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RESEARCH STUDY OF DISTRIBUTED COMPUTING WITH EMERGING PARADIGM FOR GRID COMPUTING, UTILITIES AND CLOUD COMPUTING

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ABSTRACT

A distributed system is a group of cooperating computers. In the past decades, the use of distributed systems has increased popularly in high performance computing. Such systems have several advantages over a single processor system, like as improved performance, faster in speed and increased fault tolerance. Nowadays, it is practical to design computer systems with enormous processing capacities by interconnecting a number of computers over a network. Term 'Distributed Computing' has gained a lot of importance, as they are used to elaborate new paradigms, for the management of information and computing resources. Distributed computing is the type of computing, that implement geographically and administratively separated resources. In distributed computing, individual users can access computers and data transparently, without having to consider location, operating system, account administration, computing resources and other details. In distributed computing, the details of computing are abstracted, and the resources are virtualized. In this paper, we presented this concept, its characteristics and also its architecture.

KEYWORDS: Distributed Computing, Cloud Computing, Grid Computing, Distributed Architecture & Network Models

INTRODUCTION

In the last decades, variation in microelectronic technology, provided us the products with the availability of fast, inexpensive processors, and also latest techniques of communication technology have given us cost effective and highly efficient computer networks. The overall result of changes in these two technologies is that, we can use highly interconnected, multiple processors behalf of a single, high-speed processor.

Computer architectures are basically divided into two types:

- Tightly coupled systems: In such architecture, there is a single system having a primary address space (memory), which is shared by all available processors [Fig. 1 (a)] present there. If any of the processor writes any value at address, for example, the value 20 in a memory location, any other processor subsequently reading from locations will get the modified value 20. Therefore, in these systems, the communication between the processors usually takes place, via shared memory.
- Loosely coupled systems: In this type of computational device, there is no shared memory, and each processor has its own local memory [Fig. 1 (b)]. The physical communication between all processors takes place through various methods of message passing. If a processor writes the value 20 to the memory locations, this write operation will modify only the contents of its local memory and will not update the contents of the main memory.

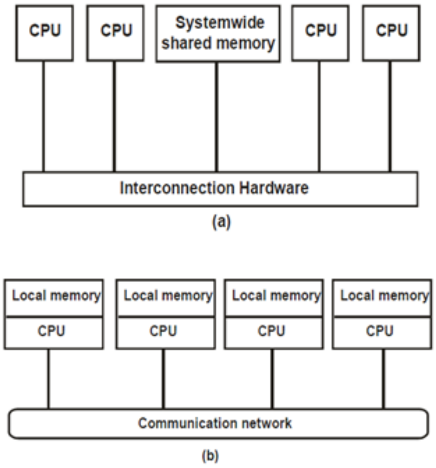


Figure (A): A Tightly Coupled Multiprocessor System; (B) A Loosely Coupled Multiprocessor System

Differences Between Tightly Coupled Multiprocessor System and Loosely Coupled Systems

- Tightly coupled systems are also referred as parallel processing systems, and loosely coupled systems are called as distributed systems.
- In contrast with the tightly coupled systems, the loosely coupled distributed system's processor can be located at a large distance over a wider geographical area.
- In Tightly coupled systems, the number of processors that can be usefully deployed is usually small and limited by the bandwidth of the shared memory. But, distributed computing systems are more freely expandable and can have an almost unlimited number of processors [2].
- In distributed computing system, a processor with own local resources, whereas processors have their remote resources globally connected over the network. Together, a processor and a collection of all local resources are called a node or site in the network.
- In the distributed computing system, the communication between processors takes place by message passing techniques over the communication network. Whereas, in parallel systems, communication takes place through shared memory or other shared resources.

This paper describes the advent of new forms of such loosely coupled systems as distributed computing, notably grid and cloud computing, the applications that they enable over the network [1], and their useful impact on future standardization.

The idea of sharing resources is not new but older and is implemented in past history where not only improvements done in computer component technology, but also in communication protocols paved the way for distributed computing. As we look behind networks based on Systems Network Architecture (SNA), created by IBM in 1974, and on ITU-T's X.25 [3], approved in March 1976, enabled large-scale public and private data networks. These were gradually replaced by more efficient or less complex protocols as per the suitability, with TCP/IP protocol. Broadband networks are also which extended the geographical reach of distributed computing, as the client-server relationship can be extended across borders and continents across the world. There are a variety of new schemes and terms related to distributed computing, which is introduced, intended to deliver better IT service to the users. While experts are not agreed on the precise boundaries in such new computing models as per requirements, the following table provides a rough taxonomy of the services and other features of these paradigms.

Table 1: Computing Paradigm

New Computing Paradigms	**New Services**	**New or enhanced Features**
Cloud computing Edge computing Grid computing Utility computing	Software as a Service (SaaS) Infrastructure as a Service (IaaS) Platform as a Service (PaaS) Service-Oriented Architecture (SOA)	Ubiquitous access Reliability Scalability Virtualization Exchangeability/Location independence Cost-effectiveness

DISTRIBUTED SYSTEM ARCHITECTURE

Distributed systems are built up on top of existing networks and operating systems software. To become an autonomous system, there exists a clear master/slave association between two computers in the network. The middleware distribution enables computers to coordinate their activities and to share the resources of the system, so that users perceive the system as a single, integrated computing facility.

Some of present middleware are for multimedia, real time computing, telecom, eCommerce, adaptive / ubiquitous systems. Thus, mask heterogeneity with middleware which act as a bridge which connects applications across dissimilar physical locations, with different hardware platforms, operating systems, network terminologies and programming languages for code generation. With, this software mask separation of the platform components, this was developed with agreed standards, platform and dimensions which provide special services like as naming, concurrency control and persistence's to confirm that accurate results are produced as fast as possible. The middleware service implements communication and sharing of resources that extends over multiple machines.

Figure 2 shows a simple architecture of a distributed system:

The whole system is composed of two layers as user layer and physical layer. The middleware separates both the components of layers and provide an interface like API which binds the application and resources or those applications.

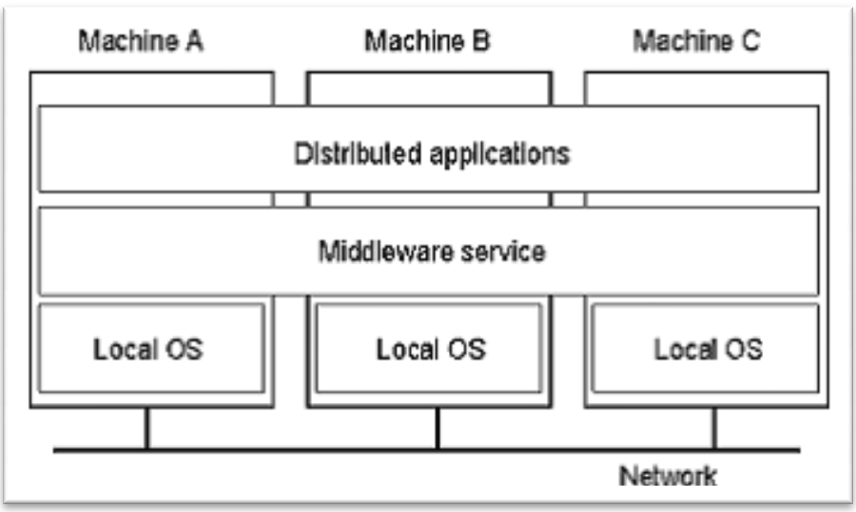


Figure 1: Distributed System

The logical model or logical layer is the view that an application has of the system. It contains a set of concurrent processes and communication channels between them.

Physical layer constitutes various local resources on a node and those nodes are interconnected through various application oriented approaches. A system is synchronous if it performs intended operation all the time in a fixed time, otherwise it is asynchronous. The failure can be noticed in a synchronous system by a lack of response from the system. Therefore, timeout oriented techniques are implemented for failure discovery.

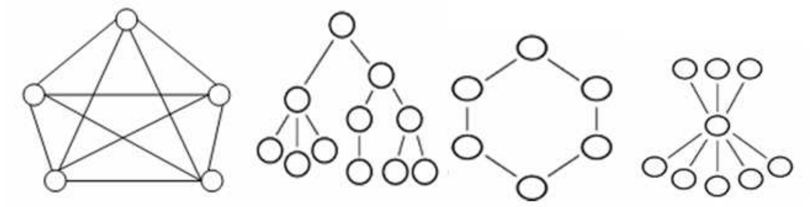
Types of Network Models

- Fully connected network
- Tree structured network
- Ring structured network
- Star network

A distributed system can be constructed, with the help of fully connected networks or partially connected networks. This type of network is said to be reliable because, when a few computers or links fail, the rest of the computers can still communicate with others. A partial connected network in which direct links exist between some but not all, pairs of computers. An example of the partially connected network models is star structured networks, multi-access bus networks; ring structured networks, and tree-structured networks (figure 3). The issue in such system is that, when the central node fails, the entire system will be collapsed.

In Tree structured network, there is one root node, which is further connected in hierarchical with two children nodes and so on. In such systems, only messages transmitted between a parent node and its child node go though one link, other messages transmitted between two nodes have to go through one or more intermediate nodes. The problem of this type of network is, if the root node fails, then whole network stop working at all. Each node in the network having some fixed number of nodes, which are associated with it at the next lower level in the hierarchy. The scalability of the tree-structured network is better than that of the fully connected network, as new node can be added, as the child node of the leaf nodes or the interior nodes.

In a ring network, each node connects to exactly two other nodes, forming a single continuous pathway for signals, through each node like a ring. As new nodes are added, the diameter of the system grows as the number of nodes in the system, resulting in a longer message transmission delay. A node failure or cable break might isolate every node attached to the ring.



Fully Connected Network Tree Structured Network Ring Structured Network Star Structured Network

TYPES OF DISTRIBUTED SYSTEM

Shared Resources

The distributed system provides transparency and efficiency in utilizing various resources to accomplish targets of the organization or firm. The resources that can be shared in grids, clouds and other distributed computing systems include:

- Communication capacity
- Operating systems
- Software and licenses
- Computational power
- Storage devices
- Tasks and applications
- Services
- Virtual memory

Now discussion focuses on types of distributed systems as follows:

GRID COMPUTING

Grids are very large-scale virtualized, distributed computing systems. They cover multiple administrative domains and enable virtual organizations. Such organizations can share their resources collectively to create an even larger grid. Grid computing enables the sharing, selection, and aggregation of users of a wide variety of geographically distributed resources owned by different organizations and is well-suited for solving IT resource-intensive problems in science, engineering and commerce. Grid technology has emerged in the scientific and academic communities and entered the commercial world. The world's largest company and banking group HSBC use a grid with more than 3,500 CPUs operating in, its data centres in four countries, to carry out derivative trades, which rely on making numerous calculations, based on future events, and risk analysis by calculating risks based on available information [13]. UNOSAT is a humanitarian initiative to deliver satellite solutions as developed organizations within and outside the UN system for crisis response, early recovery and vulnerability reduction. UNOSAT uses the grid computing to convert uncompressed satellite images into JPEG2000 ECW18 files [6].

For instance, Grid computing is implemented by combining 80,000 CPU cores, which are shared within EGEE (Enabling Grids for E-science), as one of the largest infrastructure in the world. This technology brings together more than 10,000 users in 140 institutions (300 sites in 50 countries) to produce a reliable and scalable computing resource to the European and global research community High-energy physics (HEP) is one of the other pilot application domains in EGEE, which is the largest user application of the grid infrastructure. The CERN grid is also used to support research communities outside the field of HEP. The four Large Hadron Collider (LHC) experiments at CERN, Europe's central organization for nuclear research, have a large production, which involves more than 150,000 daily jobs given to the EGEE infrastructure and produced hundreds of terabytes of data per year, in computation. This is all done in collaboration with the Open Science Grid (OSG) project, in the USA and the Nordic Data Grid Facility (NDGF) [14].

n volunteer computing, individuals donate unused or idle resources of their computers to distributed computing projects such as Folding@home, SETI@home, and LHC@home. The resources of thousands of PCs are organized, with the help of middleware systems in volunteer computing. The Berkeley Open Infrastructure for Network Computing (BOINC) is one of the most widely-used middleware, in volunteer computing made available to researchers and their projects.

In 2006, the ITU-R Regional Radio Conference (RRC06) introduced a new frequency plan for digital broadcasting in the VHF (Very high frequency) (174-230MHz) and UHF (Ultra High Frequency) (470-862MHz) bands. The complex calculations required non-trivial dependable computing capability. The tight schedule at the RRC06, with stringent time constraints in performing a full set of calculations, less than 12 hours for an estimate of 1000 CPU/hours on a 3 GHz PC) [3].

The German shipyard FSG uses high performance computing resources to solve complex and CPU-intensive calculations to create individual ship designs in a short time. By increasing the availability of computing resources and motivating to integrate data, grid computing enables organizations to solve problems that were previously too large or too complex for them to handle alone. Other commercial applications of grid computing can be found in large logistics, engineering, pharmaceuticals and the ICT secto r [14].

UTILITY COMPUTING

The shift of using grids for non-commercial, scientific applications to processing-intensive commercial applications led to use distributed systems for less challenging and resource-demanding tasks. Utility computing relies on the principle of consolidation, in which physical resources are shared by many applications and users. The concept of utility computing is simple: rather than operating servers in-house, organizations preferred an external utility computing service provider and pay only for the hardware and software resources they use. The principal of available resources used, but are not limited to, virtual computing environments which are paid per hour and data transfer, and storage capacity (paid per GB or TB used).

Utility computing allows companies to pay only for the computing resources when they require them. It creates markets for resource owners who need to sell excess capacities, and make their data centres (and business) more profitable. It is supposed that in-house data centre remains idle most of the time due to over-provisioning. Over-provisioning is essential as it can handle peak loads and also include unanticipated surges in demand. One of the best examples of online retailer Amazon was mentioned to increase efficiency; one server can host, in addition to a system managing the company’s e-commerce services, other many isolated computing environments used by its customers. These virtual machines are specified as software implementations of ‘real’ computers, which can be customized according to the customers’ needs: storage capacity, processing power, operating system (e.g., Linux, MS Windows), and software as system or application software [8]. However, in many cases it proves useful to employ data centres close enough to the customer, for example to ensure low rates of latency and packet loss in content delivery applications at a particular place.

Thus, we can say utilities have provided through the computing environment is basically corresponding to the service providers. For instance, some content delivery providers such as Akamai or Limelight Networks built their own networks of data centres around the globe, and interconnect them with high-speed fibre optic backbones, over the geographical area. These are directly connected to user access networks, in order to deliver services to a large number of users simultaneously, while minimizing the cost of a path between the user and the desired content.

CLOUD COMPUTING

For small and medium-sized enterprises, IT services and applications not only offers the potential to reduce overall costs, but also lower the barriers to entry in many processing-intensive activities market, as it eliminates the necessity of capital investment and maintaining useful infrastructure. Over the years, technology and Internet companies such as Google, Amazon, Microsoft and others, have gained a competitive growth and acquired a considerable expertise in operating large data centres, which are said to be the backbone of their businesses. Their know-how extends beyond physical infrastructure and includes experience with software, e.g., office suites, applications for process management, resource management and business intelligence, and best practices in a range of domains, like as internet search, maps; attach files, email and other communications applications.

Cloud providers gain an additional source of revenue through such schemes and also able to commercialize their expertise in managing large data centres. In cloud computing, these services are hosted by the data centre and commercialized, such that a wide range of software applications is offered as a billable service (Software as a Service, SaaS), by the provider and no longer need to be installed on the user's own PC. For example, instead of Outlook stored on the PC hard drive, Gmail offers a similar service using drive but the data is stored on the providers' servers and accessed via a web browser instead of saving that on the user's PC.

Even some large companies have preferred cloud computing solutions with the growing capacities, capabilities and success of its service providers. Another approach is to outsource certain tasks to the cloud, e.g., spam and virus filtering, and to keep other tasks in the corporate data centre, e.g., the storage of the mailbox [12]. Forrester Research suggests that cloud-based email solutions would be less expensive than on-premise solutions for up to 15,000 email accounts.

One main assumption in cloud computing is that it consists of infinite computing resources which are available on demand and delivered through broadband. Low-cost computing devices which are equipped with free and open source software may provide a solution for the hardware and software problem. However, that is not always the case as Problems including such as high cost of software and hardware, security issues, a poor power infrastructure, and limited access to broadband. Although the Internet subscribers have grown rapidly worldwide, developed economies still dominate subscriptions, and it is penetrating a wide gap between developed and developing countries. Internet users with or without broadband access are disadvantaged as without broadband systems they are unable to use certain applications, e.g., video conferencing, video and audio streaming, online backup of photos and other useful data.

Ubiquitous and unmetered or we can say fast access to broadband Internet is one of the most important requirements for the success of cloud computing technique. Applications available in the cloud include software suites, which were traditionally installed on the desktop and can now be operated over the cloud, can be accessible via a web browser (e.g., for word processing, messaging, business intelligence applications, communication, email, or customer relationship management). This paradigm excludes license fees, costs for maintenance and cost of software updating in a few cases which makes it attractive in small business firms and individuals.

Utility and Cloud Providers

The list of service providers of utility and cloud computing services is growing rapidly. Beside of many small providers which are specialized in cloud and grid services, like as Google App Engine, Oracle Database Cloud Service, Amazon Web Service, Right Scale, 3tera, and Morph Labs, are a few of the known names in web and enterprise computing. CRM solutions which include applications for sales, purchase, service and support, business outcomes and marketing is done by some of the providers like Salesforce.com. The AWS product range includes an EC2 (Elastic Compute Cloud), a web service which provides computing capacity and S3 (Simple Storage Service), a scalable storage for the Internet in the cloud, that can be used to store and retrieve any type of data, at any time, from anywhere residing on the web. Cloud service providers also bring their massive economies of scale in the areas of technology procurement and IT security; systems have their other core activities also in the areas like online retailer, Internet search engine and other software are discussed here:

- Google App Engine is a search engine platform for building and hosting web applications on infrastructure operated by Google. The service is currently in preview phase, that allows developers to sign up for free in the account and use up to 500MB of persistent storage, bandwidth and CPU for about 5 million page views in a month.
- Amazon Web Services (AWS) provide solutions of all sized infrastructure platform in the cloud, which includes computational power, mapping, storage, recommendations about search, and other infrastructure services.
- Salesforce.com is one of the vendors of Customer Relationship Management (CRM) solutions, which delivers the software as a service model. It is a Platform-as-a-Service product of the same vendor which allows facility for external developers for creating add-on applications and integrates the CRM applications and hosts them on the vendor's infrastructure.
- Cloud computing with Microsoft Azure: Services Platform (Azure) is a cloud service platform hosted in Microsoft data centres, which provides an operating system and a set of services for developers that can be implemented individually or together.

FUTURE WORK

Today's services include both proprietary and open source solutions. Many of them provide their own APIs (application programming interfaces) that improve interoperability by allowing users to adapt their code and applications according to the requirements of the service. However, the APIs are essentially proprietary and have not been subject of standardization, which means that users cannot easily extract their data and code from one site to run on another. Furthermore, standardized solutions for automation, monitoring, provisioning and configuration of cloud and grid applications need to be found, in order to provide interoperability. Users may want to employ infrastructure and services from different providers at the same time. Parallel computing can be added as a new feature between the current state of distributed computing and the early days of networking as an enhancement in the available methods of computation: independent islands of systems with some changes as per interoperability, only few standards and proprietary management interfaces:

"The problem is that there's no standard way to move things around like connecting and mapping output with the results. This is the biggest hurdle in cloud computing at present as how can we create an open environment between clouds, so that large data reside in my cloud and some things in other people's data centre? A lot of work needs to be done." Padmasree Warrior, CTO, Cisco.

Web Information Retrieval in WWW

WWW is the best example of a distributed system, which provides solution for the user's query to search anything over Google. The World Wide Web helps to select a solution of required result among a large amount of data available over the web. Web information retrieval is the process of searching the world's largest and linked document collection – the World Wide Web, for information most relevant to a user's query. Information retrieval in www faces a lot of challenges during searching of desired results. The various challenges of information retrieval on the web are:

- Data is distributed - data spans over many computers, of a variety of platforms and is not easy to filter the desired solution.
- Data is volatile - computers and files are added and removed frequently and unpredictably and sometimes it is difficult to get information exactly what is required.
- The data quality is inconsistent - data may be false, error-ridden, invalid, outdated, and ambiguous and multiplicity of sources introduces inconsistency and failure to get exact solution.
- Heterogeneous data - multiple media types and media formats and multiple languages and alphabets which is not known by all the users.
- Volume of data is very huge – growth continues exponentially, which results amount of results for the retrieved information.

As a result, it would be physically unfeasible for an individual to sift through and examine all these pages to find the required information. For the information retrieval in order to search for information on the internet a software tool called Search Engine issued. The basic working of a search engine is described in figure 4 where indexing and crawling is done for the desired result if the query. When a user enters a query into a search engine from their browser software, their input is processed and used to search the database for occurrences of particular keywords [9]. These search engine works as a centralised system or distributed system which has specific layers through which filtering and matching is done. A variety of search engines such as Google, Yahoo! Search, are available to make the web retrieval process very faster. The backbone WWW is its files, called pages or Web pages, containing information and links to resources - both text and multimedia- throughout the Internet. Two main architectures used for web searching are centralized and distributed search.

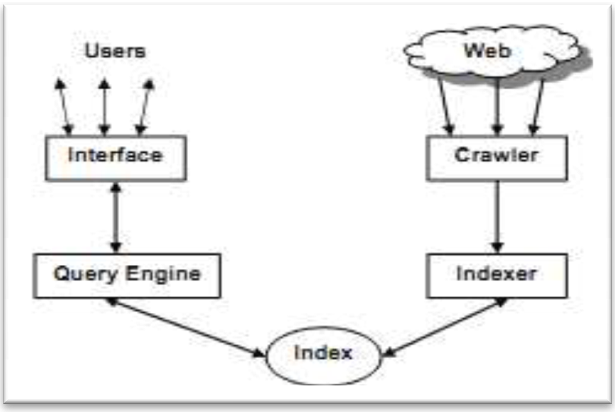


Figure 2: Search Engine (Centralized Architecture)

Centralized Architecture: The aim of centralized approach is to index sizeable portion of the Web, independently of the topic and domain. The centralized architecture based search engine has main three parts: a crawler, an indexer, and query handler. The crawler (spider or robot) retrieves web pages, compress and store into a page repository. This process is called crawling (sometimes known as robot speeding, gathering or harvesting).

Some of the most well-known crawlers include Googlebot (from Google), MSN Bot (from MSN) and Slurp (from Yahoo!). Crawlers are directed by a crawler control module, that gives the URLs to visit next. The indexer processes the web pages, collected by the crawler and builds an index, which is the main data structure used by the search engine and represents the crawled web pages. The inverted index contains, for each word a sorted list of couples, such as doc ID and position in the document. The query engine processes the user queries and returns matching results using the index. The results are returned to the user in an order determined by a ranking algorithm. Each search engine may have a different ranking algorithm, which parses the pages in the engine's database to determine relevant responses to search queries. Some search engines keep a local cache copy of many popular pages indexed in their database, to allow

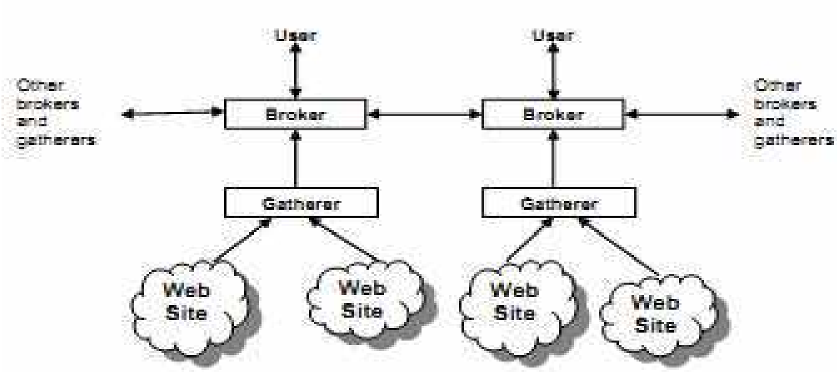


Figure 3: Search Engine – Distributed Architecture

Distributed Architecture: Searching is a coordinated effort of many information gatherers and brokers [14]. Gatherer's extracts information (called summaries) from the documents stored on one or more web servers. It can handle documents in many formats: HTML, PDF, Postscript [8] etc. Broker obtains summaries from gatherers, stores them locally, and indexes the data. It can search the data; fetch data from other brokers and makes data available for user queries and to other brokers. The advantages of distributed architecture are the gatherer running on a server reduces the external traffic on that server and evading of gatherer sending information to multiple brokers reduces work repetition.

CONCLUSIONS

In this paper, we have discussed about various types of distributed system, new paradigms in a distributed system and example of distributed systems; and Paradigm of new technologies like utilities, grid, cloud computing; and the issues regarding the mentioned technologies. We have discussed network types and interconnection of the nodes in a particular network. Problems in network models are also raised. Web information retrieval at www which is the best one to describe how a distributed operates is also discussed in this paper. This paper illustrates cloud computing grid computing and utilities provided as distributed computing system known as distributed systems. The future of distributed computing is still quite uncertain as new advancements are done as per the requirements and new features are added with time to time and application oriented approaches, since it is one of many new types of computing. The future work can be operated parallel computing with the distributed ones to combine features of both new technologies in various complex applications. New advancements are to be included and the processing is provided through GPU computing, routing and other features are improved by using further techniques [9].

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