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Cloud Computing - A Market Perspective and Research Directions

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Abstract: ***Distributed computing is a quickly creating and great promising innovation. It has stirred the worry of the PC society of entire world. Distributed computing is Web based registering, by which shared data, assets, and programming, are given to terminals and convenient gadgets on-request, similar to the energy framework. Cloud computing is the product of the combination of grid computing, distributed computing, parallel computing, and ubiquitous computing. It aims to build and forecast sophisticated service environment with powerful computing capabilities through an array of relatively low-cost computing entity, and using the advanced deployment models like SaaS (Software as a Service), PaaS (Platform as a Service), IaaS (Infrastructure as a Service), HaaS (Hardware as a Service) to distribute the powerful computing capacity to end-users. This paper will investigate the foundation and administration models and furthermore presents the current examination issues and suggestions in distributed computing like security, unwavering quality, protection, etc.***

Keywords: Cloud, SaaS, PaaS, IaaS, Cloud Computing

1. Introduction

Distributed computing is certainly not another idea; it is begun from the previous enormous scope appropriated processing innovation. In any case, it will be a disruption innovation and distributed computing will be the quick upheaval in the Software engineering and Data Innovation field. Like genuine mists which are the assortment of water atoms, the term 'cloud' in distributed computing is the assortment of organizations. The client can utilize the modalities of distributed computing limitlessly at whatever point requested. Rather than setting up their own actual foundation, the clients conventionally lean toward a go between supplier for the help of the web in distributed computing. Which address the advancement pattern in the IT business from equipment to programming, programming to administrations, and circulated administration to unified help. Distributed computing is likewise another method of business registering is virtualization. The core concept of cloud computing is reducing the processing burden on the users. All we need to have a web browser to use cloud computing.

Cloud computing is the combination of many pre-existing technologies that have matured at different rates and in different contexts. The objective of distributed computing is to permit clients to take benefit from this large number of advancements. Numerous associations are moving into cloud since it permits the clients to store their information on mists and can access at whenever from anyplace. Information breaking is conceivable in cloud climate, since information from different clients and business associations lie together in cloud. By sending the information to the cloud, the information proprietors move the control of their information to a third individual that might raise security issues.

2. Cloud Storage

Cloud storage is one of the primary use of cloud computing. We can define cloud storage as storage of the data online in the cloud. A cloud storage system is considered as a distributed data centers, which typically use cloud-computing technologies and offers some kind of interface for storing and accessing data. When storing data on cloud, it appears as if the data is stored in a particular place with specific name.

There are four primary sorts of distributed storage:

Personal Cloud Storage: It is also known as mobile cloud storage. In this type storage, individual's data is stored in the cloud, and he/she may access the data from anywhere.

Public Cloud Storage: In Public cloud storage the enterprise and storage service provider are separate and there aren't any cloud resources stored in the enterprise's data centre. The cloud storage provider fully manages the enterprise's public cloud storage.

Private Cloud Storage: In Private Cloud Storage the enterprise and cloud storage provider are integrated in the enterprise's data centre. In private cloud storage, the storage provider has infrastructure in the enterprise's data centre that is typically managed by the storage provider. Private cloud storage helps resolve the potential for security and performance concerns while still offering the advantages of cloud storage.

Hybrid cloud storage: It is a combination of public and private cloud storage where some critical data resides in the enterprise's private cloud while other data is stored and accessible from a public cloud storage provider.

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Figure 1: Network of Cloud

3. Architectural Components

Cloud administration models are regularly isolated into SaaS, PaaS, IaaS and DaaS that displayed by a given cloud framework. It's useful to add more construction to the assistance model stacks:

Fig. 2 shows a cloud reference design [13] that makes the main security-significant cloud parts express and gives a theoretical outline of distributed computing for security issue examination.

Software as a Service (SaaS)
Cloud customers discharge their applications in a facilitating climate, which can be gotten to through networks from different clients (for example Internet browser, PDA, and so on) by application clients. Cloud consumers do not have control over the cloud infrastructure that often employs multi-tenancy system architecture, namely, different cloud consumers' applications are organized in a single logical environment in the SaaS Cloud to achieve economies of scale and optimization in terms of speed, security, availability, disaster recovery and maintenance. Examples of SaaS include SalesForce.com, Google Mail, Google Docs, and so forth.

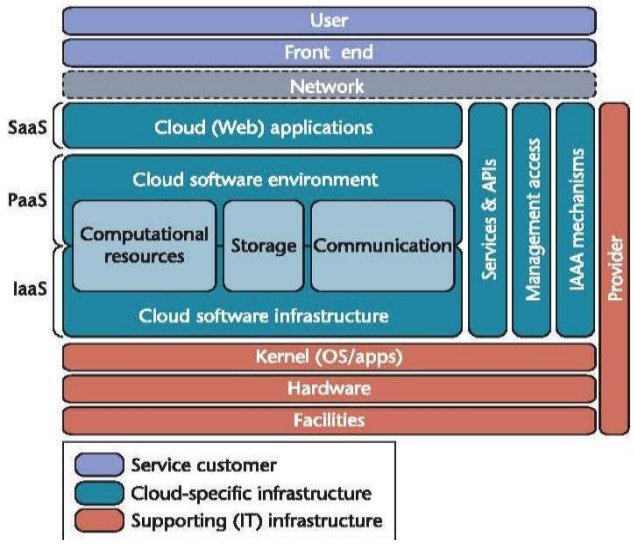

Figure 2: The Cloud Reference Architecture

Platform as a Service (PaaS)
PaaS is a development platform supporting the full "Software Lifecycle" which allows cloud consumers to develop cloud services and applications (e.g. SaaS) directly on the PaaS cloud. Hence, the difference between SaaS and PaaS is that SaaS only hosts completed cloud applications whereas PaaS offers a development platform that hosts both completed and in-progress cloud applications. This requires PaaS, in addition to supporting application hosting environment, to possess development infrastructure including programming environment, tools, configuration management, and so forth. An example of PaaS is Google AppEngine.

Infrastructure as a Service (IaaS)
Cloud consumers directly use IT infrastructures (processing, storage, networks and other fundamental computing resources) provided in the IaaS cloud. Virtualization is extensively used in IaaS cloud in order to integrate/ decompose physical resources in an ad-hoc manner to meet growing or shrinking resource demand from cloud consumers. The basic strategy of virtualization is to set up independent virtual machines (VM) that are isolated from both the underlying hardware and other VMs. Notice that this strategy is different from the multi-tenancy model, which aims to transform the application software architecture so that multiple instances (from multiple cloud consumers) can run on a single application (i.e. the same logic machine). An example of IaaS is Amazon's EC2.

Data as a Service (DaaS)
The delivery of virtualized storage on demand becomes a separate Cloud service - data storage service. Notice that DaaS could be seen as a special type IaaS. The motivation is that on-premise enterprise database systems are often tied in a prohibitive upfront cost in dedicated server, software license, post-delivery services and in-house IT maintenance. DaaS allows consumers to pay for what they are actually using rather than the site license for the entire database. In addition to traditional storage interfaces such as RDBMS and file systems, some DaaS offerings provide table-style abstractions that are designed to scale out to store and retrieve a huge amount of data within a very compressed timeframe, often too large, too expensive or too slow for most commercial RDBMS to cope with. Examples of this kind of DaaS include Amazon S3, Google BigTable, and Apache HBase, etc.

Evolution of Cloud Computing
One day in a speech at MIT around in 1960 John McCarthy indicated that like water and electricity, computing can also be sold like a utility. And in 1999, the Sales force Company started distributing the applications to the customer through a convenient website [3]. Amazon Web Services were started by Amazon in 2002 and they were providing the services of storage and computation.

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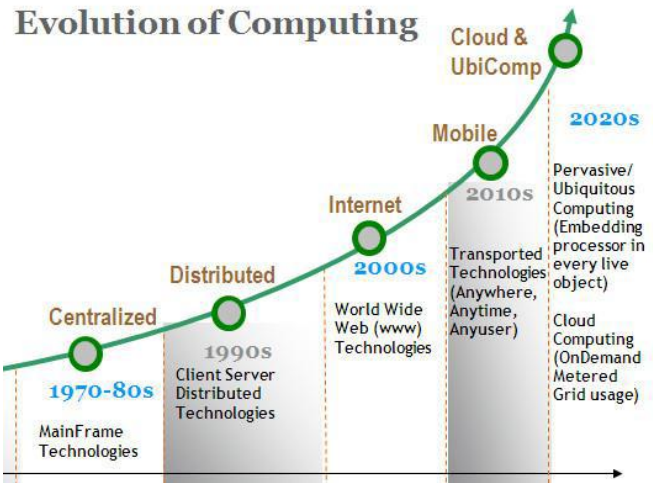

Figure 3: Evolution of Cloud Computing

In around 2009 big companies like Google, Microsoft, HP, Oracle had started to provide cloud computing services [4]. Nowadays each and every person is using the services of cloud computing in their daily life. For example Google Photos, Google Drive, and iCloud etc. In future cloud computing will become the basic need of IT Industries.

4. Cloud Computing Features

Distributed computing brings a variety of new elements and benefits contrasted with some other registering ideal models. There are momentarily depicted in this segment. **Scalability and On-Demand Services**: - Cloud computing provides resources and services for users on demand. The resources are scalable over several data centers.

Quality of Service (QoS): Cloud computing can guarantee QoS for users in terms of hardware or CPU performance, bandwidth, and memory capacity.

User-Centric Interface: Cloud interfaces are location independent and they can be accessed by well established interfaces such as Web services and Web browsers.

Autonomous System: Cloud computing systems are autonomous systems managed transparently to users. However, software and data inside clouds can be automatically reconfigured and consolidated to a simple platform depending on user's needs.

Pricing: Cloud computing does not require upfront investment. No capital expenditure is required. Users may pay and use or pay for services and capacity as they need them.

Security and Privacy Issues in Data Storage in cloud computing

Distributed computing permits the clients to store their information on the capacity area kept up with by an outsider. Once the data is uploaded into the cloud the user loses its control over the data and the data can be tampered by the attackers. The attacker may be an internal (CSP) or external. Unauthorized access is also a common practice due to weak access control. The protection of information arises the following challenges:

The security and privacy issues related to data storage are confidentiality, integrity and availability.

Confidentiality: - The major dispute in cloud computing is confidentiality. Data confidentiality means accessing the data only by authorized users and is strongly related to authentication. In another way confidentiality means keeping users data secret in the cloud systems. As we are storing the data on a remote server and transferring the control over the data to the provider here arises the questions such as:

For ensuring confidentiality, cryptographic encryption algorithms and strong authentication mechanisms can be used. Encryption is the process of converting the data into a form called cipher text that can be understood only by the authorized users. Encryption is an efficient technique for protecting the data but have the obstacle that data will be lost once the encryption key is stealed. Algorithms Blowfish is a fat and simple encryption algorithm.

It is a time consuming process and thus searchable encryption was introduced. Searchable encryption allows build an index for the file containing the keywords and is encrypted and stored along with the file, so that while searching the data only the keywords are decrypted rather than the entire file and search is made on it.

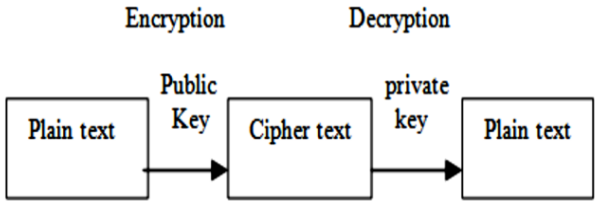

Figure 4: Asymmetric Encryption

Integrity

Another serious problem faced by cloud computing is integrity. Integrity of data means to make sure that the data has not been changed by an unauthorized person or in an unauthorized way. It is a method for ensuring that the data is real, accurate and safeguarded from unauthorized users. As cloud computing supports resource sharing, there is a possibility of data being corrupted by unauthorized users. Digital Signatures can be used for preserving the integrity of data. The simple way for providing integrity is using Message Authentication Code (MAC).

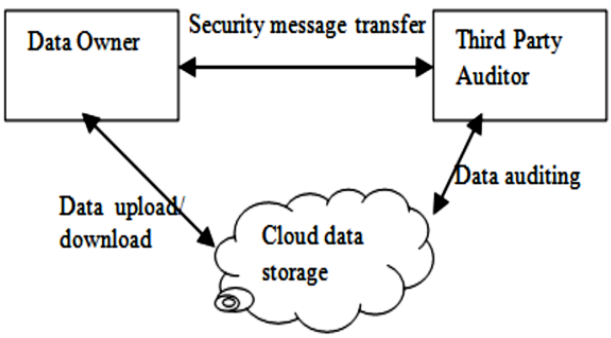

Figure 5: Remote Auditing Mechanism

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Availability: Availability refers to being available and accessible to authorized users on demand. The aim of availability in cloud computing systems is to ensure that its users can use them at any place and at any time

5. Characteristic of Cloud Computing

There are five characteristics of cloud computing. The first one is on-demand self-service, where a consumer of services is provided the needed resources without human intervention and interaction with cloud provider. The second characteristic is broad network access, which means resources can be accessed from anywhere through a standard mechanism by thin or thick client platforms such mobile phone, laptop, and desktop computer. Resource pooling is another characteristic, which means the resources are pooled in order for multi-tenants to share the resources. In the multi-tenant model, resources are assigned dynamically to a consumer and after the consumer finishes it, it can be assigned to another one to respond to high resource demand. Even if the resources are assigned to customers on demand, they do not know the location of these assigned resources.

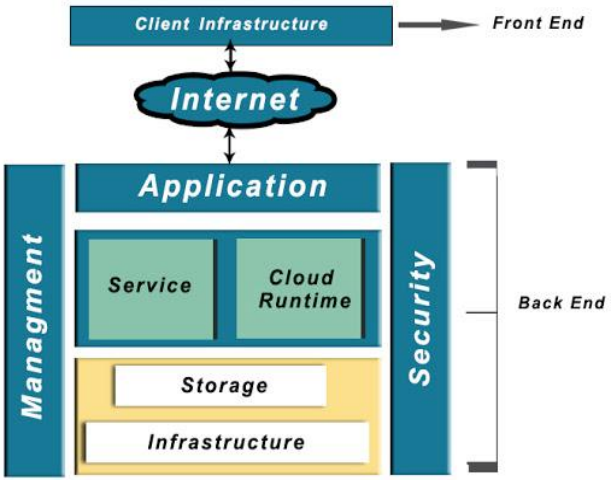

Figure 6: Cloud environment architecture

Sometimes they know the location at a high-level abstraction, such as country, state, and data centre. Storage, processing, memory, and network are the kind of resources that are assigned. Rapid elasticity is another characteristic, which means that resources are dynamically increased when needed and decreased when there is no need. Also, one of characteristics that a consumer needs is measured service in order to know how much is consumed.

6. Encrypted Data Storage for Cloud

Since data in the cloud is placed anywhere, it is important that the data be encrypted. We are using secure co-processor as part of the cloud infrastructure to enable efficient encrypted storage of sensitive data. By embedding a secure co-processor (SCP) into the cloud infrastructure, the system can handle encrypted data efficiently. Parts of the proposed instrument (see Figure 2). Basically, SCP is a tamper-resistant hardware capable of limited general-purpose computation. For example, IBM 4758 Cryptographic Coprocessor (IBM) is a single-board computer consisting of a CPU, memory and special-purpose cryptographic hardware contained in a tamper-resistant shell, certified to level 4 under FIPS.

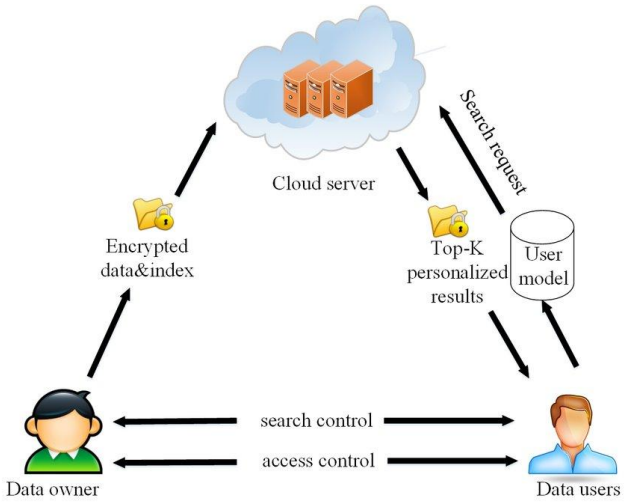

Figure 7: Encrypted Cloud Computing

When installed on the server, it is capable of performing local computations that are completely hidden from the server. If tampering is detected, then the secure co-processor clears the internal memory. Since the secure coprocessor is tamper-resistant, one could be tempted to run the entire sensitive data storage server on the secure coprocessor. Pushing the entire data storage functionality into a secure co-processor is not feasible due to many reasons.

First of all, due to the tamper-resistant shell, secure co-processors have usually limited memory (only a few megabytes of RAM and a few kilobytes of non-volatile memory) and computational power (Smith, 1999). Performance will improve over time, but problems such as heat dissipation/power use (which must be controlled to avoid disclosing processing) will force a gap between general purposes and secure computing. Another issue is that the software running on the SCP must be totally trusted and verified. This security requirement implies that the software running on the SCP should be kept as simple as possible. We can encrypt the sensitive data sets using random private keys and to alleviate the risk of key disclosure, we can use tamper-resistant hardware to store some of the encryption/decryption keys (i.e., a master key that encrypts all other keys).

7. Types of Cloud Computing

Public Cloud: In this model, computing resources are dynamically provisioned over the Internet via Web applications or Web services from trusted third party provider. Public clouds are run by third parties, and applications from different customers are likely to be mixed together on the cloud's servers, storage systems, and networks.

These services are available for any user who wants to use them and they have to pay only for the services they consumed.

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Private Cloud: In the private cloud deployment, computing resources are used and controlled by a private enterprise. It is generally deployed in the enterprises data center and managed by internal personnel or service provider. The main advantage of this model is that the security, compliance, and QoS are under the control of the enterprises the computing services provided over the internet or private network come under the private cloud and these services are offered only to the selected users in place of common people. A higher security and privacy is delegated by private clouds through the firewall and internal hosting.

Hybrid Cloud: - The Hybrid Cloud environment intersects and combines multiple Public and private cloud models. It enables the enterprise applications to running state-steady workload in the private cloud, and requesting the public cloud for intensive computing resources when peak workload occurs. Hybrid clouds introduce the complexity of determining how to distribute applications across both a public and private cloud. Hybrid cloud is the combination of public cloud and private cloud.

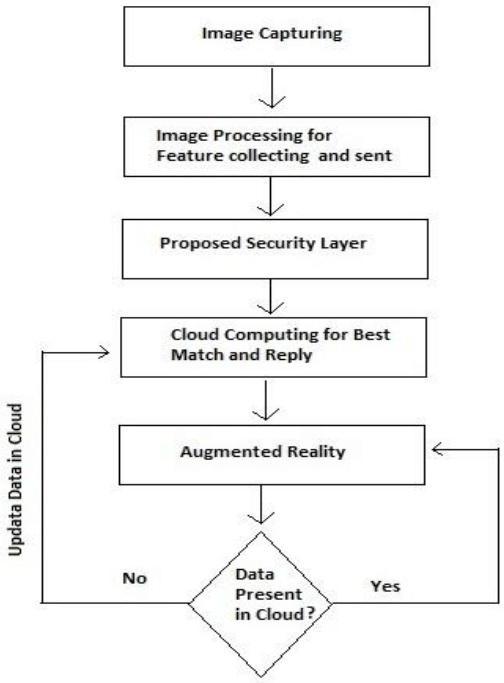

Figure 8: Flow chart of Cloud Computing

8. Components of Cloud Computing

Cloud computing has three basic components as follows-

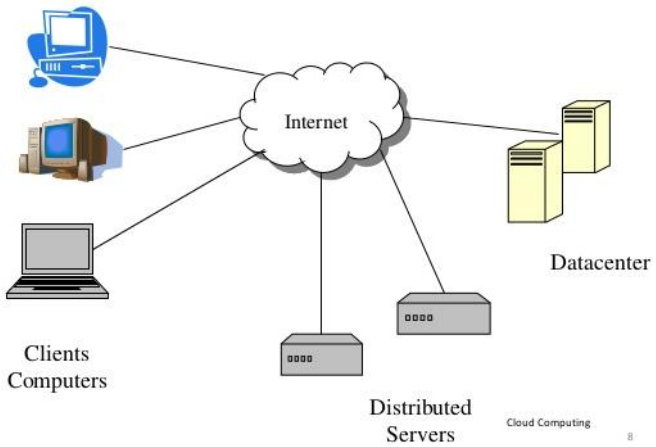

Figure 9: Components of Cloud Computing

Client Computers: Clients on cloud computing architecture are said to be the exact same things that are plain, old, everyday local area networks (LANs). They are, typically, the computers that just sit on your desk. But they might also be laptops, tablet computers, mobile phones, or PDAs - all big drivers for cloud computing because of their mobility. Clients are interacting with to manage their information on the cloud.

Distributed Servers: is a server placement in a different location. But the servers don't have to be housed in the same location. Often, servers are in geographically disparate locations. But to you, the cloud subscribers, these servers act as if they're humming away right next to each other.

Data Centers: Datacenter is collection of servers where the application to which you subscribe is housed. It could be a large room in the basement of your building full of servers on the other side of the world that you access via the Internet. A growing trend in the IT world is virtualizing servers. That is, software can be installed allowing multiple instances of virtual servers to be used. In this way, you can have half a dozen virtual servers running on one physical server.

9. Services of Cloud Computing

Software as a Service (SaaS):- The way of carrying application as a service on the internet is known as software as a service. In place of installing the software on his computer, the user can simply access it via the internet [5]. It makes the user free from managing the complex software and hardware. The SaaS users do not need to buy software or hardware, maintain, and update. The only thing user must have an internet connection and then access to the application is very easy. Example, Microsoft Office 365, Google Apps etc.

Platform as a Service (PaaS):- A development environment or platform is given to the consumers as a service in PaaS, upon which user can deploy their own software and coding. The customer has the liberty to construct his own applications that can run on the provider's infrastructure [5]. Product as service providers offers a predefined composition of operating system and application server to obtain the management capacity of the applications.

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For example, LAMP (Linux, Apache, MySQL, and PHP), J2EE, Ruby etc.

Infrastructure as a Service (IaaS):- Many computing resources are provided by the IaaS in the form of storage, network, operating system, hardware, and storage devices on demand. IaaS users can access the services using a wide area network, such as the internet [5]. For example, a user can create virtual machines by login to the IaaS platform.

10. Comparision Between Cloud and Grid Computing

A comparison can be summaries as follows:-

1) Construction of the grid is to complete a specified task, such as biology grid, Geography grid, national educational grid, while Cloud computing is designed to meet general application and there are not grid for a special field.
2) Grid emphasizes the "resource sharing" to form a virtual organization. Cloud is often owned by a single physical organization (except the community Cloud, in this case, it is owned by the community), who allocates resources to different running instances.
3) Grid aims to provide the maximum computing capacity for a huge task through resource sharing. Cloud aims to suffice as many small-to-medium tasks as possible based on users' real-time requirements. Therefore, multi-tenancy is a very important concept for Cloud computing.
4) Grid trades re-usability for (scientific) high performance computing. Cloud computing is directly pulled by immediate user needs driven by various business requirements.
5) Grid strives to achieve maximum computing. Cloud is after on-demand computing – Scale up and down, in and out at the same time optimizing the overall computing capacity.

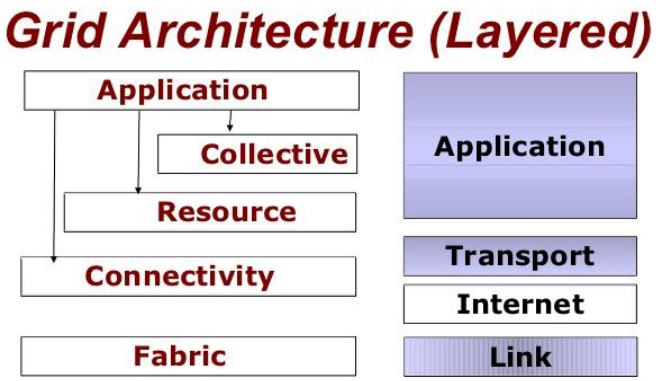

Figure 10: Grid computing architecture

11. Issues in Cloud Computing

More and more information on individuals and companies is placed in the cloud; concerns are beginning to grow about just how safe an environment it is? Issues of cloud computing [3] can summarize as follows:

Privacy:
Cloud computing utilizes the virtual computing technology, users' personal data may be scattered in various virtual data centers rather than stay in the same physical location, users may leak hidden information when they are accessed cloud computing services. Attackers can analyze the critical task depend on the computing task submitted by the users.

Reliability:
The cloud servers also experience downtimes and slowdowns as our local server.

Legal Issues:
Worries stick with safety measures and confidentiality of individual all the way through legislative levels.

Compliance:
Numerous regulations pertain to the storage and use of data requires regular reporting and audit trails. In addition to the requirements to which customers are subject, the data centers maintained by cloud providers may also be subject to compliance requirements.

Freedom:
Cloud computing does not allow users to physically possess the storage of the data, leaving the data storage and control in the hands of cloud providers.

12. Conclusion

In this survey paper we depicted in short the presentation, development, types and parts of distributed computing and furthermore various administrations of distributed computing and a portion of its benefits. Cloud computing is the newest technology that is becoming very popular now-a-days. This is a developing technology due to its applications in various fields like testing & development, big data analytics, file storage etc. Cloud Computing and their services are new but many new organizations are implementing the cloud services but there is always a risk of data breaching. The application area of distributed computing will ceaselessly be expanding. Today around all little and enormous ventures are utilizing distributed computing to oversee capacity, traffic, equipment prerequisites. In this way, obviously there is significant effect of distributed computing on society and business.

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