Resource Management using I-Cluster in Cloud

Jayshree Ghorpade , Amit Bawaskar , Rohan Kasat

Department of Computer Engineering, Pune University, India

***Abstract*— In today's "E-World" computing is taking up an essential part of business. Computing is coming up as the fifth utility after water, gas, electricity and telephony. This has led to the development of various computing paradigms like grid computing and Cluster computing. This article deals with cloud computing as the upcoming and most efficient source of computing. It aims at explaining the importance of cloud computing as an appropriate method for computation in the near future. It also tries to explain how I-Cluster clouds can work as a framework of tools that takes advantage of unused network resources and federates them into a huge virtual cluster. The virtual cluster is created by crystallizing the unused network resources into specific virtual functions using resource management strategies. I-Cluster Cloud enables automatic real time analysis of work load and allocates the set of machines into a virtual cluster and proceeds with the execution of the function. So basically this paper gives an idea of cloud computing and the use of I-Cluster Cloud for resource management.**

***Keywords*— Cloud computing, I-Cluster Cloud, Virtual Machine, Sandbox mechanism.**

I. INTRODUCTION

Computing as a resource is fast developing in today's digital world. Development of applications and data management is taking up a big part in the industries. An efficient method of computing is 'Cloud Computing'. It is basically location independent computing, wherein the resources, software, data and sometimes even the infrastructure is shared. An efficient way of handling security issues and distributed resource management is with the help of the 'I-Cluster Cloud' which recognises the nodes capabilities, propagates information within the cloud and offers a high security level to the users. This article aims at helping the user understand the basics of cloud computing and illustrates the use of I-Cluster Cloud in distributed resource management.

A. What Is Computing?

Computing is usually defined as the activity of using and improving computer hardware and software utilisation. It is the computer-specific part of information technology. A computer is a machine that manipulates data according to a set of instructions called a computer program. The program has an executable form that the computer can use directly to execute the instructions. The same program in its human-readable source code form enables a programmer to study and develop the algorithm.

Computation is a general term for any type of information processing. It helps the user to make complex calculations easy and fast. It enhances the available data so that business decisions can be made effectively.

B. Why Cloud Computing?

Computing is being transformed to a model consisting of services that are commoditized and delivered in a manner similar to traditional utilities such as water, electricity, gas, and telephony. In such a model, users access services based on their requirements without regard to where the services are hosted or how they are delivered.

Cloud computing [1] in simple terms is location independent computing. The basis of cloud computing is server sharing. The resources, software, data and sometimes even infrastructure are shared. The service is provided as and when required on demand. As such it is a service oriented architecture where details of execution are hidden, i.e. they are in a cloud! Using such a cloud, businesses and users are able to access applications from anywhere in the world on demand. Thus, the computing world is rapidly transforming towards developing software for millions to consume as a service, rather than to run on their individual computers. Cloud computing can be thought of as an upgrade to the internet wherein in, it is common to access content independently without reference to the underlying hosting infrastructure. This infrastructure consists of data centres that are monitored and maintained around the clock by content providers. Cloud computing provides capabilities of business applications over a network. One can say that cloud computing is emerging as the 'next best thing' in computation and with advances in cloud computing business applications are becoming more and more efficient as well as dynamic. This has led to globalization of the applications along with businesses.

Using cloud computing the user can have ubiquitous computing. This greatly improves his area of business leading to yield of greater profits without any additional costs of setting up new branches or infrastructure where the new business is to be provided.

C. Scope Of Computing

Cloud Computing is emerging as the new era of efficient computing. Providers such as Amazon, Google, Salesforce, IBM, Microsoft and Sun Microsystems have started using cloud computing on a large scale. They have set up new data centres around the world to provide data redundancy and ensure reliability of data in case of site failures. With significant advances in microprocessor technology, a new concept of virtual machines has surfaced. A virtual machine (VM) [1] is a software implementation of a machine (i.e. a computer) that executes programs like a physical machine. System virtual machines allow the sharing of the underlying physical machine resources between different virtual machines, each running its own operating system. This has led to increasing ability of commodity hardware to run applications within Virtual Machines (VMs) efficiently. VMs allow both the isolation of applications from the underlying hardware and other VMs, and the customization of the platform to suit the needs of the end user.

So we can say that the scope of cloud computing is to create an environment for dynamically interconnecting and provisioning clouds from multiple domains within and across enterprises. After facing the various challenges involved in creating such clouds, global operations with faster response time using cloud computing technology can be developed which will help the businesses to make to thrive globally.

II. 21ST CENTURY VISION

In 1969, Leonard Kleinrock [1], one of the chief scientists of the original Advanced Research Projects Agency Network (ARPANET) project which seeded the Internet, said: “As of now, computer networks are still in their infancy, but as they grow up and become sophisticated, we will probably see the spread of ‘computer utilities’ which, like present electric and telephone utilities, will service individual homes and offices across the country”. This vision of providing computing as a basic day-to-day need to everyone anticipates massive growth in computing industry. In its earlier times computing was done on individual computers with very little or no transparency. Huge infrastructure and maintenance of complex IT departments required large financial support. So, software developers have taken up the significant challenge to create software which can be accessed by millions to use as a service sitting at home rather than to run on individual computers.

This vision has led to creation of the world wide system of computer networks which helps computers communicate with each other to offer more stability and lessen the processing time. This creates the potential of utilizing seemingly endless amount of distributed computing resources owned by different owners as shown in fig. 1.

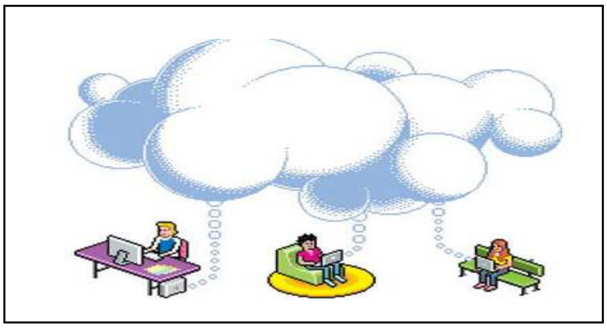


Fig. 1: Vision Of Cloud [7]

The emergence of cloud computing ensures reliable services to be delivered anywhere and anytime. The development of cloud computing provides us with next generation data centres which guarantees data security and sustainability. Cloud Computing provides us with services that are highly reliable, scalable, and autonomic to support ubiquitous access, dynamic discovery and composability. Cloud computing paradigm appears to be the most promising one to leverage and build on the developments from other paradigms.

In accordance to this need, the software developers have started to make advances in cloud computing. We are still far way from developing the True Cloud. Today’s Cloud is dependent on location, technology and provider. True cloud will be independent, flexible and efficient, as shown in fig. 2.

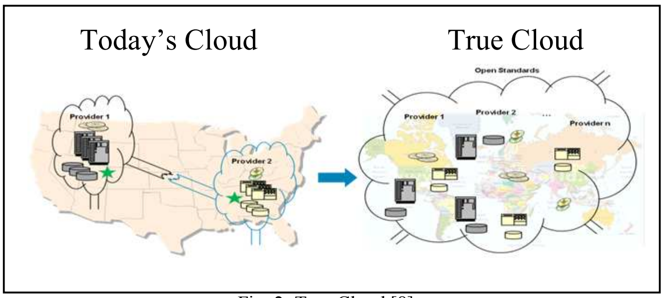


Fig. 2: True Cloud [8]

III. MARKET ORIENTED CLOUD ARCHITECTURE

The consumers rely on cloud providers to supply more of their computing needs by ensuring quality of service and maintenance in order to meet their computing requirement. Now-a-days the cloud providers have started to provide the same clouds to more than one consumer. As such the cloud providers cannot afford to deploy traditional system-centric resource management architecture. This architecture does not provide incentives for them to share their resources and still regard all service requests to be of equal importance. Cloud providers have to meet the different needs of different consumers as agreed in the Service Level Agreement. This led to the origin of market-oriented cloud architecture wherein there will be a standard which will be developed to ensure that the demand of a resource to any particular cloud will be ensured a supply to achieve market equilibrium. This will help the cloud providers to develop their clouds and the cloud users to reduce their finances by using someone else's infrastructure.

There are mainly four entities involved in the market-oriented architecture [1]:

A. Users/Brokers :

Users or brokers acting on their behalf are the cloud users. They submit requests to the clouds for processing their data from anywhere in the world.

B. Resource Allocators :

The users or brokers submit their queries to the resource allocators. They act as the interface between the data providers/cloud service provider and the users. It decides as to which system to send the request. It ensures that there is no overloading, determines the pricing for the request and keeps tracks of the virtual machines running the requests.

C. Virtual Machines :

VMs are the ones actually running the requests. Multiple VMs can be started or stopped to provide flexibility.

D. Physical Machines :

The data centres comprise multiple computing servers to meet service demands.

IV. CLOUD COMPUTING

Basically 'Cloud' means 'Internet'. So, cloud computing means internet based computing. 'Cloud' is an aggregation of servers, low end computers and storage hosting programs and data. Cloud basically consists of three components [6] clients, the data centres and the distributed servers, as shown in Fig. 3.

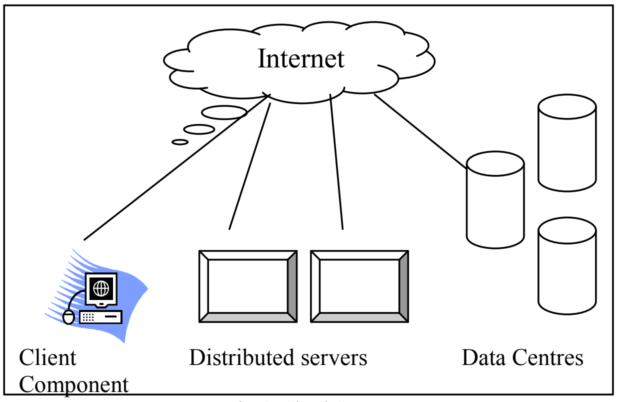


Fig. 3: Cloud Components

Cloud computing "is not"

- Network computing, where application and data are not confined to any specific company's server and there is no VPN access
- Traditional outsourcing: not a contract to host data by 3rd party hosting business.

It is a style of computing where massively scalable IT-enabled capabilities are provided "as a service" over the network.

Basic characteristics of cloud computing are:

- Accessibility
- Service Management
- User Metering
- Automation
- Agility
- Flexibility
- Cost Efficiency
- Virtualization

The three primary models for cloud-computing as shown in fig. 4, are [5]:

- SaaS (Software as a service)
- PaaS(Platform as a service)
- IaaS(Infrastructure as a service)

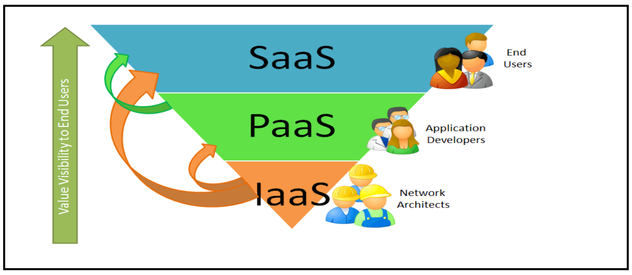


Fig. 4: Cloud Computing Models [9]

SaaS:

Software as a service (SaaS) is the model in which an application is hosted as a service to customers who access it via the internet. Typically, software that performs a simple task without much need to interact with other systems makes them ideal candidates for SaaS. SaaS provides network based access to commercially available software.

One of the biggest benefits of SaaS is, of course, costing less money than buying the application outright. SaaS faces challenges from the availability of open source applications and cheaper hardware.

Example: Google Apps, Salesforce.com

PaaS:

Following on the heels of SaaS, Platform as a Service (PaaS) is another application delivery model. PaaS supplies all the resources required to build applications and services completely from the internet without having to download or install software.

PaaS is expected to be used by many users simultaneously. It generally provides automatic facilities for concurrency management, scalability, failover and security. Developers of PaaS face the hurdle of being locked up into single provider as vendors use proprietary services.

Example: salesforce.com, Amazon E2C, Microsoft Azure.

IaaS:

Infrastructure as a Service (IaaS) is the next form of service in cloud computing. Where SaaS and PaaS are providing applications to customers, IaaS doesn't. It simply offers the hardware so that the organisation can put whatever they want onto it. Additionally, the infrastructure can be dynamically scaled up or down, based on the application resource needs. IaaS allows rent resources such as

- Server space
- Network equipment
- Memory
- CPU cycles
- Storage space

Example: HP adaptive infrastructure as a service, Rackspace, Amazon E2C and S3.

V. TYPES OF CLOUDS

The Clouds are categorized into two levels as shown in table 1:

- Private Cloud
- Public Cloud

Parameters	Private	Public
Definition	Uses cloud technologies to expose services across a private enterprise.	All information accessed is housed inside the public domain.
Organisation	Private clouds are deployed inside the firewall and managed by the user organization	Public cloud is offered as a service, usually over an Internet connection.
Flexibility	Users can scale the storage on-demand and will never need to purchase storage hardware. Courier), cell in a table	Scaling the cloud is as simple as adding another server to the pool and the self-managing architecture expands the cloud by adding performance and capacity.
Security	Less risk – security, resiliency, infrastructure and support processes will not differ significantly from current environment.	Greater risks in terms of security, resiliency, transparency and performance predictability (at least in the near term).
Example	Amazon's virtual private cloud, VMware's virtual server hosting app.	Amazon's elastic compute cloud, IBM's Blue cloud.

Table 1: Types of Clouds

VI. I-CLUSTER CLOUD

I-Cluster [2] aims at organizing computing resources within a cloud of processing units at user's disposal. It uses the gossiping algorithm [3] to propagate information about the nodes and harnesses idle-cycles. It stands on the base of projects like Condor, Diet, Xtrem-Web, Mosix.

The main standing of I-Cluster over these projects was that

- It federates computing resources of all sorts and aggregate idle machines into high throughput virtual cluster.
- It tackles security issues.

Services provided by I-Cluster Cloud:

- Determining the capabilities of nodes such as CPU power, memory
- Propagating information within cloud.
- Offering high level security to users.

A. Node Capabilities

Each machine belonging to the cloud is provided with sensor whose function is to look after the local resources such as number, type and frequency of processor, memory and disk size and network connectivity. Nodes IP address, sub-network and default gateway are automatically investigated.

B. Propagating Information

The cloud has to distribute the information about the nodes it handles i.e.: entering or leaving the system. Also information related to nodes activities is propagated in order to allocate new jobs to idle nodes.

C. High-Security Level

I-Cluster aims at controlling the nodes that may enter or leave the structure dynamically. "Sand-Box" mechanism is used in order to deal with security issues in which nodes can operate in two different modes "user mode" and "cluster mode" thus providing security through isolation.

VII. ARCHITECTURE AND WORKING OF THE I-CLUSTER CLOUD

Architecture [2] is basically divided into three parts as shown in fig. 5, the entry point, the I-Cluster cloud and the I-Cluster node. At entry point the I-Cluster deal with job submission to find match between job and resource and to schedule task. Under I-Cluster node , each node has a sand-box and resource sniffer discovers new nodes while the I-Cluster Cloud deals with the resource management and topology scanner.

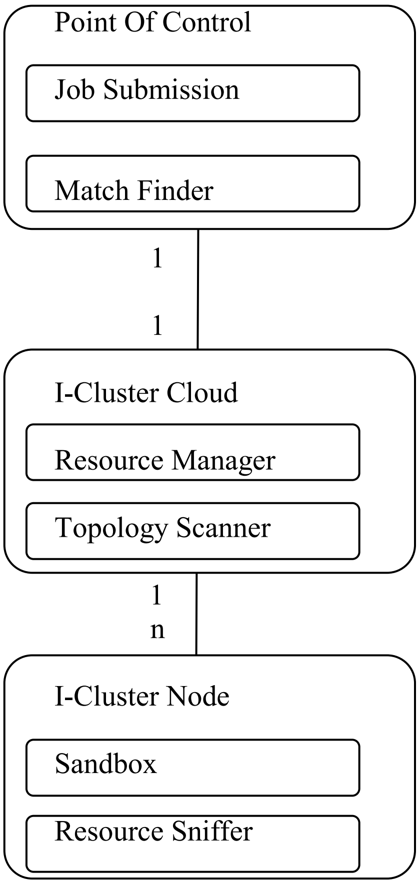


Fig.5 I-Cluster architecture

A. Job Submission :

When the user wants the computing service to be executed, it uses the job submission engine to provide the system with detail of job's requirements which includes number of machines to be reserved, individual characteristics topology of machines, entry parameters and location for output data.

B. Match Finder :

The detailed data now is used by the match finder to find proper set of machines to satisfy the requirements of the requested service. Each node in the cloud knows a list of available machines of the network that it can use for submitting jobs. The user selects computing service and sets some additional information which is handled by match finder which finds a group of nodes with best capabilities for the execution of job. The I-Cluster Framework makes use of the available network resources and topology and thus possibly executes finely grained supercomputing jobs on allocated resources. Match Finder uses a 2-phase commit algorithm, first attempts allocation of each required computer and commits them if available, a double commit is used when there is a problem of having two different attempts occur at the same time on a single machine.

Machines once allocated cannot be changed during execution.

C. Resource Management :

Information about each machine is characterized by a triplet (t, id, s), where't' is the timestamp, 'id' is an unique identifier generated randomly and 's' state of machine(on-line, off-line, running, hibernating). The triplet is updated by the machine itself, but at times when it is confirmed that the machine is not responding at all then it may be updated by the nodes of the cloud. When node A wants to connect to the cloud it must know 'id' of at least one peer, B already connected to the cloud. 'A' will send message to 'B' and in response will get information about other nodes in the cloud thus, starts interacting with them. The handling of disconnection is as:

- Node A detects time out in a tentative to connect to peer B and add it to suspect list.
- If another node C is not successful to connect to B and finds B in suspect list then considers B been suspected.
- C will change B's status to disconnected and B will be removed from the suspect list.

The global set of triplets and the suspect list are stored in a distributed database , each node of a cloud has its own partial view of global database, which is only a part of the whole set of nodes. Update of partial database is done through gossiping [3].

D. Topology Scanner :

Our system needs to be able to efficiently solve fine-grained problem. We are allocating idle machines from the network for distributed computations then we have to ensure that the allocated set of machines are of the same type in respect to CPU speed and resources and we should also ensure that the network latency is minimal. In case of latency it's not possible to allocate the set of machines so that latency will be as small as possible. It requires deep knowledge of the topology, which is not convenient to gather. For this reason, a set of machines allocated to a single job must always be located on a single subnet. This ensures that the inter node latency will always be limited.

E. The I-Cluster Sandbox :

Sandbox characterizes a safe and isolated area for the execution of untrusted code on a machine. It allows access to some of the system features (network access, for example) while protecting the target machine from malicious or erroneous code thus increasing the security level.

Hawblitzel et al [4] suggested classification of protection mechanism in classes:

- The first class includes mechanism based on physical virtual memory, which enables isolation of execution codes using hardware. Hardware modifications were not feasible for I-Cluster.
- The second class of solutions is for capacity systems This system, based on examination of datatypes on execution, requires instrumentation of source code Java Runtime Environment may have a sandbox which activates when applets belonging to this class are executed. A capacity system class sandbox enables to natively run windows applications and thus resource sharing bt running I-Cluster application behind. This, class of mechanism requires recompilation so it has been droped.
- The last class of mechanism contains SFI, Software based Fault Isolation mechanism. I-Cluster sandbox is in this class and shares resources of each machine on time basis. At a point of time, the machine will be fully available to its users or fully allocated to I-Cluster tasks.

F. Resource Sniffer :

To look after the hardware capabilities of each node, a software sensor is used with the machines. The Sensor extracts very precise information from the BIOS such as processor(s) number, family, type, speed, size of level-2 and level-3 memory cache, storage capacity also connectivity in terms of networks (Ethernet, wireless modem) and IP parameters. The information thus obtained is made available through the cloud, so that all the characteristics of machine are available and all the allocated machines in the same group or set will be of the same type (homogeneous) as possible.

VIII. APPLICATIONS AND ADVANTAGES

The applications of cloud computing are practically limitless. With the right middleware, a cloud computing system could execute all the programs a normal computer could run. Potentially, everything from generic word processing software to customized computer programs designed for a specific company could work on a cloud computing system.

Benefits of cloud computing:

- Reduced cost: There are a number of reasons to attribute Cloud technology with lower costs. The billing model is pay as per usage; the infrastructure is not purchased thus lowering maintenance.
- Increased storage: With the massive Infrastructure that is offered by Cloud providers today, storage & maintenance of large volumes of data is a reality. Sudden workload spikes are also managed effectively & efficiently, since the cloud can scale dynamically.
- Flexibility: Cloud computing stresses on getting applications to market very quickly, by using the most appropriate building blocks necessary for deployment.

With cloud computing, the action moves to the interface that is, to the interface between service suppliers and multiple groups of service consumers. Cloud services will demand expertise in distributed services, procurement, risk assessment and service negotiation - areas that many enterprises are only modestly equipped to handle.

I-Cluster aims at providing an environment, the Cloud that federates computing resources of all sorts and aggregate idle machines into high-throughput.

Virtual clusters. The main concerns in today's work are:

- The new scale that distributed resources may reach, since a big company's intranet, for instance, may host up tens of thousands nodes distributed worldwide.
- Security issues, since using idle cycles from such a wide pool of resources only can be considered if the normal users do not suffer any damage with their data.

The I-Cluster is a realistic attempt to tackle these issues.

IX. CONCLUSION

Cloud computing, as we have discussed has taken up the role of a very important upcoming paradigm. It is the future of computing. In this paper, we have learned the history and vision behind the surge of cloud computing as the 5th utility. We have presented the need of cloud computing, the futuristic scope of cloud computing and the fundamentals of cloud computing. Through this paper we have tried to show the various reasons why cloud computing will be regarded as the best computing paradigm. Also we have tried to show the various features and basic characteristics of cloud computing as an efficient mean to make well-informed business decisions. The paper has given us a brief understanding of the I-Cluster Cloud as a resource management tool that makes use of different algorithms to allocate sets of idle systems to different tasks to speedily and efficiently perform the required task. The I-Cluster aims at federating computing resources during their idle time in order to dispose of dynamic high-throughput virtual clusters. Thus the cloud is able to manage and use thousands of nodes to run arbitrary jobs on virtual clusters without any interference of normal users. Cloud computing and other related paradigms need to converge so as to produce unified and interoperable platforms for delivering IT services.

REFERENCES

[1] Cloud computing and emerging IT platforms: Vision, hype, and reality for delivering computing as the 5th utility. Rajkumar Buyya, Chee Shin Yeo, Srikumar Venugopal, James Broberg, Ivona Brandic.

[2] The I-Cluster cloud: Distributed management of idle resources for intense computing. Bruno Richard, Nicolas Meillard, Cesar A.F. De Rose, Reynaldo Novaes.

[3] Gossip Algorithms: Design, Analysis, Applications, Stephen Boyd, Arpita Gosh, Balaji Prabhalkar, Devavrat Shah, Information systems laboratory, Stanford University, Stanford.

[4] C.Hawblitzel, T. Von Eichen, A case for language based protection, technical report 98-1670, Cornell University, Department of Computer Science 1998.

[5] Cloud computing- An overview. Torry Harris

[6] Wikipedia :- http://en.wikipedia.org/wiki/Cloud_computing

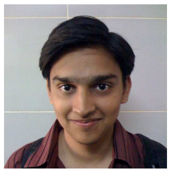
[7] Cloud Computing presentation by Jaiheng LU

[8] Cloud Computing in public Sector, Carolyn Purcell

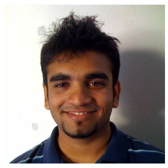
[9] Moving your campus into clouds, Shelton Waggener

Authors:

Jayshree Ghorpade
M.E. [Computer],
Assistant Professor, MAEER'S MITCOE, Pune, India.
8 years of experience in IT and Academics & Research. Area of interest is Image Processing, BioInformatics & NN.



Amit Bawaskar
T.E. [Computer],
MITCOE, Pune, India.
Area of interest is in developing algorithms, networking and softtwares.



Rohan Kasat
T.E. [Computer],
MITCOE, Pune, India.
Area of interest is in artificial intelligence and developing softwares.