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COIMBATORE-641 035, TAMIL NADU

19CSE310GRIDANDCLOUD COMPUTING

UNITI INTRODUCTION

Evolution of Distributed computing: Scalable computing over the Internet – Technologies for network based systems – clusters of cooperative computers - Grid computing Infrastructures – cloud computing - service oriented architecture – Introduction to Grid Architecture and standards – Elements of Grid – Overview of Grid Architecture.

EVOLUTIONOFDISTRIBUTEDCOMPUTING

(a)DefineDistributedComputing(2marks)

1. DescribeaboutEvolutionofDistributedcomputing.(8marks)

- **Distributed computing** is a field of computer science that studies distributed systems. A distributed system is models in which components located on networked computers communicate and coordinate their actions by passing messages
- Thecomponentsinteractwitheachotherinordertoachieveacommongoal.
- Threesignificantcharacteristicsofdistributedsystemsare:concurrencyofcomponents,lackofa global clock, and independent failure of components.
- ExamplesofdistributedsystemsvaryfromSOA-basedsystemstomassivelymultiplayeronline games to peer-to-peer applications.
- Acomputerprogramthatrunsinadistributedsystemiscalledadistributedprogram,and distributed programming is the process of writing such programs.
- Therearemanyalternativesforthemessagepassingmechanism,includingpureHTTP,RPC-like connectors and message queues.

HISTORY

- The use of concurrent processes that communicate by message-passing has its roots in operating system architectures studied in the 1960s.
- The first widespread distributed systems were local area networks such as Ethernet, which was invented in the 1970s.
- ARPANET, the predecessor of the Internet, was introduced in the late 1960s, and ARPANETemail was invented in the early 1970s. E-mail became the most successful application of ARPANET, and it is probably the earliest example of a large-scale distributedapplication.
- In addition to ARPANET, and its successor, the Internet, other early worldwide computernetworks included Usenet and FidoNet from the 1980s, both of which were used to support distributed discussion systems.
- The study of distributed computing became its own branch of computer science in the late 1970s and early 1980s.
- The first conference in the field, Symposium on Principles of Distributed Computing (PODC),

dates back to 1982, and its European counterpart International Symposium on Distributed Computing (DISC) was first held in 1985.

SCALABLECOMPUTINGOVERTHEINTERNET

Part-A	➢ ListoutthetypesofComputingparadigms. ➢ Highlighttheimportanceoftheterm"CloudComputing"(April/May2017) ➢ TabulatethedifferencebetweenHighPerformanceComputingandHigh Throughput Computing (April/May 2017)
Part-B	1) ExplainindetailaboutScalablecomputingovertheInternet

Over the past 60 years, computing technology has undergone a series of platform andenvironment changes. Evolutionary changes in machine include architecture, operating system platform, network connectivity, and application workload. Instead of using a centralized computer to solve computational problems, a parallel and distributed computing system uses multiple computers to solve large-scale problems over the Internet. Thus, distributed computing becomes data-intensive and network- centric.

TheAgeofInternetcomputing

- Theplatformevolution
- Highperformancecomputing
- Highthroughputcomputing
- Threenewcomputingparadigm
- Computingparadigmdistinction
- Distributedsystemfamilies

Scalablecomputingtrendsandnewparadigms

- Degreesofparallelism
- Innovativeapplications
- Thetrendtowardsutilitycomputing
- Thehypecycleofnewtechnologies

Theinternetofthingsandcyberphysicalsystem

- Theinternetofthings
- Cyberphysicalsystem

TheAgeofInternetComputing

- BillionsofpeopleusetheInterneteveryday.
- Supercomputersitesandlargedatacentersmustprovidehigh-performancecomputingservicesto huge numbers of Internet users concurrently.
- TheLinpackBenchmarkforhigh-performancecomputing(HPC)applicationsisnolonger optimal for measuring system performance.
- Theemergenceofcomputingcloudsinsteaddemandshigh-throughputcomputing(HTC)systems built with parallel and distributed computing technologies.
- Thepurposeistoadvancenetwork-basedcomputingandwebserviceswiththeemergingnew technologies.

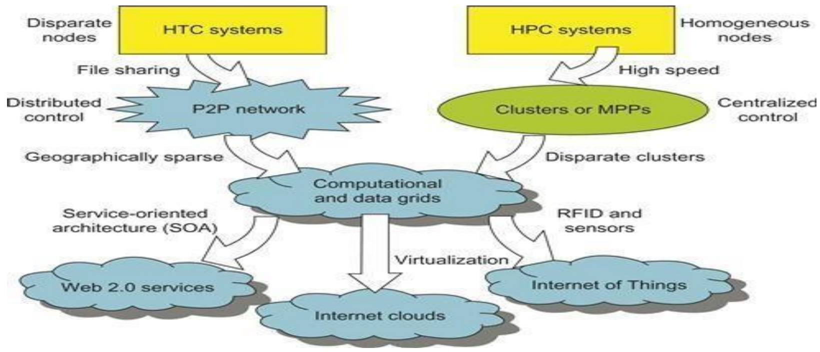
ThePlatformEvolution

- Computertechnologyhasgonethroughfivegenerationsofdevelopment,witheachgeneration lasting from 10 to 20 years.
- 1950to1970–mainframes–eg:IBM360andCDC6400.
- 1960to1980-lower-costmini-computers–eg:DECPDP11andVAXSeries.
- 1970to1990-personalcomputersbuiltwithVLSImicroprocessors.

- 1980to2000-portablecomputers

High-PerformanceComputing

- Formanyyears,HPCsystemsemphasizetherawspeedperformance.
- ThespeedofHPCsystemshasincreasedfromGflopsintheearly1990stonowPflopsin 2010.
- Thisimprovementwasdrivenmainlybythedemandsfromscientific,engineering,and manufacturing communities.



High-ThroughputComputing

- The development of market-oriented high-end computing systems is undergoing a strategic change from an HPC paradigm to an HTC paradigm.
- Themainapplicationforhigh-fluxcomputingisinInternetsearchesandwebservicesbymillions or more users simultaneously.
- The performance goal thus shifts to measure high throughput or the number of tasks completed per unit of time.
- HTC technology needs to not only improve in terms of batch processing speed, but also address the acute problems of cost, energy savings, security, and reliability at many data and enterprise computing centers.

ThreeNewComputingParadigms:

- Thematurityof*radio-frequencyidentification(RFID)*,*GlobalPositioningSystem(GPS)*,and *sensortechnologies*hastriggeredthedevelopmentofthe*InternetofThings(IoT)*.

ComputingParadigmDistinctions:

Thefollowing listdefines theseterms moreclearly;theirarchitecturaland operationaldifferences are discussed further in subsequent chapters.

- **Centralized computing:** This is a computing paradigm by which all computer resources are centralized in one physical system. All resources (processors, memory, and storage) are fully sharedandtightlycoupledwithinoneintegratedOS.Manydatacentersandsupercomputers are centralized systems, but they are used in parallel, distributed, and cloud computing applications.
- **Parallel computing:** In parallel computing, all processors are either tightly coupled with centralized shared memory or loosely coupled with distributed memory. Some authors refer tothis discipline as parallel processing. Inter processor communication is accomplished through shared memory or via message passing
- **Distributed computing**: A distributed system consists of multiple autonomous computers, each having its own private memory, communicating through a computer network. Information exchange in a distributed system is accomplished through message passing. A computer program that runs in a distributed system is known as a distributed program. The process of writing distributed programs is referred to as distributed programming.

- **Cloud computing** An Internet cloud of resources can be either a centralized or a distributed computing system. The cloud applies parallel or distributed computing, or both. Clouds can be built with physical or virtualized resources over large data centers that are centralized or distributed. Some authors consider cloud computing to be a form of utility computing or service computing.

Distributed system families ---The system efficiency is decided by speed, programming, and energy factors (i.e., throughput per watt of energy consumed). Meeting these goals requires yielding thefollowing design objectives:

- Efficiency
- Dependability.
- Adaptationintheprogrammingmodel
- Flexibilityinapplicationdeployment

Scalablecomputingtrendsandnewparadigms

a) DegreesofParallelism

- **Bit-level parallelism (BLP**) converts bit-serial processing to word-level processing gradually. Over the years, users graduated from 4-bit microprocessors to 8-, 16-, 32-, and 64-bitCPUs.
- **Instruction-level parallelism (ILP),** in which the processor executes multiple instructions simultaneously rather than only one instruction at a time. For the past 30 years, ILP practiced through pipelining, super-scalar computing, VLIW (very long instruction word) architectures, and multithreading. ILP requires branch prediction, dynamic scheduling, speculation, and compiler support to work efficiently.
- **Data-level parallelism (DLP)** was made popular through SIMD (single instruction, multiple• data) and vector machines using vector or array types ofinstructions.

b) InnovativeApplications

- BothHPCandHTCsystemsdesiretransparencyinmanyapplicationaspects.
- For example, data access, resource allocation, process location, concurrency in execution, job replication, and failure recovery should be made transparent to both users and system management.
- Usersmustdealwithmultipledatabaseserversindistributedtransactions.Maintainingthe consistency of replicated transaction records is crucial in real-time bankingservices.
- Othercomplicationsincludelackofsoftwaresupport,networksaturation,andsecuritythreatsin these applications.

c) TheTrendtowardUtilityComputing

Characteristics:

- Ubiquitous
- Reliability
- Scalability
- Autonomic
- Self-organizedtosupportdynamicdiscovery.
- ComposablewithQoSandSLAs(service-levelagreements).
- Utility vision - Utility computing focuses on a business model in which customers receive computing resourcesfrom apaid service provider.Allgrid/cloudplatformsareregarded asutility service providers.

d)

e) The hype cycle of new technologies ❼For example, at that time consumer-generated media wasat the disillusionment stage, and itwas predicted to take less than two years to reach its plateau ofadoption. Internet micropayment systems were forecast to take two to five years to move from the enlightenment stage to maturity. It was believed that 3D printing would take five to 10 years to move from the rising expectation stage to mainstream adoption, and mesh network sensors were expected to take more than 10 years to move from the inflated expectation stage to a plateau of mainstreamadoption.

THEINTERNETOFTHINGSANDCYBERPHYSICALSYSTEM

THEINTERNETOFTHINGS(IOT)

- ThetraditionalInternetconnectsmachinestomachinesorwebpagestowebpages.Theideaisto tag every object using RFID or a related sensor or electronic technology such asGPS.
- WiththeintroductionoftheIPv6protocol,2128IPaddressesareavailabletodistinguishallthe objects on Earth, including all computers and pervasivedevices.
- TheIoTresearchershaveestimatedthateveryhumanbeingwillbesurroundedby1,000to5,000 objects.
- TheIoTdemandsuniversaladdressabilityofalloftheobjectsorthings.
- TheIoTobviouslyextendstheInternetandismoreheavilydevelopedinAsiaandEuropean countries.

CYBERPHYSICALSYSTEM

- A cyber-physical system (CPS) is the result of interaction between computational processes and the physical world. A CPS integrates “cyber” (heterogeneous, asynchronous) with “physical” (concurrent and information-dense) objects.
- A CPS merges the “3C” technologies of computation, communication, and control into an intelligent closed feedback system between the physical world and the information world, a concept which is actively explored in the United States.

TECHNOLOGIESFORNETWORKBASEDSYSTEMS

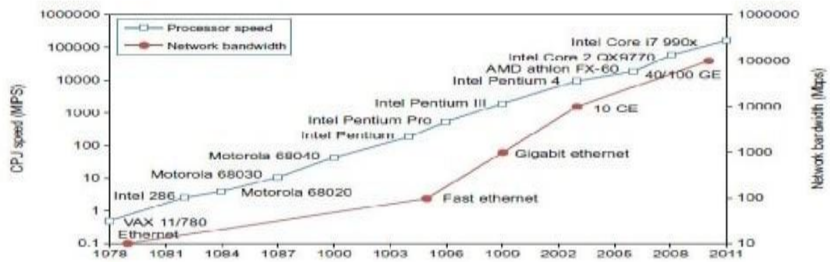
PART-A	**1) GivetheBasicOperationofaVM(AU/April/May2017)**
PART-B	**1) ExplainindetailaboutMulticoreCPUsandMultithreadingTechnologies** **2) ExplainindetailaboutGPUComputingtoExascaleandBeyond** **3) BrieftheinteractionbetweentheGPUandCPUinperformingParallel execution of operation (AU/April/May 2017)** **4) IllustratetheArchitectureofVirtualmachineandbriefabouttheoperations(AU/Nov/Dec2016)**

- MulticoreCPUsandmultithreadingtechnologies

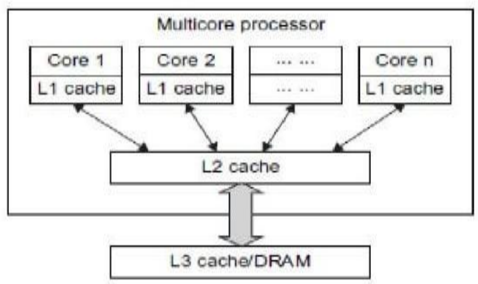
        - AdvancesinCPUprocessors
        - MulticoreCPUandmanycoreGPUarchitectures Multithreading
        - technology
    - GPUcomputingtoexascaleandbeyond
        - How GPUs work
        - GPUprogrammingmodel
        - Power efficiency of GPU
    - Memory,storageandWideareanetworking
        - Memory technology
        - Diskandstoragetechnology
        - System area interconnect
        - Wide area networking
    - Virtualmachinesandvirtualizationmiddleware
        - Virtual machines
        - VMprimitiveoperations
        - Virtual infrastructure
    - Data center virtualization for cloud computing
        - Datacentergrowthandcostbreakdown
        - Low cost design philosophy
        - Convergence of technologies

1) MulticoreCPUsandMultithreadingTechnologies

- Amulticorearchitecture-withdual,quad,six,ormoreprocessingcores.
- TheseprocessorsexploitparallelismatILPandTLPlevels.
- Processorspeedgrowthisplottedintheuppercurveinacrossgenerationsofmicroprocessorsor CMPs.
- 1MIPS-fortheVAX780in1978
- 1,800MIPS-fortheIntelPentium4in2002,
- 22,000MIPS-theSunNiagara2in2008.
- Asthefigureshows,Moorelawhasproventobeprettyaccurateinthiscase.
- Theclockratefortheseprocessors:10MHzfortheIntel286,4GHzforthePentium4
- However,theclockratereacheditslimitonCMOS-basedchipsduetopowerlimitations.
- Theclockratewillnotcontinuetoimproveunlesschiptechnologymatures.
- Thislimitationisattributedprimarilytoexcessiveheatgenerationwithhighfrequencyorhigh voltages.
- Bothmulti-coreCPUandmany-coreGPUprocessorscanhandlemultipleinstructionthreadsat different magnitudes today.
- Eachcoreisessentiallyaprocessorwithitsownprivatecache(L1cache).
- Multiple cores are housed in the same chip with an L2 cache that is shared by all cores. In the future, multiple CMPs could be built on the same CPU chip with even the L3 cache on thechip.
- Multicore and multi- threaded CPUs are equipped with many high-end processors, including the Intel i7, Xeon, AMD Opteron, Sun Niagara, IBM Power 6, and X cell processors. Each corecould be also multithreaded.



Improvement in processor and network technologies over 33 years.



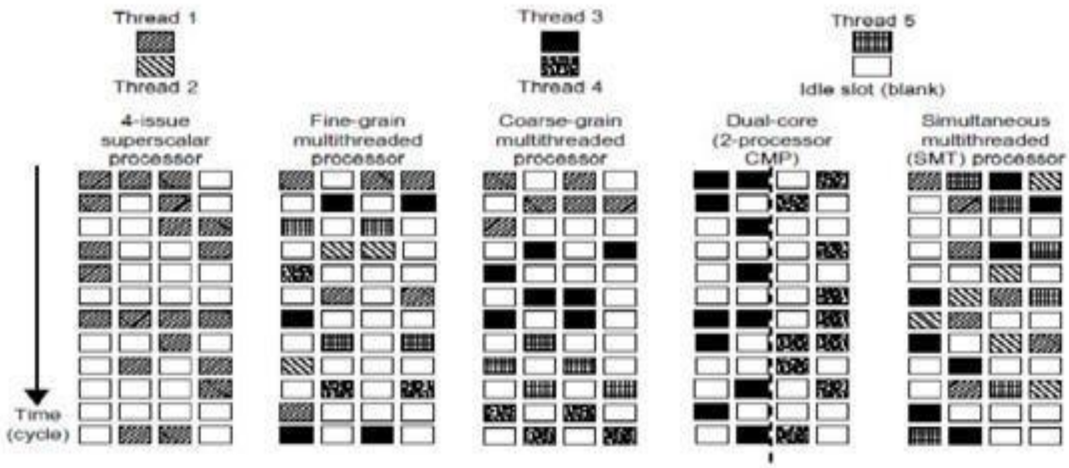
Schematic of a modern multicore CPU chip using a hierarchy of caches, where L1 cache is private to each core, on-chip L2 cache is shared and L3 cache or DRAM Is off the chip.

MulticoreCPUandMany-CoreGPUArchitectures

- MulticoreCPUsmayincreasefromthetensofcorestohundredsormoreinthefuture.
- ButtheCPUhasreacheditslimitintermsofexploitingmassiveDLPduetothememorywall problem.
- Amany-coreGPUshavewithhundredsormorethincores.
- Both IA-32 and IA-64 instruction set architecturesarebuilt into commercial CPUs. Now, x-86 proc➢essorshavebeenextendedtoserveHPCandHTCsystemsinsomehigh-endserverprocessors.

MultithreadingTechnology

Thedispatchoffiveindependentthreadsofinstructionstofourpipelineddatapaths(functionalunits)ineach of the following five processor categories from left to right: a



Five micro-architectures in modern CPU processors, that exploit ILP and TLP supported by multicore and multithreading technologies.

- **Thesuperscalarprocessor**issingle-threadedwithfourfunctionalunits.Eachofthethree multithreaded processors is four-way multithreaded over four functional data paths.
- **In the dual-core processor**, assume two processing cores, each a single-threaded two-way superscalar processor. Instructions from different threads are distinguished by specific shading patterns for instructions from five independent threads.
- **Fine-grainmultithreading**switchestheexecutionofinstructionsfromdifferentthreadsper cycle.
- **Course-grainmulti-threading**executesmanyinstructionsfromthesamethreadforquiteafew cycles before switching to another thread.
- ThemulticoreCMPexecutesinstructionsfromdifferentthreadscompletely.Theseexecution patterns closely mimic an ordinary program.
- Theblanksquarescorrespondtonoavailableinstructionsforaninstructiondatapathata particular processor cycle.

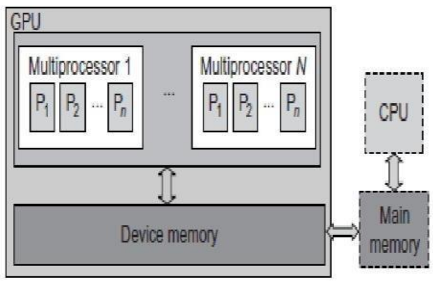
2) GPUcomputingtoexascaleandbeyond

- AGPUisagraphicscoprocessororacceleratormountedonacomputer’sgraphicscardor video card.
- AGPUoffloadstheCPUfromtediousgraphicstasksinvideoeditingapplications.
- Theworld’sfirstGPU,theGeForce256,wasmarketedbyNVIDIAin1999.
- TheseGPUchipscanprocessaminimumof10millionpolygonspersecond.
- TraditionalCPUsarestructuredwithonlyafewcores.
- Forexample,theXeonX5670CPUhassixcores.,amodernGPUchipcanbebuiltwith hundreds of processing cores.
- GPUs have a throughput architecture that exploits massive parallelism by executing many concurrent threads slowly, instead of executing a single long thread in a conventional microprocessor very quickly.
- General-purposecomputingonGPUs,knownasGPGPUs,haveappearedintheHPCfield. NVIDIA’s CUDA model was for HPC using GPGPU.

<u>HowGPUs Work</u>

- EarlyGPUsfunctionedascoprocessorsattachedtotheCPU.
- Today,theNVIDIAGPUhasbeenupgradedto128coresonasinglechip.
- Furthermore,eachcoreonaGPUcanhandleeightthreadsofinstructions.

- Thistranslatestohavingupto1,024threadsexecutedconcurrentlyonasingleGPU.
- ModernGPUsarenotrestrictedtoacceleratedgraphicsorvideocoding.
- TheyareusedinHPCsystemstopowersupercomputerswithmassiveparallelismat multicore and multithreading levels.
- GPUsaredesignedtohandlelargenumbersoffloating-pointoperationsinparallel.
- Inaway,theGPUoffloadstheCPUfromalldata-intensivecalculations.
- GPUarewidelyusedinmobilephones,gameconsoles,embeddedsystems,PCs,andservers.
- TheNVIDIACUDATeslaorFermiisusedinGPUclustersorinHPCsystemsforparallel processing of massive floating-pointing data.
- TheinteractionbetweenaCPUandGPUforperformingparallelexecutionoffloating-point operations concurrently.
- TheCPUistheconventionalmulticoreprocessorwithlimitedparallelismtoexploit.
- TheGPUhasamany-corearchitecturethathashundredsofsimpleprocessingcores organized as multiprocessors.



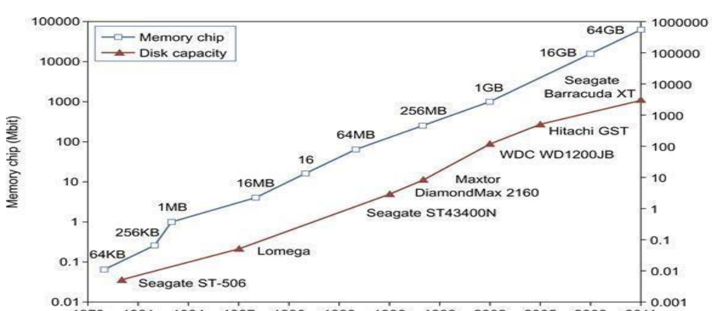
The use of a GPU along with a CPU for massively parallel execution in hundreds or thousands of processing cores.

PowerEfficiencyoftheGPU

- BillDallyofStanfordUniversityconsiderspowerandmassiveparallelismasthemajorbenefits of GPUs over CPUs for the future.
- Byextrapolatingcurrenttechnologyandcomputerarchitecture,itwasestimatedthat60 Gflops/watt per core is needed to run an exaflops system
- PowerconstrainswhatwecanputinaCPUorGPUchip.

3) <u>MEMORY,STORAGEANDWIDEAREANETWORKING</u>

The upper curve in <u>Figure 1.10</u> plots the growth of DRAM chip capacity from 16 KB in 1976 to 64 GB in 2011. This shows that memory chips have experienced a 4x increase in capacity every three years. Memory access time did not improve much in the past. In fact, the memory wall problem is getting worse as the processor gets faster. For hard drives, capacity increased from260 MB in 1981 to 250 GB in 2004.



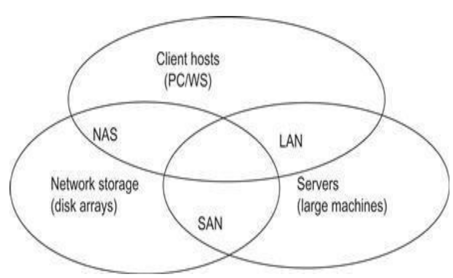


Fig1(a)Improvementinmemoryanddisktechnologiesover 33 years

Fig1(B)Threeinterconnection networksforconnectingservers,client hosts, and storage devices.

System-AreaInterconnects:

The nodes in small clusters are mostly interconnected by an Ethernet switch or a *local area network*(LAN).AsFigure1(B)shows,aLANtypicallyisusedtoconnectclienthoststobigservers. A *storage area network* (SAN) connects servers to network storage such as disk arrays. *Network attached storage*(NAS) connects client hosts directly to the disk arrays. All three types of networks often appear in a large cluster built with commercial network components. If no large distributed storage is shared, asmall cluster could be built with a multiport Gigabit Ethernet switch plus copper cables to link the end machines.

4) VIRTUALMACHINESANDVIRTUALIZATIONMIDDLEWARE

VirtualMachineDefinition:

AVirtualMachine(VM)isanoperatingsystemOSorapplicationenvironmentthatis installedonsoftwarewhichimitatesdedicatedHardware.Theenduserhasthesameexperienceona virtual machine as they would have on dedicated hardware

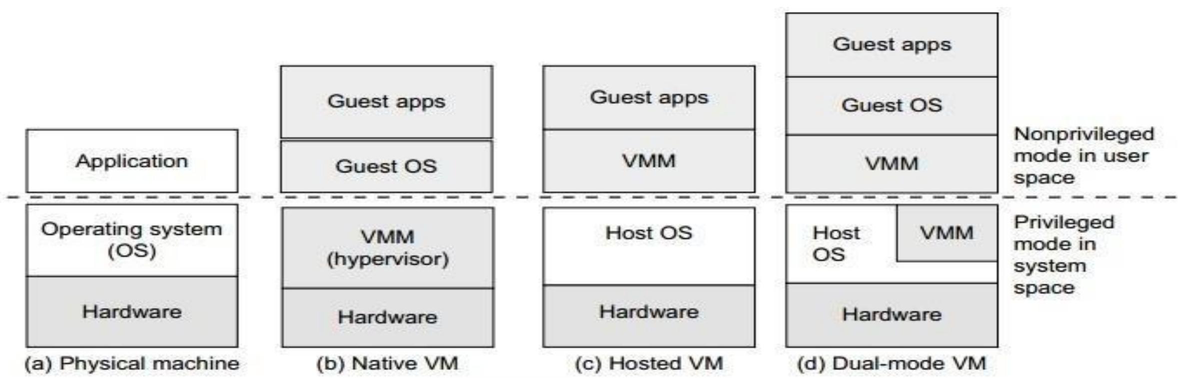


FIGURE 1.12

Three VM architectures in (b), (c), and (d), compared with the traditional physical machine shown in (a).

- The host machine is equipped with the physical hardware.The VM can be provisioned for any hardware system.
- The VM is built with virtual resources managed by a guest OS to run a specific application. Between the VMs and the host platform, one needs to deploy a middleware layer called a virtual machine monitor (VMM).).
- A native VM installed with the use of a VMM called a hypervisor in privi-leged mode. For example, the hardware has x-86 architecture running the Windows system.

VMPRIMITIVEOPERATIONS:

With full virtualization, the VMM exports a VM abstraction identical to the physical machine so that a standard OS such a Windows 2000 or Linux can run as it would on the physical hardware.

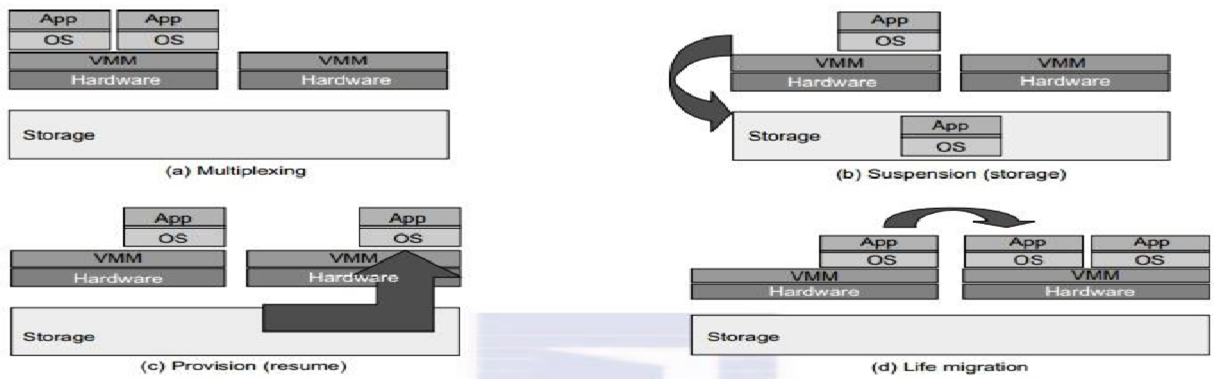


FIGURE 1.13
VM multiplexing, suspension, provision, and migration in a distributed computing environment.

- First,theVMscanbemultiplexedbetweenhardwaremachines.
- Second,aVMcanbesuspendedandstoredinstablesuspension.
- Third,asuspendedVMcanberesumedorprovisionedtoanewhardwareplatform.Finally,a VM can be migrated from one hardware platform to another.

5) DATACENTERVIRTUALIZATIONFORCLOUDCOMPUTING

- Cloudarchitectureisbuiltwithcommodityhardwareandnetworkdevices.
- Low-costterabytedisksandGigabitEthernetareusedtobuilddatacenters.
- Data center design emphasizes the performance/price ratio over speed performance alone. In otherwords,storageandenergyefficiencyaremoreimportantthanshearspeedperformance.
- Worldwide,about43millionserversareinuseasof2010.Thecostofutilitiesexceedsthecostof hardware after three years.

CONVERGENCEOFTECHNOLOGIES

Essentially,cloudcomputingisenabledbytheconvergenceoftechnologiesinfourareas:
(1) hard-warevirtualizationandmulti-corechips,
(2) utilityandgridcomputing,
(3) SOA,Web2.0,andWSmashups,
(4) autonomiccomputinganddatacenterautomation.

CLUSTERSOFCOOPERATIVECOMPUTERS

PART–B

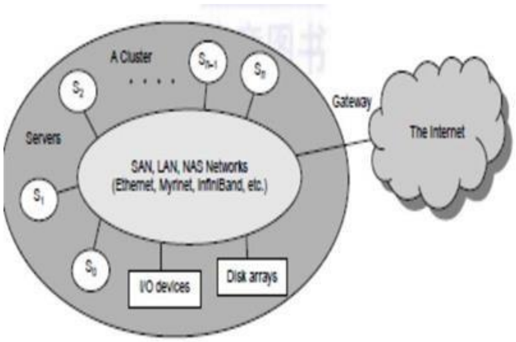
1) WriteShortnotesonClusterofCooperativecomputers(Nov/Dec2016)

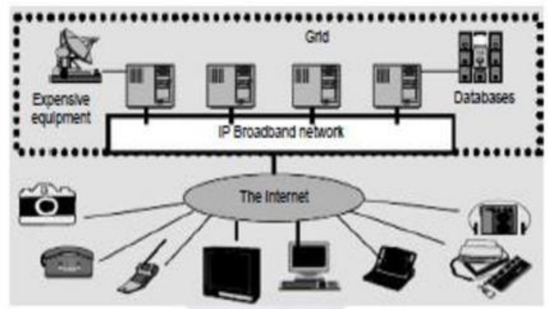
Definition:

Acomputerclusterconsistsofasetofflooselyortightlyconnectedcomputersthatwork together in many respect, they can be viewed as a single system. Clusters are generally deployed to improve speed or reliability.

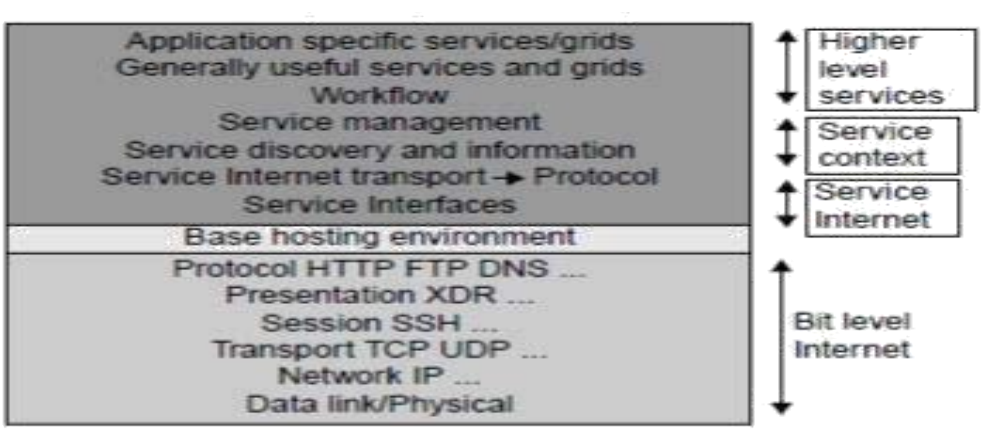
ClusterArchitecture:

- The architecture of a typical server cluster built around a low-latency, high bandwidth interconnectionnetwork.ThisnetworkcanbeassimpleasaSAN(e.g.,Myrinet)oraLAN(e.g., Ethernet).
- Tobuildalargerclusterwithmorenodes,theinterconnectionnetworkcanbebuiltwithmultiple levels of Gigabit Ethernet, Myrinet, or InfiniBand switches.





Through hierarchical construction using a SAN, LAN, or WAN, one can build scalable clusters with an increasingnumberofnodes.TheclusterisconnectedtotheInternetviaavirtualprivatenetwork(VPN) gateway. The gateway IP address locates the cluster. The system image of a computer is decided by the way the OS manages the shared cluster resources.



Single-SystemImage

An ideal cluster should merge multiple system images into a single-system image (SSI). Cluster designers desire a cluster operating system or some 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.SSI makes the cluster appear like a single machine to the user. A cluster with multiple system images is nothing but a collection of independent computers.

GRIDCOMPUTINGINFRASTRUCTURES

PartB❼DescribetheInfrastructurerequirementsforgridComputing(AU/Nov/Dec2017)

- Users have experienced a natural growth path from Internet to web and grid computing services. Internet services such as the Telnet command enables a local computer to connect to a remote computer. Web service such as HTTP enables remote access of remote web pages.
- Grid computing is envisioned to allow close interaction among applications running on distant computers simultaneously.

ComputationalGrids

- Like an electric utility power grid, a computing grid offers an infrastructure that couples computers, software/middleware, special instruments, and people and sensors together.
- The grid is often constructed across LAN, WAN, or Internet backbone networks at a regional, national, or global scale Enterprises or organizations present grids as integrated computing resources.
- Theycanalsobeviewedasvirtualplatformstosupportvirtualorganizations.Thecomputersused in a grid are primarily workstations, servers, clusters, and supercomputers. Personal computers, laptops, and PDAs can be used as access devices to a gridsystem

GridFamilies

- Gridtechnologydemandsnewdistributedcomputingmodels,software/middlewaresupport, network protocols, and hardware infrastructures.
- Nationalgridprojectsarefollowedbyindustrialgridplatformdevelopmentby IBM,Microsoft, Sun, HP, Dell, Cisco, EMC, Platform Computing, and others.
- Newgridserviceproviders(GSPs)andnewgridapplicationshaveemergedrapidly,similartothe growth of Internet and web services in the past two decades.

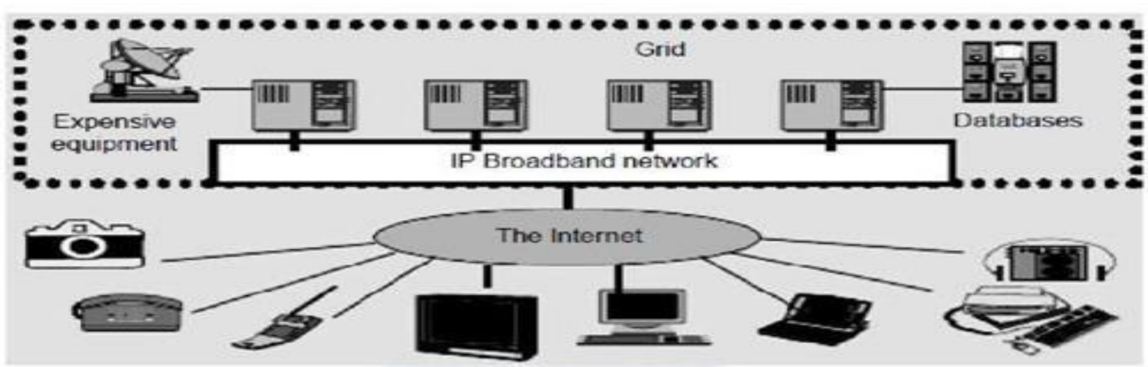


Table 1.4 Two Grid Computing Infrastructures and Representative Systems

Design Issues	Computational and Data Grids	P2P Grids
Grid Applications Reported	Distributed supercomputing, National Grid initiatives, etc.	Open grid with P2P flexibility, all resources from client machines
Representative Systems	TeraGrid built in US, ChinaGrid in China, and the e-Science grid built in UK	JXTA, FightAid@home, SETI@home
Development Lessons Learned	Restricted user groups, middleware bugs, protocols to acquire resources	Unreliable user-contributed resources, limited to a few apps

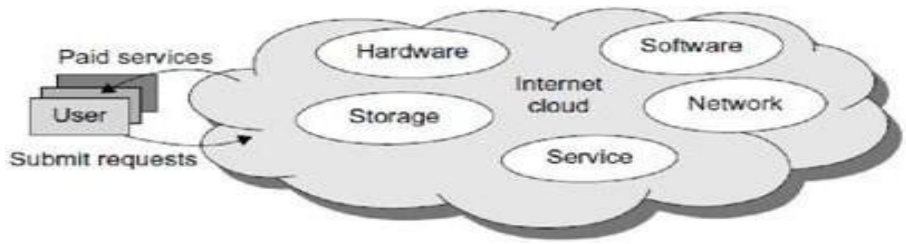
CLOUDCOMPUTINGOVERTHEINTERNET

Part–A❼Highlighttheimportanceoftheterm"CloudComputing"(AU/Nov/Dec2016)

- **Definition** - "A cloud is a pool of virtualized computer resources. A cloud can host a variety of different workloads, including batch-style backend jobs and interactive and user-facing applications"
- Thecloudallowsworkloadstobedeployedandscaledoutquicklythroughrapidprovisioningof virtual or physical machines.
- Thecloudsupportsredundant,self-recovering,highlyscalableprogrammingmodelsthatallow workloads to recover from many unavoidable hardware/softwarefailures.
- Finally,thecloudsystemshouldbeabletomonitorresourceuseinrealtimetoenable rebalancing of allocations when needed.

InternetClouds

- Cloudcomputingappliesavirtualizedplatformwithelasticresourcesondemandbyprovisioning hardware, software, and data sets dynamically.
- Theideaistomovedesktopcomputingtoaservice-orientedplatformusingserverclustersand huge databases at data centers.
- Cloudcomputingleveragesitslowcostandsimplicitytobenefitbothusersandproviders.



TheCloudLandscape

Thetraditionalsystemshaveencounteredseveralperformancebottlenecks:constantsystemmaintenance, poor utilization, and increasing costs associated with hardware/software upgrades. Cloudcomputingasanon-demandcomputingparadigmresolvesorrelievesusfromthese**problems.**

CLOUDSERVICEMODELS:

- **InfrastructureasaService(IaaS**)---Thismodelputstogetherinfrastructuresdemandedbyusers —namelyservers,storage,networks,andthedatacenterfabric.
- **PlatformasaService(PaaS)-** ❼ Thismodel enablesthe usertodeploy user-builtapplications ontoavirtualizedcloudplatform.PaaSincludesmiddleware,databases,developmenttools,and someruntimesupportsuchasWeb2.0andJava.
- **Software as a Service (SaaS)-** ❼ The SaaS model applies to business processes, industry applications,consumerrelationshipmanagement(CRM),enterpriseresourcesplanning(ERP), human resources (HR) , and collaborative applications.

Thefollowinglisthighlightseightreasonstoadaptthecloudforupgraded Internetapplicationsandweb services:

- Desiredlocationinareaswithprotectedspaceandhigherenergyefficiency
- Sharingofpeak-loadcapacityamongalargepoolofusers,improvingoverallutilization
- Separationofinfrastructuremaintenancedutiesfromdomain-specificapplicationdevelopment
- Significantreductionincloudcomputingcost,comparedwithtraditionalcomputingparadigms
- Cloudcomputingprogrammingandapplicationdevelopment
- Serviceanddatadiscoveryandcontent/servicedistribution
- Privacy,security,copyright,andreliabilityissues

SERVICEORIENTEDARCHITECTURE

Part-A	**DifferentiatebetweenGridandCloudComputing(AU/Nov/Dec2017)**

Part-B	WriteShortnotesonServiceOrientedArchitecture(AU/Nov/Dec2016)

- Ingrids/webservices,Java,andCORBA,anentityis,respectively,aservice,aJavaobject,anda CORBA distributed object in a variety of languages.
- ThesearchitecturesbuildonthetraditionalsevenOpenSystemsInterconnection(OSI)layersthat provide the base networking abstractions.
- Eg:.NETorApacheAxisforwebservices,theJavaVirtualMachineforJava,brokernetworkfor CORBA.

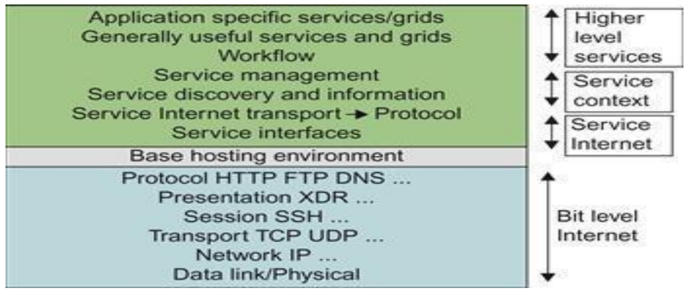


Fig:Layeredarchitectureforwebservicesandthegrids.

LayeredArchitectureforWebServicesandGrids

- TheentityinterfacescorrespondtotheWebServicesDescriptionLanguage(WSDL),Java method, andCORBA interface definition language (IDL) specifications in these example distributed systems.
- Theseinterfacesarelinkedwithcustomized,high-levelcommunicationsystems:SOAP,RMI, and IIOP in the three examples.
- Thesecommunicationsystemssupportfeaturesincludingparticularmessagepatterns

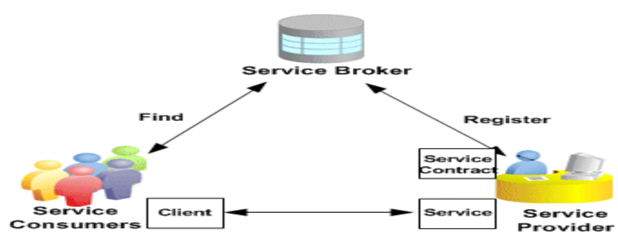


Fig:SOAArchitecture

WebServicesand Tools

- Loosecouplingandsupportofheterogeneousimplementationsmakeservicesmoreattractive than distributed objects.
- Inwebservices,oneaimstofullyspecifyallaspectsoftheserviceanditsenvironment.
- ThisspecificationiscarriedwithcommunicatedmessagesusingSimpleObjectAccessProtocol (SOAP).
- Thehostingenvironmentthenbecomesauniversaldistributedoperatingsystemwithfully distributed capability carried by SOAP messages.
- Thisapproachhasmixedsuccessasithasbeenhardtoagreeonkeypartsoftheprotocoland even harder to efficiently implement the protocol by software such as ApacheAxis.
- IntheRESTapproach,oneadoptssimplicityastheuniversalprincipleanddelegatesmostofthe difficult problems to application (implementation-specific) software.
- For Java, this could be as simple as writing a Java program with method calls replaced by Remote Method Invocation (RMI), while CORBA supports a similar model with a syntax reflecting the C++ style of its entity (object)interfaces.

EVOLUTIONOFSOA

- AsshowninFigure1.21,service-orientedarchitecture(SOA)hasevolvedovertheyears.
- SOA applies to building grids, clouds, grids of clouds, clouds of grids, clouds of clouds (also known as interclouds), and systems of systems in general.
- A large number of sensors provide data-collection services, denoted in the figure as SS (sensor service). A sensor can be a ZigBee device, a Bluetooth device, a WiFi access point, a personal computer, a GPA, or a wireless phone, among other things.
- Rawdataiscollectedbysensorservices.
- All the SS devices interact with large or small computers, many forms of grids, databases, the compute cloud, the storage cloud, the filter cloud, the discovery cloud, and so on. Filter services (fs in the figure) are used to eliminate unwanted raw data, in order to respond to specific requests from the web, the grid, or web services.

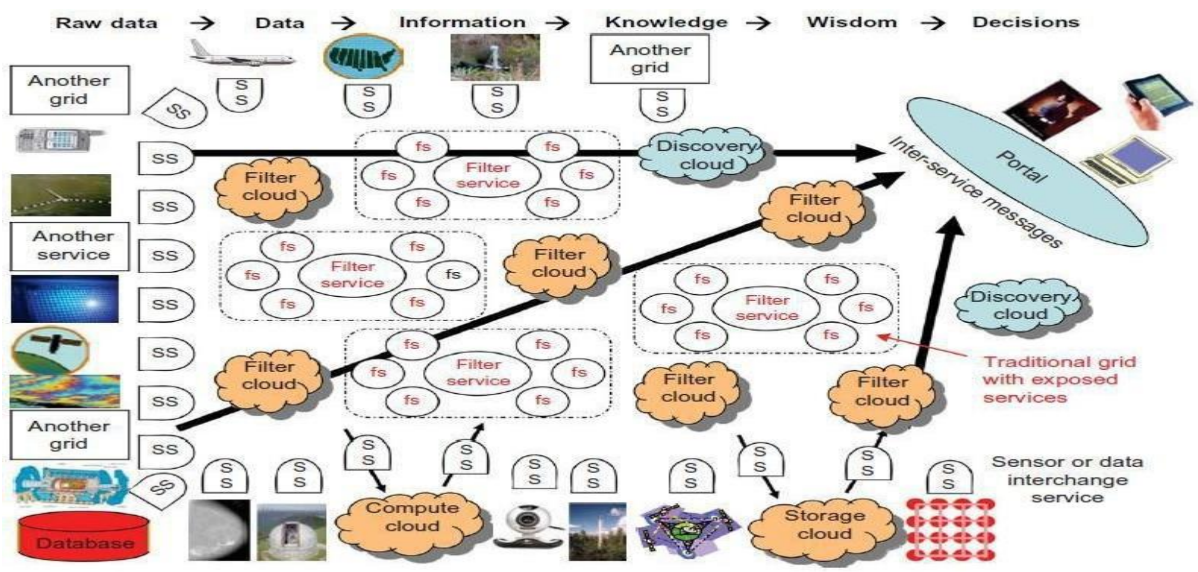


Fig:EvolutionofSOA

GridVsCloud

- Ingeneral,agridsystemappliesstaticresources,whileacloudemphasizeselasticresources.
- For some researchers, the differences between grids and clouds are limited only in dynamic resource allocation based on virtualization and autonomic computing. One can build a grid out of multiple clouds.
- This type of grid can do a better job than a pure cloud, because it can explicitly supportnegotiated resource allocation.
- Thus one may end up building with a *system of systems*: such as a *cloud of clouds, a grid of clouds*, or a *cloud of grids*, or *inter-clouds* as a basic SOAarchitecture.

INTRODUCTIONTOGRIDARCHITECTUREANDSTANDARDS–ELEMENTSOFGRID–OVERVIEW OF GRID ARCHITECTURE

PART–B1)DescribeLayeredGridArchitecture.HowdoesitmapontointernetProtocolarchitecture (AU/Nov/Dec 2017

- Gridcomputingisapplyingtheresourcesofmanycomputersinanetworktoasingleproblemat the same time.

- Gridcomputingtechnologies&infrastructuresupportthesharing&coordinateduseofdivers resources in dynamics, distributed virtual organization.
- Gridarchitectureidentifiesthefundamentalsystemcomponents,specifiespurposeandfunction of these components and indicates how these components interact with eachother.
- Thegridcanbethoughtofasadistributedsystemwithnon-interactiveworkloadsthatinvolvea large no of files.
- ThedifferentGridcomputingfromconventionalhighperformancecomputingsystemsuchas cluster computing is that grid to be more loosely coupled, heterogeneous& geographically dispersed.
- Gridsareoftenconstructedwithgeneralpurposegridmiddlewaresoftwarelibraries.

GRIDCOMPUTINGARCHITECTURE:

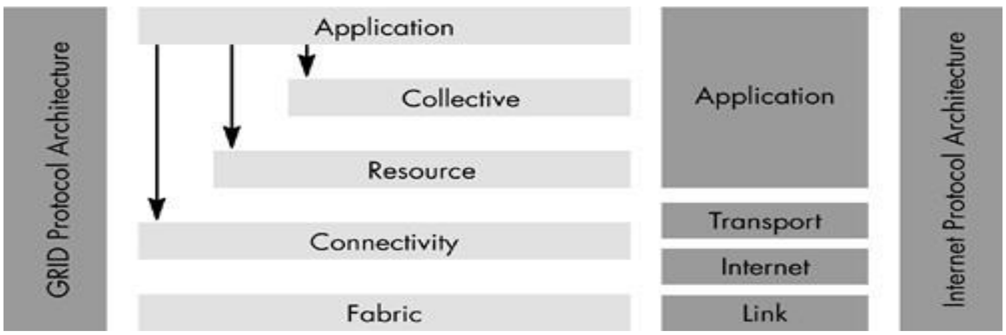


Figure:GridComputing architecture

ADVANTAGESOFGRIDCOMPUTING:-

- Noneedtobuylargesymmetricmultiprocessorserver.
- Muchmoreefficientuseofidleresources.
- Gridenvironmentaremuchmoremodularanddon’thavesinglepointoffailure.
- Policescanbemanagedbythegridsoftware.
- Upgradingcanbealone.
- Jobscanbeexecutedinparallelspeed.

DISADVANTAGESOFGRIDCOMPUTING:-

- Forasmallmemoryapplicationsmemorypassinginterfacesyoumayneedtohaveafast interconnect between the computer resources.
- Someapplicationmayrequirefulladvantagesofnewmodel.
- Politicalchallengesassociatedwithsharingresources.

GRIDCOMPUTINGSTANDARDS:

a) **OGSA (Open Grid Service Architecture):** The aim of OGSA is to standardize grid computing and to defineabasicframeworkofagridapplicationstructure.Someofthekeyconceptsarefirstpresentedby Ian Foster who still leads the OGSA working group. This Architecture combines different aspects from grid computing with advantages from Web Services.

b) **OGSA Services:** The OGSA specifies services which occur within a wide variety of grid systems. They canbedividedinto4broadgroups:i)CoreServicesii)DataServicesiii)ProgramExecutionServicesand iv)ResourceManagementServices.

c) **OGSI(OpenGridServiceInfrastructure):**OGSAdefinesaGridApplicationandwhataGridService should be able to do. OGSI specifies a Grid Services indetail.

d) WSRF (Web Service Resource Framework): WSRF is a derivative of OGSI. A first implementationcan be found in GT4 (Global Toolkit 4). The framework combines 6 different WS specifications “that define what is termed the WS-Resource approach to modeling and managing state in a Web services context. WSRF Specifications: i) WS-ResourceLifetime: mechanisms for WSRessource destruction ii) WS-ResourceProperties: manipulation and definition of WS properties iii) WS-Notification: event management iv) WS-RenewableReference: defines updating proceeding v) WS-ServiceGroup: interface for by-reference collections of WSs vi) WS-BaseFaults: standardization of possible failures.

ELEMENTSOFGRID:

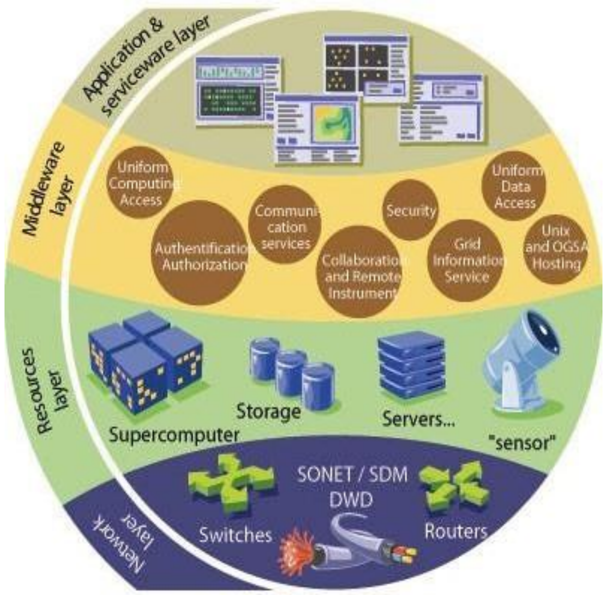
Grid computing combines elements such as distributed computing, high-performance computing and disposable computing depending on the application of the technology and the scale of operation. Grids can create a virtual supercomputer out of the existing servers, workstations and personal computers.

Present-daygridsencompassthefollowingtypes

- **Computational grids,** in which machines will set aside resources to “number crunch” data or provide coverage for other intensive workloads
- **Scavenging grids,** commonly used to find and harvest machine cycles from idle servers and desktop computers for use in resource-intensive tasks (scavenging is usually implemented in a way that is unobtrusive to the owner/user of the processor)
- **Data grids,** which provide a unified interface for all data repositories in an organization, and through which data can be queried, managed and secured.
- **Market-oriented grids,** which deal with price setting and negotiation, grid economy management and utility driven scheduling and resource allocation.

OVERVIEWOFGRIDARCHITECTURE:

The architecture of a grid system is often described in terms of “layers”, each providing a specific function as shown in the following figure. Higher layers are user centric, whereas the lower layers are hardware-centric. In Figure 1 a generic grid architecture showing the functionality of each layer.



NETWORKLAYER: Itisthebottomlayer which assures the connectivity for the resources in the grid.
RESOURCE LAYER: It is made up of actual resources that are part of the grid, such ascomputers,storagesystems,electronicdata catalogues, and even sensors such as telescopes or other instruments, which can be connected directly to the network.
MIDDLEWARELAYER: Itprovidesthe toolsthatenablevariouselements(servers, storage, networks, etc.) to participate in a unified grid environment.
APPLICATIONLAYER: Inwhichincludes different user applications (science, engineering, business, financial), portal and developmenttoolkits-supportingapplications.

Fig:GridLayerArchitecture **TypesofLayer&itsFunction**

MAINCHARACTERISTICSOFGRIDS:

Themaincharacteristicsofagridcomputingenvironmentcanbelistedasfollows:

- **Large scale:** A grid must be able to deal with a number of resources ranging from just a few to millions.
- **Geographicaldistribution:**Gridresourcesmaybespreadgeographically.
- **Heterogeneity:** Agridhostsboth softwareand hardwareresourcesthatcan berangingfromdata, files, software components or programs to sensors, scientific instruments, display devices, personal digital organizers, computers, super-computers and networks.
- **Resource sharing and coordination:** Resources in a grid belong to different organizations that allow other organizations (i.e. users) to access them. The resources must be coordinated in order to provide aggregated computing capabilities.
- **Multiple administrations:** Each organization may establish different security and administrative policies under which resources can be accessed and used.
- **Accessibility attributes:** Transparency, dependability, consistency, and pervasiveness are attributes typical to grid resource access. A grid should be seen as a single virtual computing environment and must assure the delivery of services under established Quality of Service requirements.