

The Collaboration of the Trio of Quantum Computing, IOT and AI Powered by Cloud Architecture

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ABSTRACT

With the advancement in computer field and related technologies in recent years have changed tremendously the way in which the computer can be used. Over past years various developments have triggered that has revolutionized the odd methods of working of individuals or organizations and one of such development is the cloud computing. Cloud computing has changed the traditional way of handling the data and various applications managed by the business/organizations and individual user or developer. Cloud computing provide various remarkable features such as scalability, cost effectiveness and global reach to name a few. This paper deals with the whereabouts of cloud computing model along with various infrastructure required by this and also discusses its present use and deployment. As the discussion progresses the untapped potential areas related to cloud computing are discussed and the tremendous potential this field posses is dwelled and future trends of cloud computing are identified. Again various other computer related technology and concepts are identified that presently have or can have some intersection points with cloud computing. Finally how their collaboration with cloud computing is presently working in some areas or can be done in near future is identified and their impact on relevant computer field is investigated.

Keywords: Cloud Computing, Future Trends of Cloud Computing, Data And Various Applications, Collaboration With Cloud Computing

I. INTRODUCTION

Cloud computing is advancement in computer field that has become a buzzword in recent years. It has changed tremendously the way in which the computer and existing technologies can be used. Cloud computing is an innovative service concept that has paved the way to previous unimaginable possibilities and now has become reality.

The paper first defines some terms necessary to understand the concept of cloud computing [1] and discusses the whereabouts of cloud computing. The main preexisting concept with services and infrastructure required behind the cloud is investigated. Discussion progresses with present as well its future area of application. Again as we know that there are other technologies as well that have evolved over time such as AI, ML, IOT etc. we have tried to identify the intersection of such various technologies with cloud by investigating how such intersection can lead to collaboration that can be useful and have been implemented or can be implemented in near future in relevant computer related fields to fulfill the growing needs of organizations.

II. CLOUD FUNDAMENTALS AND ARCHITECTURE

Before we start let us get some brief insight in cloud régime. The term “cloud “is similar to “fog” that is existence of some virtual thing that is remotely located. We start by defining the term cloud computing and it goes like this.

Cloud computing is an on demand technology [2] that provides access to a set of computing resources which includes servers, storage, applications etc and services to its users. That is the users can access any of these computing resources from anywhere in world on any device by using an internet connection. By obtaining the computing resources directly individuals or organization [3] can add or drop the desired resources into their current working platform without installation or purchasing them. This considerably reduces not only the budget requirements but also contributes towards freedom and ease of operation with which one can operate.

To further delve into this we first try to take a deeper in sight about the architecture or built-up of the cloud technology. The cloud architecture [4] can be majorly divided into following 3 components:

- A. Front and Back end
- B. Network
- C. Service Models

A. Front and Back end

A front end can be defined as a user's side of the cloud computing system from where the user can access the cloud resources and services as discussed above in the cloud fundamental part. Front end typically consists of a Graphical user interface and set of tools.

A back end on the other hand is a set of components that actually work in the background or behind the scene type concept. Back end cloud architecture can be divided into following components:

- Back end applications which are basically soft wares to send the client service request to front end.
- Cloud storage that provides scalable and flexible storage to the cloud applications.
- Cloud runtime refers to an environment that includes os and memory to run cloud services.
- Infrastructure that consists of back end resources, networking devices [5] and required software.
- Necessary computing services contains services such as storage services, web services , security services etc.
- Middleware that coordinates the communication between front end and back end.
- Security tools

B. Network

A cloud network [6] is necessary to obtain high bandwidth requirement so that the user can easily access the cloud resources and services. There is also a concept of networking gears that supplement the network requirement.

C. Service Models

This is the most important component of cloud architecture .These are known as service models because they provide essential services [7,8]that are required to run cloud. There are various types of cloud service models namely SaaS, IaaS , PaaS, XaaS, FaaS as depicted in Fig 1.

- SaaS (Software as a service) states that the software is hosted on the cloud itself instead of individual user machine and can be made available to users on demand using apps or interfaces. This is perfectly suitable for situations where the computing power and resources on individual user computer is limited and we want to provide high computation performance to user then this is the ideal model [9]to use for .The SaaS provider is responsible for 3 tasks of operating ,managing and maintaining the software and the infrastructure only. The customer may be asked to pay a certain fees to use this service.

This service reduces the time required in installation and thus it speeds up the software development process. . Some examples of SaaS providers are Intercom , Trello[10], Hipchat, and Rackspace [11].

- IaaS (Infrastructure as a service) states that all virtual infrastructure such as servers, storage, networking and the back end required infrastructure are available to run any application by user. Extending this the user can expand or shrink the infrastructure according to his /her need for the application to run. This service reduces the high cost and time involved in purchasing of such infrastructure so that the user's application may be made run on this infrastructure. This is very much advantageous to small organizations where funds are in big scarcity or for startup organizations. An example of an IaaS provider is Amazon EC2 [12].
- PaaS(Platform as a service) states that instead of software or infrastructure the entire platform can be made available as service to develop and run the user application. The PaaS provider hosts literally everything ranging from the servers and network to storage, o.s and databases and development tools.An example of a PaaS [13].provider is Microsoft Windows Azure .
- XaaS(Anything/Everything as a service) states anything as a service can be provided that is the compilation of all features of the above services and some additional services that means scalability is more enhanced.
- Faas(Function as a service) states that it is an event driven model where customers can develop and run the entire code or application as a function. The main punch point of this model is that user can update the

code any time without worrying about maintenance of the infrastructure. Auto scaling up and down can be done easily here.



Fig. 1 Service Models In Cloud Computing

III. DELIVERY MODELS

After discussing the cloud architecture let us learn about cloud delivery models because ultimately the use of cloud technology is bullishly leveraged when we can successful deliver it to user. As depicted in Fig 2 it can be majorly divided into 4 types:

- Private cloud: As the name suggests this is the type of cloud in which all resources that are requested will be operated only within the organization or privately managed. The main punch point for private cloud is the high level of security and maximum control on the infrastructure can be achieved easily.
- Public cloud: As the name suggests this is the type of cloud in which all resources that are requested will be made available to users on public internet domain. This can be understood as a type of cloud [14] where a set of resources are shared. That is public cloud consists of a third party that initially holds the resources and then delivers to different users of cloud but using internet.
- Hybrid cloud: As the name suggests that it is combinations of various types of cloud so that a single best cloud can be created that can cater to user’s need better than any single cloud model. For example an organization can use a private cloud for its current research and patent related work that demands higher level of security and another public cloud [15]for interfacing with the its clients and based on internet.
- Community cloud: As the name suggests community cloud is provision of different cloud services but it is based on a community or we can term it as a group of organizations with same objectives and security demands.

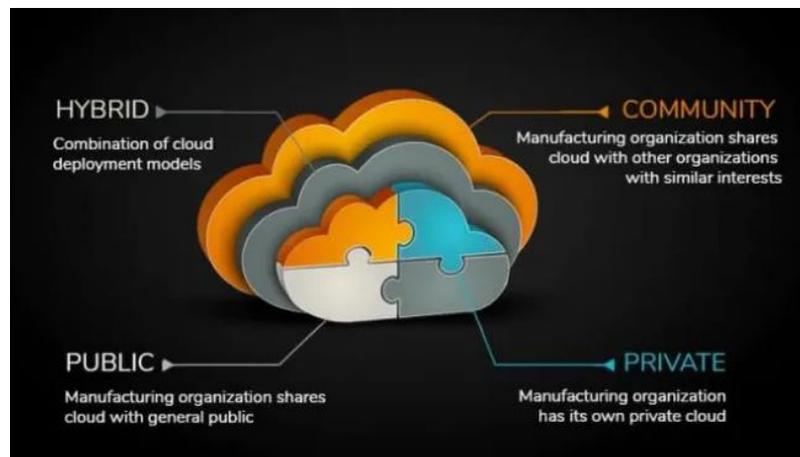


Fig. 2 Delivery Models Available In Cloud Computing

IV. FUTURE TRENDS OF CLOUD COMPUTING

Cloud computing is a fast growing technology in the area of computing. As it is evident from above discussion that cloud is a new concept that can be leveraged according to a user’s customized service that may be about software, platform, service, function or literally anything. Now in our discussion we would survey about future trends of cloud computing.

But cloud is not alone in the list of fast growing technologies. We are not of the opinion that cloud is of limited use or not questioning about the future of cloud but in real world there are various other technologies and some of them are still in phase of continuous development. All new technologies have also left some profound effect and the ways in which the tasks are done and implemented. So the discussion is not complete without discussing cloud computing in context of its intersection with various other technologies. We would try to investigate future trends of cloud computing in context of intersection of various technologies with cloud.

A. Quantum Computing

Quantum computing is based on the concept of quantum mechanics that talks about sub atomic particles which are different in behavior than atomic particles as explained in classical Newtonian physics. The basic entity is Qubits.

Thus quantum computing can be defined as a cutting edge technology with underlying conceptual foundation on quantum mechanics and quantum computing systems are more powerful as compared to classical digital based computing systems. A qubit can be used to store either a 0 or 1 as a container .So a new terminology “Quantum cloud computing” is evolved that is a mixture of the concept of quantum [16] and cloud computing . This terminology states that user’s access and use of the quantum computing can be facilitate ed using cloud computing. The quantum computer can be placed on cloud and API can be used by the users at other end to fully harness the quantum computing features. Cloud is the ideal platform that can provide storage, network infrastructure etc to handle requirements of quantum computing. Some of the advantages can be summarized as in following table I.

Table I. Advantages of Cloud In Quantum Computing

Purpose	Explanation
Resource Requirement	Allocation of various resources can be done using cloud technology using various service models
Testing quantum computing newly written code	Cloud-based quantum computing techniques can be used for testing such quantum algorithms before final deployment and it can reduce the cost of development too
Contribution	As quantum is a relatively new field so with cloud it is very easy to contribute using cloud sharing
Security Cost	On site physical security measures that is a costly affair can be reduced

Future trends states that as quantum computing [17] is a relatively new field there is a lot of research that has yet to be done. Some of the new insights may be:

- Integration of quantum concept with large data set involved AI using cloud.
- Develop the quantum computing algorithms that can be used in health care sector and in the areas that are directly related with society welfare.
- A further future trend may be to develop low cost quantum computing models as quantum computing is very costly affair these days.

B. IoT

The Internet of things is a buzzword heard every where now a days in today’s internet world. Some are of the opinion that IoT is the next Internet related revolution. This technology [18] enables millions and billions of devices to be connected with each other.

Thus IoT can be defined as the interconnection of computing devices using the internet and then enabling each of the connected devices to send and receive the data between them where the word “thing” in the term Internet of Things indicate the presence of hardware communication devices that are used for data transfer. Now again a new terminology “IoT cloud computing” is evolved that intersects the above discussed IoT concept with cloud computing. This terminology states that IoT can’t be fully functional [19] without the existence of internet and cloud on the other hand is a successful technology that allows the user’s to access variety of good services via internet. So if cloud is integrated

with already existing IoT services then it would increase the efficiency of IoT many folds. Some of advantages can be summarized as in following table II.

Table II. Advantages of cloud in IoT

Purpose	Explanation
Healthcare	Cloud based IoT has done exceptionally well in healthcare industry to provide healthcare services
Smart cities	The backbone for the design of future ready smart cities is IoT with cloud and connecting devices like streetlights with phone
Environment	By interesting both the technologies a high speed information system can be generated that can be used to monitor environment related sensors for various purposes.

Future trends states that as IoT [20] is a revolution in the IT enables services yet there is a lot of research that has yet to be done. Some of the new arenas can be :

- Big data is still considered an open field and cloud based IoT can be fully used in managing the vast amount of data originating from various sources and from various physical locations.
- Managing security and secrecy is still a challenge and security breaches from the unethical hackers' side still remain a challenge. IoT and cloud can be efficiently used to provide authentication and authorization rules in a commendable way and future research can be done in this field immensely by researchers.

C. AI

Artificial Intelligence is a term that needs no introduction in today's computer era. The presence of AI and the other AI related technologies are being felt in each and every field that is relatable to humans. Going further to this argument now AI is doing wonders that couldn't be even dreamt of before AI[21].

AI has two terms contained in it that are "artificial" and "intelligence". Artificial means something that is not natural or not made by humans and on the other hand it is generated or manufactured using some machine or some technology. Intelligence is on the other hand is the capability associated with human to think and understand things. Artificial Intelligence popularly known as AI can be defined as a computer system that uses algorithms and other related data to accomplish those tasks that otherwise would require human intelligence. AI can perform tasks also which humans can't such as performing complex calculations, analyzing large amount of data in fraction of seconds etc. Now a new terminology "AI in cloud computing" is evolved that intersects the above discussed AI with cloud computing. This terminology states that cloud service providers can apply AI in automating the cloud systems to deliver IT services and SaaS applications both in low cost and with trusted reliability. In short we can say that in order to fully leverage AI capabilities [22] intersection of AI and cloud is the best answer. Some of the advantages can be summarized in following table III.

Table III. Advantages of cloud with AI

Purpose	Explanation
Cloud management	AI helps in automation of variety of cloud services such as scaling up /down , failure detection ,detect cyber attacks well in advance ,workload monitoring etc.
Predictive analysis	AI with cloud can be used in predictive analysis to identify certain statistical data pattern, trends ,correlation so that better decisions can be taken
Automation	Variety of IT processes or tasks can be automated using AI and the integration of cloud helps in.
Data management	Data can be stored on cloud and AI can be used to manage this data on cloud in a more cheaper and efficient way

Future trends states that as AI [23] is a revolutionary development in the history of mankind. A lot of work has been done but due to its upcoming importance a lot of research has yet to be done. Some of the new developments can include:

- The biggest hurdle of current intelligence is its inability to handle multiple tasks to further research is required to be done
- Still the costing of using cloud AI services is high. Further research in the architecture or technology is required in this area.
- In cloud and AI area security concerns about the technology and most importantly the concerns and global threats over data still remains a challenge to AI cloud developers.

V.CONCLUSION

Today cloud computing is one of the top most used technology in computer enabled industry. As in the discussion we have gone through the basics of cloud and the power and the potential it holds. There is variety of models in service and delivery category that makes the cloud the real power packed technology. More and more IT companies are using cloud in their products to keep pace with the market and on the other hand lowering their cost by using any type of available cloud service on a very minimal costing that would otherwise had incurred a huge expense on the services only that are now taken from cloud.

Further as we move in the paper the future trends of cloud computing with intersection of Quantum computing, IoT and AI with cloud are discussed in great detail by first defining them, counting their advantages with future trends of each of the above new technology with cloud. We have investigated that each technology when integrated with cloud definitely has some advantages associated and also we have identified some future trends in associated area.

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