environment generates a demand for enterprise – wide data access, which, in turn, sets the stage for end user productivity gains. Data access requirements have given rise to an environment in which computers work together to form a system, often called distributed computing, cooperative computing, and the like.

To be competitive in a global economy, organizations in developed economies must employ technology to gain the efficiency necessary to offset their higher labour costs. Re-engineering the business process to provide information and decision-making support at points of customer contact reduces the need for layers of decision-making management, improves responsiveness, and enhance customer service. Empowerment means that knowledge and responsibility are available to the employee at the point of customer contact. Empowerment will ensure that product and services problems and opportunities are identified and centralized. Client/Server computing is the most effective source for the tools that empower employees with authority and responsibility.

However, Client/Server computing has become more practical and cost-effective because of changes in computer technology that allow the use of PC-based platforms with reliability and robustness comparable to those of traditional mainframe system. In fact, the accelerating trend toward system development based on Internet Technologies, particularly those supplied by Web, has extended the Client/Server model's reach and relevance considerably. For example, to remain competitive in a global business environment, businesses are increasingly dependent on the Web to conduct their marketing and service operations. Such Web-based electronic commerce, known as E-commerce, is very likely to become the business norm for businesses of all sizes.

Even a cursory examination of Websites will demonstrate the Web's search. Organizations that range in size from Microsoft, IBM, GM, and Boeing to local arts/craft and flower shops

conduct part – or even most – of their business operations via E-commerce. There are various forces that drive the move to client/server computing. Some of them are:

(*i*) The changing business environment.
(*ii*) Globalization: The world as a market.
(*iii*) The growing need for enterprise data access.
(*iv*) The demand for end user productivity gains based on the efficient use of data resources.
(*v*) Technological advances that have made client/server computing practical like microprocessor technology, data communication and Internet, Database systems, Operating Systems and Graphical User Interface, PC-based and end user application software.
(*vi*) Growing cost and performance advantages of PC-based platforms.
(*vii*) Enterprise network management.

2.2 DRIVING FORCES

Forces that drives the move to Client/Server computing widely can be classified in two general categories based on:

(*i*) Business perspective.
(*ii*) Technology perspective.

2.2.1 Business Perspective

Basically the business perspective should be kept in mind for obtaining the following achievements through the system:

- For increased productivity.
- Superior quality.
- Improved responsiveness.
- Focus on core business.

The effective factors that govern the driving forces are given below:

The changing business environment: Business process engineering has become necessary for competitiveness in the market which is forcing organizations to find new ways to manage their business, despite fewer personnel, more outsourcing, a market driven orientation, and rapid product obsolescence.

Due to globalization of business, the organizations have to meet global competitive pressure by streamlining their operations and by providing an ever-expanding array of customer services. Information management has become a critical issue in this competitive environment; marketing fast, efficient, and widespread data access has become the key to survival. The corporate database has become a far more dynamic asset than it used to be,

and it must be available at relatively low cost. Unfortunately, the demand for a more accessible database is not well-served by traditional methods and platforms. The dynamic information driven corporate worlds of today require data to be available to decision makers on time and in an appropriate format. Because end users have become active in handling their own basic data management and data analysis, the movement towards freedom of data access has made Client/Server computing almost inevitable.

One might be tempted to urge that microcomputer networks constitute a sufficient answer to the challenge of dynamic data access. Unfortunately, even the use of networks that tie legions of PC's together is an unsatisfactory solution if request processing overloads the network. The Client/Server model's ability to share resources efficiently by splitting data processing yields a more efficient utilization of those resources. It is not surprising that Client/Server computing has received so much attention from such a wide spectrum of interested parties.

Globalization

Conceptually, the world has begun to be treated as a market. Information Technology plays an important role in bringing all the trade on a single platform by eliminating the barriers. IT helps and supports various marketing priorities like quality, cost, product differentiation and services.

The growing need for enterprise data access: One of the major MIS functions is to provide quick and accurate data access for decision- making at many organizational levels. Managers and decision makers need fast on-demand data access through easy-to-use interfaces. When corporations grow, and especially when they grow by merging with other corporations, it is common to find a mixture of disparate data sources in their systems. For example, data may be located in flat files, in hierarchical or network databases or in relational databases. Given such a multiple source data environment, MIS department managers often find it difficult to provide tools for integrating and aggregating data for decision-making purposes, thus limiting the use of data as a company asset. Client server computing makes it possible to mix and match data as well as hardware. In addition, given the rapidly increasing internet-enabled access to external data through the Internet's inherent Client/Server architecture, corporate Client/Server computing makes it relatively easy to mix external and internal data.

The demand for end user productivity gains based on the efficient use of data resources: The growth of personal computers is a direct result of the productivity gains experienced by end-users at all business levels. End user demand for better ad hoc data access and data manipulation, better user interface, and better computer integration helped the PC gain corporate acceptance. With sophisticated yet easy to use PCs and application software, end user focus changed from how to access the data to how to manipulate the data to obtain information that leads to competitive advantages.

2.2.2 Technology Perspective

Technological advances that have made Client/Server computing practical by proper use of the following:

- Intelligent desktop devices.
- Computer network architectures.
- Technical advances like microprocessor technology, data communication and Internet Database system, operating system and graphical user interface.
- Trends in computer usage like:

(*i*) Standardization: Trend towards open systems and adaptation of industry standards, which includes:

* *de facto* standard: protocol or interface that is made public & widely accepted. (e.g., SNA, TCP/IP, VGA)
* *de jure* standard: protocol or interface specified by a formal standards making body. (e.g., ISO's OSI, ANSI C)

(*ii*) Human-Computer Interaction (HCI): trend towards GUI, user Control.

(*iii*) Information dissemination: trend towards data warehousing, data mining.

- PC-based end user application software together with the increasing power and capacity of workstations.
- Growing cost and performance are advantages of PC-based platforms.

The PC platform often offers unbeatable price/performance ratio compared to mainframe and minicomputer platforms. PC application cost, including acquisition, installation, training, and use, are usually lower than those of similar minicomputer and mainframe applications. New PC-based software makes use of very sophisticated technologies, such as object orientation, messaging, and tele-communications. These new technologies make end users more productive by enabling them to perform very sophisticated tasks easily, quickly, and efficiently. The growing software sophistication even makes it possible to migrate many mission-critical applications to PCs.

The pursuit of mainframe solutions typically means high acquisition and maintenance costs, and chances are that managers are locked into services provided by single source. In contrast, PC hardware and software costs have both declined sharply during the past few years. PC-based solutions typically are provided by many sources, thus limiting single-source vulnerability. However, multi-source solutions can also become a major management headache when system problems occur.

Enterprise Computing and the Network Management

If a business is run from its distributed locations, the technology supporting these units must be as reliable as the existing central systems. Technology for remote management of the distributed technology is essential in order to use scarce expertise appropriately and to reduce costs.

All computing and communications resources are integrated functionally as a single, seamless system. To maximize productivity by providing universal, up-to-date information the technology requirements are that computing technology must be widely deployed. All computers must be networked together in a consistent architecture such that computing and networking resources must be reliable, secure, and capable of delivering accurate information in a timely manner. Maximum capture of information relating to the business and its customers must occur within every business process. That information must be normalized, within reach of all users. To achieve that, mechanics employed to locate, access the data and also for hiding the transmit data. And all the applications must be flexible to user preferences and work styles i.e., applications must interwork with in a common framework.

Client/server technology gives cost-effective, logical, and consistent architectural model for networking that generalizes the typical computer model. Client/Server can simplify network interactions that will give transparent interaction to the users. See the Fig. 2.1 illustrated below:

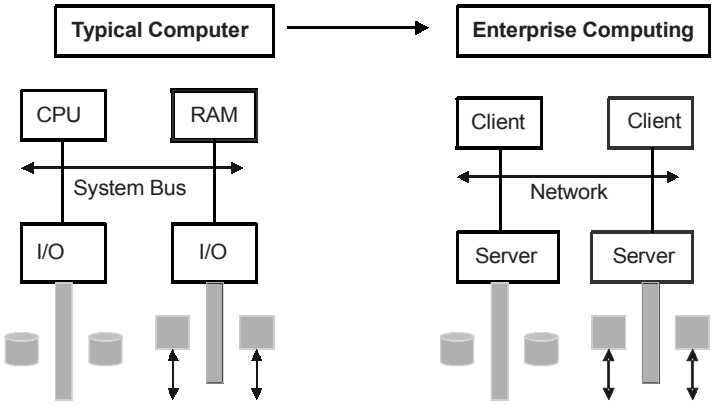

Fig. 2.1: Enterprise Computing

2.3 DEVELOPMENT OF CLIENT/SERVER SYSTEMS

The development of Client/Server systems differs greatly in process and style from the traditional information systems development methods. For example, the systems development approach, oriented towards the centralized mainframe environment and based on traditional programming language, can hardly be expected to function well in a client server environment that is based on hardware and software diversity. In addition a modern end users are more demanding and are likely to know more about computer technology than users did before the PC made its inroads. Then the concerning manager should pertain their knowledge about new technologies that are based on multiple platforms, multiple GUIs, multiple network protocols, and so on.

2.3.1 Development Tools

In today's rapid changing environment, choosing the right tools to develop Client/Server applications is one of the most critical decisions. As a rule of thumb, managers tend to choose a tool that has a long-term survival potential. However, the selection of a design or application development tool must also be driven by system development requirements. Once such requirements have been delineated, it is appropriate to determine the characteristics of the tool that you would like to have. Client/Server tools include:

- GUI-based development.
- A GUI builder that supports multiple interfaces (Windows, OS/2, Motif, Macintosh, and so on).
- Object-oriented development with a central repository for data and applications.
- Support for multiple database (flat file, hierarchical, networked, relational).
- Data access regardless of data model (using SQL or native navigational access).
- Seamless access to multiple databases.
- Complete SDLC (System Development Life Cycle) support from planning to implementation and maintenance.
- Team development support.
- Support for third party development tools (CASE, libraries, and so on)
- Prototyping and Rapid Application Development (RAD) capabilities.
- Support for multiple platforms (OS, Hardware, and GUIs).
- Support for middle ware protocols (ODBC, IDAPI, APPC, and so on).
- Multiple network protocol support (TCP/IP, IXP/SPX, NetBIOS, and so on).

There is no single best choice for any application development tool. For one thing, not all tools will support all the GUI's, operating system, middleware, and databases. Managers must choose a tool that fits the application development requirements and that matches the available human resources, as well as the hardware infrastructure. Chances are that the system will require multiple tools to make sure that all or most of the requirements are met. Selecting the development tools is just one step. Making sure that the system meets its objectives at the client, server, and network level is another issue.

2.3.2 Development Phases

It is important that a marketing plan be developed before actually starting the design and development efforts. The objective of this plan is to build and obtain end user and managerial support for the future Client/Server environment. Although there is no single recipe for this process, the overall idea is to conceptualize Client/Server system in terms of their scope, optimization of resources and managerial benefits. In short, the plan requires an integrated effort across all the departments within an organization. There are six main phases in Client/Server system development.

(*i*) Information System Infrastructure Self-study

The objective is to determine the actual state of the available computer resources. The self-study will generate atleast the following.

- A software and hardware inventory.
- A detailed and descriptive list of critical applications.
- A detailed human resource (personal and skills) inventory.
- A detailed list of problems and opportunities.

(*ii*) Client/Server Infrastructure Definition

The output of Phase One, combined with the company's computer infrastructure goal, is the input for the design of the basic Client/Server infrastructure blueprint. This blue print will address the main hardware and software issues for the client, server, and networking platforms.

(*iii*) Selecting a Window of Opportunity

The next stage is to find the right system on which to base the Client/Server pilot project. After identifying the pilot project, we need to define it very carefully by concentrating on the problem, available resources, and set of clearly defined and realistic goals. The project is described in business terms rather than technological jargon. When defining the system, we must make sure to plan for cost carefully. We should try to balance the cost carefully with the effective benefits of the system. We should also make sure to select a pilot implementation that provides immediate and tangible benefits. For example, a system that takes two years to develop and another three to generate tangible benefits is not acceptable.

(*iv*) Management Commitment

Top to bottom commitment is essential when we are dealing with the introduction of new technologies that affect the entire organization. We also need managerial commitment to ensure that the necessary resources (people, hardware, software, money, infrastructure) will be available and dedicated to the system. A common practice is to designate a person to work as a guide, or an agent of change, within the organization's departments. The main role of this person is to ease the process that changes people's role within the organization.

(*v*) Implementation

Guidelines to implementation should atleast include:

- Use "open" tools or standard-based tools.
- Foster continuing education in hardware, software, tools, and development principles.
- Look for vendors and consultants to provide specific training and implementation of designs, hardware, application software.

(*vi*) Review and Evaluation

We should make sure that the system conforms to the criteria defined in Phase Three. We should continuously measure system performance as the system load increases, because typical Client/Server solutions tend to increase the network traffic and slow down the

network. Careful network performance modelling is required to ensure that the system performs well under heavy end user demand conditions. Such performance modeling should be done at the server end, the client end, and the network layer.

2.4 CLIENT/SERVER STANDARDS

Standards assure that dissimilar computers, networks, and applications scan interact to form a system. But what constitutes standards? A standard is a publicly defined method to accomplish specific tasks or purposes within a given discipline and technology. Standards make networks practical.

Open systems and Client-Server computing are often used as if they were synonymous. It does not make long-term sense for users to adopt a Client/Server environment that is not based on standards. There are currently very few Client/Server technologies based on standards at every level. Proprietary Client/Server technologies (applications, middleware etc.) will always lock you into a particular supplier. The existing costs are always high. Failure to appreciate the spectrum of technologies within the Client-Server model, will always lead to dysfunctional Client/Server solutions. This will result in compromises in key areas of any company's Client/Server infrastructure, such as Usability, Security, and Performance.

There are quite a few organizations whose members work to establish the standards that govern specific activities. For example, the Institute of Electrical and Electronics Engineers (IEEE) are dedicated to define the standards in the network hardware environment. Similarly, the American National Standards Institute (ANSI) has created standards for programming languages such as COBOL and SQL. The International Organization for Standardization (ISO) produces the Open System Interconnection (OSI) reference model to achieve network systems communications compatibility.

Benefits of Open Standards

- Standards allow us to incorporate new products and technology with existing I.T. investments — hardware, operating environments, and training, with minimum effort.
- Standards allow us to mix and match the 'best of breed' products. Thus databases and development tools, and Connectivity software become totally independent.
- Standards allow us to develop modular applications that do not fall apart because the network has been re-configured (e.g., change of topology, or transport protocol etc.), or the graphical user interface standard as changed, or a component-operating environment has changed.
- Standards maintain tighter security.
- Standards reduce the burden of overall maintenance and system administration.
- Standards provide faster execution of pre-compiled code.
- Standards prevent the database and its application and possibly others on the server from having their response time degraded in a production environment by inefficient queries.

2.5 CLIENT/SERVER SECURITY

A security threat is defined as circumstance, condition, or event with the potential to cause economic hardship to data or network resources in the form of destruction. Disclosure, modification of data, denial of service, and/or fraud, waist and abuse. Client/Server security issues deal with various authorization methods related to access control. Such mechanisms include password protection, encrypted smart cards. Biometrics and firewalls. Client/Server security problems can be due to following:

- **Physical security holes:** These results when any individual gains unauthorized access to a computer by getting some user's password.
- **Software security holes:** These result due to some bug in the software, due to which the system may be compromised into giving wrong performance.
- **Inconsistent usage holes:** These may result when two different usages of a systems contradict over a security point.

Of the above three, software security holes and inconsistent usage holes can be eliminated by careful design and implementation. For the physical security holes, we can employ various protection methods. These security methods can be classified into following categories:

(i) Trust-based security.
(ii) Security through obscurity.
(iii) Password scheme.
(iv) Biometric system.

2.5.1 Emerging Client/Server Security Threats

We can identify emerging Client/Server security threats as:

(i) Threats to local computing environment from mobile code,
(ii) Threats to servers that include impersonation, eavesdropping, denial of service, packet reply, and packet modification.

Software Agents and the Malicious Code Threat

Software agents or mobile code are executable programs that have ability to move from machine to machine and also to invoke itself without external influence. Client threats mostly arise from malicious data or code. Malicious codes refers to viruses, worms (a self-replicating program that is self-contained and does not require a host program. The program creates a copy of itself and causes it to execute without any user intervention, commonly utilizing network services to propagate to other host systems.)e.g., Trojan horse, logic bomb, and other deviant software programs. Virus is a code segment that replicates by attaching copies of itself to existing executables. The new copy of the virus is executed when a user executes the host programs. The virus may get activated upon the fulfilment of some specific conditions.

The protection method is to scan for malicious data and program fragments that are transferred from the server to the client, and filter out data and programs known to be dangerous.

2.5.2 Threats to Server

Threats to server may be of the following types:

(*i*) Eavesdropping is the activity of silently listening to the data sent over the network. This often allows a hacker to make complete transcript of network activity and thus obtain sensitive information, such as password, data, and procedures for performing functions. Encryption can prevent eavesdroppers from obtaining data traveling over unsecured networks.

(*ii*) Denial of service is a situation, where a user renders the system unusable for legitimate users by hogging or damaging a resource so that it can be used. The common forms of this, are:

- **Service overloading:** A server may be rendered useless by sending it a large amount of illegitimate service requests so as to consume up its CPU cycle resource. In such a situation, the server may deny the service request of legitimate requests.
- **Message flooding:** It is a process of increasing the number of receiving processes running over the disk of the server by sending large files repeatedly after short intervals. This may cause disk crash.
- **Packet replay** refers to the recording and retransmission of message packets in the network. Medium tapping can do this. A checker may gain access to a secure system by recording and later replaying a legitimate authentication sequence message. Packet reply can also be used to distort the original message. Using a method like packet time stamping and sequence counting can prevent this problem.

2.6 ORGANIZATIONAL EXPECTATIONS

As we have already discussed the advantages and disadvantages associated with Client/Server computing, from the organizational point of view the managers are looking for the following Client/Server benefits.

- Flexibility and adaptability.
- Improved employee productivity.
- Improved company work flow and a way to re-engineering business operations.
- New opportunities to provide competitive advantages.
- Increased customer service satisfaction.

Flexibility and Adaptability

Client/Server computing is expected to provide necessary organizational flexibility to adapt quickly and efficiently in changing business conditions. Such changes can be driven by technological advantages; government regulations, mergers and acquisitions, market forces and so on. A company that can adapt quickly to changes in its market conditions is more likely to survive than one that cannot.

Multinational companies, whose widely dispersed offices must share information across often-disparate computer platforms, are especially well-positioned to benefit from the flexibility and adaptability offered by the Client/Server infrastructure.

Improved Employee Productivity

Client/Server computing opens the door to previously unavailable corporate data. End users can manipulate and analyze such data on an ad hoc basis by means of the hardware and the software tools that are commonly available with client server environments. Quick and reliable information access enables end users to make intelligent decisions. Consequently, end users are more likely to perform their jobs better, provide better services, and become more productive within the corporation.

Improved Company Work Flow and a Way to Re-engineering Business Operations

Organizations that face problems with their internal data management typically favour the introduction of Client/Server computing. Providing data access is just the first step in information management. Providing the right data to the right people at the right time is the core of decision support for MIS departments. As competitive conditions change, so do the companies' internal structure, thus triggering demands for information systems that reflect those changes. Client/Server tools such as Lotus Notes are designed exclusively to provide corporations with data and forms distribution, and work group support, without regard to geographical boundaries. These workgroup tools are used to route the forms and data to the appropriate end users and coordinate employee work. The existence and effective use of such tools allows companies to re-engineer their operational processes, effectively changing the way they do the business.

New Opportunities to Provide Competitive Advantages

New strategic opportunities are likely to be identified as organizations restructure. By making use of such opportunities, organizations enhance their ability to compete by increasing market share through the provision of unique products or services. Proper information management is crucial within such a dynamic competitive arena. Therefore, improved information management provided by a Client/Server system means that such systems could become effective corporate strategic weapons.

Increased Customer Service Satisfaction

As new and better services are provided, customer satisfaction is likely to improve. Client/Server systems enable the corporate MIS manager to locate data closer to the source of data demand, thus increasing the efficiency with which customer enquiries are handled.

2.7 IMPROVING PERFORMANCE OF CLIENT/SERVER APPLICATIONS

Client/Server-developed applications may achieve substantially greater performance when compared with traditional workstations or host-only applications.

(*i*) Offload work to server: Database and communications processing are frequently offloaded to a faster server processor. Some applications processing also may be offloaded, particularly for a complex process, which is required by many users. The advantage of offloading is realized when the processing power of the server is significantly greater than that of the client workstation. Separate processors best support shared databases or specialized communications interfaces. Thus, the client workstation is available to handle other client tasks. These advantages are best realized when the client workstation supports multitasking or atleast easy and rapid task switching.

(*ii*) Reduce total execution time: The server can perform database searches, extensive calculations, and stored procedure execution in parallel while the client workstation deals directly with the current user needs. Several servers can be used together, each performing a specific function. Servers may be multiprocessors with shared memory, which enables programs to overlap the LAN functions and database search functions. In general, the increased power of the server enables it to perform its functions faster than the client workstation. In order for this approach to reduce the total elapsed time, the additional time required to transmit the request over the network to the server must be less than the saving. High-speed local area network topologies operating at 4, 10, 16, or 100Mbps (megabits per second) provide high-speed communications to manage the extra traffic in less time than the savings realized from the server. The time to transmit the request to the server, execute the request, and transmit the result to the requestor, must be less than the time to perform the entire transaction on the client workstation.

(*iii*) Use a multitasking client: As workstation users become more sophisticated, the capability to be simultaneously involved in multiple processes becomes attractive. Independent tasks can be activated to manage communications processes, such as electronic mail, electronic feeds from news media and the stock exchange, and remote data collection (downloading from remote servers). Personal productivity applications, such as word processors, spreadsheets, and presentation graphics, can be active. Several of these applications can be dynamically linked together to provide the desktop information-processing environment. Functions such as Dynamic Data Exchange (DDE) and Object Linking and Embedding (OLE) permit including spreadsheets dynamically into word-processed documents. These links can be *hot* so that changes in the spreadsheet cause the word-processed document to be updated, or they can be *cut and paste* so that the current status of the spreadsheet is copied into the word-processed document.

Systems developers appreciate the capability to create, compile, link, and test programs in parallel. The complexity introduced by the integrated CASE environment requires multiple processes to be simultaneously active so the workstation need not be dedicated to a single long-running function. Effective use of modern CASE tools and workstation development products requires a client workstation that supports multitasking.

2.8 SINGLE SYSTEM IMAGE

Rapid changes have occurred in computer technology resulting in system of increased capabilities. This indicates that maximum resources are available to accepts all these new products. For the organizations using Client/Server systems the environment is heterogeneous whereas the users prime concern to achieve the maximum functionality. Every Client/Server system should give equal importance to the developers' and users' requirements. For the users, this means the realization of a single-system-image. "A single-system-image is the illusion, created by software or hardware, that presents a collection of resources as one, more powerful resource." SSI makes the system appear like a single machine to the user, to applications, and to the network. With it all network resources present themselves to every user in the same way from every workstation (See the Fig. 2.2, given below) and can be used transparently after the user has authorized himself/herself once. The user environment with a desktop and often-used tools, such as editors and mailer, is also organized in a uniform way. The workstation on the desk appears to provide all these services. In such an environment the user need not to bother about how the processors (both the client and the server) are working, where the data storage take place and which networking scheme has been selected to build the system.

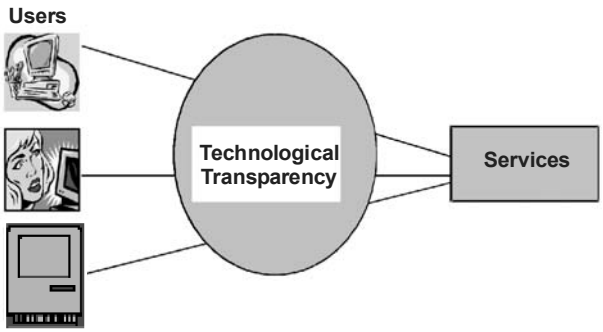

Fig.2.2: Single Image System

Further desired services in *single-system-image* environment are:

- Single File Hierarchy; for example: xFS, AFS, Solaris MC Proxy.
- Single Control Point: Management from single GUI and access to every resource is provided to each user as per their valid requirements.

- Single virtual networking.
- Single memory space e.g. Network RAM/DSM.
- Single Job Management e.g. Glunix, Codine, LSF.
- Single User Interface: Like workstation/PC windowing environment (CDE in Solaris/NT), Web technology can also be used.
- Standard security procedure: Access to every application is provided through a standard security procedure by maintaining a security layer.
- Every application helps in the same way to represent the errors and also to resolve them.
- Standard functions work in the same way so new applications can be added with minimal training. Emphasis is given on only new business functions.

Hence, *single-system-image* is the only way to achieve acceptable technological transparency.

"A single-system-image of all the organization's data and easy management of change" are the promises of client/server computing.

But as more companies follow the trend towards downsized Client/Server networks, some find the promise elusive. Security, scalability and administration costs are three of the key issues. For example, the simple addition of a new user can require the definition to be added to every server in the network. Some of the visible benefits due to *single-system-image* are as given below:

- Increase the utilization of system resources transparently.
- Facilitates process migration across workstations transparently along with load balancing.
- Provides improved reliability and higher availability.
- Provides overall improved system response time and performance.
- Gives simplified system management.
- Reduces the risk covered due to operator errors.
- User need not be aware of the underlying system.
- Provides such architecture to use these machines effectively.

2.9 DOWNSIZING AND RIGHTSIZING

Downsizing: The downward migrations of business applications are often from mainframes to PCs due to low costing of workstation. And also today's workstations are as powerful as last decade's mainframes. The result of that is Clients having power at the cost of less money, provides better performance and then system offers flexibility to make other purchase or to increase overall benefits.

Rightsizing: Moves the Client/Server applications to the most appropriate server platform, in that case the servers from different vendors can co-exist and the network is known as the 'system'. Getting the data from the system no longer refers to a single mainframe. As a matter of fact, we probably don't know where the server physically resides.

Upsizing: The bottom-up trend of networking all the stand alone PCs and workstations at the department or work group level. Early LANs were implemented to share hardware (printers, scanners, etc.). But now LANs are being implemented to share data and applications in addition to hardware.

Mainframes are being replaced by lesser expensive PC's on networks. This is called computer downsizing. Companies implementing business process reengineering are downsizing organizationally. This is called business downsizing. All this would result in hundreds of smaller systems, all communicating to each other and serving the need of local teams as well as individuals working in an organization. This is called cultural downsizing. The net result is distributed computer systems that support decentralized decision-making. This is the client/server revolution of the nineties.

2.10 CLIENT/SERVER METHODOLOGY

Many PC-based developers, particularly those who never knew of any other type of computer, believe that today's methodologies are not only wrong, but also unnecessary. They believe that prototyping based on rapid application development tools make methodologies completely unnecessary. Is this true? If yes, should the methodologies be thrown away? The answer to all these questions depends on the scale and complexity of the application being developed. Small applications that run on a single desktop can be built within hours. The use of methodology in such cases can be waste of time.

However, bigger systems are qualitatively different, especially in term of their design process. Whenever, a system, particularly one involving a database, expands to include more than one server, with servers being located in more than one geographical location, complexity is bound to go up. Distributed systems cross this complexity barrier rapidly. We can say.

- Methodologies are important, and will continue to remain so for the construction of large applications.
- Distributed systems will need these methodologies most of all.
- Today's methodologies will have to change to meet the needs of a new generation of developers and users, accommodate the design of distributed systems, and yield friendly, maintainable systems.

EXERCISE 2

1. Explain various Clients/Server system development tools.
2. Write short notes on the following.
   (*a*) Single system image.
   (*b*) Downsizing and Client/Server computing.
3. Explain Client/Server System development methodology and explain various phases and their activities involved in System Integration Life Cycle (SILC).
4. Explain the following in detail:-
   (*a*) Performance evaluation of Client/Server Application.
   (*b*) Reliability and Serviceability of Client/Server Architecture.
5. Differentiate between Downsizing and Client/Server Computing.
6. Explain different ways to improve performance in Client/Server developed applications.
7. What is client server system development methodology? Explain different phases of System Integration Life-Cycle.
8. How are software's distributed in client server model? In the client server environment, what are performance- monitoring tools for different operating system?
9. What are the various ways to reduce network traffic of client server computing?