CLOUD COMPUTING

Chapter 1

-It is the delivery of on-demand computing services over the internet on a pay-as –you-go basis.

-Rather than managing files on a local storage device, cloud computing makes it possible to save them over internet.

1.Cloud computing

-The "cloud" is a set of different types of hardware and software that work collectively to deliver many aspects of computing to the end-user as an online service.

-Cloud Computing is the use of hardware and software to deliver a service over a network (typically the Internet). With cloud computing, users can access files and use applications from any device that can access the Internet.

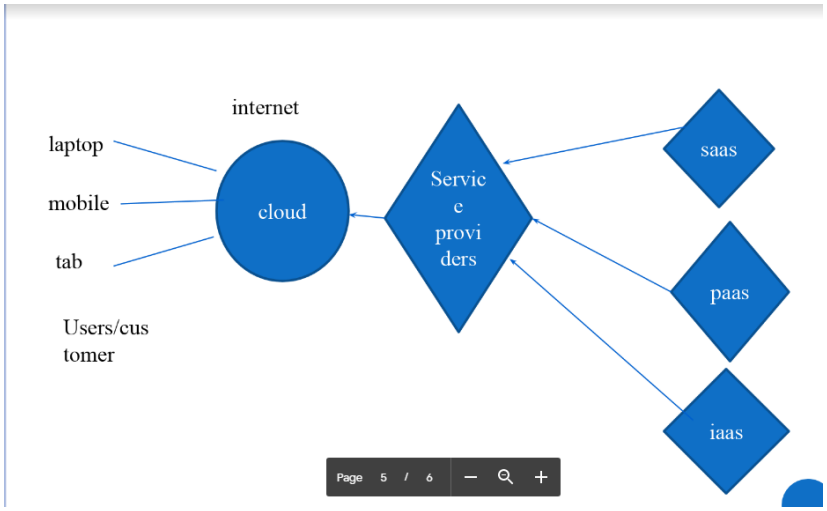
-The main principle behind this model is offering computing, storage and software as a service.

-Clouds are a large pool of easily usable and accessible virtualized resources such as hardware development platform and services.

2.Definition of cloud computing:

“Cloud is a Parallel and Distributed computing system consisting of a collection of inter-connected and virtualized computers that are dynamically provisioned and presented as one or more unified computing resources based on service level agreements(SLA) established through negotiation between service providers and consumers “.

-Use someone else’s server to host, process,store data



3.Features of cloud computing

- Pay for what you use
- No server space required
- No experts required for hardware &software maintenance
- Better data security
- Disaster recovery
- High flexibility
- Automatic software updates
- Teams can collaborate from widespread location
- Data can be accessed and shared anywhere over internet
- Rapid implementation

4.advantages&disadvantages of cloud computing

Advantages of cloud computing

1. **Cost Proficient**

The 1st most advantage of cloud computing is its proficiency in cost factors to be used, maintained and for promoted. The old fashion desktop software was so much cost consuming for the firms. Adding fees for against each single user was so much more expensive for business concern. On the other hand cloud computing is so much cost proficient and available at lower rates, that significantly lower the company expenses.Cloud has raised the output, productivity and lowers the cost per unit or project factors. No need of spending too much money on hardware, software or licensing etc

2. More Security

The 2ndand utmost advantage of cloud computing is more security level. Before switching to the cloud firms are afraid about **security issues**. The Company's data are very important so it's your duty to know about the exact location of a company's data on the cloud. So you should be very clear about adopting the right place for your data. Choose right service providers to save your sensitive data information over the cloud. That will responsible to keep your secret information totally secure

3. More Flexible

Cloud computing allows all employees to be work in a flexible environment. For example, you can access information from home on vacations/leave days. These facilities provide you ease to connect from your remote location quickly. And you can easily develop a virtual office if you have an internet connection.

4. More Scalability

Your business can be scaled as up or down by your business operation, storage and management needs situations. Instead of purchasing, installing or upgrading you just need to move cloud environment. Cloud computing easily handles all these things just for you. Switching to cloud frees you from time limit and you can get for your business with ease.

5. Infinite Storage

The most favorable advantage of cloud computing is that it can store huge amount data in contrast to desktop computers. Cloud offers a limitless storage capacity. In short, we can say that cloud has eradicated the worries related to the storage space. In fact, it provides extra space for business needs to upgrade computer hardware, which lowers the overall IT Systems cost.

6. Automatic Software Integration

Cloud system can be upgraded easily and run in a very short period. It makes development in a quicker way. So it provides the ease of adding a new user in the system instantly by removing the waiting periods. Software integration occurs automatically on cloud.

7. Rapid Development

The most stunning advantage of cloud computing is rapid development that is its key benefit. Once you pick this method of functioning your whole system will become functional in a few minutes. The exact amount of time taken will be depending on the technology or the structure of the cloud that is being used.

8. Higher Economical Graph

The Cloud allows you to monitor all projects more effectively. That is ultimately beneficial to stay within your budget line while completing your project cycle time.

9. Globalization of Work & Streamline Workflow

The most amazing feature of cloud is the globalization of work that gives the ease of accessibility. This strategy permits the employees to use their personal devices at workplaces. The end user has been given the choice to select the device and the service, he/she wants to use over the cloud. There is no restriction of position & medium. You can access your application from anywhere in the world anytime, this is the most attractive advantage of cloud computing.

10. Effective Monitoring

Cloud computing allows you to monitor all current projects and the previous one effectively. These monitoring features give you the opportunity to fix every issue/ bug on the spot and checked their severity level at once. You easily update or mold your project as per change in requirements of clients. These characteristics permit you to stand alone your budget and project deadline commitments successfully.

11. Lower Personal Training Cost

The most astonishing advantage of cloud applications is that they demand smaller learning curve. And the users can easily use them. Being a new user, you can easily adapt their working and come up with much faster speed. **For example: Google Docs** and **Gmail.** The Cloud takes fewer people to do more work. Cloud require minimum learning bend on hardware and software issues.

12. Disaster Recovery

The most remarkable advantage of cloud computing is disaster recovery and backup. Since all data/information is stored on the cloud, so it's easy to back up or restore the same data on a cloud in distinction to a physical device. Be wise to select a competent Cloud Service Provider that will competent enough to give a warranty of information recovery.

13. Document Control

If a company that haven't switched to cloud yet, workers have to communicate over emails. Only one person can work on a file at one time. So the one file/document has to named, formatted and stored repeatedly. That leads to data duplication and can affect the memory limits. On the other hand cloud computing offers central database location for files. And each employee just works once on one central copy. The Employee can communicate with each other while changing/deleting or updating any file. This feature ultimately boosts the collaborative work environment & brings efficiency in the work.

14. Environment Friendly

The companies that use cloud computing needs on server space that lower their carbon footprint. Using cloud means **30% less usage of energy** and carbon emission than on-site servers. A small organization that is not switched to cloud, their estimated carbon emission is 90%.

15. Lock in

It is very difficult for the customer to switch from one cloud service provider to another.it is not possible because each of the cloud provider uses different standard language for their platforms.

16. downtime

Cloud service provider take care of a number of clients each day, so sometimes this heavy load can lead to business processes being temporarily suspended.

Disadvantages of Cloud Computing

#1. Risk of data confidentiality

There is always a risk that user data can be accessed by other people. So data and cloud protection must be good because if it won't be dangerous for data confidentiality.

#2. Depends on internet connection

The internet is the only way to cloud computing. When there is no internet connection in your place, or the internet path to the cloud provider is in trouble, automatically access to your cloud computing machine will be disconnected. Now this is where the biggest obstacle is happening in developing countries and remote areas that do not have good internet access.And the weakness of public cloud is where everyone accesses the same server and server and will increase the risk of attack, and down the server.

#3. The level of security

Secrecy and security are among the most doubtful things in cloud computing. By using a cloud computing system means we are fully entrusted with the security and confidentiality of data to companies that provide cloud computing servers. When you experience a problem, you cannot sue the server for errors in the data. When you experience a problem, you cannot sue the server for errors in the data.

#4. Compliance

Which refers to the risk of a level compliance deviation from the provider against the regulations applied by the user.

#5. Vulnerable in the event of an attack

There are lots of arguments against cloud computing one of which is computing because the Cloud Computing work system is online, each component that is on Cloud Computing can be exposed to a wide range, this is a wide open opportunity for attacks on data or activities stored on the server. When an attack is carried out by hackers, the problems that occur are data security, and data privacy.

#6. Data Mobility

which refers to the possibility of sharing data between cloud services and how to retrieve data if one day the user makes a process of terminating cloud computing services.And there is local storage where the data can be used at any time as needed.

#7. Technical problem

Besides that the use of Cloud Computing makes you unable to manage it yourself when there is a problem or a problem, you must contact customer support who is not necessarily ready 24/7. This is a problem because for some support you also have to pay more money.

#8. Low Connection

Does not work well if the connection is slow. The quality of cloud computing servers is one of the most important considerations before we decide to provide cloud computing server service providers. When the server is down or the permorma is not good, we will be harmed because of poor server quality.

5.Benefits/Characteristics of cloud computing

On-demand self-service

A consumer can unilaterally provision computing capabilities, such as server time and network

storage, as needed automatically without requiring human interaction with each service provider.

Broad network access

Capabilities are available over the network and accessed through standard mechanisms that

promote use by heterogeneous thin or thick client platforms (e.g., mobile phones, tablets, laptops, and workstations).

Resource pooling

-The provider’s computing resources are pooled to serve multiple consumers

-Resources can be dynamically assigned and reassigned according to customer demand

Customer generally may not care where the resources are physically located but should be

aware of risks if they are located offshore

Rapid elasticity

Capabilities can be expanded or released automatically (i.e., more cpu power, or ability to handle

additional users) To the customer this appears seamless, limitless, and responsive to their changing

requirements .

Measured service

-Customers are charged for the services they use and the amounts. There is a metering concept where

-customer resource usage can be monitored, controlled, and reported, providing transparency for both the provider and consumer of the utilized service

6.Historical development

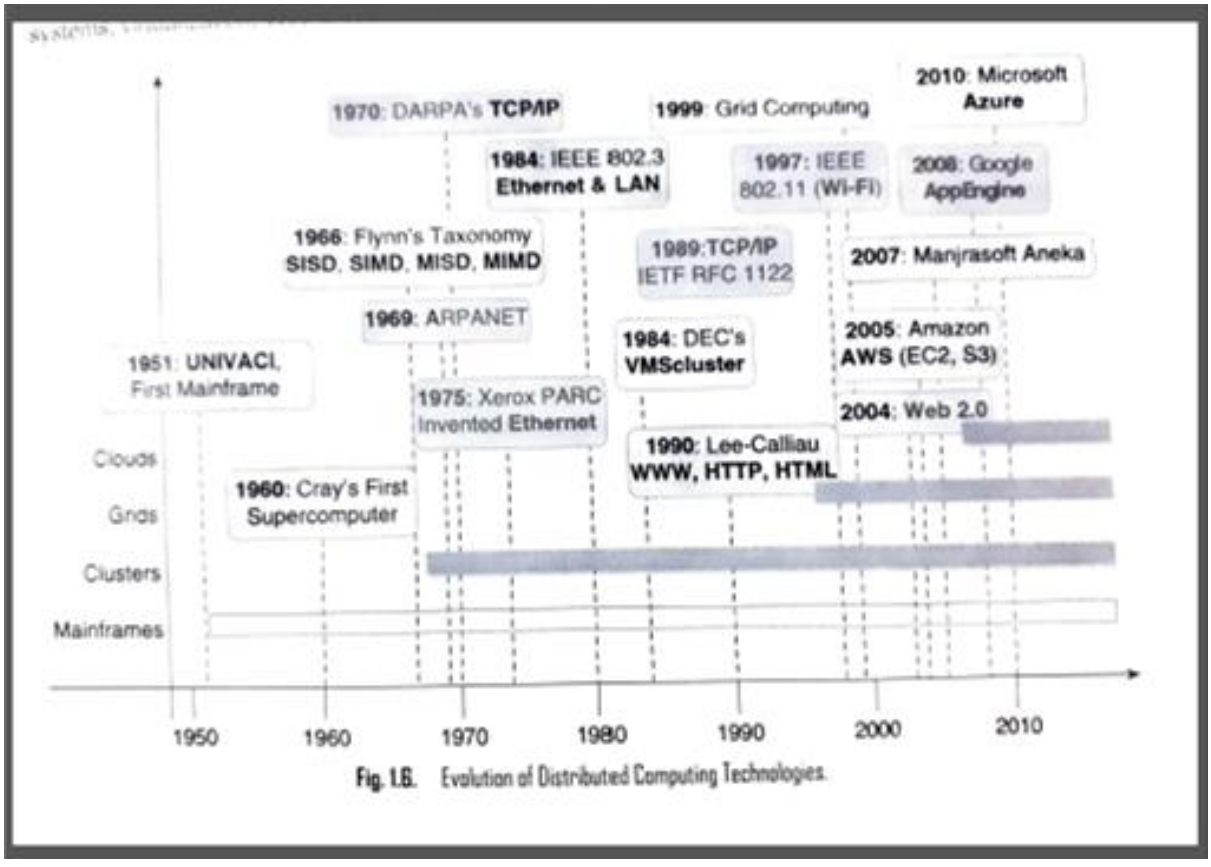


Fig. 1.6. Evolution of Distributed Computing Technologies

- 5 core technologies working behind the cloud computing platforms making cloud computing flexible, reliable, and usable. These technologies are listed below:
  - Distributed system
  - Virtualization
  - Web 2.0

- Service oriented computing
- Utility computing

1950-mainframe computing

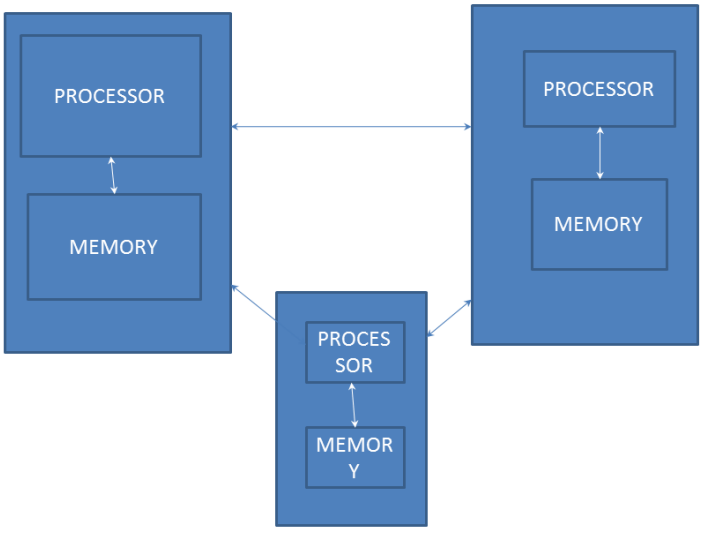
1980-cluster computing

1990-grid computing

Later- cloud computing

Distributed system

- It is a collection of independent computers that appears to it's users as a single system and also it acts as a single computer.
- The main and primary motive of distributed systems is to share resources and to utilize them better.
- EX:ATM MACHINE



Characteristics:

- Heterogeneity-different computer
- Openness
- Transparency
- Concurrency-multiple activities executed at the same time
- Continuous availability
- Scalability

❖ Independent failure

✓ This is absolutely true in case of cloud computing because in cloud computing we are sharing the single resource by paying rent.

✓ The resource is single because the definition of cloud computing clearly states that in cloud computing the single central copy of a particular software is stored in a server (which is located on a anonymous location) and users are accessing that on PAY PER USE BASIS.

Mainframes

- It is highly reliable, powerful, centrally located form of computing service.
- Tolerating failures transparently.
- A user of a mainframe system may access applications using a thin client(A thin client (sometimes also called a lean, zero or slim client) is a computer or a computer program that depends heavily on some other computer (its server) to fulfill its computational roles)). These classic green screen systems provides businesses with reliable and large scale processing power.

  Characteristics:
- Heterogeneity-different computer
- Openness
- Transparency
- Concurrency-multiple activities executed at the same time
- Continuous availability
- Scalability
- Independent failure

✓ Each mainframe system is designed to run at a high level of utilization without failure, and to support hardware up gradation.

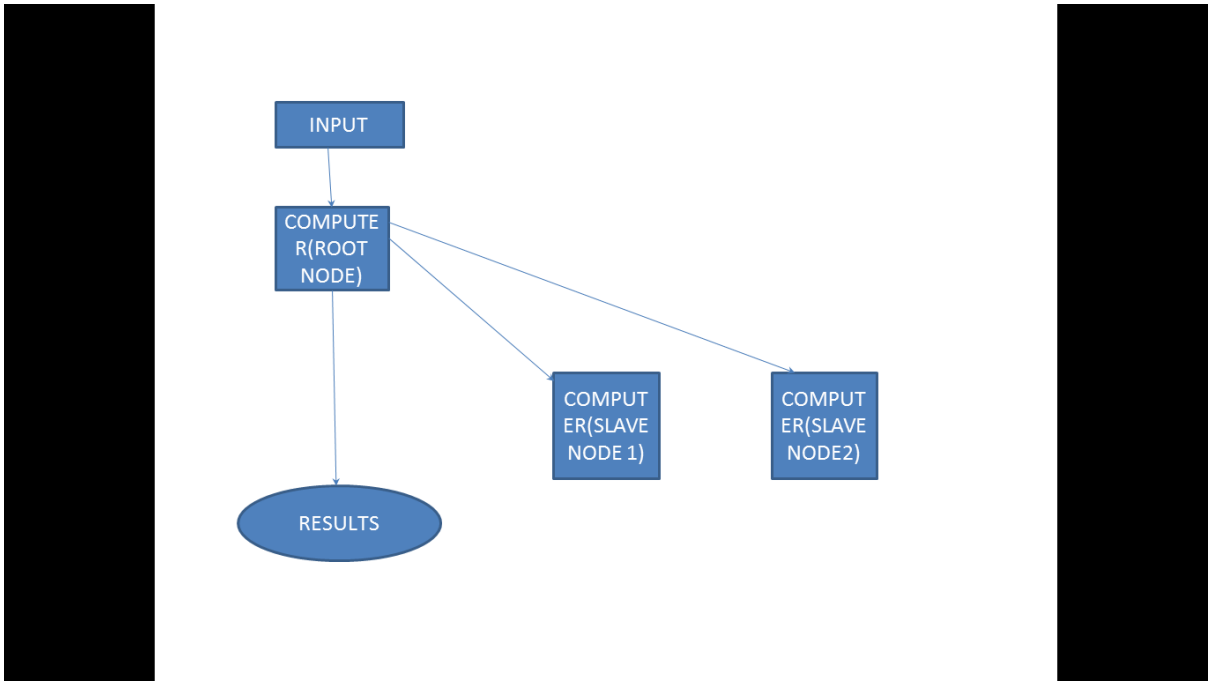
✓ The mainframes can host multiple virtual instances of operating system and this is a crucial requirement for supporting scalability within cloud computing

✓ Used by large organizations for bulk data processing such as online transactions,enterprise resource planning,and other operations involving the processing of significant amount of data.

Cluster computing

- cluster is a group of machines that are virtually or geographically separated and that work together to provide the same service or application to clients.

- It is defined as a cluster because the servers are fault-tolerant, and they provide seamless access to a service.
- Cluster computing refers to the process of sharing the computation task to multiple computers of the cluster. The number of computers are connected on a network and they perform a single task by forming a Cluster of computers where the process of computing is called as cluster computing.
- Cluster Computing is a high performance computing framework which helps in solving more complex operations more efficiently with a faster processing speed and better data integrity.



  - Low cost alternative to the use of mainframes and supercomputers.
  - Computational power of commodity machines used to solve problems which is previously managed by supercomputers.
  - Cluster technology contributed to the evolution of tools and framework for distributed computing .some of them are:
    - Condor
    - Parallel virtual machine(PVM)
    - Message Passing Interface(MPI)

Grid

- The use of specialist supercomputers, or large number of computers configured to run in parallel in a ‘grid’ to solve the complex problems such as predicting the weather or decrypting data encrypted with strong encrypting algorithms.

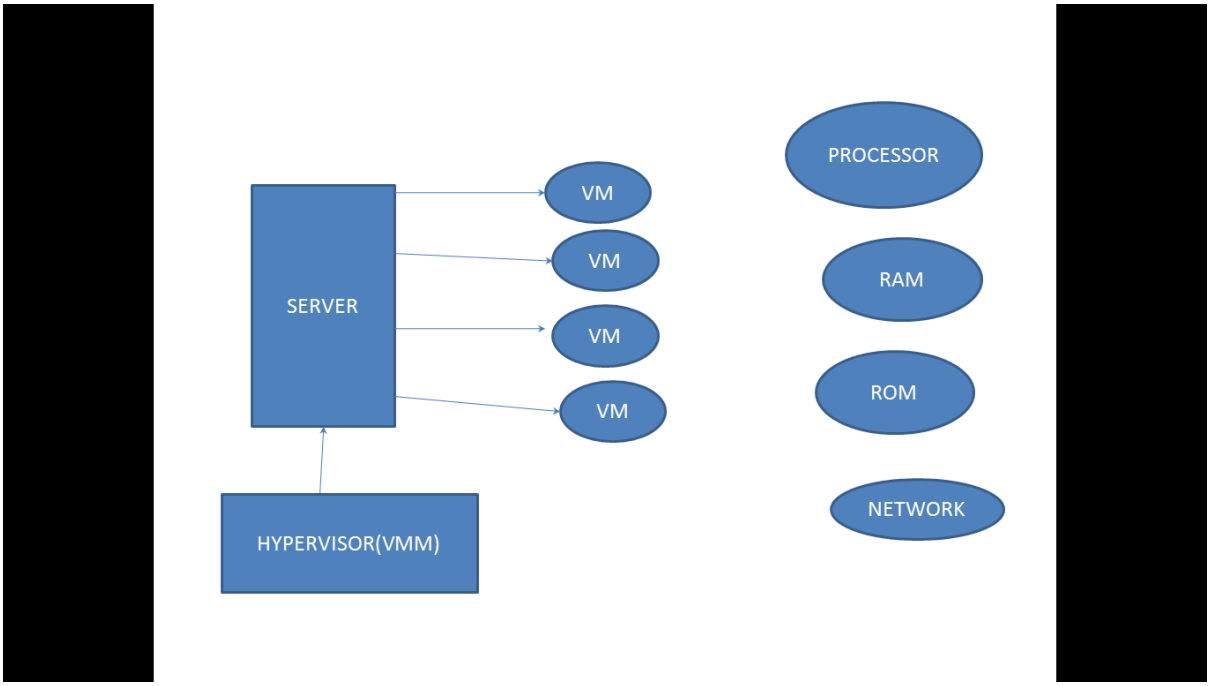
- Grid computing is a collection of computers working together to perform various tasks. It distributes the workload across multiple systems, allowing computers to contribute their individual resources to a common goal.
- A computing grid is similar to a cluster, but each system (or node) on a grid has its own resource manager. In a cluster, the resources are centrally managed, typically by a single system.

Scalability and on demand processing power

- The use of a supercomputer or grid computing service provides a level of scalability to those needing resources that may be too cost prohibitive to purchase in house.
- The processing power within these systems can be shared and provided to multiple users concurrently to execute complex software programs

Virtualization

- It is the "creation of a virtual (rather than actual) version of something, such as a server, a desktop, a storage device, an operating system or network resources".
- In other words, Virtualization is a technique, which allows to share a single physical instance of a resource or an application among multiple customers and organizations



- ❖ Creation of a virtual machine over existing operating system and hardware is known as Hardware Virtualization. A Virtual machine provides an environment that is logically separated from the underlying hardware.
- ❖ The machine on which the virtual machine is going to create is known as Host Machine and that virtual machine is referred as a Guest Machine
- ❖ The meaning of Virtualization began shifting in the 1970s, and now describes the creation of a virtual machine, that acts like a real computer, with a fully functional operating system. The concept of Virtualization has evolved with the Internet, as businesses began offering "virtual" private networks as a rentable service. The use of virtual computers became popular in the 1990s, leading to the development of the modern Cloud Computing infrastructure

Types of Virtualization:

- ❖ Hardware Virtualization.
- ❖ Operating system Virtualization.
- ❖ Server Virtualization.
- ❖ Storage Virtualization

1) Hardware Virtualization:

- When the virtual machine software or virtual machine manager (VMM) is directly installed on the hardware system is known as hardware virtualization.
- The main job of hypervisor is to control and monitoring the processor, memory and other hardware resources.
- After virtualization of hardware system we can install different operating system on it and run different applications on those OS.

Usage:

Hardware virtualization is mainly done for the server platforms, because controlling virtual machines is much easier than controlling a physical server.

2) Operating System Virtualization:

When the virtual machine software or virtual machine manager (VMM) is installed on the Host operating system instead of directly on the hardware system is known as operating system virtualization.

Usage:

Operating System Virtualization is mainly used for testing the applications on different platforms of OS.

3) Server Virtualization:

When the virtual machine software or virtual machine manager (VMM) is directly installed on the Server system is known as server virtualization.

Usage:

Server virtualization is done because a single physical server can be divided into multiple servers on the demand basis and for balancing the load.

4) Storage Virtualization:

- Storage virtualization is the process of grouping the physical storage from multiple network storage devices so that it looks like a single storage device.
- Storage virtualization is also implemented by using software applications.
- Pool of available storage capacity that is managed from a central console.
- Storing most information in a particular place can cause loss of data,congestion.so properly dividing storage&storing data can be useful

Usage:

Storage virtualization is mainly done for back-up and recovery purposes.

Web 2.0

- Improved version of web 1.0
- Characterized by the change from static to dynamic or user generated content&also growth of social media

Ex:facebook,twitter,blogs,wikipedia,flickr

Advantages:

- Availability
- Variety of media
- Easy to use
- Dynamic
- Real time discussion

Web 2.0 tools and features

- Allow user to go beyond just information from website
- Content-create,share(google drive,twitter,youtube)

Features:

- Free classification of information

- Rich user experience
- User can be contributor
- Dispersion

Web 2.0 technology concepts

- Rich internet Application(RIA)-graphics ,interactivity
- Web oriented architecture(WOA)-RSS feed
- Social web-user generated content

Limitation

- Keyword based search
- Time consuming
- Inconsistent terminologies
- Failure to remove outdated information
- Missing of intelligence

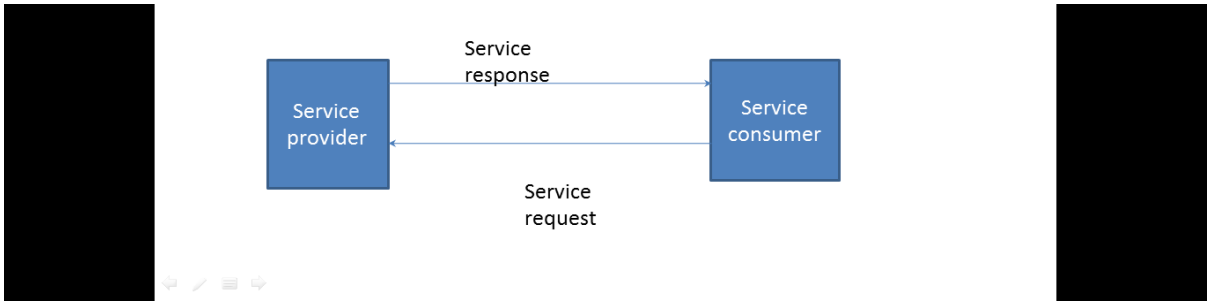
- Publisher type sites that allow it's users to create their pages with a unique URL
- The global presence of the internet and the introduction of wireless networking and mobile devices featuring always on internet connectivity has raised expectations of users and demand for services over the internet.
- Web 2.0 is the term given to describe a second generation of the World Wide Web that is focused on the ability for people to collaborate and share information online. Web 2.0 basically refers to the transition from static HTML Web pages to a more dynamic Web that is more organized and is based on serving Web applications to users.
  - Other improved functionality of Web 2.0 includes open communication with an emphasis on Web-based communities of users, and more open sharing of information. Over time Web 2.0 has been used more as a marketing term than a computer-science- based term. Blogs, wikis, and Web services are all seen as components of Web 2.0.

Utility Computing

- Computing services that can be metered and billed to customers in the same way that electricity or telephony system operate, are known as utility computing services.

- It is a service provisioning model ;computing resources(storage,compute power,applications,infrastructure) available for consumers as needed on pay-per-use basis.

Service oriented computing

- It is the computing paradigm that utilizes services as fundamental elements for developing applications/solutions
- Soc supports the development of rapid ,low cost ,flexible,interoperable, and evolvable applications and systems.
- Service is supposed to be loosely coupled,,reusable,programming language independent,and location transparent.
- Services are composed and aggregated into a service oriented architecture(SOA),which is a logical way of organizing software systems to provide end users and other entities distributed over the network with services through published and discoverable interfaces.
- 

Soc introduce 2 important concepts,which is also fundamental for cloud computing.

1)Quality of service(QoS)

- Identifies set of functional and non-functional attributes that can be used to evaluate the behaviour of a service from different perspectives.this could be performance metrics such as response time,or security attributes,transactional integrity,reliability,scalability,availability.
- QoS requirements are established between client and the provider between a service level agreement(SLA)that identifies the minimum values for QoS attributes that need to be satisfied upon service call

2.Saas

- Appln available on subscription basis

- Client is freed from maintenance cost and difficult upgrades.
- Economies of scale reached by means of multitenancy

7.Cloud computing reference model

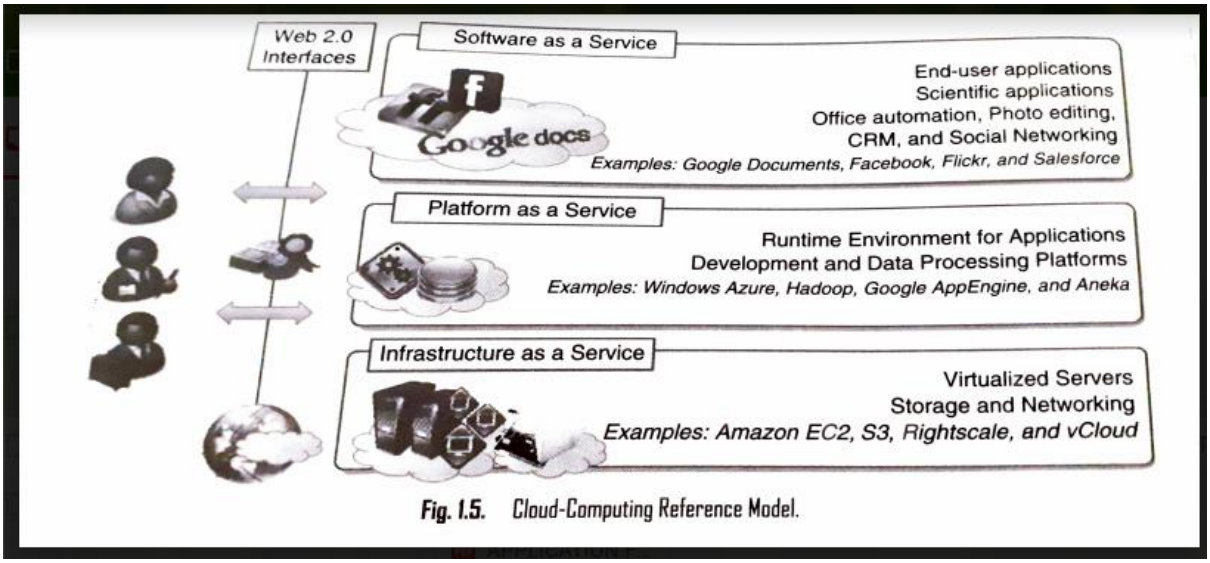


Fig. 1.5. Cloud-Computing Reference Model.

- A fundamental characteristic of cloud computing is the capability of delivering on demand IT services.
- Cloud computing services can be categorized into 3.They are
  - SaaS(software as a service)
  - PaaS(Platform as a service)
  - IaaS(Infrastructure as a service)
- Each layer provide different service to users.
- This model organizes the wide range of cloud computing services into a layered view from bottom to top

IaaS

- Deliver infrastructure on demand in the form of virtual hardware ,storage and networking.
- Virtual hardware is utilized to provide compute on demand in the form of virtual machine instances.These are created on user's request on the provider's infrastructure,and user's are given tools and interfaces to configure the software stack installed on the machine.
- Hourly cost influenced by characteristics of virtual hardware.
- Virtual storage delivered in the form of raw disk space.

- Virtual networking identifies the collection of services that manage the networking among virtual instances and their connectivity towards the internet or private networks.
- Iaas solutions target mostly end users,who want to benefit from the elastic scalability of the cloud without doing any software development,installation,configuration and maintenance.

PaaS

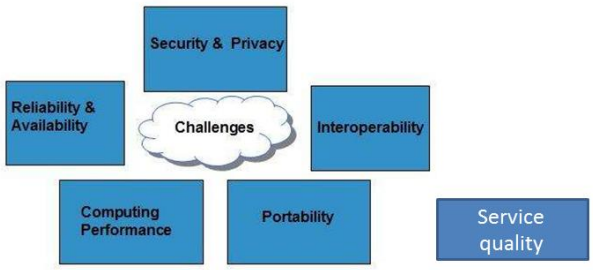
- Deliver scalable and elastic runtime environments on demand that host the execution of applications.
- It is appropriate when new systems have to be developed.
- Responsibility of service provider is to provide scalability and manage fault tolerance

Saas

- Provide applications and services on demand .
- Most of the common functionalities of desktop applications-office automation,document management,photo editing ,and customer Relationship Management software(CRM)-these are replicated on the providers infrastructure ,made more scalable,and accessible through a browser on demand.these applications are shared across multiple users ,whose interaction is isolated from other users.
- Saas layer is also the area of social networking websites, which manage cloud based infrastructure to sustain the load generated by their popularity.

8.Challenges of cloud computing

Cloud computing, an emergent technology,
has placed many challenges in different
aspects of data and information handling.
Some of these are shown in the following
diagram:



Security and Privacy

Security and Privacy of information is the biggest challenge to cloud computing. Security and privacy issues can be overcome by employing encryption, security hardware and security applications,data loss software.

Portability

This is another challenge to cloud computing that applications should easily be migrated from one cloud provider to another. There must not be vendor lock-in. However, it is not yet made possible because each of the cloud provider uses different standard languages for their platforms.

Interoperability

It means the application on one platform should be able to incorporate services from the other platforms. It is made possible via web services, but developing such web services is very complex.

Service quality

The SLA of the provider not enough to guarantee the availability and scalability

The business is not willing to switch to cloud without strong service quality guarantee

Computing Performance

Data intensive applications on cloud requires high network bandwidth, which results in high cost. Low bandwidth does not meet the desired computing performance of cloud application.

Reliability and Availability

It is necessary for cloud systems to be reliable and robust because most of the businesses are now becoming dependent on services provided by third-party.

A closer look

- Cloud computing helping enterprises , governments,public and private institutions as well as research organizations to shape more effective and demand driven computer systems.Access to, as well as integration of,cloud computing resources are easy
- Large enterprises can offload some of their activities to cloud based systems
- Small enterprises and start-ups can afford to translate into business results their ideas more quickly without excessive upfront costs
- System developers can concentrate on the business logic rather than dealing with the complexity of infrastructure management and scalability
- End users can have their documents accessible from everywhere and any device

9. Major deployment models for cloud computing

Cloud is an Internet-based computing in which shared the pool of resources are available over a broad network access, these resources can be provisioned or released with minimum management efforts and service provider interaction.

1.**public/internet cloud**-3rd party ,multitenant cloud infrastructure and services…available on subscription basis to all

2. **private/enterprise cloud**- a public cloud model within company's own data center/infrastructure for internal and /or partners use

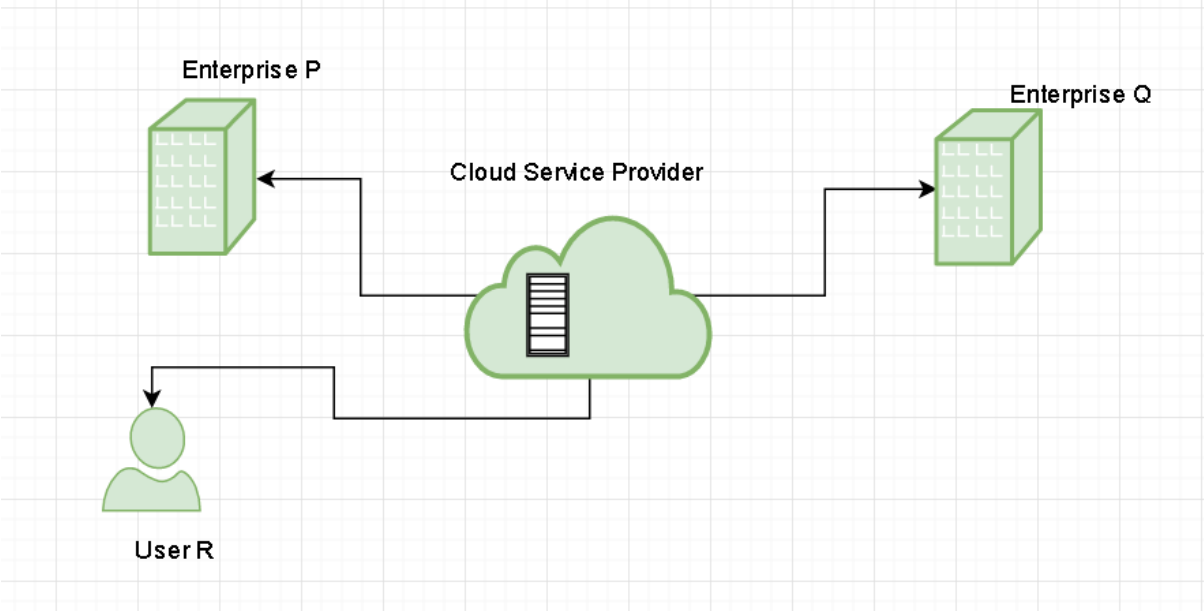
3.**Hybrid/inter cloud**-mixed usage of public and private clouds. leasing public cloud services when private cloud capacity is insufficient.

Public cloud:

Public cloud are managed by third parties which provide cloud services over the internet to public, these services are available as pay-as-you-go billing mode.

- They offer solutions for minimizing IT infrastructure costs and act as a good option for handling peak loads on the local infrastructure. They are a goto option for small enterprises, which are able to start their businesses without large upfront investments by completely relying on public infrastructure for their IT needs.
- A fundamental characteristic of public clouds is multitenancy. A public cloud is meant to serve multiple users, not a single customer. A user

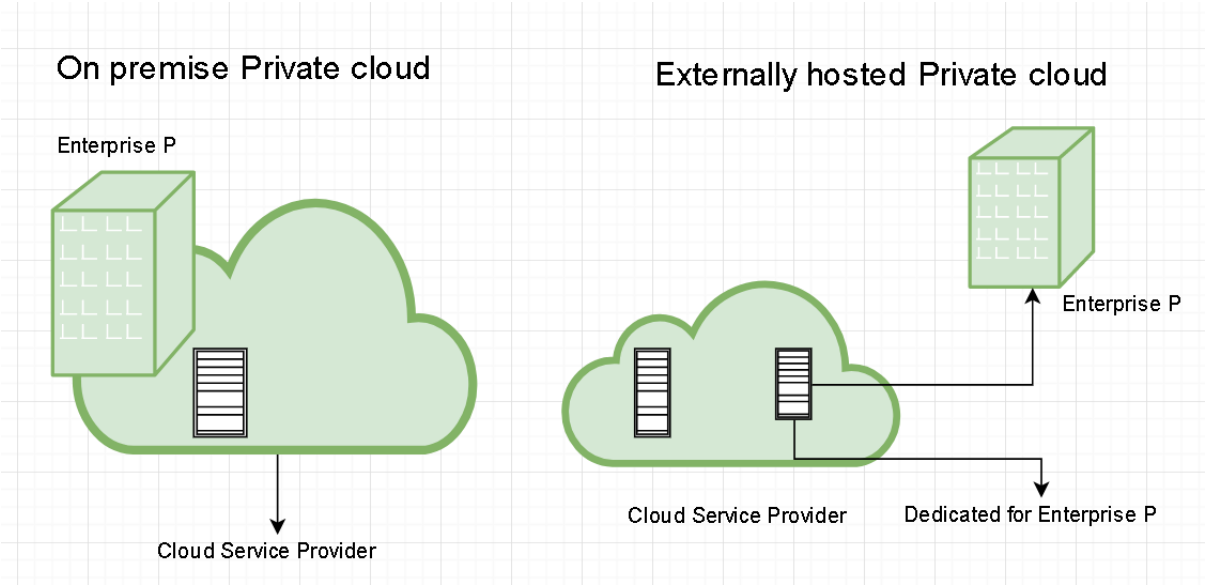
requires a virtual computing environment that is separated, and most likely isolated, from other users.



- **Private-cloud**

  Private clouds are distributed systems that work on a private infrastructure and providing the users with dynamic provisioning of computing resources. Instead of a pay-as-you-go model as in public clouds, there could be other schemes in that take into account the usage of the cloud and proportionally billing the different departments or sections of an enterprise.

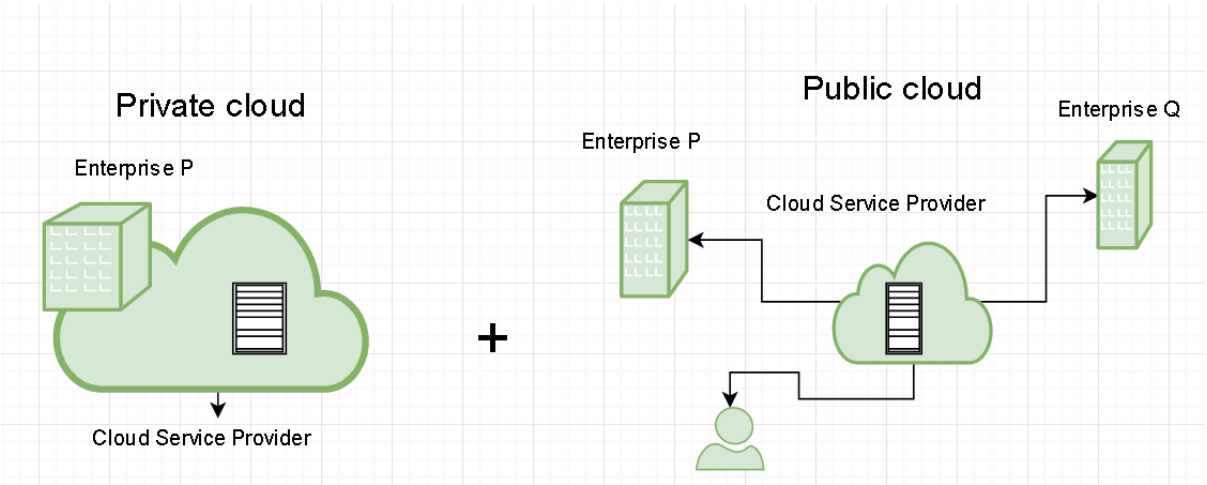
- The advantages of using a private cloud are:
- **Customer information protection:** In private cloud security concerns are less since customer data and other sensitive information does not flow out of a private infrastructure.
- **Infrastructure ensuring SLAs:** Private cloud provides specific operations such as appropriate clustering, data replication, system monitoring and maintenance, and disaster recovery, and other uptime services.
- **Compliance with standard procedures and operations:** Specific procedures have to be put in place when deploying and executing applications according to third-party compliance standards.This is not possible in case of public cloud.



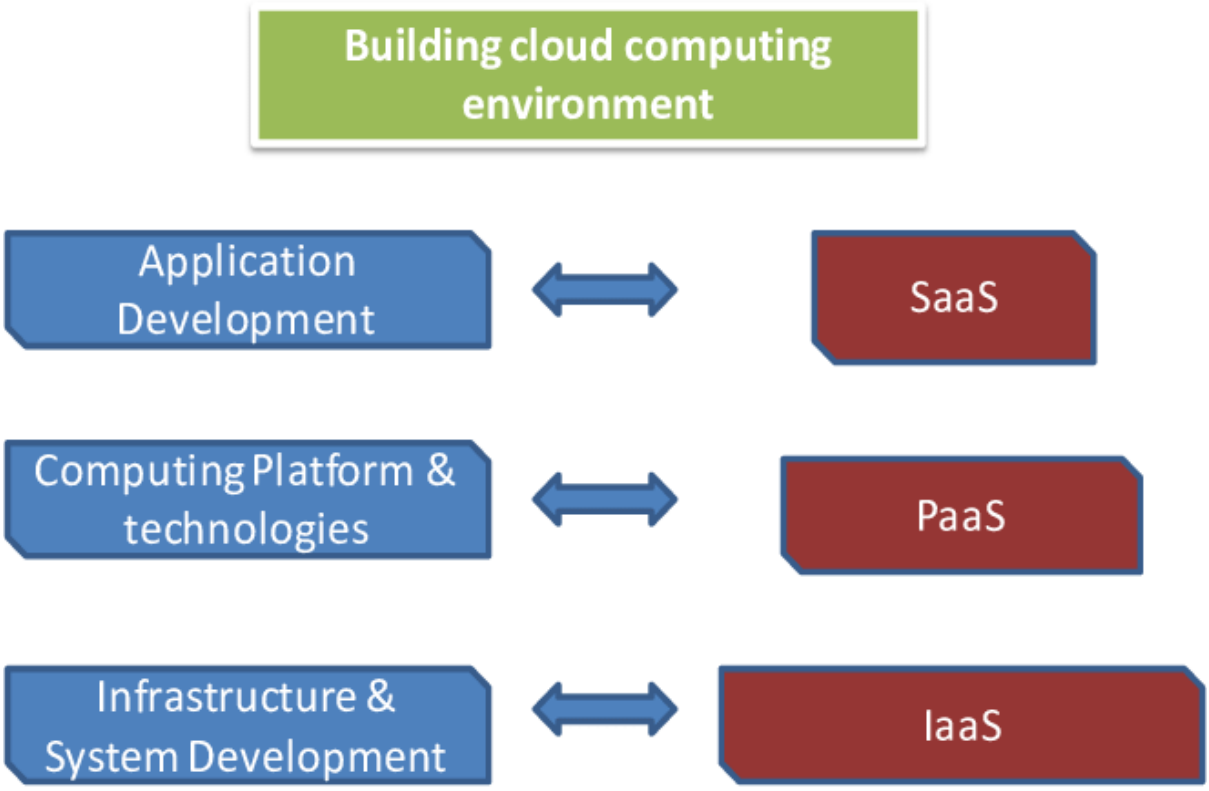
- **Hybrid cloud:**

  Hybrid cloud is a heterogeneous distributed system resulted by combining facilities of public cloud and private cloud. For this reason they are also called **heterogeneous clouds.**

  A major drawback of private deployments is the inability to scale on demand and to efficiently address peak loads. Here public clouds are needed. Hence, a hybrid cloud takes advantages of both public and private cloud.



10. Building cloud computing environment



- The creation of cloud computing environments consists of both the development of applications and systems that use cloud computing solutions and the creation of frameworks, platforms and infrastructures delivering cloud computing services.
    - Application development
    - Infrastructure and system development
    - Computing platforms and technologies

Application development

- Applications that use cloud computing benefit from its capability of dynamically scaling on demand.
- One class of applications that take the biggest advantage from this feature is web applications. Their performance is mostly influenced by the workload generated by varying user demands.
- By using web 2.0 technologies web has become a platform for developing rich and complex applications including enterprise applications which uses internet as the preferred channel for service delivery and user interaction.
- Another class of applications that can potentially gain considerable advantage by using cloud computing is represented by resource

intensive applications.These can be either data- intensive or compute intensive applications.In both cases ,considerable amount of resources are required to complete execution in a reasonable time frame.

- Large amount of resources is not needed constantly or for a long duration.
- For ex: scientific applications can require huge computing capacity to perform large scale experiments once in a while ,so it is not feasible to buy the infrastructure supporting them . In this case ,cloud computing can be a solution.
- Cloud computing provides solution for on demand and dynamic scaling across the entire stack of computing. This is achieved by
- a)Providing methods for renting compute power ,storage and networking.
- b)Offering runtime environments designed for scalability and dynamic sizing
- c)Providing application services that mimics the behavior of desktop applications but that are completely hosted and managed on provider site.

- Developers access such services via simple web interfaces.

Infrastructure and system development.

- Distributed computing ,virtualization,service orientation and web 2.0 form the core technologies enabling the use of cloud services from anywhere in the globe.
- Distributed computing is a fundamental model for cloud computing,because cloud systems are distributed systems.
- Distributed system hide the complexity,like wise cloud also hide the complexity.
- IaaS solutions provide the capabilities to add and remove resources.
- PaaS solutions embed into their core offering algorithms and rules that control the provisioning process and lease of resources.
- Web 2.0 technologies constitute the interface through which cloud computing services are delivered ,managed, provisioned. Beside the

interaction through the web browsers ,web services have become the primary access point to cloud computing systems.

- Service orientation is the underlying paradigm that defines the architecture of a cloud computing system.
- Cloud computing is summarized with XaaS-Everything as a service.
- Virtualization is a core feature of the infrastructure used by cloud providers.
- Virtualization is the abstraction of virtual hardware or of a runtime environment.

11. Cloud Computing Platforms and Technologies

- **Amazon Web Services (AWS) –**
  AWS provides different wide-ranging clouds IaaS services, which ranges from virtual compute, storage, and networking to complete computing stacks.
- **Amazon EC2(Amazon Elastic compute cloud)-**provide users with customizable virtual hardware that can be used as the base infrastructure for deploying computing systems on cloud
- **S3(simple storage service)-**delivers persistent storage on demand.
- **Google AppEngine –**
  Google AppEngine is a scalable runtime environment frequently dedicated to executing web applications.
- AppEngine provides both a secure execution environment and a collection of services that simplify the development of scalable and high performance web applications.These services include:in-memory caching,scalable data store.job queues,messaging and cron tasks.
- Developers can build and test applications on their own machine by using the AppEngine SDK,once the development complete developers can easily migrate their application to AppEngine.

- The languages currently supported are: Python ,java,Go
- **Microsoft Azure –**
  Microsoft Azure is a Cloud operating system and a platform in which user can develop the applications in the cloud. Generally, a scalable runtime environment for web applications and distributed applications is provided.
- Applications in azure are organized around the concept of roles-3 types of role: web role,worker role,virtual machine role
- Web role-is designed host web application.
- Worker role-it is a generic container of applications and can be used to perform workload processing.
- Virtual machine role-provides a virtual environment where the computing stack can be fully customized including os.
- Additional services of azure which complement application execution such as support for storage,networking,caching,content delivery and others.
- **Hadoop**

  Apache Hadoop is an open source framework that is appropriate for processing large data sets on commodity hardware. Hadoop is an implementation of MapReduce, an application programming model which is developed by Google,which provides 2 fundamental operations for data processing:map and reduce.
- Map-transforms and synthesizes the input data provided by the user
- Reduce-aggregate the output obtained by the map operations.
- Hadoop provides the run time environment ,and developers need only to provide the input data,and specify map and reduce functions that need to be executed.
- Hadoop is an integral part of yahoo.
- **Force.com and Salesforce.com** –
  Force.com is a Cloud computing platform at which user can develop social enterprise applications.
- This platform is the basis of salesforce.com-a saas solution for customer relationship management.

- Force.com allows creating applications-consist of complete set of components supporting all the activities of an enterprise.
- It is possible to develop your own components or integrate those available into our applications.
- The platform provides complete support for developing applications:from the design of the data layout,to the definition of business rules and workflows ,and the definition of user interface.
- Force.com is completely hosted on the cloud,and provide complete access to it's functionalities ,and those implemented in the hosted applications through web services technologies.
- **Manjrasoft Aneka**
- Is a cloud application platform for rapid creation of scalable applications,and their deployment on various types of clouds in a seamless and elastic manner.
- It supports collection of programming abstractions for developing applications and a distributed runtime environment that can be deployed in a heterogenous hardware(clusters,networked destop computers,cloud resources)
- Developers can choose different abstractions to design their application:tasks,distributed threads and map reduce.these applications are then executed on the distributed service oriented runtime environment,which can dynamically integrate additional resource on demand
- The service oriented architecture of the runtime has a great degree of flexibility and simplifies the integration of new features such as abstraction of a new programming model and associated execution management environment

12.Parallel computing, distributed computing

Eras of computing

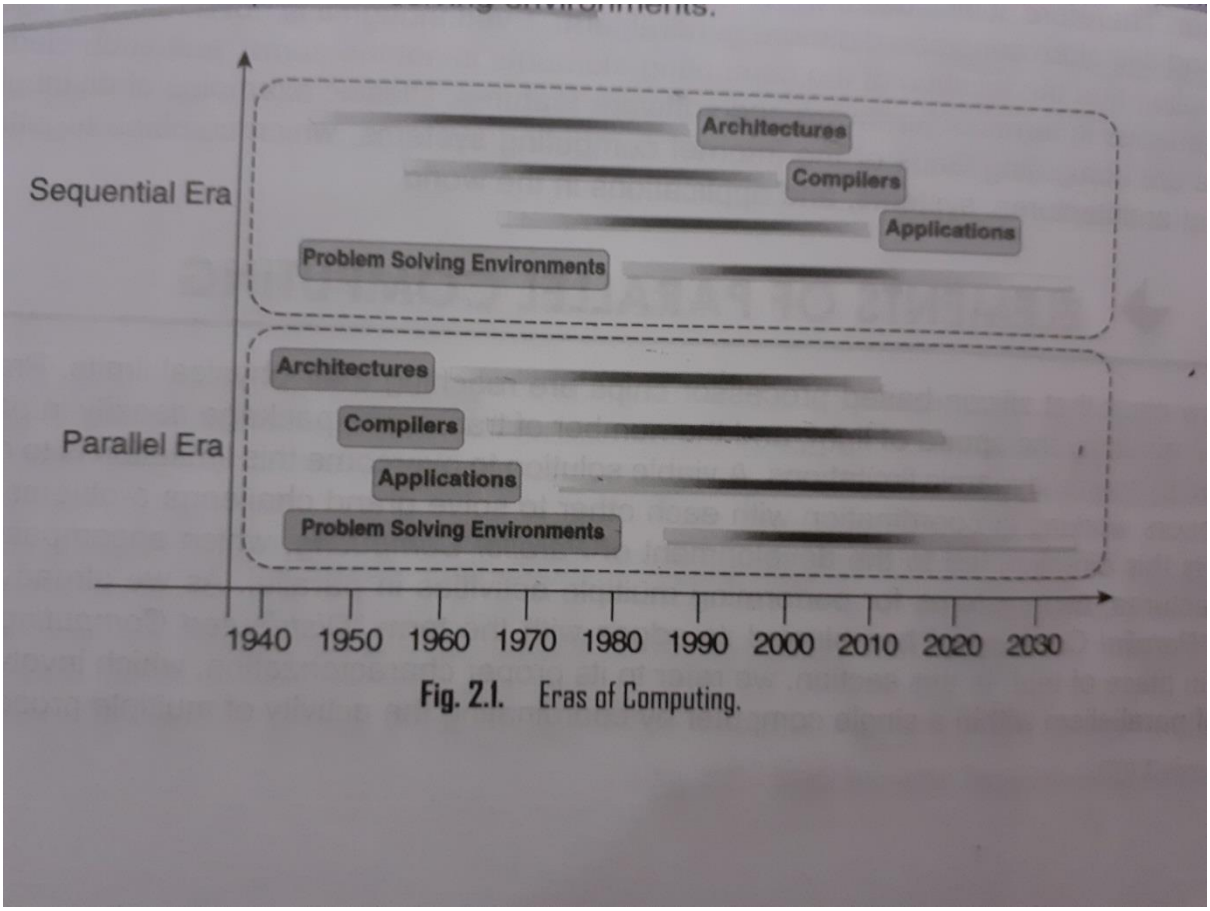
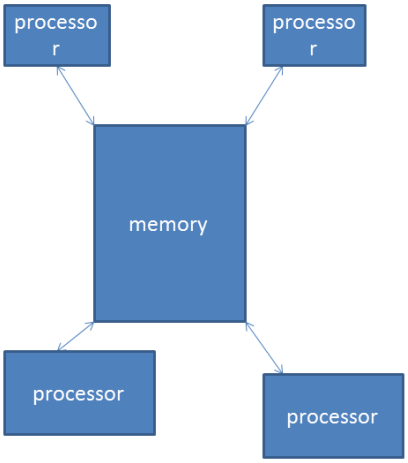


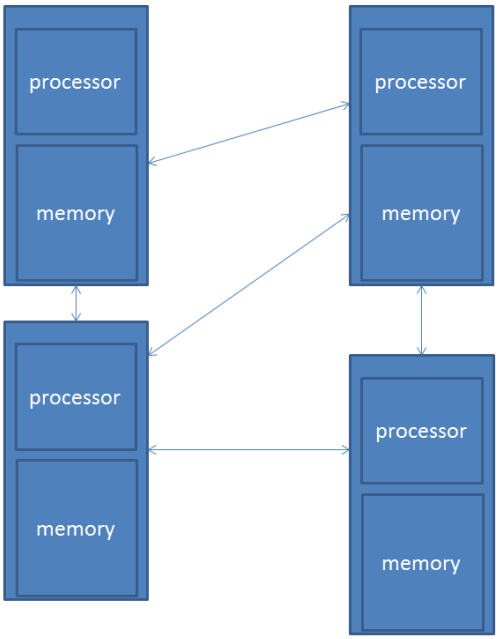
Fig. 2.1. Eras of Computing.

- The 2 fundamental and dominant models of computing are:sequential and parallel.
- The sequential computing era began in1940's ;parallel(and distributed)computing era follows it .
- The four key elements of computing developed during these eras were:architectures,compilers,applications, and problem solving environments.
  - The computing era started with a development in hardware architectures,which actually enabled the creation of system software-particularly in the area of compilers and os-which supported the management of such systems and the development of applications.problem solving environments are designed and introduced to facilitate and empower engineers.
  - Every aspect of this era underwent a 3 phase process:research and development(R&D),commercialization,commoditization
  - **Parallel computing**
  - A system is said to be parallel system in which multiple processor have direct access to shared memory which forms a common address space.

- **Advantages:**
- Provide concurrency
- Cost&time saving
- Provide user friendly programming
- Taking advantage of non local resources



- **Distributed system**
- A system is said to be distributed system if it is a collection of independent computers interconnected via network,capable of collaborating on a task.
- **Advantage**
- Information&resource sharing
- Shorter response
- Higher reliability
- Better price,performance ratio
-



• **Parallel computing**	• **Distributed computing**
• It is a type of computation in which many calculations or the execution of processes are carried out simultaneously	• A system where components are located on different networked computers which communicate and coordinate their actions by passing messages to one another
• It occurs in a single computer	• It involves multiple computers
• Multiple processors execute multiple tasks at the same time.	• Multiple computers perform task at the same time
• Computer have shared memory or distributed memory	• Each computer have it's own memory
• Processors communicate with each other by using a bus	• Computers communicate with each other through the network

• Increase the performance of the system	• Allows scalability,sharing resources and helps to perform computation task very efficiently
• Main focus-performance,scientific computing	• Main focus-performance,reliability, • Resource sharing

- **13. Elements of parallel computing**
- Silicon based processor chips have physical limits.
- Processing speed is constrained by the speed of light;and the number of transistors package density in processor is constrained by thermodynamic limitations.
- A solution to overcome this limitation is to connect multiple processors working in coordination with each other to solve grand challenge problems.
- The first step towards this direction led to the development of parallel computing.
- Parallel computing consists of techniques,architectures and systems for performing multiple activities in parallel.
- Parallel computing has blurred it's edges with the term distributed computing and it is often used in place of that
- **Parallel processing**
- Processing of multiple tasks simultaneously on multiple processors is called parallel processing.
- The parallel program consists of multiple active processes simultaneously solving a given problem.
- A given task is divided into multiple subtasks using divide-and-conquer technique,and each one of them processed on different CPU's
- Programming on multi-processor system using divide-and-conquer technique is called parallel programming
- Many applications today require more computing power than a traditional sequential computer can offer.

- Parallel processing provides a cost effective solution to this problem by increasing the number of CPU's in a computer by adding an efficient communication system between them.
- The workload can be shared between different processors.this results in higher computing power and performance than a single processor system.
- The development of parallel processing is being influenced by many factors.They are:
- Computational requirements are ever increasing,both in the area of scientific and business computing.The technical computing problems which require high speed computational power,are related to life sciences,aerospace,geographical information systems,,mechanical design and analysis etc
- Sequential architectures are reaching physical limitation as they are constrained by the speed of light and thermodynamics laws.
- Hardware improvements in pipelining ,superscalar etc are non-scalable and require sophisticated compiler technology.Developing such compiler technology is a difficult task.
- Vector processing works well for certain kind of problems
- Parallel processing is mature and can be exploited commercially.
- Significant development in networking technology is paving way for heterogeneous computing

14.Hardware architectures for parallel computing

- The core elements of parallel processing are CPU's .based on number of instruction and data streams that can be processed simultaneously,computing systems are classified into following 4 categories
- SISD
- SIMD
- MISD
- MIMD
    - Single Instruction single Data(SISD)

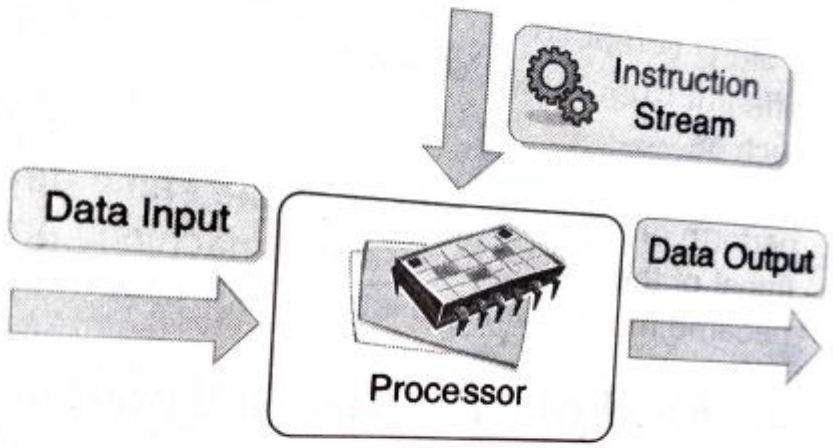


Fig. 2.2. Single Instruction Single Data (SISD) Architecture.

- It is a uniprocessor machine capable of executing a single instruction,which operates on a single data stream.
- In SISD,machine instructions are processes sequentially,and hence computers adopting this model are popularly called sequential computers.
- All the instructions and data to be processed have to be stored in the primary memory.the speed of processing element in SISD model
- Is limited by the rate at which the computer can transfer information internally

2.Single Instruction Multiple Data(SIMD)

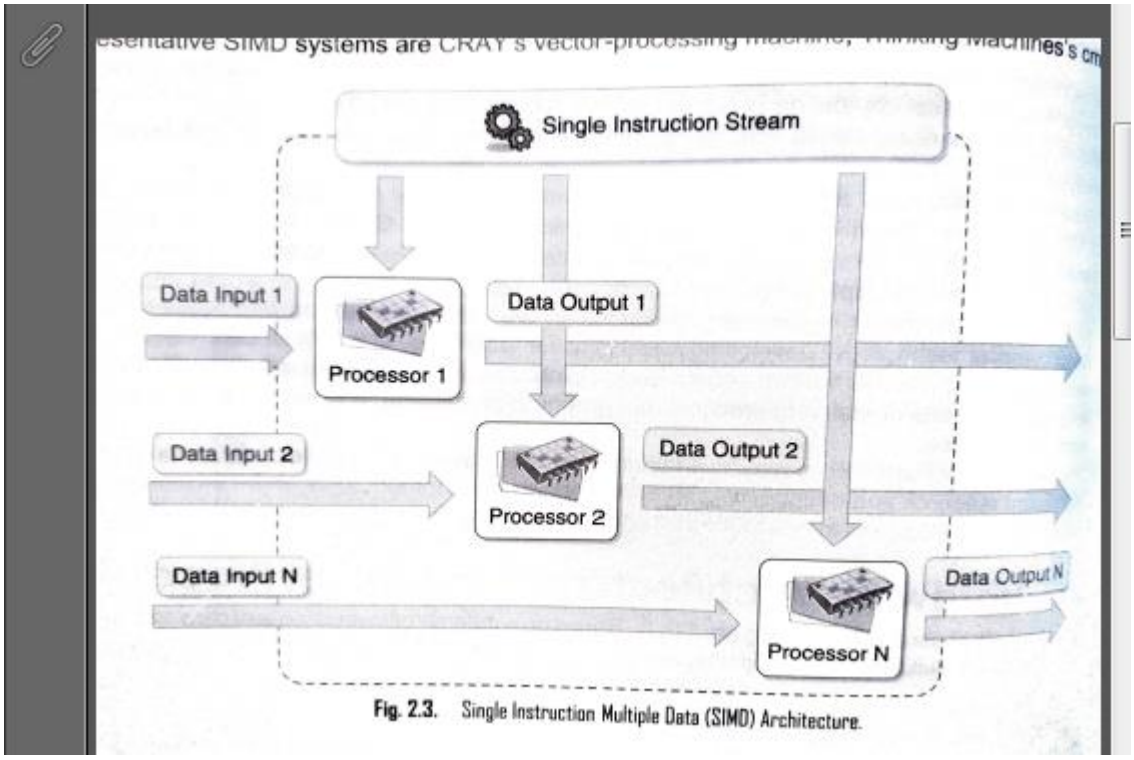


Fig. 2.3. Single Instruction Multiple Data (SIMD) Architecture.

- A SIMD computing system is a multiprocessor machine capable of executing the same instruction on all the cpu's but operating on different data streams.
- machines based on SIMD model are well suited for scientific computing since they involve lots of vector and matrix operations.
- Ci=Ai*Bi

3.MISD

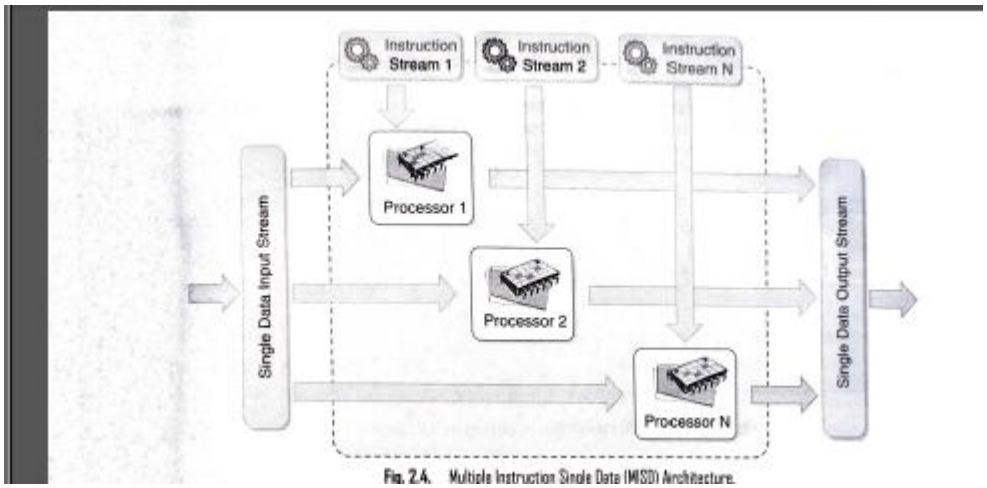
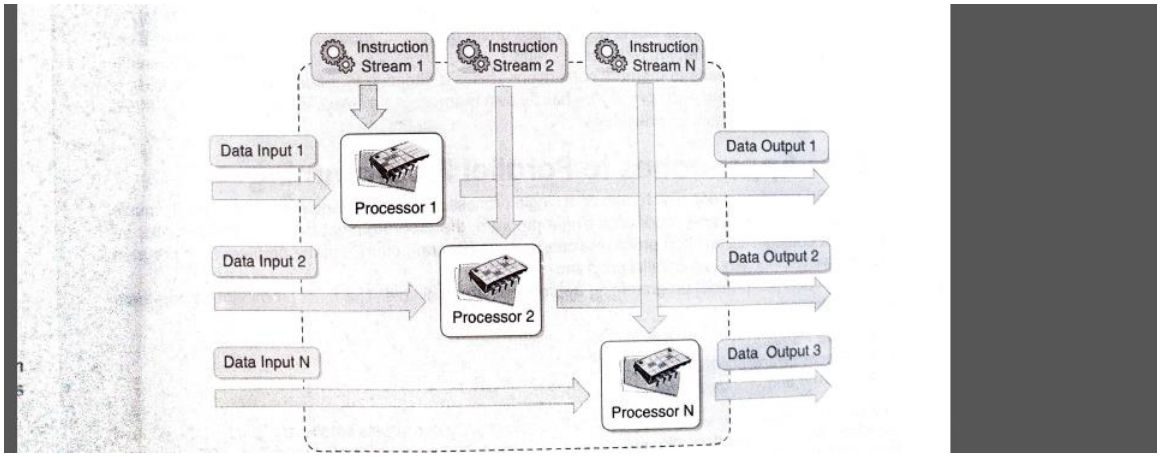
- It is a multiprocessor machine capable of executing different instructions on different PEs,but all of them operating on the same data set
- Y=sin(x)+cos(x)+tan(x)
- 

Fig. 2.4. Multiple Instruction Single Data (MISD) Architecture.
- **4.MIMD**

- 

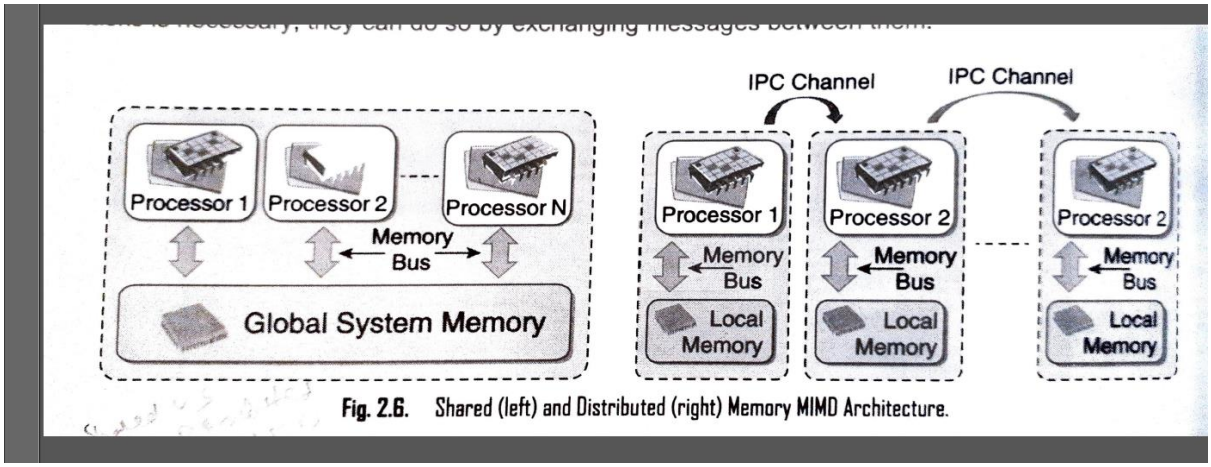
- It is a multiprocessor machine capable of executing multiple instructions on multiple data set.Each PE in the MIMD model has separate instructions and data streams,and hence machines built using this model are well suited for any kind of application.
- MIMD machine broadly categorized into shared- memory MIMD and distributed –memory MIMD based on how Pes are coupled to the main memory
- **a)Shared memory MIMD machine**
- All the PEs are connected to a single global memory and they all have access to it.systems based on this model are also called tightly- coupled multiprocessor systems.
- The communication between PEs in this model takes place through the shared memory; modification of the data stored in the global memory by one PE is visible to all other Pes
- 

Fig. 2.6. Shared (left) and Distributed (right) Memory MIMD Architecture.
- **b)Distributed memory MIMD machine**
- PE have a local memory.

- Systems based on this model are also called loosely coupled multiprocessor systems.
- The communication between Pes in this model takes place through the interconnection network(IPC)
- **Shared memory VS Distributed memory MIMD**
- Shared memory architecture is easier to program but is less tolerant to failures and harder to extend with respect to the distributed memory MIMD model
- Failures in shared memory MIMD affect the entire system whereas this is not in the case of a distributed model where each of the Pes can be easily isolated.
- In shared memory MIMD,Addition of more PE cause memory contention but this didn't happen in the case of distributed memory MIMD(each of the PE's has it's own memory)

15.Approaches to parallel programming

- A sequential program is one which runs on A single processor and has A single line of control.
- To make many processors collectively work on A single program,the program must be divided into smaller independent chunks so that each processor can work on separate chunks of the problem
- **Data parallelism**
- -divide and conquer technique is used to split data into multiple sets,and each data set is processed on different PE by using the same instruction.This approach is highly suitable for processing on machines based on the SIMD model
- **Process parallelism**
- -given operation has multiple activities,which can be processed on multiple processors
- **Farmer and worker model.**
- -job distribution approach is used,one processor configured as master and all other remaining PE are designated as Slaves.master assign job to slave PE,and they on completion inform the master which in turn collects the results..
- **Levels of parallelism**

• **Grain size**	• **Code item**	• **Parallelized by**

• Large	• Separate and heavy weight process	• programmer
• Medium	• Function or procedure	• programmer
• Fine	• Loop or instruction block	• Parallelizing compiler
• Very fine	• instruction	• processor

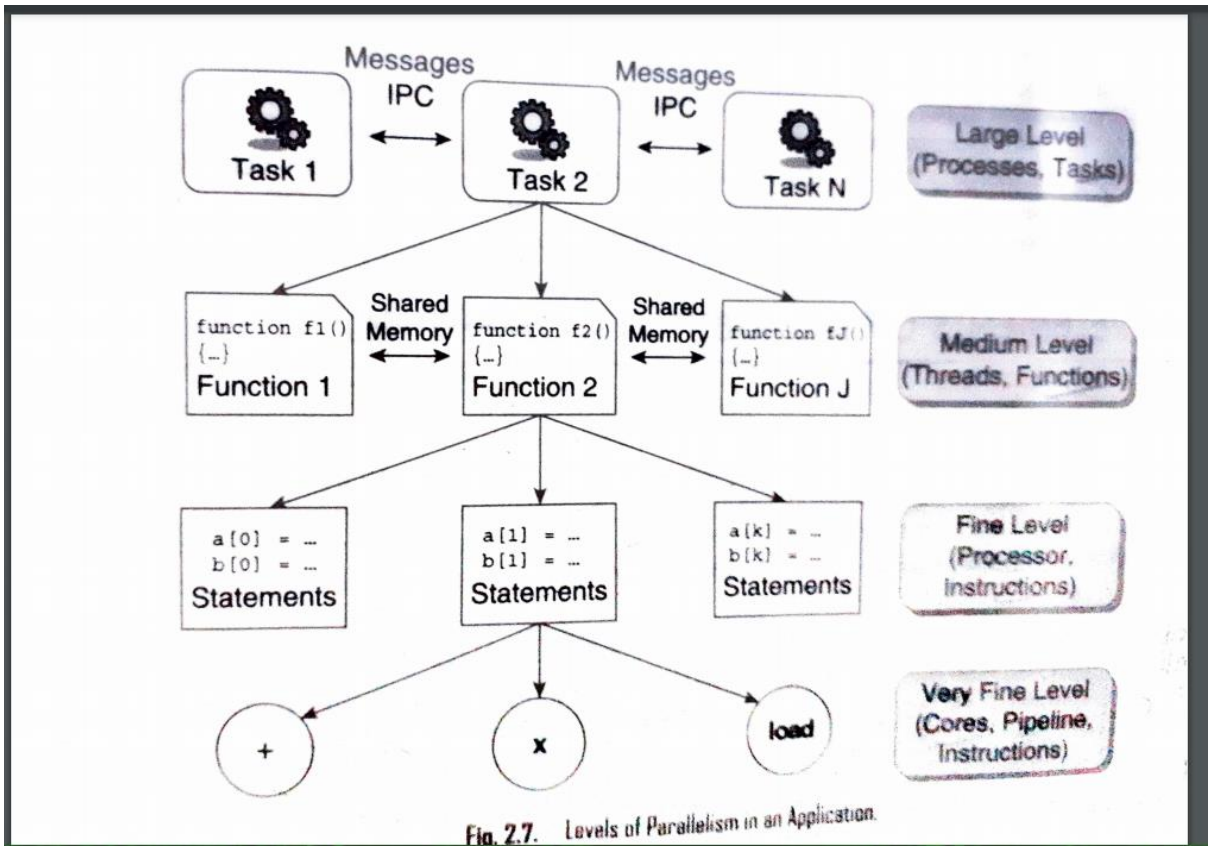
- All these approaches have common goal to boost processor efficiency by hiding latency.
- To conceal latency,there must be another thread ready to run whenever A lengthy operation occurs.
- The idea is to execute concurrently two or more single threaded applications,such as compiling,text formatting,database searching,device simulation..
- 

Fig. 2.7. Levels of Parallelism in an Application.
- **Laws of caution**
- Parallelism is used to perform multiple activities together so that the system can increase its throughput or it’s speed..

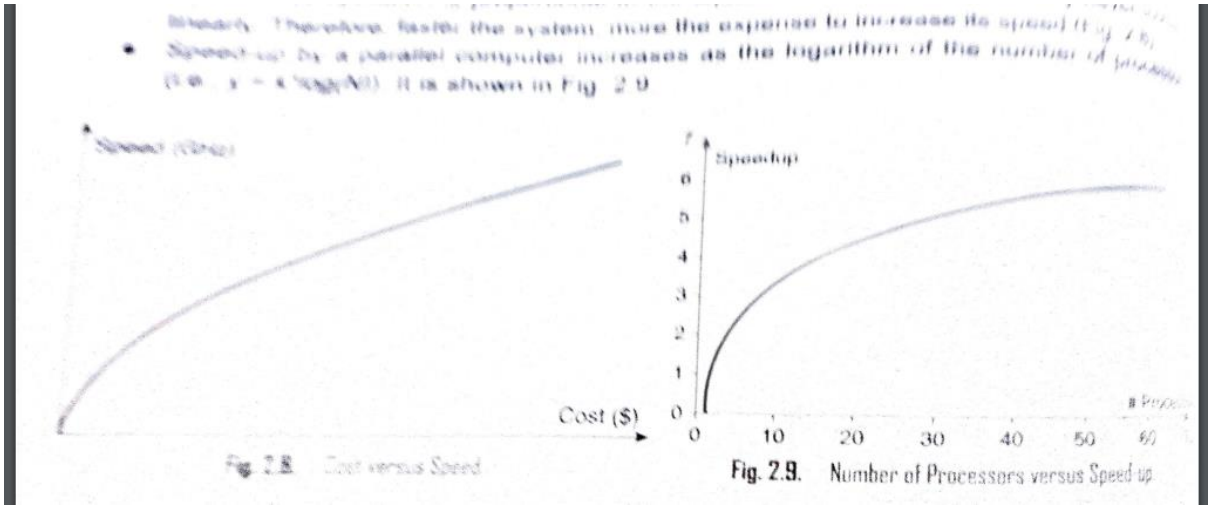
- 

Fig. 2.9. Number of Processors versus Speed up

16.Elements of Distributed computing

- A distributed system is A collection of independent computers that appears to users as A single coherent system.
- A distributed system is one which components located at networked computers communicate and coordinate their actions only by passing messages
- **Components of A distributed system**

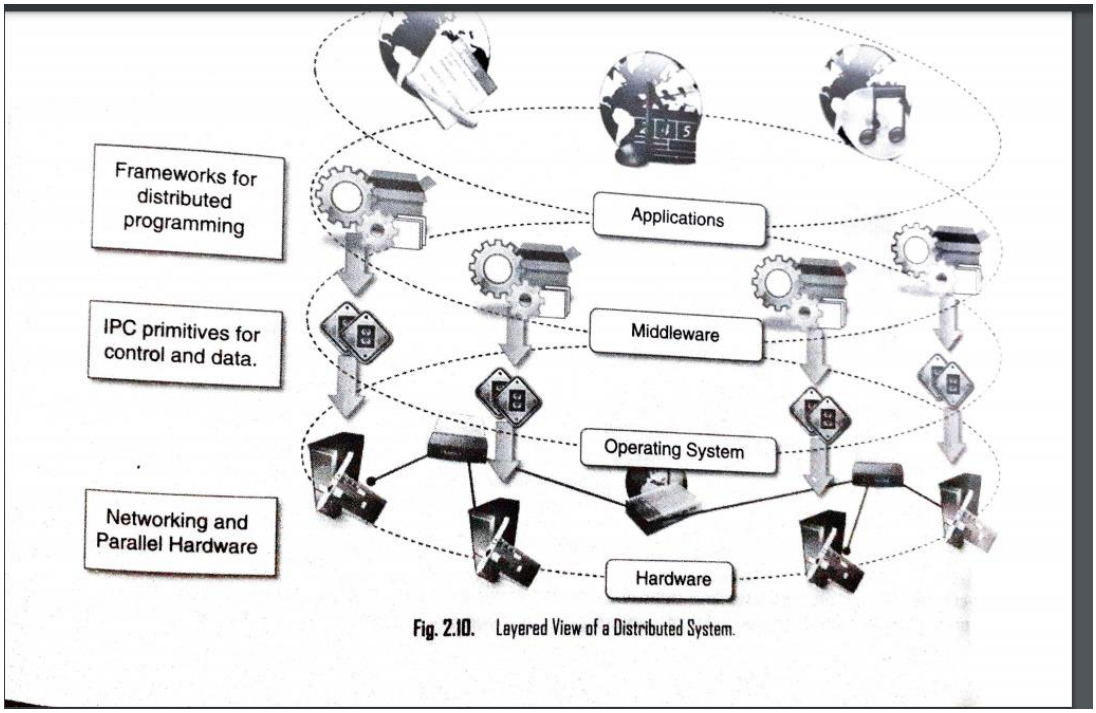


Fig. 2.10. Layered View of a Distributed System.

- At the very bottom layer,computer and network hardware constitute the physical infrastructure.;

- These components are directly managed by the operating system that provides the basic services for:inter-process communication,process scheduling and management,and resource management.
- These 2 layers(hardware,os)become the platform on top of which specialized software is deployed to turn A set of networked computers into A distributed system..
- At the operating system level,inter-process communication services are implemented on top of standardized communication protocols such as TCP/IP and UDP
- The middleware layer provide the services to build uniform environment for the development and deployment of distributed applicationsa.
- By depending on the services offered by os,the middleware develops it's own protocols,data format,and programming llanguage or frameworks for the development of distributed applications..
- On top ,applications and services designed and developed to use the middleware

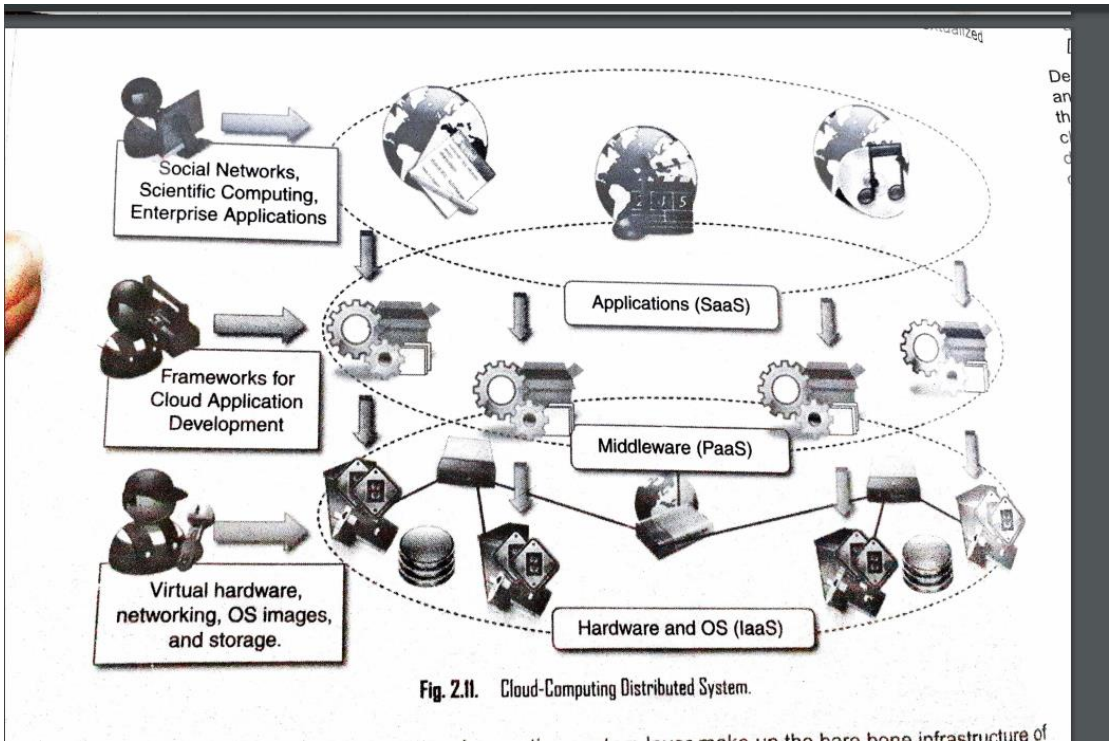


Fig. 2.11. Cloud-Computing Distributed System.

17.Architectural styles for distributed computing

- Distributed system comprises of several layers.
- The middleware is the one that enables distributed computing.
- It provides a coherent and uniform runtime environment for applications**.**

Architectural styles for distributed computing

Architectural styles help in understanding and classifying the organization of software systems in general and distributed computing in particular.

Two classes of architectural styles:

1.Software architectural styles-logical organization of the software.

2.System architectural styles-physical organization of distributed software systems in terms of their major components.

Components and connectors

- A component represents A unit of software that encapsulates a function or feature of the system.
- Eg:programs,objects,processes,pipes,filters.
- A connector is A communication mechanism that allows the cooperation and coordination among components
- Connectors are not encapsulated in A single entity but they are implemented in A distributed manner over many system components.
- **Software architectural styles**

• **category**	• **Most common architectural styles**
• **Data centered**	• **1.repository**
•	• **2.blackboard**
• **Data flow**	• **1.Pipe and filter**
•	• **2.Batch and sequential**
• **Virtual machine**	• **1.Rule based system**
•	• **2.interpreter**

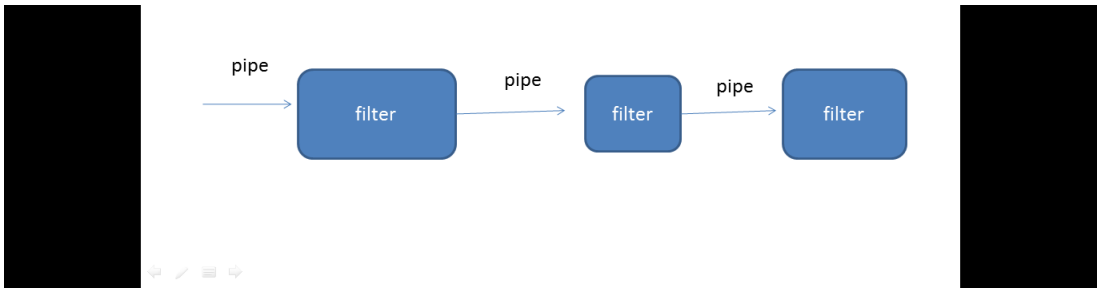
• **Call &return**	• **1.Main program and subroutine call/top down systems**
•	• **2.Object oriented systems**
•	• **3.layered systems**
• **Independent components**	• **1.Communicating processes**
•	• **2.Event systems**

Data centered architectures

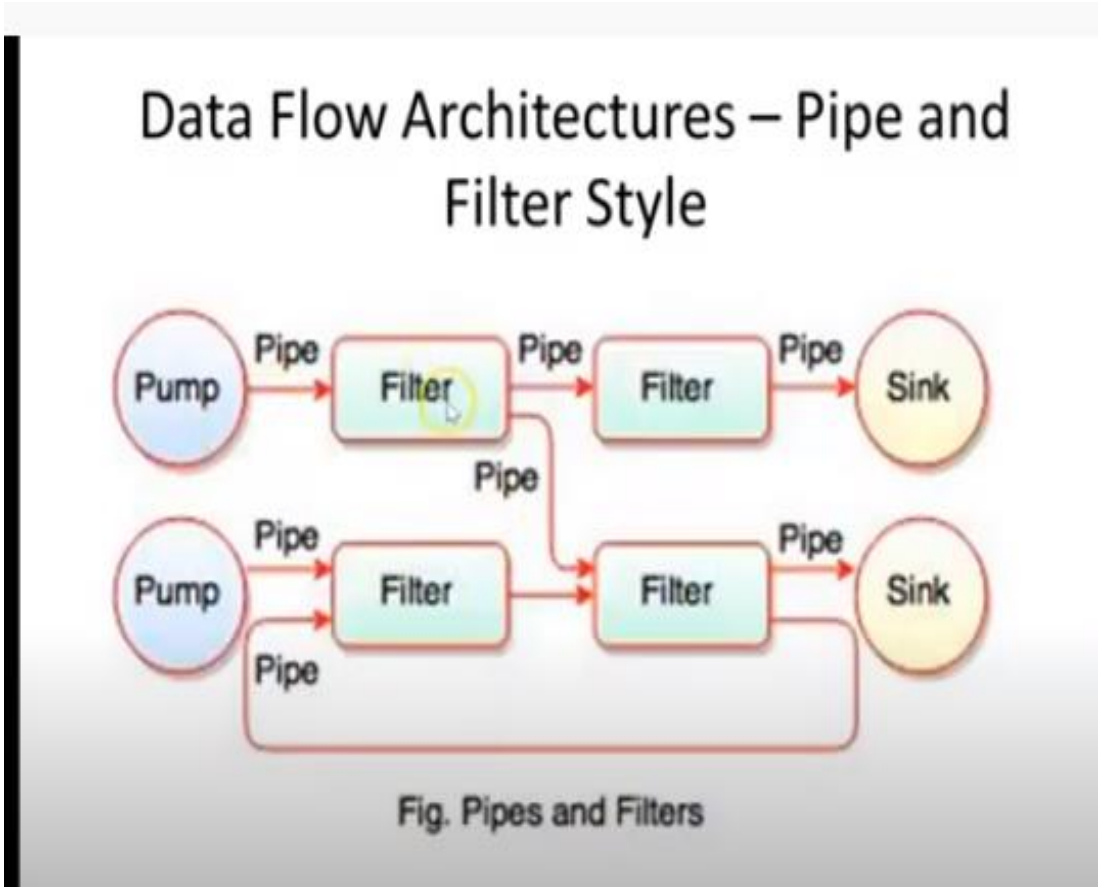
- Fundamental element of software system is data
- Core characteristic is the access to shared data
- Overall goal is the integrity of data.
- 1.repository
- 2.blackboard

Data centered architectures-repository

- Two components
- 1.Central datastructure-represents the current state of the system.
- 2.Collection of independent components-operates on the central data..
- **Data centered architectures-blackboard**
- Three components
- 1.Knowledge sources:entities that update the knowledge sources that is maintained in the blackboard
- 2.blackboard:this represents the data structure that is shared among the knowledge sources and stores the knowledge base of the application.
- 3.control:collection of triggers and procedures that govern the interaction with the blackboard and update the status of knowledge base..
- **Data flow architectures**

- Availability of data controls the computation,
- Design is determined by an orderly motion of data from component to component.
- Styles within this category differs in:
- 1.How control is exerted?
- 2.The degree of concurrency among components
- 3.The topology that describes the flow of data
- **Data flow architectures-batch sequential style**
- In batch sequential,separate programs are executed in order and the data is passed as an aggregate from one program to next
- It is A classical data processing model
- 

- **Data flow architectures-batch sequential style**
- It provides simpler divisions on subsystems and each subsystem can be independent pgm working on input data and produces output data.
- The main disadvantage is that,it does not provide concurrency and interactive interface .it provides high latency and low throughput
- **Data Flow Architectures-Pipe and Filter Style**
- Pipe is a connector which passes the data from one filter to the next.
- Pipe is a directional stream of data implemented by a data buffer to store all data,until the next filter has time to process it.
- It tranfers the data from one data source to one data sink.
- Pipes are the stateless data stream



- All filters are the processes that run at the same time, it means that they can run as different threads,coroutines or be located on different machines entirely.
- Each Pipe is connected to a filter and has its own role in the function of the filter.
- The filters are robust where pipes can be added and removed at runtime
- Filter reads the data from its input pipes and performs its function on this data and places the result on all output pipes.
- If there is insufficient data in the input pipes,the filter simply waits.
- **Advantages of Pipes and filters**
- Pipe-filter provides concurrency and high throughput for excessive data processing.
- It simplifies the system maintenance and provides reusability.
- It has low coupling between filters and flexibility by supporting both sequential and parallel execution.
- **Disadvantages of Pipe and Filter**
- Pipe and Filter are not suitable for dynamic interactions.
- It needs low common denominator for transmission of data in ASCII format.
- It is difficult to configure Pipe-filter architecture dynamically.

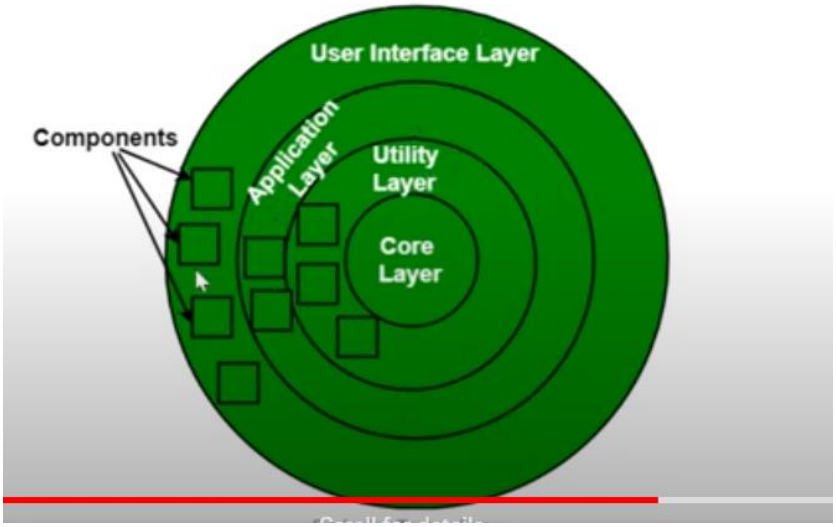
Comparison between Batch Sequential & Pipe and Filter styles

Batch Sequential	Pipe and Filter
• **Corase grained**	• **Fine grained**
• **High latency**	• **Reduced latency due to the incremental processing of input.**
• **External access to input**	• **Localized input**
• **No concurrency**	• **Concurrency Possible**
• **Non-interactive**	• **Interactive awkward but possible**

Virtual Machine Architectures

- Virtual machine architecture provides a virtual abstraction,a set of attributes and operations.
- This architecture appears similar to emulator software,for ex.JVM,virtual box.
- It pretends some functionality,which is not native to the hardware or software on which it is implemented.
- Virtual machine architecture is suitable for solving a problem by simulation or translation if there is no direct solution.
- It includes interpreters of microprogramming,XML processing,script command language execution,smalltalk and java interpreter typed programming language.
- The examples of virtual machines are rule based system,syntactic shells and command language processors.
- It introduces modifications at runtime and provides flexibility through the ability to interrupt.
- It provides portability and machine platform independency.

- Virtual machine architecture has disadvantage,it slows execution of the interpreter due to the interpreter nature and it incurs extra performance cost because of the additional computation involved in execution.
- **Virtal machine architecture-Rule-based style**
- Inference engine parses user input and determines whether it is a fact/rule or a query.
- If it is a fact/rule,it adds the entry to the knowledge base.
- Otherwise,it queries the knowldge base for applicable rules and attempts to resolve the query.
- **Virtual machine architecture-interpreter style**
- Interpreter parses and executes the input commands,updating the state maintained by the interpreter.
- **Call and Return Architecture**
- Systems that are composed by components mostly connected together by method calls.
- The three major subcategories ,which differentiates how the system is structured and how methods are invoked are,
- 1.top down style
- 2.object oriented style
- 3.layered style
- **Call and return architecture-top down style**
- Divide and conquer approach.
- One larger program.it accomplishes it’s tasks by invoking sub-programs or procedures.
- Components:procedures,subprograms
- Connections:method calls or invocation.
- Hard to maintain and manage in case of large systems.
- **Call and return architecture-object oriented style**
- Systems are specified in terms of classes and implemented in terms of objects.
- Class define the type of components by specifying the data that represent their state and the operations that can be done over this data.
- Advantages:there is a coupling between data and operations used to manipulate them.

- Object instances hide their internal state representation and protect the integrity
- **Disadvantages:**
- Each object needs to know the identity of an object if it wants to invoke operations on it.
- Shared objects need to be carefully designed in order to ensure the consistency of their state.
- **Call and return architecture-layered style**
- A number of different layers are defined with each layer performing a well-defined set of operations.Each layer will do some operations that becomes closer to machine instruction set progressively.
- At the outer layer,components will receive the user interface operations and at the inner layers,components will perform the operating system interfacing(Communication and coordination with os)
- Intermediate layers do utility services and application software functions.
- 

- **Architectural styles based on independent components**
- Systems have their own life cycle
- Independent components interact to eachother to perform their activities.
- Based on the way the interaction among the components is managed,there are 2 major categories
- 1.communicating process
- 2.event systems
- **independent components-communicating processes**
- Components are independent processes

- Suitable to model distributed systems
- The concurrent processes provide services to other processes
- The conceptual organization of the processes and communication happens vary according to the specific model used:peer to peer or client server
- Connectors:IPC facilities
- **independent components-event systems**
- Component publishes a collection of events.
- Other components can register with
- Advantages:fosters the development of open systems,new modules can be added,invocation pattern is implicit,the event source does not need to know the identity of the event handler in order to invoke the callback
- **Disadvantages:**
- When a component triggers an event,it does not know how many event handlers will be invoked and if there is any registerd handler.
- The info is available only at runtime.
- From a static design point of view,to identify the connections among components become more complex

Architectural styles of distributed computing

- **1.Software architectural styles-logical organization of the software**
- **2.System architectural styles-physical organization of the components**

System Architectural Styles

- Covers the physical organization of components and processes over a distributed infrastructure.
- Provide a set of reference models for the deployment of such systems.
- Two fundamental reference styles:
- 1.client server
- 2.peer-to-peer
- **System Architectural Styles-client server**
- 2 major components:A server,a client.

- These two components interact with each other through a network connection by using a given protocol.
- The communication is unidirectional
- Client issues a request to the server,server after processing it returns a response.
- Important operations in the client server paradigm are request,accept and listen and response
- Multiple clients are interested in such services and the server must be appropriately designed to server requests coming from different clients efficiently.
- This consideration has implications on both client design and server design.
- 1.Thin client model
- 2.Fat client model.
- **System Architectural Styles-client server-Thin client model**
- Load of data processing and transformation is put on the server side.
- Client has a light implementation,retrieving and returning the data it is being asked for,with no considerable further processing

  System Architectural Styles-client server-Fat client model
- Client component is also responsible for processing and transforming the data before returning it back to the user.
- Server features a relatively light implementation.
- Ie.management of access to the data.
- **System Architectural Styles-client server**
- The three major components in the client server model are:
- Presentation
- Application logic
- Data storage.
- **Thin client**
- Client:presentation
- Server:application logic,data storage.
- **Fat client**
- Client:presentation+Application Logic
- Server:data storage,maintenance

- Based on the mapping between the conceptual layers and their physical implementation in modules and components,there are two types of architectures.
- 1.two tier
- 2.three tier
- **System Architectural Styles-client server:two tier**
- Partitions the system into two tiers:
- Client component:presentation tier-provides user interface.
- Server component:Application logic and data storage.
- Suitable for systems of limited size and suffers from scalability issues.
- As the number of users increases,performance decreases.
- Also feels difficulty in maintaining,managing and accessing data.
- **System Architectural Styles-client server:three tier**
- 1.presentation
- 2.application logic
- 3.Data storage
- Generalized into N-tier
- Can further divide the stages composing application logic and storage tiers.
- **System Architectural Styles-peer to peer**
- A symmetric architecture
- All the components are called peers
- Peers play the same role and incorporate both client and server capabilities.
- Suitable for highly decentralized architecture,
- Can scale better.
- But the management of the implementation of algorithms is complex.
- **Models for inter-process communication**
- Distributed systems are composed of a collection of concurrent processes interact with each other by means of network connection.
- IPC is used to either exchange data and information or to coordinate the activity of a process.
- It is what ties together the different components of a distributed system,thus making them acting as a single system.

- There are several different models in which processes can interact with each other,and these map to different abstraction for IPC;shared memory,remote procedure call(RPC),and message passing.
- 1.Message –based communication
- -The abstraction of message has played an important role in the evolution of the models and technologies enabling distributed computing.
- Distributed system can be defined as “one in which components located at networked computers communicate and coordinate their actions only by passing messages”.
- The term “message” identifies any discrete amount of information that is passed from one entity to another.it encompasses any form of data representation that is limited in size and time.
- Several distributed programming paradigms eventually use message-based communication despite the abstraction that are presented to developers for programming the interaction of distributed components.
- **a)Message Passing**
- This paradigm introduces the concept of message as the main abstraction of the model.The entities exchanging information explicitly encode,in the form of message,the data to be exchanged.
- The structure and content of a message vary according to the model.
- Examples of this model:message passing interface(MPI) and openMP
- **B)Remote Procedure call(RPC)**
- This paradigm extends the concept of procedure call beyond the boundaries of a single process,thus triggering the execution of code in remote processes.in this case ,underlying client-server architecture is implied.
- A remote process hosts a server component,thus allowing client processes to request the invocation of methods and returns the result of execution.
- *RPC is a protocol that one program can be used to request a service from a program located in another computer on a network without having to understand the network details*
- *RPC uses client server model.*
- **c)Distributed objects.**

- It refers to the software modules that are designed to work together ,but reside either in multiple computers connected via a network or in different processes inside the same computer.
- EX:CORBA(Common object Request Broker Architecture),Component object model(COM),
- Java Remote Method invocation(java RMI).
- **d)Distributed Agents and Active objects**
- Programming paradigms based on agents and active objects involve the presence of instances,whether they are agents of objects,despite the existance of requests.
- Objects have their own control thread,which allows them to carry out their activity.
- These models often make explicit use of messages to trigger the execution of methods and a more complex semantics is attached to the messages.
- **e)Web services**
- Web service technology provides an implementation of the RPC concept over the HTTP transfer protocol,thus allowing the interaction of components that are developed with different technologies.
- **2.Models for Message-based communication**
- An important aspect characterizing the interaction among distributed components is how these messages are exchanged and among how many components.
- In several cases,client-server model is the underlying reference model for the interaction.
- **a)point-to-point message model**
- This model organizes the communication among single components.
- Each message is sent from one component to another,and there is a direct addressing to identify the message receiver.
- In a point-to-point communication model,it is necessary to know the location or how to address another component in the system.
- There is no central infrastructure that dispatches the messages and the communication is initiated by the sender of the message**.**
- It is possible to identify 2 major subcategories:direct communication and queue based communication.

- Direct communication:message is sent directly to the receiver and processed at the time of reception.
- Queue based communication:receiver maintains a message queue where the messages received are placed for later processing.
- **b)publish-subscribe message model.**
- This model introduces a different strategy which is based on notification among components.
- There are 2 major roles:the publisher and the subscriber.
- Publisher provides facilities for the subscriber to register it's interest in a specific topic or event.
- Specific conditions holding true on the publisher side can trigger the creation of messages which are attached to a specific event.
- This message will be available to all the subscribers that registered for the corresponding event.
- There are 2 major categories for dispatching the event to the subscribers:
- **Push strategy**:it is the responsibility of the publisher to notify all the subscribers,for ex. With a method invocation.
- **Pull strategy**:the publisher simply makes available the message for a specific event,and it is the responsibility of the subscribers to check whether there are messages on the events that are registered.
- **c)Request –Reply message model**
- It identifies all those communication models ,where for each of the message sent by a process,there is a reply.
- This model is quite popular,and provides a different classification that does not focus on the number of the components involved in the communication.
- Point-to-point message models are more likely to be based on request-reply interaction especially in the case of direct communication**.**
- Publish-subscribe model are less likely to be based on request-reply since they rely on the notifications.
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