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Provisioning Quality of Service for Multimedia Applications in Cloud Computing

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Abstract**—**Since the last decade, many new trends have been introduced to access network technologies and services through internet. Cloud computing is one of those significant technologies that reduce the cost and increase the productivity by providing a variety of services. Recently, cloud computing based system is primarily used for multimedia applications. Over the cloud computing, multimedia applications has some significant quality of service (QoS) requirements such as bandwidth, jitter, latency etc. But due to some limitations in services providing, it is constantly complex to make selection for an appropriate service. Keeping in view the provision of multimedia services through cloud computing, many different concepts and approaches that provide better cloud services under the constraints of QoS attributes have been described in the literature. The goal of this paper is to assess the applicability and provision of multimedia applications over cloud computing through enhanced quality of service. We have identified the primary quality of service msetrics evaluation of multimedia services over cloud computing. Furthermore, under these metrics we evaluated the existing approaches that provide multimedia related services with their strengths and limitations. This evaluation approach could provide the service that can provide better QoS in multimedia applications over cloud computing.

Index Terms**—**Cloud computing, Quality of Services (QoS), Multimedia, bandwidth, jitter, latency, network service, Service level agreement, virtualization, PaaS, SaaS, IaaS.

I. INTRODUCTION

Cloud computing is one of most interactive trend in IT that provide the opportunely to run the applications and cloud services on distributed network using virtualized resources and to access these services we use common internet protocols and network standards. In cloud computing, users can access the services and resources which are resided across the internet and you have no need to worry about the maintenance of physical resources. So, under the cloud computing paradigm, we can access hardware's, computing resources, and development environment and user applications remotely over the internet and pay for usage only. The services are added quickly on demand and release the resources when not in use [2].

The Cloud computing paradigm is very useful for multimedia applications over the internet such as video conferencing, surveillance where video streaming is required. In order to meet the requirements of clients and services, it is necessary to provide a certain level of QoS by the service provider Such services are device independent where multimedia data is streamed through network and saved cloudily which is accessible from anywhere in the future over the network. According to traditional way, the multimedia data is stored on dedicated servers which are designed for peak usage. Hence a major obstacle for cloud computing system to provide better quality of service is to develop the novel layers that could have ability to interact among cloud service provider and the user. By multimedia over cloud system perspectives, the fundamental aspect is how to achieve better QoS which could be supportive for multimedia applications and services over the network [10]. Moreover by future perspectives, many new High Performance Computing approaches are being introduced to overcome multimedia application challenges over cloud computing [34]. Based on HPC many approaches were proposed that can deal such cloud based applications [35, 36].

In order to provisioning such QoS, a lot of companies are working on cloud computing technology to fulfil the user demand under then QoS parameters constraints such as: Netflix, YouTube, Rulu, and Facebook etc. In order to provision of QoS for multimedia services in cloud computing, a variety of models and architectures are proposed. We have made a widespread survey on QoS for multimedia applications in Cloud computing with respect to their proposed frameworks, strengths and Limitations. We also described the cloud computing architecture that is the base architecture in order to provision of QoS for multimedia applications.

Further, other sections of this paper are organized in such a way that, section II describe the basic architecture for cloud computing. Section III explains the others contribution in provision QoS for multimedia applications in cloud computing. In section IV, we have presented a comprehensive analysis of proposed solutions with their strong points and weakness and then conclusion and future directions in last V section is presented.

II. BASIC ARCHITECTURE OF CLOUD COMPUTING

Basically, cloud computing comprises of three fundamental layered architectures including Infrastructure as a Service (IaaS) which is considered as the bottom layer in cloud computing system, Platform as a Service (PaaS) the middle layer in architecture and the third top most layer Software as a Service (SaaS) [1].

In current trend, the technologies that involve the provisions of QoS for multimedia applications are majorly following the cloud computing architecture as a base architecture [1]. Therefore a brief description of this base architecture is as follows:

A. IAAS

The bottom layer IaaS (Infrastructure as a Service) in cloud computing architecture is creditworthy to provide the physical infrastructure (such as VMs, Hardware resources, storage, network resources) by a vendor which you can access over internet and use to install your software, build or deploy your applications i.e.: Amazon Rackspace. The suitable situations for IaaS to be applicable are as follows:

- When demand is volatile—that is, any time there are significant spikes and troughs of demand on the infrastructure
- For new organizations without the capital to invest in hardware
- When the organization is growing rapidly and scaling hardware would be problematic
- When there is pressure on the organization to limit capital expenditure and to move to operating expenditure
- For specific line of business, trial, or temporary infrastructure needs

Furthermore there are several characteristics for IaaS layer in a cloud computing system which are given as below:

- Resources distributed as a service
- Allows for dynamic scaling
- Has a variable cost, utility pricing model
- Generally includes multiple users on a single piece of hardware

B. PAAS

The second and middle layer PAAS (Platform as a service) that is essential part of cloud computing architecture which is capable to deliver the deployment service for user application over the cloudy system. PaaS provides a server along with software environment such as development tools, video on demand, databases etc. The most famous PaaS service provider such as Microsoft Azure platform [32] which is facilitate the users to deploy the applications. Another one as Google App engine [33] contained built in services to build a scalable application. PaaS layer could be idealistic in following circumstances:

- The application needs to be highly portable in terms of where it is hosted.
- Proprietary languages or approaches would impact the development process.
- A proprietary language would hinder later moves to another provider (concerns about vendor lock-in).
- Application performance requires customization of the underlying hardware and software

C. SAAS

The third and most upper layer SaaS (Software as a Service) is responsible to provide the services such as word processing. During interaction between service provider and the user, set of Service level agreements (SLAs) are used to determine that at what level of performance and QoS is demanded by the user. Some fundamental characteristics of SaaS layer are as follows:

- Web access to commercial software
- Software managed from a central location
- Software delivered in a "one to many" model
- Users not required to handle software upgrades and patches
- Application Programming Interfaces (APIs) allow for integration between different pieces of software.

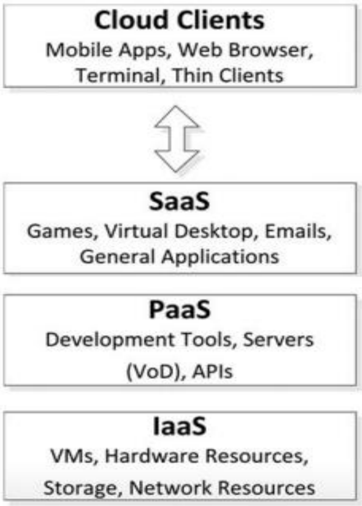

Fig.1. Cloud Service Layered Architecture [2]

Figure 1, clearly shows how users interact with cloud computing paradigm and use the services as required. Moreover, it describes that how all three fundamental layers are organized to provide different services over a cloud. These layers are considered and being follow for any large scaled cloud system. Based on these layers and leading to QoS in cloud, we have defined different QoS metrics for multimedia applications which have been described in next section.

III. QoS Metrics for Cloudy Multimedia Evaluation

Distinctly the selection of an appropriate framework depend on provision of its features that could be evaluated through fundamental metrics [30]. In this section, we have presented the fundamental aspects and their perspective QoS metrics through that the services (which provide QoS for multimedia applications over cloud computing) could be evaluated. Ordinarily, QoS in multimedia applications is evaluated on the base of some limited functional and non-functional quality attributes. Our taxonomy of QoS metrics based on four fundamental aspects including service performance [16][17][18][19] presented in table 1, economics [20][21][22] described in table 2, security [24][25][26] described in table 3 and , QoS attributes [27][28] (such as bandwidth, jitter, latency) presented in table 4 as follows below:

***Symbols description**: '✗' states that the corresponding parameter is in failure while '✓' state that attribute working fine.*

Table 1. Performance Based Metrics

QoS Metrics (performance)			Description
Comp.Time	Stor.Rsp	C.Time	
✓	✓	✓	Service performance in Data streaming, processing and storage response is perfect.
✓	✓	✗	Communication issue states bad streaming and data throughput is affected.
✓	✗	✓	Streamed data problem could cause of over streaming and delay in packets.
✓	✗	✗	Service not responding properly due to problem during streaming and local access.
✗	✓	✓	Service performance decreased due to low computation but no packet loss.
✗	✓	✗	Performance is almost zero due to neither computation and nor streaming properly.
✗	✗	✓	Performance affected by delay in throughput.
✗	✗	✗	Service doesn't perform.

Table 2. Economics Based Metrics

QoS Metrics (Economics)			Description
T.Cost	C.I.Ratio	Thr.Cost	
✓	✓	✓	Economically, service performing in senses.
✓	✓	✗	In average, service do perform well but not individually.
✓	✗	✓	Service perform within budget but ratio wise cost increased.
✓	✗	✗	In average, service is inexpensive but not tolerable by throughput.
✗	✓	✓	Service is efficient as per ratio and individually but over cost exceeds.
✗	✓	✗	Rate of service input/output is efficient but unit wise and overall service expensive.
✗	✗	✓	Overall service is costly but outcome of cost per unit is better.
✗	✗	✗	Service couldn't perform within the budget.

Table 3. Security Based Metrics

Abbreviations: Total Cost (T.Cost) [23], *Cost Incremental Ratio (C.I.Ratio), Throughput Cost (Thr.Cost)*

QoS Metrics (Security)			Description
Conf.	Sens.	Auth.	
✓	✓	✓	Service fully secured.
✓	✓	×	Verification from destination is not sure in service but data streaming is secured.
✓	×	✓	Data stream is entrusted and verified but need to
✓	×	×	Provided service is confidential but acquired verification.
×	✓	✓	Service provides validation from source/destination but required concealment.
×	✓	×	Streaming data is untrusted and non-verified but unsusceptible.
×	×	✓	Data is verified but streamed over untrusted and susceptible service.
×	×	×	Service is fully unsecured.

Abbreviations: Confidentiality (Conf.), Sensitivity (Sens.), Authentication (Auth.) [24][25][26][29][31]

IV. QoS Provision Approaches for Multimedia

Hongli, Aaron and Timothy.[1] proposed an architecture for private multimedia cloud computing using virtualization infrastructure and addressed variety of challenges including heterogeneity of network and limitation of mobile devices for provisioning QoS for multimedia applications. They implemented the QoS provisioning mechanism in IaaS layer of proposed model. The proposed virtualized video streaming server architecture provides a high performance under limited cost but over a fully no implementation of all QoS parameters when it is utilized across heavy traffic over the network.

P. Manoj et al. [2] continued effort on service delivery framework for cloud service management and resource allocations automatically. By utilizing this proposed framework, it help out to manage extra consumption and reduce jitter for cloud based multimedia services. According to this framework, the basic concept is to run the cloud services on public cloud depending on network status and client's service demand. This scalable framework provides many features including availability on demand, load-balancing and robustness. In this why, a heavy traffic over the network could be prevented. The proposed model accomplishes three major functions of MM-aware cloud as follows:

- Providing and supporting the QoS
- QoS adaptation.
- Process the applications in parallel in distributed system.

Pei-Jia Yang and Yang-Fang.[3] proposed cloud computing based model an architecture *"IMS Cloud system architecture"* to access high quality multimedia services via android base appliances. They used service prioritizing mechanism and Improve system performance. They focus on heterogeneity and mobility issues using IMS QoS policy and overall video stream throughput increased using proposed architecture. The proposed model was implementable for android platform only.

Fragkiskos et al.[4] introduced a layered architecture system that relates to OSI layers model for cloud resources management in provision better QoS for multimedia applications. The proposed SPM mechanism have multiple features in QoS provisioning. It provides automated resources allocation service which is optimized and consume less bandwidth by reducing jitter. But found a drawback of increasing latency on user movement while streaming a video.

Anand V Akella and Kaiqi Xiong.[5] proposed a SDN (Software defined networking) based approach called "Open VSwitch". According to authors, the proposed model provides an opportunity to automatically switch on available path for higher priority clients to ensure the guarantee of QoS with multiple parameters such as bandwidth, number of hops and RTT. They implemented and tested the proposed model in GENI (Global Environment for Networking Innovations) but not by using Open Flow physical switch.

Michael et al. [6] introduced a new PAAS architecture targeting real-time QoS guarantees for online interactive multimedia applications. There were two major key aspects of proposed PaaS as QoS oriented Service Engineering and on demand service management. But there were some weakness for dynamic uncertainty management. This PaaS architecture is still in progress to improve the quality of service and being verified as well.

K.Saravanan and M.Lakshmi Kantham.[7] proposed an approach for advance reservation and ranking of multimedia cloud services using QoS attributes. They emphasized on QoS provision when a vast number of users request for cloud services. To overcome this issue, they proposed ranking technique. In proposed model, they explained all the QoS characteristics but not used during implementation.

S.Kumar, S.Versteeg and Rajkumar.[8] targeted quality measurement and prioritization of multimedia cloud services and proposed AHP (Analytical Hierarchical Process) based framework. In context of provision SLA and QoS, this framework create a strong competition and impacted. Authors proposed taxonomy of QoS attributes. Hence each attribute might be fall in quantifiable or non-quantifiable category. According to authors, the proposed approach is applicable for only quantifiable attributes but facing several challenges during implementation for non-quantifiable attributes.

Ruozhou et al.[9] proposed different algorithms to make an appropriate selection for QoS-aware cloud services. Generally, a cloud computing system contained tailor-made MM cloud services through which a user could interact with cloud system. Cloud computing services are not only limited to provide the services but also interconnection among these cloud services as well. To overcome this issue, they proposed number of algorithms to select the service automatically as requested. Provision of QoS is enhanced using these algorithms and virtualization mechanism but some other major parameters were skipped like latency and jitter.

Wenwu et al [10] addressed the challenges

Worked on cloud services for multimedia over cloud computing and addressed number of challenges in QoS provisioning. In order to improve the better quality of service for multimedia applications in cloud, authors proposed a new architecture as “MEC (Media Edge Cloud)-computing architecture”. Moreover, the cloud media resources could be used optimally using the proposed architecture. They also described the some future directions and problems for multimedia cloud computing and how MEC architecture could be enhanced to get better QoS of multimedia applications in cloud computing.

W.Hui, C.Lin and Yang [11] worked on three major challenges for Multimedia cloud computing such as “heterogeneity, scalability, and multimedia QoS provisioning” and proposed a new architecture as “MediaCloud”. They also introduced the key technologies through which users could be provided multimedia applications and services effectively and efficiently with QoS provisioning along MediaCloud architecture. MediaCloud was designed particularly to process complex services with efficient resource allocation, scalability, and QoS provisioning. According to authors, there are still number of challenges in order to determining quality of experience (QoE) of multimedia services and how to address the potential security threats.

Yee Chen, Yi Peng.[12] worked on finding optimal service path route and proposed a QoS Aware Services Mashup(QASM) model. According to authors, QoS aware path routing is an NP-Hard problem so it must be explored deeply and fixed. They implemented the proposed model as a simulation test witch’s results clarify the correctness of proposed model and algorithm and will implement a prototype of their model in a real internet environment. In actual implementation, it is important to investigate that how to include some other system properties such as stability and fault tolerance.

C. Lai, H. Wang, H. Chao and G. Nan. [13] Proposed a new system architecture for cloud based media streaming to maintain the multimedia QoS for a certain level. They proposed two interactive modules Network and Device-Aware Bayesian Prediction Module (NDBPM) used for the prediction of network and hardware features and Dynamitic Network Estimation Module (DNEM) to control switch virtual circuit (SVC) multimedia steaming and communication frequency. According to authors, the proposed solution assures for a smooth and complete multimedia streaming services. But SVC coding scheme still required a lot of consideration to make more refinement for cloud media streaming.

I. Trajkovska, J. Salvachúa and A. Velasco, [14] introduced a cloud media API that contains the built in functions to calculate QoS and its parameters automatically among cloud media service providers and its prospective clients. The proposed architecture is basically joiner of peer to peer and cloud computing that support for multimedia streaming in both CS (cloud streaming) and P2P style. Due to less implementations of proposed API, there is an open issue to implement proposed API in a cloud infrastructure by extending Isabel system functionality and also to test its consequence behavior.

A. Li, X. Yang, S. Kandula and M. Zhang [15] discussed on performance monitoring and analysis tools for multimedia application in cloud computing paradigm. These tools can be used to measure the QoS for media cloud services and data ranking as well. Furthermore, these tools also applicable to make performance comparison between different cloud services such as Rackspace, windows azure and Amazon EC2 etc. During comparison they emphasized on resources utilization, network throughput and QoS parameters at a low level performance of cloud services. Conversely, they didn’t deploy the more constraints in order to achieve high QoS for multimedia applications in cloud computing.

V. Comparative Analysis and Results

In this section, we have made a comprehensive analysis of proposed approaches in era of QoS for multimedia in cloud computing. We have described the proposed approach with its strong points and limitations as well. Some of the techniques are very useful and directed in very right way but still required a lot of concentration to in order to get targeted outcome. Most of multimedia frameworks have still weaknesses in many significant parts to achieve a high QoS for multimedia applications over the network. For such a frameworks and models, there are number of open issue for future research and directions. To review the proposed approaches and its perspective strong points and limitations, follow the below: table 5.

Table 5. Evaluation of proposed techniques and frameworks

Ref.	Proposed Approaches	Strong Points	Limitations
1	Architecture of Multimedia cloud computing	All QoS attributes are considered only.	Not tested at large level. No implementation in real network
2	Service delivery framework	QoS support, provisioning and parallel processing for distributed systems.	No implementation at large network. Performance and economically expensive.
3	IMS Cloud system architecture	Video stream throughput increased Fixed heterogeneity and mobility	Implementable only for specific platform “android” Facing Performance challenge.
4	Layered system architecture relates to OSI	automated resource allocation reduce bandwidth and jitter	increase of latency as a user moves while streaming
5	Open vSwitch based algorithm	Switch service automatically priority base including perms (bandwidth, RTT, and the no. of hop).	Not implemented and tested by using Open Flow physical switch
6	New PAAS architecture	QoS oriented Service Engineering On demand service management	Lake of assurance for dynamic uncertainty management Still in progress to improve the quality of PaaS
7	Ranking and advanced reservation framework	Explained basic QoS attributes such as bandwidth, jitter, etc.	No implementation practically for mentioned QoS attributes.
8	AHP(Analytical Hierarchical Process) based framework	Approachable only for quantifiable attributes	Several challenges faced during achieving non-quantifiable attributes
9	Proposed different algorithms	Automatic service selection on requested.	Some major parameters skipped like latency and jitter.
10	MEC(Media Edge Cloud)-computing architecture	High Provision QoS Optimal resource allocation	Mentioned future work and problems in MEC.
11	MediaCloud architecture	Resource allocation, scalability, and multimedia QoS provisioning	determining (QoS) of MM services and to address potential security threats
12	QoS Aware Services Mashup (QASM) model	Optimal QoS path route allocation	No real internet environment implementation
13	NDBPM and DNEM Modules	Provide smooth multimedia streaming services	SVC coding scheme is not implementable for large network traffic. Need refinement.
14	Joined (P-2-P and Cloud computing) API	Calculate QoS and its parameters automatically by providing media services	Need implementation for Isabel system functionality and test behavior
15	Performance monitoring and analysis tool	QoS measurement and at low level performance analysis	No constraint to deploy in order to achieve high QoS

The above evaluation shows how the proposed services having limitations in order to provide QoS for multimedia applications over cloud computing. Majorly QoS attributes and performance aspects are still required a lot of considering by future perspective because still a massive bandwidth is required to deliver better service which directly affect the overall economics of service provision. However, QoS attributes, communication time, computational time and storage response are the primarily areas that should be considered in priority to improve the services for multimedia applications in cloud computing. This evaluation is not limited to just for these listed proposed frameworks but could be implementable to evaluate in future being proposed approaches.

VI. CONCLUSION

The Cloud computing is one of the new emerging technology which has made a rapid growth to offer cloud based media services to various consumers. Recently, Cloud computing is being used for multimedia applications extensively. It is constantly complex to make selection for an appropriate service that could provide better quality of service for multimedia applications over cloud computing. Distinctly the selection of an appropriate framework depend on provision of its features that could be evaluated through fundamental metrics. We have presented some fundamental QoS metrics that could evaluate the service by different aspects. These QoS metrics are classified into four major aspects including Service performance, service economy, service attributes and service security. Furthermore, through a critical analysis, we have evaluated the strengths and limitations of the existing approaches that provide services for multimedia applications in cloud computing. The proposed evaluation approach could guarantee it that the selected service could provide better QoS or not. By future perspective, our plan is to propose a framework that could provide better QoS by evaluating through these defined metrics.

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