Grid and Cloud Computing

UNIT-I

Introduction

Evolutionary Trend :

This Chapter mainly asses the evolutionary changes in machine architecture, Operating system platform, network connectivity and application workload.

To solve the Computational problems in Centralized computer, parallel and distributed computing system is used.

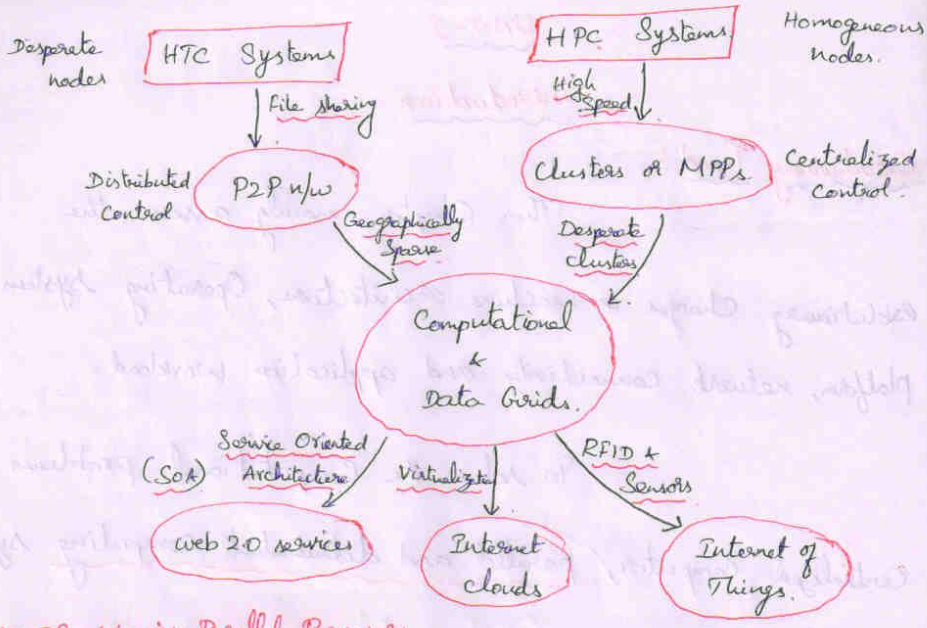
It uses multiple computers to solve large scale problems over internet.

The super computer sites and large data centers must provide high performance computing services to huge no. of internet users concurrently.

Based on high demand, high performance Computing (Internet) (HPC) applications is no longer optimal for measuring system performance.

High Throughput computing (HTC) (Cloud computing) systems built with parallel and distributed computing technologies.

The purpose is to advance network based computing and web services with emerging new technologies.



* MPP - Massive Parallel Processors.

The HPC & HTC systems are both adopted by consumers and high end web scale computing & information services.

In HPC Systems, the super computers are replaced by clusters of cooperative computers to share computing resources. A cluster is a collection of ~~node~~ homogeneous nodes connected with shorter distances.

In HTC systems, Peer to peer networks are formed for distributed file sharing and content delivery applications. A P2P systems built on many client systems. Cloud computing and web service platforms are focused on HTC applications.

High Performance Computing (HPC):

HPC systems emphasize the raw speed performance. The speed of HPC systems are improved by the demands from scientific, engineering and manufacturing communities. The majority of computer users are using desktop computers or large servers when they conduct Internet searches and market driven computing tasks.

High Throughput Computing (HTC):

HTC systems pays more attention to high flux computing. The main application of high flux computing is in Internet searches and web services. The throughput is defined as number of tasks completed per unit of time. HTC not only improves batch processing speed, but also address problems of cost, energy, savings, security and reliability.

Computing Paradigms:

The three main computing paradigms are

(i) web 2.0 services.
(ii) Internet clouds
(iii) Internet of Things (IOT)

With an introduction of SoA, Web2 service is available.

Advance in Virtualization makes the growth of Internet cloud. The growth of Radio Frequency Identification & sensor, GPS has triggered the development of IOT.

Computing paradigms:-

a) Centralized Computing:-

This is a computing paradigm by which all computer resources are centralize in one physical syst. All resources such as processors, memory and storage are fully shared and tightly coupled within one integrated OS.

Eg:- Datacenters and super computers are centralized systems, but they are used in paralled, distributed and cloud computing applications.

b) Parallel Computing:-

All processors are either tightly coupled with centralized shared memory (or) loosely coupled with distributed memory. It is also referred as Parallel processing. Interprocessor communication is accomplished through shared memory via message passing. A system capable of parallel comput is known as Parallel Computer. Programs runs in parallel computers are called parallel programs. The process of writi paralled programs are refered as parallel programming

c) Distributed Computing:-

A Distributed system consists of multiple autonomous computers. Each having its own private memory communicating through a computer network. Information exchange is accomplished by message passing. A computer program that runs in distributed system is known as Distributed Programs. The process of writing distributed programs is known as Distributed Programming.

d) Cloud Computing:-

An Internet cloud of resources can either a centralized or distributed computing system. The cloud can be parallel or distributed Computing. Clouds can be built with physical or virtualized resources over large data centers.

e) Ubiquitous Computing:-

It refers to computing with pervasive devices at any place and time using wired or wireless communication.

f) (IOT) Internet of Things:-

It is a networked connection of everyday objects. It is supported by Internet clouds to achieve ubiquitous Computing.

Design objectives of HTC & HPC systems.

a) Efficiency :

It measures the utilization rate of resources in an execution model by exploiting massive parallelism in HPC.

For HTC, efficiency is related to job throughput, data access, storage and power efficiency.

b) Dependability :

It measures the reliability and self manage from chip to the system and application levels. The purpose is to provide high throughput service with quality of Service (QOS), even under failure state.

c) Adaptation in programming model :

It measures the ability to support large job requests over massive data sets and virtualized cloud resources under various workload and service models.

d) Flexibility in Application Deployment :

It measures the ability of distributed systems to run both in HPC & HTC applications.

Scalable Computing Trends and Parallelism.

Degrees of Parallelism.

a) Bit level Parallelism. (BLP)

- Converts bit-serial processing to word level processing.

b) Instruction level Parallelism. (ILP)

- processor executes multiple instructions simultaneously.

c) Data level Parallelism. (DLP)

- Through SIMD (Simple Instruction, multiple data). It requires more hardware support and compiler assistance.

d) Task Level Parallelism (TLP)

- due to an introduction of Multicore processors and Chip multiprocessors (CMPs). It is fair due to difficulty in programming and compilation of code for efficient execution on multicore CMPs.

e) Job level Parallelism (JLP).

- due to move from parallel processing to distributed processing. The coarse grain parallelism is built on top of fine grain parallelism.

Applications of HTC and HPC systems.

a) Science and Engineering

- Earthquake prediction, Global warming.

b) Business, Education, Services ~~Industry and Health care~~

- Telecommunication, Content delivery, e-Comm

c) Industry and Health care.

- Banking, Stock exchanges, Hospital Automat

d) Internet & web services, Government Applications.

- Data centers, Cyber security, online-tax return processing, social networking.

e) Mission-critical applications.

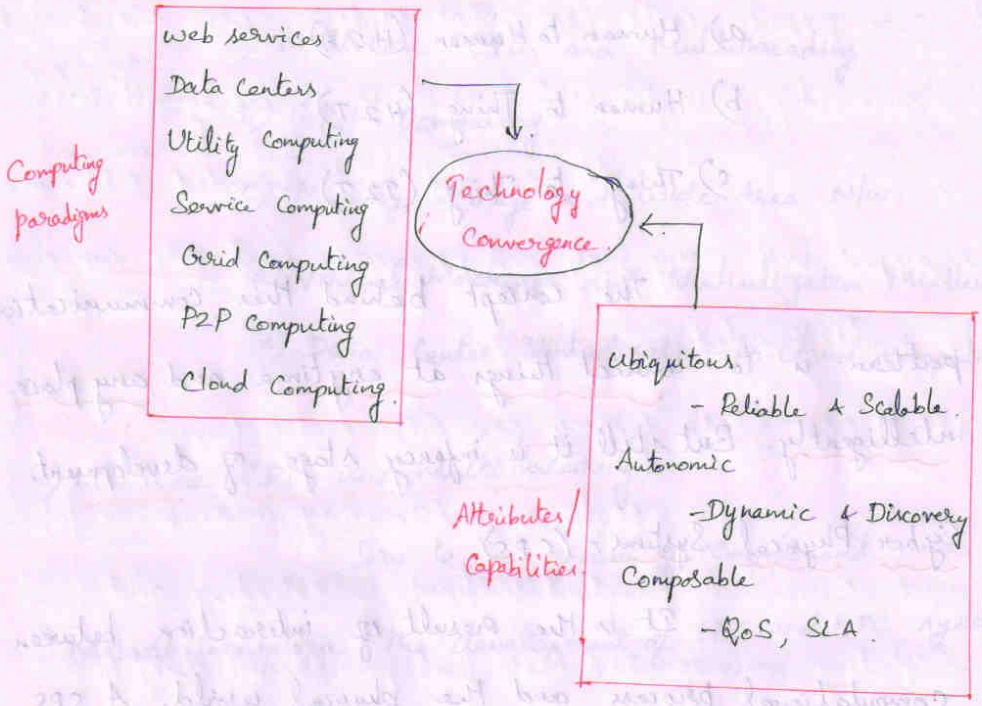
- Military command and control, Intellig systems.

Trend towards Utility Computing.

Utility Computing:-

It focuses on a business model in which customers receive computing resources from a paid service provider. All grid and cloud platforms are regarded as utility service providers.

HTC in business and HPC in scientific applications.



Internet of Things.

The IoT refers to the networked interconnection of everyday objects, tools, devices. These things can be large or small and they vary with respect to time and place. The idea is to tag every object using RFID (or) sensor (or) electronic technology.

The IoT needs to be designed to track many static (or) moving objects simultaneously. It demands universal addressability of all the objects.

It reduces the complexity of Identification, search and storage and set the threshold to filter out fine grain object.

Three Communication patterns exist

a) Human to Human (H2H)

b) Human to Thing (H2T)

c) Thing to Thing (T2T)

The concept behind this communicati pattern is to connect things at anytime and any place intelligently. But still it is infancy stage of development.

Cyber Physical Systems: (CPS)

It is the result of interaction between computational process and the physical world. A CPS integrates cyber (heterogeneous, asynchronous) with physical (concurrent, information-dense) objects.

It merges 3C technologies

a) Computation

b) Communication +

c) control - into an intelligent closed feedback system between the physical world and informati world.

It emphasizes the exploration of Virtual Reality applications in physical world.

Technologies for Network Based Systems:

a) Multicore CPUs and Multithreading

b) GPU Computing

c) Memory, Storage and wide-Area N/w.

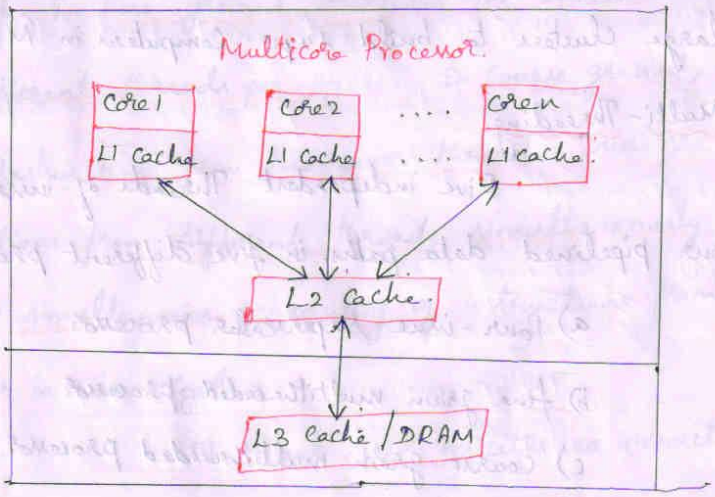
d) Virtual Machines and Virtualization Middleware

e) Data Center Virtualization for cloud computing.

a) Multicore CPUs and Multi Threading:

Due to the growth of component and network technologies, the development of HTC and HPC systems are crucial.

The processor speed is measured in millions of instructions per second (MIPS). The network bandwidth is measured in Mbps (or) Gbps.



a) Schematic diagram for Multicore Chip.

Each Core is essentially a processor with its own private cache (L1 cache). Multiple cores are housed in same chip with L2 cache as it is shared by all cores.

Multi core and multithreaded CPUs are equipped with many high end processors. Each core can also be multithreaded.

i) Multicore CPUs & many-core GPU Architectures:

Multicore CPUs may increase in future but CPU has reached its limit in extending and exploiting massive DLP (Data level parallelism) due to a forementioned memory wall problem.

So Many-Core GPUs introduced.

Both IA-32 & IA-64 instruction set architectures are built into commercial CPUs. The GPU has been applied in large clusters to build super computers in MPPs.

(ii) Multi-Threading

Five independent Threads of instructions to four pipelined data paths in five different processors.

a) Four-issue superscalar processor.

b) fine grain multithreaded processor

c) Coarse grain multithreaded processor.

d) Dual core CMP.

e) Simultaneous Multithreaded processor.

The Superscalar processor is single threaded with four functional units. Each of the three multi threaded processors is four way multithreaded over four functional data paths. The dual core processor assume two processing cores, each a single threaded two way superscalar processor.

In superscalar processor, same thread is executed. In Fine grained, switches the execution of instructions from different threads per cycle. In Coarse grained, executes many instructions from the same thread. Dual core executes instructions from different threads simultaneously. SMT allows simultaneous scheduling of instructions from different threads in same cycle.

The blank field indicates no instructions available.

b) GPU Computing:

GPU is a graphics coprocessor (or) accelera mounted on computer graphics card (or) video card. A GP offloads CPU from tedious graphics tasks in video edit applications.

These chips can process a minimum of 10 million polygons per second.

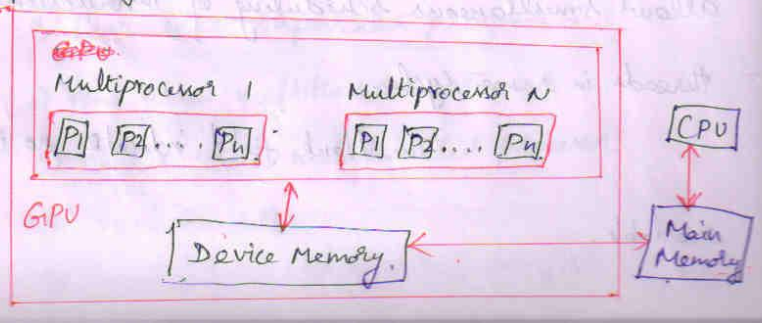
(i) Working of GPUs:

NVIDIA GPU has been upgraded to 128 cores on a single chip. Each core on a GPU can handle eight threads of instructions. This translates to having upto 1024 threads executed concurrently on a single GPU.

CPU is optimized for latency caches, while GPU is optimized to deliver higher throughput with explicit management of on-chip memory.

GPUs are designed to handle large no. of floating point operations, in parallel. GPU offloads the CPU from all data intensive calculations.

(ii) GPU Programming Model:



CPU is the conventional multicore processor with limited parallelism to exploit. GPU has many core architecture that has hundreds of simple processing cores organized as multiprocessors.

Each core can have one or more threads. The CPU instructs the GPU to perform massive data processing. CPU's floating point kernel computation role is largely offloaded to many core GPU.

c) Memory, Storage and Wide Area Networking:

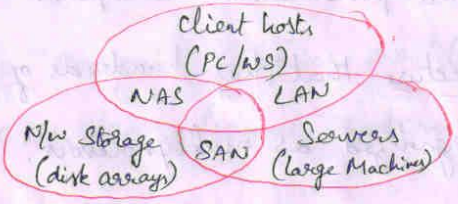
(i) Memory Technology:

The capacity increase of disk arrays will be greater. Faster processor speed and larger memory capacity result in a wider gap between processors and memory. The memory wall may become even worse a problem limiting CPU performance.

(ii) Disks and Storage Technology:

The rapid growth of flash memory and Solid State Drives (SSD) also impacts the future of HPC and HTC systems. Power increases linearly with respect to clock frequency. The clock rate cannot be increased indefinitely. SSDs are expensive to replace stable disk arrays.

(iii) System Area Interconnects:

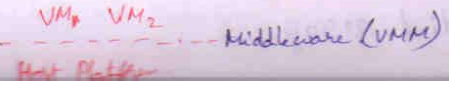


The nodes in small clusters are mostly interconnected by an Ethernet switch (or) LAN. LAN is used to connect client hosts to big servers. SAN connects servers to network storage such as disk arrays. NAS connects client hosts directly to disk arrays.

d) Virtual Machines and Virtualization Middleware

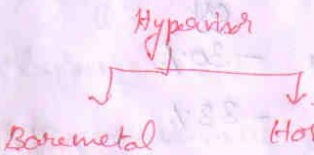
Virtual Machine offers novel solutions to underutilized resources, application inflexibility, software manageability, security in existing physical machines.

The VM can be provisioned for any hardware system. The VM is built with virtual resources managed by guest OS to run a specific application. Between VMs and host platform one needs to deploy a middleware called Virtual Machine Monitor (VMM).



a) Bare-metal VM hypervisor, because the hypervisor handles the hardware directly.

b) Host VM Hypervisor, the host OS need not to be modified.



The user application running on its dedicated OS could be bundled together as a virtual appliance that can be ported to any hardware platform.

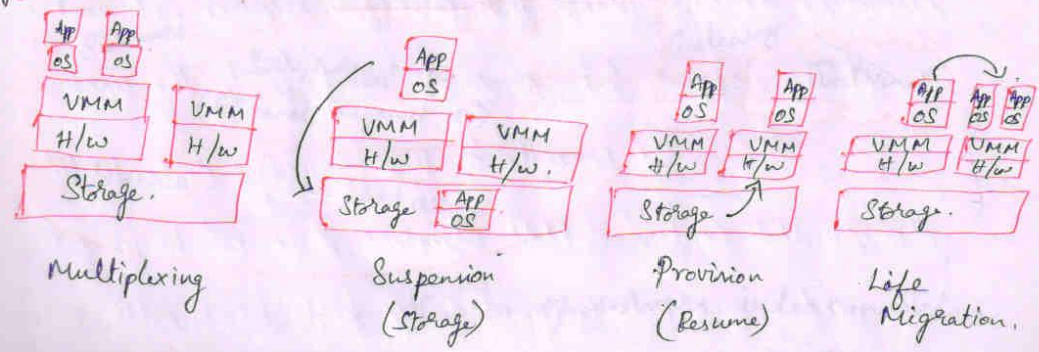
Low level Virtual Machine Operations:

Mux a) the VMs can be multiplexed b/w hardware machines.

Suspension b) the VMs can be suspended and stored in stable storage

Provision c) a suspended VM can be resumed (or) provisioned to a new hardware platform.

Life Migration d) VM can be migrated from one h/w platform to another.



e) Data Center Virtualization for Cloud Computing:

Data Center design emphasizes the performance/price ratio over speed performance alone.

A large data center is built with thousand of servers

Cost	
Servers & disks	- 30%
Chiller	- 33%
UPS	- 18%
A/c	- 9%
Power distribution	- 7%
	97%

Installation cost of Data Center.

The Cloud computing is enabled in four areas. They are

a) Hardware Virtualization and multicore chips.

b) Utility and grid Computing

c) SoA, web 2.0

d) Atonomic Computing and Data center automation

System Models for Distributed and Cloud Computing.

(or)

Massive System Classification.

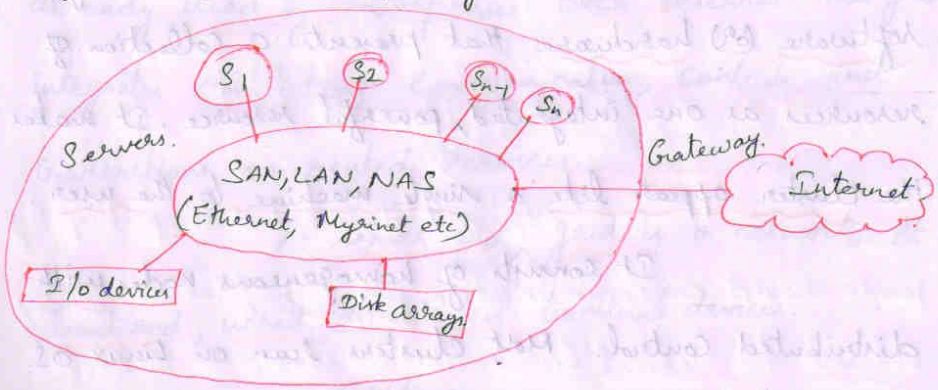
The Massive Systems are classified into four groups. They are.

a) Clusters
b) P2P networks.
c) Computing Grids.
d) Internet Clouds.

These four system classes consists of million of computers as participating nodes. These machines work collectively, collaboratively at various levels.

a) Clusters:

A computing cluster consists of interconnected stand alone computers which work cooperatively as a single integrated computing resource.



A cluster of servers interconnected by high bandwidth SAN (or) LAN with shared I/o devices

and disk arrays. The cluster acts as a single computer attached to the internet via Virtual Private Network (VPN) gateway. The gateway IP address locates the cluster.

The system image of computer is decided by the way the OS manages shared cluster resources. Most clusters have loosely coupled node computers. All resources of server node are managed by their own OS.

An ideal cluster should merge multiple system images into a Single System Image (SSI). The middleware to support SSI at various levels, including the sharing of CPUs, memory and I/O across all cluster nodes.

An SSI is an illusion created by software (or) hardware that presents a collection of resources as one integrated, powerful resource. It makes the cluster appear like a single machine to the user.

It consists of homogeneous nodes with distributed control. Most clusters run on Linux OS. The nodes are interconnected by high bandwidth netwo Special cluster middleware supports are needed to

Create SSI (or) High availability.

Cluster Design Issues:

(i) Complete resource sharing is not available.

(ii) Without middleware, cluster nodes cannot work together effectively.

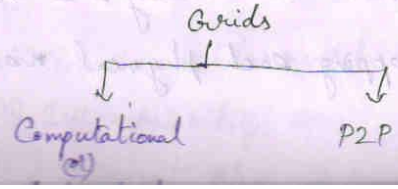
~~b) P2P Network~~:

b) Computational Grids:

The Computational grid offers an infrastructure that couples computers, software/hardware, special instruments, people and sensor together. The computers used in grid are workstations, servers, clusters and supercomputers. PDAs, laptops can be used as access devices to grid system.

The grid is built across various IP broadband networks including LAN and WAN already used by enterprises over internet. The grid integrates computing, communication, contents and transactions as rented services.

At server end, grid is a network. At the client end, wired (or) wireless terminal devices.

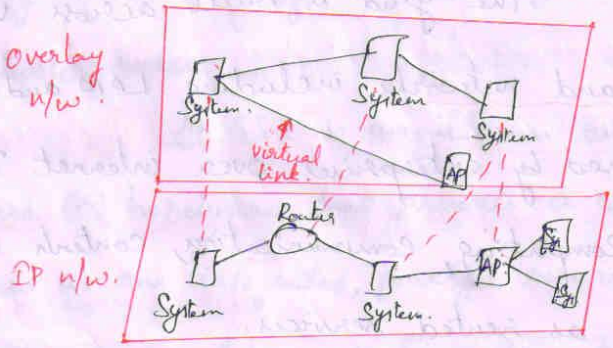


c) P2P Network :- (Peer to Peer)

P2P architecture offers a distributed model of networked systems. In P2P, every node acts as both client and server, providing part of system resources.

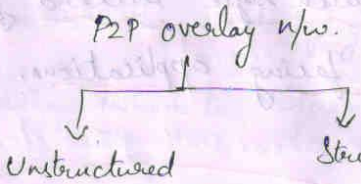
Peer machines are client connected over internet. All client machines act autonomously to join or leave the system freely. There is no master slave relationship and no central database.

Only the participating peers form the physical network at any time. The physical network is simply an adhoc network formed at various Internet domains randomly using TCP/IP protocols.



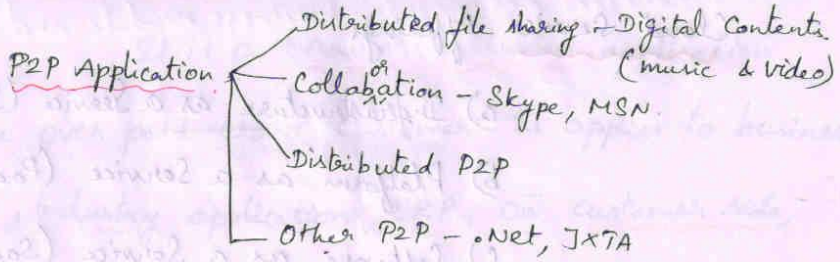
Files are distributed in participating peers. Based on communication, peer IDs form an overlay network at logical level. This overlay is a virtual network formed by mapping each physical machine with ID.

when new peer joins the system, peer ID is added as node in overlay network. When a peer removes the system, peer ID is removed from overlay network.



In unstructured overlay n/w, it is characterized by random graph. There is no fixed route to send messages or files among nodes. Flooding is applied to send a query. Disadv: It results in heavy network traffic and nondeterministic search results.

In Structured overlay n/w follows certain topology and rules for inserting and removing nodes. Routing mechanisms are also developed and used.



Issues:

(i) Too many h/w models and architecture.

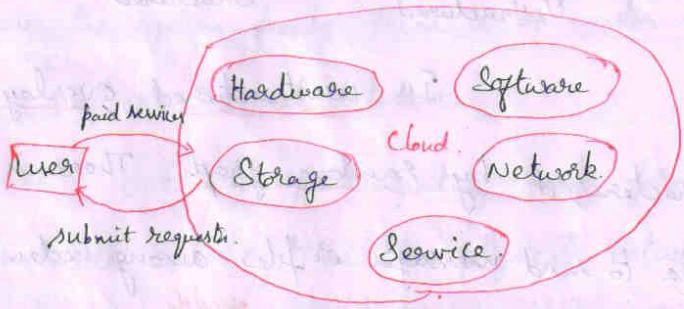
(ii) Incompatibility exists b/w software and OS.

(iii) Different n/w connections and protocol

d) Internet Clouds:

Cloud computing:

A Cloud is a pool of virtualized compu resources. A cloud can host a variety of different workloads, including batch style backend jobs and interactive and user facing applications.



Cloud computing applies a virtuali platform with elastic resources on demand by provisio hardware, software and data sets dynamically. Virtualiz resources from data centers to form an Internet cloud paid users to run their applications.

Cloud Service offerings

a) Infrastructure as a Service (IaaS)
b) Platform as a Service (PaaS)
c) Software as a Service (SaaS)

(i) Infrastructure as a Service :-

-put together infrastructures demanded by users. The users can deploy and run on multiple VM running guest OS on specific applications. The user doesnot manage or control the underlying cloud infrastructure, but can specify when to request and release the needed resources.

(ii) Platform as a Service :-

This model enables the user to deploy user built applications onto a virtualized cloud platform. It includes middleware, databases, development tools and runtime support. This platform includes both hardware and software integrated with specific programming interfaces. The user is freed from managing the cloud infrastructure.

(iii) Software as a Service :-

It is a browser initiated application software over paid cloud customers. It applies to business process, industry applications, ERP. On customer side, there is no upfront investment in servers. On provider side, costs are low, compared with hosting of user applications.

Deployment modes

a) private

b) public

c) Managed &

d) Hybrid cloud.

Advantages of cloud over Internet:

(i) Desired location in areas with protected space and higher energy efficiency.

(ii) Sharing of load capacity among large pool of users

(iii) Separation of infrastructure maintenance duties from domain specific application development.

(iv) Cost reduction.

(v) Cloud computing programming and application development.

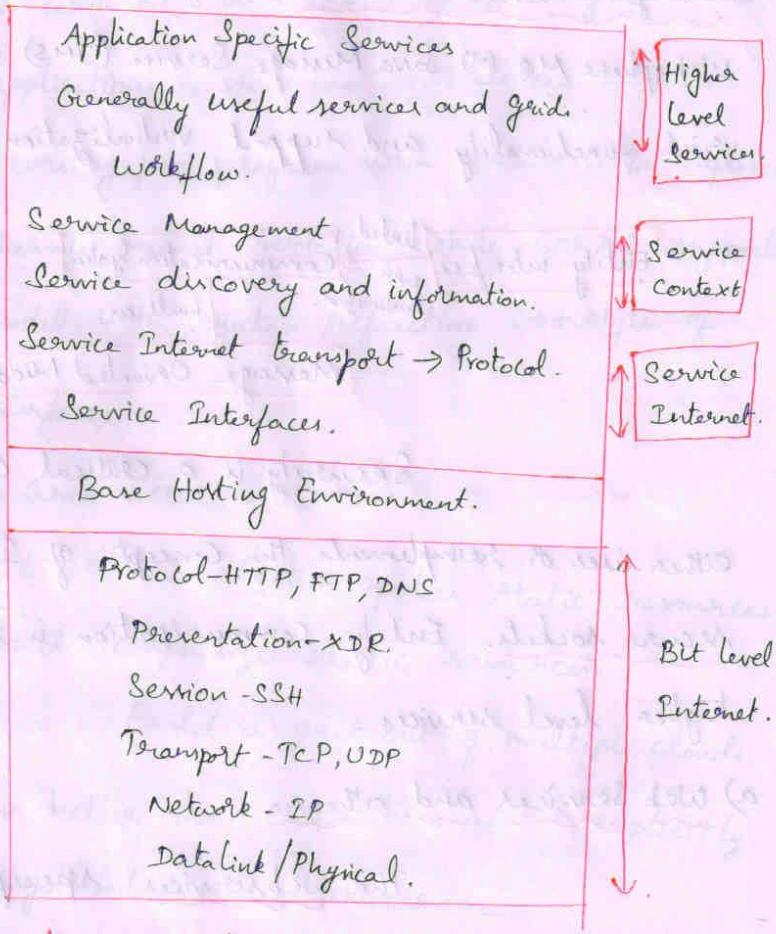
(vi) Service and data discovery

(vii) Privacy, security, copyright and reliability.

(viii) Service agreements, business models and pricing

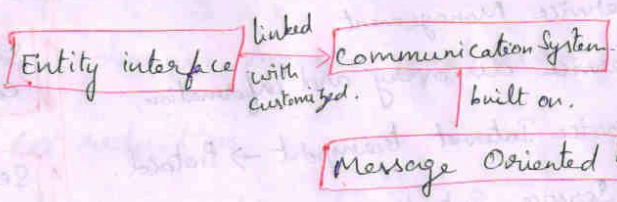
Service Oriented Architecture (SOA)

In grid and webservices, Java and CORBA architectures built on traditional OSI layers, that provide base networking abstractions. The base software environment such as .Net, Apache Axis for web services, Java Virtual Machine for Java.



Layered Architecture for webservice & grids.

The entity interfaces corresponds to WSDL Java method and CORBA interface definition language (IDL) These interfaces are linked with customized, high level communication system. The communication system supports features including RPC, fault recovery and specialized routing. These communications built on message oriented middleware infrastructure such as Websphere MQ (or) Java Message Service (JMS) which provide rich functionality and support virtualization.



Security is a critical capability that either uses or reimplements the concepts of IPsec and secure sockets. Entity communication is supported by higher level services.

a) Web Services and others

The webservices specifies all aspects of service and its environment, The specific is carried out using SOAP communication messages The hosting environment becomes universal distribu

The REST Approach, adopts universal principle and delegates most of difficult problems to application software. It has minimal information in header, message body contains all information. It is appropriate for rapid technology environments.

In CORBA and Java, the distributed entities are linked with RPC and the simplest way to build Composite applications, to view the entities as objects. For Java, writing java program with method calls replaced by (RMI) Remote Method Invocation, while CORBA supports similar model with syntax reflecting C++ style of object interfaces.

Diff. b/w Grid & Cloud:-

Grid System applies static resources, while cloud emphasizes elastic resources.

Build a grid out of multiple clouds. So Grid is better than Cloud because it explicitly support negotiated resource allocation.