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Network Performance of a Video Application in the Cloud

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ABSTRACT

Cloud computing is a technology that uses the internet and central remote servers to maintain data and applications. There are different cloud services of which cloud Infrastructure as a service enables a company to grow very fast. All small and large-scale companies are shifting their applications towards cloud. As usage of the internet all over the world, the number of video applications are increasing more and becoming popular. Smart phones use wireless networks to transfer large amount of data. Users access the video application from the cloud through web browsers in laptop and smart phone. First, a systematic literature review is conducted on the performance issues of cloud infrastructure as a service. Second, the performance metrics jitter, round trip time and page loading time are analyzed while accessing a video application from the cloud. Finally, results are analyzed for various browsers in Smartphone and laptop. From the obtained results it helps the users to choose better browser for accessing cloud applications.

Keyword: infrastructure as a service, jitter, page load time, round trip time, cloud.

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ACRONYMS

AaaS-Application as a service.

ACK-Acknowlegement.

AWS-Amazon web services.

CDF-Cumulative distribution function.

CDN-Content delivery network.

CIFS-cloud infrastructure Frames work.

CPU-central processing unit.

EC2-Elastic compute cloud.

EIP-Elastic internet protocol.

HTML-HyperText Markup Language.

HTTP-Hypertext Transfer Protocol.

IaaS-Infrastructure as a service.

ICMP-Internet control Message Protocol.

IEEE- Institute of Electrical and Electronics Engineers.

IP-Internet Protocol.

Mbps-Megabits per second.

NTP-Network Time Protocol.

P2P-Peer to Peer.

PaaS-Platform as a service.

PHP-Hypertext Preprocessor.

RAM-Random Access Memory.

RTT-Round Trip Time.

S3-Simple Storage Services.

SaaS-Software as a service.

SLR-Systematic literature review.

SOAP-Simple Object Access Protocol.

SRB-Service oriented Resource broker.

SSH-Secure Shell.

SYN-Synchronize.

TCP-Transmission Control Protocol.

TPM-Trusted Platform Modules.

UDP-User Datagram protocol.

VM-Virtual Machine.

XML-Extensible Markup Language.

1 INTRODUCTION

Cloud computing is a general term that involves in delivering hosted services through internet. Cloud computing is a metaphor for remotely accessing computing resources through a network [2]. It provides on-demand network access to shared resources that can be physically located anywhere across the world. It is being ubiquitously designed and deployed in major places all over the world. New cloud services will soon be available in the market from the established IT and Telecom providers such as Microsoft, IBM, Accenture, Fujitsu, China Mobile and Sign Tel join cloud pioneers like Google, Amazon and salesforce.com in [6]. Cloud Computing provides greater flexibility, authentication issues and cost savings.
Today, cloud computing covers several kinds of services.

- Software as a service: cloud-based applications.
- Infrastructure as a service: processing and storing data.
- Platform as a service: developing, testing and running applications for clouds.
- Anything as a service: increasing number of services that are delivered over the internet.

Mobile cloud computing is emerging as one of the most important branches of cloud computing and becomes a massive force in the mobile world and is still in its infancy and eventually it will become the dominant way in mobile applications. The applications developed are using data storage and processing capacities in mobile phones.

In Mobile cloud computing, Mobile browser plays an important role as it supplies an open door to the Internet for mobile phones. The mobile browser is optimized to display web contents most effectively for small screens on portable devices. In wireless handheld devices, mobile browser software must be small, low bandwidth and efficiency to accommodate low memory capacity. The mobile browser usually connects to the server via wireless LAN or cellular network using standard Hyper Text Transfer Protocol (HTTP) over TCP/IP and displays web pages written in XML, HTML, and SOAP. At the user end, performance should be faster, easier and reliable. There are various browsers available in smart phones to access video application from the cloud. They are Firefox, xscope, dolphin, opera and android inbuilt browser.

In future, cloud may replace a traditional office setup. Cloud services are replacing desktop computing due to increase in traffic exponentially. The traffic generated in mobiles is User Datagram Protocol (UDP), Transmission Control Protocol (TCP) and Internet control Message Protocol datagram's [63]. Many more applications are shifting to cloud infrastructure such as video streaming, online chats, and file transfer. Due to rapid increase of video streaming applications occurs to increase of traffic. Growth in traffic, leads to some problems as per flow loss rate in network congestion. Due to this loss rate, the performance of the network will be degrading 100% in utilized link, and delays are occurring on client side when they are accessing the web application. The increase in delay affects the overall performance of Round Trip Time (RTT) and Page loading time. This delay and retransmission can cause jitter, which is problematic for video streaming applications.

This paper mainly focuses on Network performance analysis of video application in the cloud, while accessing video using smart phone and laptop with various browsers. Metrics chosen for the experiment are Round Trip Time, Page load time and jitter. A systematic literature review has been conducted on performance issues on cloud infrastructure.

RTT is defined as the time taken to travel the packet from client to server and as a response from server to the client. The choice of this metric provides the time elapsed from the propagation of a message to a remote place and to its arrival back at the source. The page loading time [18, 19] is defined as the time taken to load the web page from the server through mobile browser or laptop browser. Jitter is the variation in packet transit delay caused by queuing, congestion and serialization effects on the path through the network. Jitter is also variation or the degree of unpredictability in delay like these reasons makes wireless as unreliable. This term is associated with the loss of data packets in a real-time data stream. The transmission rate of the channel varies over time. The video display interruption may occur if the data don't deliver on time. Jitter reduces the perceived video quality and is inconvenient video streaming [11].

1.1 Aims and objectives

The aim of this thesis project is:

To analyze the network performance issues in various browsers while accessing a video application from the cloud using a Smartphone.

Our aim is to calculate the RTT and page loading time using TCP packets while accessing a video based application which is launched in local server and in the cloud. To do this, need to install shark tool in the android mobile. The time stamps are collected for various browsers that are available in the android mobile. This is to identify the impact of browsers on the smart phone while accessing video streaming application.

Our aim is to see the impact of jitter in laptops and smart phones while accessing a video streaming application from the Amazon Cloud Service using Right Scale. For this network traces are collected at both the ends using shark tool.

1.2 Survey of Related works

In today's world, Cloud computing has began to migrate from the public and private market. The infrastructure and performances in cloud computing are attracted to adopt different applications in the research of the business world. In [22] it shows the performance analysis of amazons computing services of EC2, S3, SQS and security facilities, at the time of measuring Amazon EC2 was performed well while considering cost-time tradeoff. This paper shows the performance of cloud depends on the dynamic load balancing, security, independent running application to better performance [64]. IBM is also developing its own cloud platforms and gaining great response in the world market. In [5] the cloud technologies have limited support for market oriented resource management and negotiating Quality of Service between users and providers. An extensive research work has been done to overcome the time synchronization problem. In [8] the study of 3G authentication traces from a provider to measure the correlations between locations, time of day and application usage. In [7] the author monitored the device consists of 43 users and found that browsing contributes most traffic, and lower layer protocols higher overhead due to small transfer sizes. They also found the current server-side transfer buffers and radio power management are not well tuned for smart phone workloads. In [9] the analysis of different providers like Amazon, EC2 with measured

performance metrics like waiting time, response time and experiments were conducted on many tasks computing based scientific computing. In the cloud, sharing of computer and storage resources has become a popular solution for a number of key enterprise applications. Distribution of high workloads between the sites and distributing critical data and risk failures are minimized. It is transforming current Internet practices providing multiple search engine facilities, traditional services, application running on the Internet or broadband to deliver services to an end user.

In [21] some of the network performances are measured between different zones in Amazon web services. The work includes link to evaluate network Quality of Service in different zones of the Amazon. They conclude streaming service can be efficiently used to improve the quality of service compared to traditional P2P and CDN systems by distributing a hybrid P2P and cloud streaming network. In [65] solutions based on caching of entire dynamic page are explained. The RTT has calculated using SYN, SYN ACK of TCP connection in [11, 12, and 13].

In some papers, the comparison of network performance in smart phones has been explained on the application based measurement software. Work in [16] suggested which operating system for mobile is most suitable for users in mobile gaming and applications. In [15] with the help of software measurement application tools they compared different operators and network protocols in various smart phone operating systems.

1.3 Research Questions

Some of the research questions are identified related to mobile cloud.

1. What are the performance issues that are influencing cloud infrastructure?
2. How does a jitter vary in Laptop and Smartphone while accessing a video streaming service in the cloud?
3. Does Round Trip Time (RTT) depend on the type of mobile browser?
4. How page loading times varies with various browsers in the smart phone?

1.4 Research Methodology

While doing a thesis, some of the research methods are followed to explain research methodology in [4].

1. Literature Study: - This phase includes the thorough analysis of journals and conference papers obtained from reputed scientific databases for specified search criteria. By performing literature study the network performance issues that are related to cloud infrastructure. White papers are included in the search for even more knowledge on the real time and corporate expertise scientific knowledge in the performance analysis in cloud computing. Thus, the first research question is addressed using Systematic Literature Review (SLR).

2. To solve the second research question an experimental test bed was designed. A video application is deployed in the cloud and accessed through Smartphone and laptop. While accessing the service network performance issues like jitter are calculated and analyzed using the collected traces.

3. For the third and fourth research question various browsers are considered to calculate the round trip time and page loading times with the help of packet sniffing tools. Thereby round trip time and page load time dependencies and underlying factors on various mobile browsers are analyzed.

In order to validate the experiments each experiment is repeated for 25 times on different browsers in a smart phone to ensure that results are not affected due to the time of the day.

1.5 Motivation

The cloud providers around the world are developing more infrastructure and facilities due to increase in number of customers who are willing to launch their applications in the cloud. Now, most of the large companies are trying to build their own clouds so that they cannot lose their customer base. Multimedia applications are increasing day by day. According to cisco forecast reports, internet video is expected to be 50% of the total consumer traffic. This shows the importance of video application on wireless devices like smart phones. Usually mobile browsers are used to access the video applications. This is the motivation to pursue this work. On the basis of our study, the collected timestamps are crucial to analyze network metrics such as RTT, page loading time and jitter in smart phone while accessing video from the cloud in real time networking. This paper shows the browsers behavior comparison in android Smartphone and laptop. This thesis helps to see the network performance of laptop and smart phone for video streaming application in real time environment when launched in the cloud.

1.6 Contributions

This thesis provides the steps in deploying a video application in the cloud. It shows how network performance varies in the cloud and in the local server when the same video application is launched and video is accessed through smart phone with various browsers. It also provides knowledge on cloud infrastructure services offered to the users.

1.7 Thesis Outline

The thesis document gives as follows.

- Chapter 2 explains about cloud computing, systematic literature review (SLR) and results.
- Chapter 3 experimental setup for jitter in cloud and its results.
- Chapter 4 experimental setup for round trip time and page loading time in local server and results.
- Chapter 5 Conclusion and Future Work.

2 Cloud Computing

2.1 Introduction

The National Institute of Standards and Technology (NIST) definition essentially says that: **"**Cloud Computing is a model for enabling convenient, on-demand network access to a shared pool of configurable computing resources (e.g., Networks, servers, storage, applications and services) that can be rapidly provisioned and released with minimal management effort or service provider interaction" [60]. The three service models are

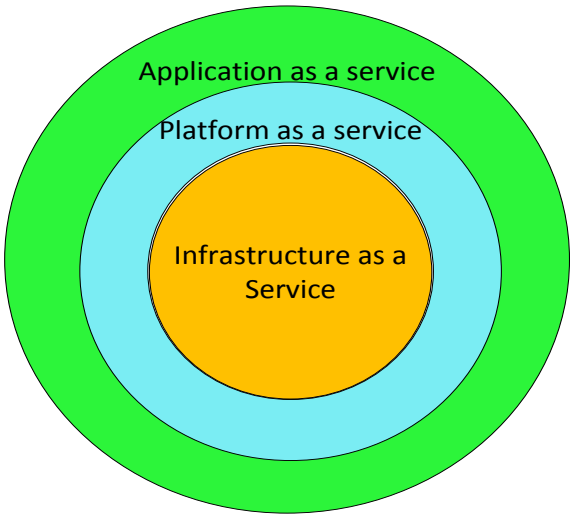

Fig. 1 Cloud Computing Services

Software as a Service (SaaS) –It provides industry-standard functions when you need them, where you need them, without any capital investment in [5, 6]. It allows users to run existing online applications. These applications are designed for end users, delivered over the web.

Platform as a Service (PaaS) - It gives ready-made platforms to build new, unique applications faster to help the business to grow. Furthermore, allows users to create their own cloud applications using supplier specific tools and languages. In [2, 6] PaaS is the set of tools and services designed to make coding and deploying those applications quick and efficient.

Infrastructure as a Service (IaaS) – IaaS is a way of delivering cloud computing Infrastructure servers, storage, network and operating systems as an on demand service. In [6, 21] Virtualization allows users to share the same physical server without interfering with each other's application over the internet. It allows users to run any applications, which are placed on cloud hardware of their own choice so that it reduces the IT cost.

All this service makes users to run applications and store data online. Anyhow, each offers a different level of user flexibility and control.

IaaS comes in different categories in [60] [6]. They are

1. Public cloud- public cloud is considered as an infrastructure that consists of shared resources, deployed on self basis over the internet.
2. Private cloud- private cloud is considered as an infrastructure that emulates some of cloud computing features like virtualization.
3. Dedicated Hosting- when the physical servers are on demand. Furthermore, matching all their requirements to the customers.
4. Hybrid cloud- some hosting providers are beginning to offer a combination of traditional dedicated hosting with public and private cloud networks.

Amazon web services are operating on IaaS model. For example, Amazon has a number of products of which one is Amazon Elastic Cloud (EC2) and variety of instance types are available in the market which are purchased on an hourly basis. Here they provide a choice of selecting servers, RAM, CPU, storage, power, firewall, security, hardware load balancing and other network equipment. IaaS is to enterprise customers with high secured, high resilience and high availability solution for the applications in business modeling.

2.2 Systematic Literature Review

A systematic literature review (often referred to as a systematic review) is a means of identifying, evaluating and interpreting all available research relevant to a particular research question, topic area, or phenomenon of interest in [20].

There are many reasons for choosing a systematic literature review. The most common reasons are:

1. To summarize the existing evidence concerning to technology.
2. To identify gaps in further research in order to suggest areas for significant investigation.
3. To provide a background in order to ensure new research activities.

2.2.1 Features of Systematic Literature Reviews

Some of the features that differentiate a systematic review and conventional expert literature review of [20] are:

- Systematic reviews start by defining a review protocol that specifies the research question being addressed, and the method will be used to perform the review.
- Systematic review defines search strategy that aims to find the most relevant literature material.
- Systematic reviews require explicit inclusion and exclusion criteria to assess each potential primary study.
- A systematic review is a prerequisite for quantitative meta-analysis.

A systematic review is conducted mainly in three phases. They are

- Planning the review: -At this stage here the identification of the need for a review and development of the review protocol has been proposed.
- Conducting the review: -This phase includes primary study, data extracting, and data analysis.
- Reporting the review: -Finally, this part is associated with reporting the results and in documentation process.

The Systematic Literature Review is one of the leading research methodologies in the research work. The principal reasons to do systematic literature review is to collect necessary data for solving the RQ1 by perusing relevant research published on articles, journals and conference proceedings from different publication sources by following the predefined review protocol. Systematic reviews are based on distinct search strategies that aim to collect much of the relevant literature as possible.

Planning the Review

At the planning stage, a review protocol has been defined which includes the search strategy, search string formulation, used data sources, selection criteria, data extracted and quality assessment strategies.

Major keywords in a search string were formulated from the research question. In addition synonyms and alternative terms are identified.

(("cloud infrastructure") AND ("performance" OR "practice" OR "operation" OR "efficiency") AND ("issue*" OR "risk*" OR "challenge*" OR "problem*"))

Table 1 SLR Search string.

2.3 Defining the Research Questions

What are the performance issues that are influencing cloud infrastructure?

The purpose to conduct SLR is to evaluate and interpret all available issues relevant to a cloud infrastructure as a service. The SLR is conducted on databases, articles, journals and conference from distinct publications by predefined review protocol. The detailed and the preliminary results are explained below.

2.4 Defining Keywords

In [20] PICO (Population, Intervention, Comparison, and Outcome) criteria are used to frame research questions with the help of keywords.

Population: An industry group such as Telecommunications companies or Small IT companies. Here, it refers to a very specific area and chosen “Cloud Computing” as for this research.

Intervention: The intervention is the software tool to address a specific issue. "Cloud infrastructure" is intervention for research.

Comparison: This is the tool or procedure with the intervention is being compared. When the comparison technology is the commonly used technology, but authors are not comparing any technology in this research.

Outcomes: Outcomes should relate to factors such as reliability, reduced production costs and relevant outcomes should be specified.

2.5 Study Quality Assessment

The researchers should develop quality checklists to assess the individual studies. The purpose of the quality assessment is to develop the checklists [20, 61] has shown in the table.

No.	Quality Assessment	Yes/No
1	Does the Aims and objectives are clearly stated?	Yes
2	Does the data collection method describe?	Yes
3	Does the citations in the paper explained?	Yes

Table 2 Quality Assessment Checklist.

2.5.1 Review Protocol

A review protocol specifies the method that will be used to undertake a specific systematic review [61]. Taking SLR into consideration to extract the papers related to the performance issues of infrastructure in cloud computing associated with infrastructure as a service. The published papers of recent years [2008-2011] are considered.

2.5.2 Data Extraction

The Data extraction process is used to collect the accurate and necessary information obtained from the primary studies with minimum bias, which address the research question [20]. The data is extracted based on cloud infrastructure issues. The necessary information was collected using inclusion and exclusion study criteria from the popular and well known databases. The methodology extraction was mainly focused on performance, issues and challenges in cloud infrastructure.

Title of the paper/article	
Name of the author	
Publication	Journal article Conference paper Book
Database	Engineering village IEEE Xplore Science Direct
Research Method	Survey Case study

	Experiment Experience Report The model proposed
Context	Industry Academic

Table 3 Data Extraction Strategy.

2.6 Selection Criteria and Procedures

A selection criterion was followed as mentioned in kitchenham [20]. Search strategy includes papers which are appropriate for the research work. Based on inclusion and exclusion of the selection criteria, the papers are filtered which are not relevant to the research question. Inclusion and exclusion selection of criteria are performed to identify that interpreted data is identified correctly.

2.6.1 Inclusion Criteria

1. The collection of cloud infrastructure papers gives the information about the research question.
2. The collections of different database papers on the performances of the cloud infrastructure are collected using online library provided by Blekinge Tekniska Högskola.
3. Search string: search string needs to be formed first. Extract only the papers which are published in English and with full text of recent years from 2008-2011.
4. Title and abstract: studies covering cloud infrastructure, which relates to cloud computing. And paper covers infrastructure issues which are used in cloud computing.

2.6.2 Exclusion Criteria

The exclusion criteria show the removal of unwanted material and papers by the search strategy.

1. Papers which do not relate to cloud infrastructure in cloud computing.
2. Do not relate the online or the papers which are not published.
3. Do not relate the papers which are not in English.
4. Remove the duplicates.
5. Remove the papers in which full texts are not available.

The search string is used to extract the papers from distinct databases, which are published recently. The selection procedure has step by step to follow, which are shown in figure 2.

Step 1:

To identify the papers, the search has been performed by both the authors simultaneously in three different databases using the search string. The papers which are relevant and related to our research question are considered in our research work.

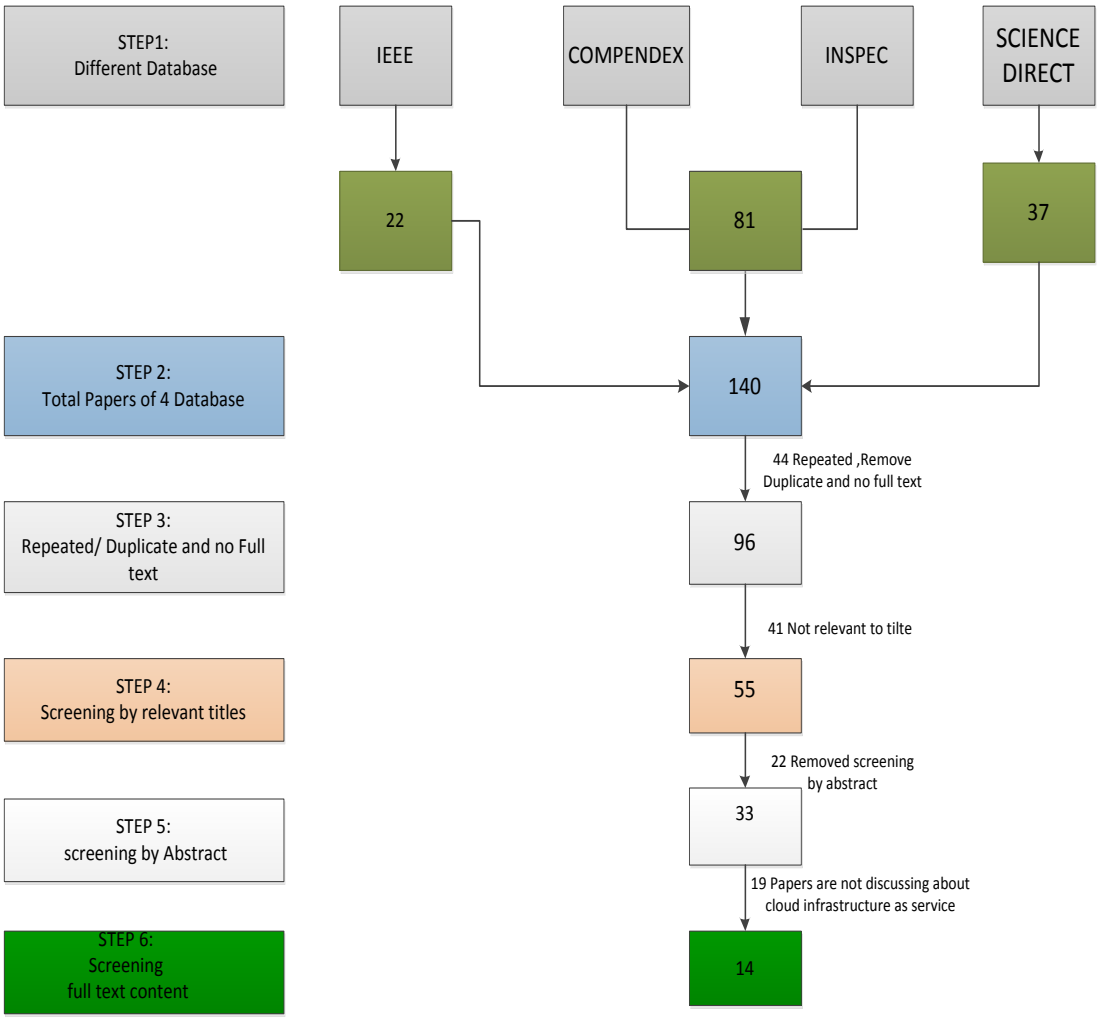

Fig. 2 Step by Step process of Systematic Literature Review.

IEEE Xplore:

IEEE Xplore is a simple, flexible and convenient database. To obtain the relevant papers logical operators like AND/OR/NOT are provided to from the keywords easily. With the help of keywords, a search string is framed to extract the papers relevant to the research, of which 22 papers are extracted as shown in fig 2. The papers are collected from past three years because cloud computing has became popular and more papers are published in 2008-2011.

Compendex and Inspec:

Engineering Village consists of two different database hosts. They are Compendex and Inspec. There are many search fields like quick search, expert search and thesaurus. Here, there are many search options present with the help of the search string the authors extracted 81 papers from both Compendex and Inspec database and which are published from [2008 - 2011] in English.

Science Direct:

Science Direct is another popular database, which has a different search engines authors have extracted the journals using the search string.

Step 2:

The papers obtained from step 1 with the help of search string, and are used in four databases for extracting papers related to the research question and year wise. By combining all the databases total 140 papers were collected in step 2 which are relevant to the subject cloud computing.

Step 3:

In these step Duplicates and the papers which are not in full text are filtered of which 44 papers had been removed in this process. Here, the inclusion criteria are chosen for selection of papers which are available in full text. And even repetition of papers in four databases is also filtered. Out of which 96 papers are collected in this step.

Step 4:

Papers are identified on cloud infrastructure performance. When all the data bases brought together there are 96 papers. Now, the papers are extracted with the title of which 41are not relevant to the title.

Step 5:

55 papers are available from step 4 the selection of papers are relevant to the research question or work after studying title, abstract and conclusion of the papers. Then authors have identified 33 papers related to the research work. Then new lists are compared between both the authors. If there is any change in the selected list of papers. Then both discuss and come up with a single list.

Step 6:

The collection of papers is obtained from step 5. And individually both read the entire text of the research papers. Then both authors finally analyzed all the information related to cloud infrastructure performance issues, which are currently used in research to answer the research question. Furthermore, comes up with 14 papers, which are most relevant to the cloud infrastructure as a service performance.

2.7 Results of SLR

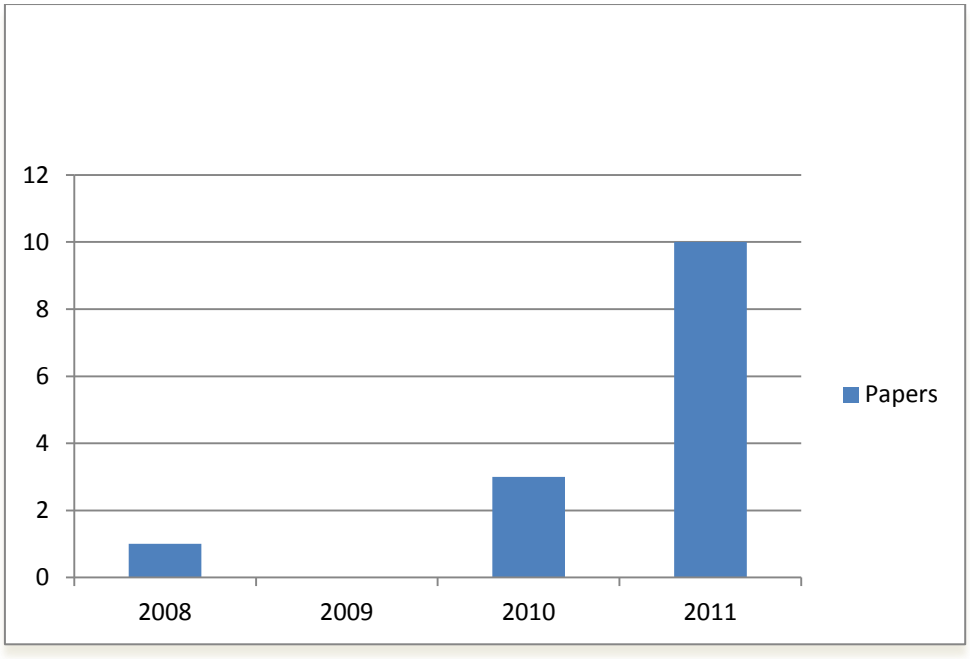

Fig. 3 Number of papers per Year Wise.

Cloud computing research is growing very rapidly in the recent years. The authors conducted SLR on the Network performances in cloud infrastructure. From the recent years 14 relevant papers are selected from different databases. Mostly selected papers are from 2010 and 2011 respectively. The fig. 3 shows the papers published as per year wise.

These are SLR results obtained from different databases which are shown in table 4.

S.no	Performance issues	Main contribution	Conclusion
1 ref [23]	Hardware and Network failure	To show the hardware and network reduces with different algorithms for fault tolerance in computing framework.	A Twister algorithm is found to solve fault tolerance.
2 ref [24]	Security and hardware	To ensure Private data protection service is used for protecting data before storage.	A symmetric key will check the data before upload in the cloud.

3 ref [25]	Networking	To solve network failure problem a cloud network service is implemented.	The novel cloud network is implemented for network failure.
4 ref [26]	Networking and hardware	To design a model for infrastructure in monitoring the failures in IAAS.	Thaific model monitors the network and hardware. Even scalability and robustness are increased due to thaific model.
5 ref [27]	Security	It explains about Data of service attack (DOS) in cloud infrastructure.	The novel estimation tool is designed for controlling a DOS attack.
6 ref [28]	Large Scale applications	To ensure that how data is partitioned and how computation is distributed so that applications can have higher performance.	Grid Batch allows writing parallel programs for data intensive batch applications.
7 ref[29]	Data storage	On cloud infrastructure that can be seamlessly integrated into an Enterprise Architecture.	An approach towards automated integration of open source EAM tool iteraplan and private or public infrastructure cloud via push and pull protocols.
8 ref[30]	Network and data transfer	To ensure guarantee service of bulk data transfer in cloud computing.	Cloud infrastructure framework (CISF) and a service oriented broker (SRB) to transfer data to cloud.
9 ref[31]	Network performance	Future grid distributed cloud characteristics of the network, transport and application levels.	Flexible sensor centric grid framework with cloud infrastructure likes future grid.
10 ref[32]	Parallel and distributed simulation techniques	Core architecture and simulation as a service are emerging in public cloud.	An approach to implement ARTIS/GAIA+ simulation based on the multi-agent system.
11 ref[33]	Security	Benefits of eucalyptus cloud based on design and deployment of a trusted eucalyptus cloud architecture on the remote attestation via trusted platform modules (TPM).	Eucalyptus is to ensure the integrity and confidentiality of user data and computation for Security and privacy issues in cloud infrastructure.
12 ref[34]	Virtual layer	To identify the effect of services and analyzes the middleware self managed services.	It provides automated services, security and privacy.

13 ref[35]	Industrial	To deploy large scale enterprises on cloud infrastructure implemented within the framework of the IRMOS EU project.	It shows the evaluation, validation and optimization of the implemented service mechanisms.
14 ref[36]	Hardware	To ensure data distribution across the cloud are managed by security, storage and cost efficiency.	To Improve the security while storage, quality of service and resource management.

Table 4 SLR results.

2.8 Cloud infrastructure

Cloud computing is internet based computing where virtual shared servers provide software, platform, infrastructure services and hosting to customers on a pay as you use basis. Below shown are some of the popular cloud infrastructure company details.

2.8.1 GoGrid

GoGrid cloud hosting allows you to build scalable cloud infrastructure in multiple data centers using dedicated cloud servers and cloud storage with total control through automation and self service this made easy use of cloud infrastructure [48]. GoGrid is a service infrastructure in the cloud, Linux and Windows virtual machine's, control panel server management and more comfortable hosting API. GoGrid is a private company and compete on Rackspace for dedicated hosting space, hosted in the cloud. The current version of GoGrid API is 1.8. GoGrid can be easily managed cloud infrastructure and easy use of tools allowing you to monitor, manage and scale your infrastructure in real time.

GoGrid provides the data center to achieve go grid infrastructure, which supplies a easy to use tools. This makes it easy for the business on multiple locations using an individual infrastructure as a service (IaaS) provider. GoGrid hosted private cloud is secure and dedicated, infrastructure on demand and cost savings. Its minimum cost to start is 68.5$ per month in [49].

2.8.2 Cloud.com

Cloud.com is an open source cloud compute platform used to deliver infrastructure as a service. Cloud.com is simple, automated, elastic, scalable and efficient for users and service providers. Cloud.com is the user requirements, and how is the best choice of choosing infrastructure with a company that seeks to cloud computing data center of [50]. "Unlimited" resources that can be accessed on-demand. Increased business agility because invests only in the areas that need to invest and to make a business successful. Reducing costs by using the required as the need through by public service provider. Cloud.com is also a Pay as you go policy.

Open source cloud computing platform for building and managing of public and private cloud infrastructure [51]. Cloud.com provides three benefits for private clouds they are end user self-administration, service offering management and virtual data center deployments.

Citrix:

Citrix systems have acquired cloud.com which is a cloud computing provider [52]. Citrix provides software, platform and infrastructure as a service for the cloud providers. Cloud stack is used to implement, simple and cost effective services. Citrix is open source software and is designed to deploy and manage large networks of virtual machines, secure, and scalable cloud computing platform. For the acquisition of cloud providers is growing rapidly as the market leader in infrastructure based on Citrix.

2.8.3 IBM Smart Cloud

IBM Smart Cloud [53, 54, and 55] is a Cloud Computing solution and IBM brand ecosystem. IBM smart cloud includes Infrastructure as a service (IaaS), Software as a service (SaaS) and Platform as a service (PaaS) delivery model, through the provision of public, private and hybrid clouds. This allows IBM to show that they are the smart cloud foundation, smart cloud services and smart cloud solutions.

IBM offers a flexible approach to the cloud. When start working on the cloud, depending on the needs of business. The short-term goal is to get in the middle of the balance for the future and is ready to take advantage of opportunities. The challenge of the pressure on IT infrastructure with business growing, cloud computing companies are looking forward to provide IT services. With the IBM, transformative power of cloud computing will drive the way to do business that can apply. IBM cloud solutions can helps to

- Create new business value.
- Improve speed and dexterity.
- Deliver IT without boundaries.

IBM offers High-Performance Computing Cloud (HPC) provides methods and manages the HPC management tools for the use of cloud computing technology. The concessions designed for both private hosting and private HPC cloud to include

- IBM Intelligent Cluster.
- IBM HPC Management suite for Cloud.
- HPC Cloud service from IBM.

IBM provides a different type of charge plans named copper, bronze, silver and gold each varies with the price and services. Otherwise pay as per use plan.

2.8.4 Rackspace

One of the cloud web hosting provider is Rackspace that startup bills on a utility computing offering. It is also one of the commercial computing services. The rack space [57] clouds are simple, scalable and pay as per use.

Rackspace cloud has been designed and constructed on the requirement of user's perspectives. It provides cost effective, great service and support, particularly to the provision and use of support scalable solutions. Rackspace servers consist of both windows and Linux virtual servers in the cloud that can deploy in minutes and pay on an hourly basis. Pay as per use that is from the start of server to the end. Pay for each cloud server based on the selection of RAM, data-storage type, operating system, on the server type also these prices vary according to your configurations and requirements per hour in [56, 57] .

Rackspace server provides a world-class service to the cloud extends to management services offering Rackspace cloud hosting. This product provides cloud monitoring, operating systems and application layer infrastructure support, including a technical guidance to support more cloud servers.

2.8.5 Eucalyptus

Eucalyptus provides a cloud platform with a worldwide development community and professional support in deploying software, platform and infrastructure as a service in cloud. Eucalyptus is interface-compatible with AWS, so there is flexibility to expand for hybrid, private and public cloud. AWS cloud resources for network and storage [59]. From modern infrastructure, Virtualization software is to create flexible benefits for eucalyptus that can be dynamically zoomed in or out on the application workload may be set. Eucalyptus is specifically designed for the web service using Amazon Web Service API industry standard hybrid clouds [58]. The advantage is high efficiency, scalability and control for IT as a service.

Eucalyptus can build and manage on-premise IaaS clouds using existing heterogeneous compute, network and storage IT infrastructure resources. It supports IaaS for the most demanding, business critical cloud deployments in [59].

3 EXPERIMENTAL SETUP

3.1 Experimental Setup for Cloud Performance

The Fig.4 shown below represents the experimental setup for calculation of jitter from cloud to smart phone and laptop using a Right scale account.

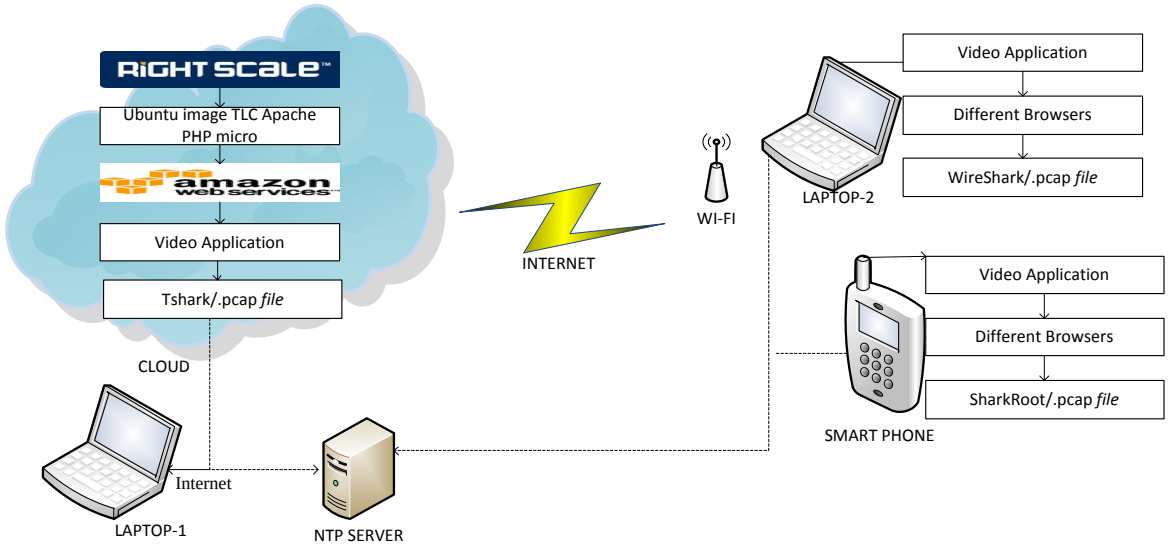

Fig. 4 Experimental Setup for Cloud performance.

To study the Network performance of the cloud, a video-based application is embedded with javascript and is deployed in the Amazon AWS EC2 cloud using Rightscale, TLC Apache/PHP micro server template. TLC Apache/PHP micro consists of ubuntu_10. 04_i386 with 32bit micro EC2 instance and an Apache server is installed in the Amazon AWS in us-east zone. The tshark tool is installed in the cloud for collecting traces on the server side. HP laptop-1 of windows7 64 bit, Intel core i3 processor with 4 GB RAM is used to collect traces using SSH with wired cable of 25 Mbps speed. On the receiver side, experiments are conducted at Blekinge Institute of Technology, Sweden. Using speed test application the WI-FI bandwidth is measured and usually varies around 10 Mbps while performing each experiment. The sender and receiver clock is synchronized to Network Time Protocol (NTP). Experiments are conducted on both Smartphone and laptop on the receiver side. A shark root tool is used in the android HTC desire Smartphone to collect traces at the receiver side. Experiments are repeated for 25 times on each browser at different time slots on various browsers like Android inbuilt browser, Firefox, Opera, Xscope and Dolphin in android mobile. In laptop-2, Firefox, Opera and Safari browser is considered. Before start of every experiment browser cache has been cleared. The Wireshark 1.6.5 tool is used to collect traces in Toshiba laptop with operating system windows 7, 32-bit Intel Core 2 Duo processor and RAM of 3GB. The jitter analysis is performed using the collected traces. From the obtained graphs, results are analyzed.

3.2 Experimental Procedure

This block diagram of Fig. 5 gives in detail experimental procedure. Steps are explained in detail below.

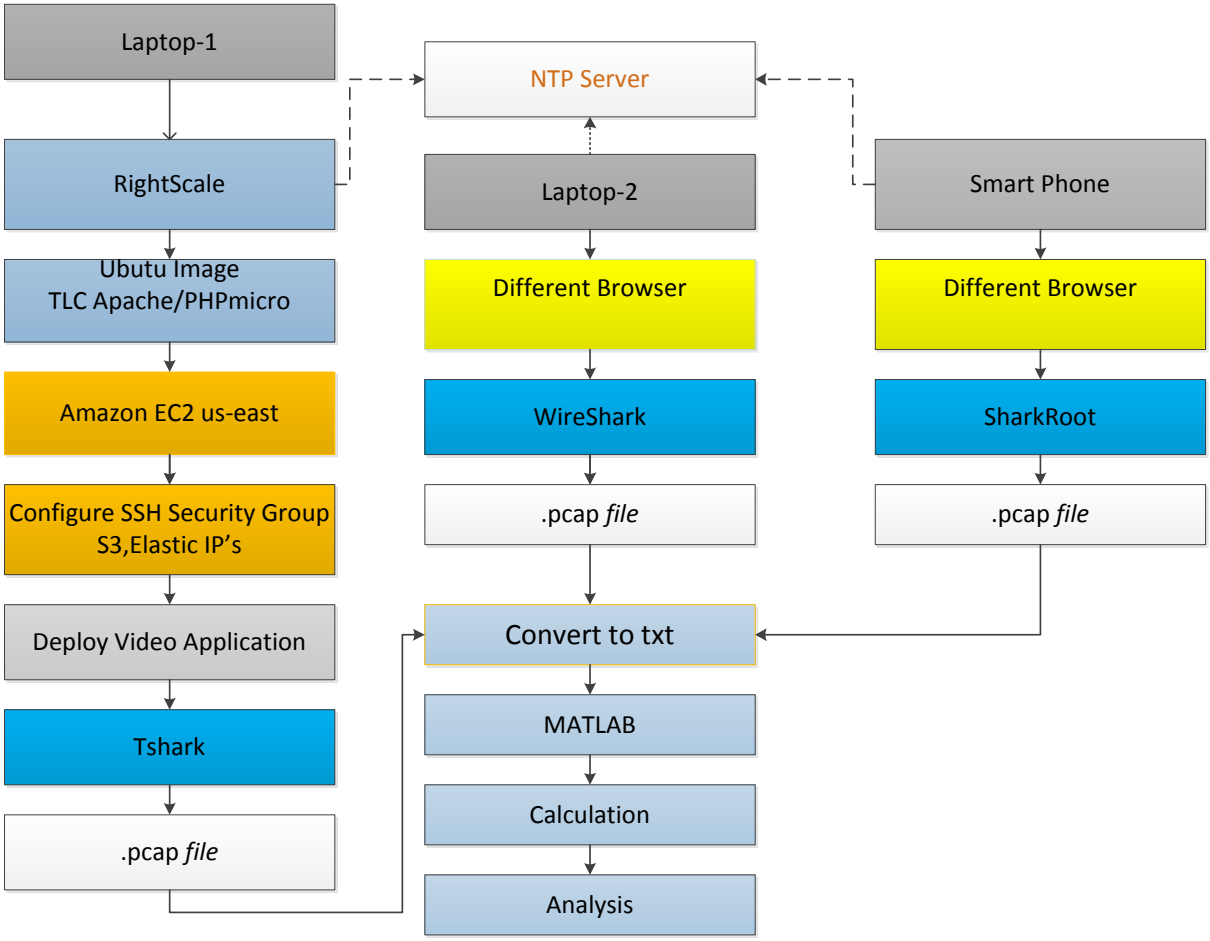

Fig. 5 Block diagram for analysis of Jitter from Cloud.

The services of the Rightscale cloud provider are used. The Logica Company and Telecom city of Karlskrona have a subscription from the rightscale. Cloud services are provided by the Telecom city and Logica Company for the thesis work. From Rightscale provider Amazon web services and EC2 are accessed.

3.2.1 Laptop-1

For this experiment HP laptop of windows7 64 bit, Intel core i3 processor with 4 GB RAM is used to access the cloud providers and collect traces using SSH. For this wired cable is used with a broad band speed of 25Mbps. The traces are then downloaded to the local machine using secure copy of SSH.

i.e.: scp *filename*.pcap root *@ipaddress:/home/path*

3.2.1 Rightscale

Rightscale is a web-based management platform for managing cloud infrastructure from multiple providers [37]. The right scale manages all three platforms they are public, private and hybrid clouds. The workloads between private and public cloud are operated by distinct services like Amazon Web Services (AWS), Rack space, logic works, soft layer and Tata.

The public cloud has basically changed to quick enterprise IT. Day by day, demand has been increasing because they pay as per use, so that the developers and business lines are showing more interest towards it. Rightscale cloud management is a platform that brings together an entire ecosystem for cloud based IT [38]. Their partners develop different server template software to access a large number of users by providing security and large data. Rather than purchasing servers, and networks, the clients buy those resources with the help of the platform as a service from rightscale.

Rightscale cloud management is the bridge between an application and cloud infrastructure. Right scale is portable, automated and controls the user permission, audit entries, version control. It supports public, private and hybrid clouds. Rightscale is leading the infrastructure provider in the cloud. Now, the rightscale provides software for VM, storage and networking. It provides the tools to create own data center, which is automated, reliable and secure.

3.2.2 Server Template

Rightscale provides several templates that are ready to configure and built by the right scale team and other partners. Server templates allow users to configure servers from the first stage of a base image and addition of scripts that runs the task during the operation, booting phase and in shutdown phases. A server template main idea is to boot any server from set of images and configure the server at boot time. List of scripts that are yet to run at boot time to install and configure all software [39].

TLC Apache/PHP Micro

TLC Apache/PHP Micro server template is available in the rightscale multi cloud market place, which is supported by the Amazon Web Service provider. This template is used in the thesis work.

An AWS t1.Micro all in one server with Ubuntu 32bit Operating System, Apache, PHP, common PHP modules and site enabling link manageable through rightscale.

The different contents to configure the server template are

- Multi Cloud Image: Ubuntu_10.04_i386_micro.
- Right Script: Apache Ubuntu vhost configure.
- Right Script: SYS SYSLOG remote logging client -11H1
- Right Script: SYS Time Zone Set – 11H1
- Right Script : MAIL Postfix local delivery – 11H1
- Right Script: WEB Apache (re) starts – 11H1
- Right Script: WEB Apache base install – 11H1
- Right Script: WEB PHP installs – 11H1

3.3.3 Amazon Web Services (AWS)

In 2006, AWS began to provide IT infrastructure services to all types of business in the form of web services now it's called as cloud computing [41]. The advantage of cloud computing is the chance to replace up the capital infrastructure expenses with low cost, which helps the business. No need to launch the own servers and infrastructure. Instantly, they provide you the thousands of servers in minutes as per the requirements and deliver the results faster. Amazon cloud is a partner of Rightscale so that authors have chosen Amazon Cloud.

Today, AWS is a highly scalable, reliable, efficient, open, flexible and low cost infrastructure platform in the cloud that covers hundreds of companies or business around the world [41]. AWS covers all over the world by providing data centers at different locations in the U.S., Europe, Singapore and Japan. Now they also launched their servers in Oregon and Paulo.

The main concept of AWS cloud computing is pay-as-you–go pricing with no up-front investment or expenses or without long-term plans or commitments. AWS provides a flexible, cost-effective, secure, scalable and easy to use cloud computing platform for business of all sizes of [41]. It is comfortable to deploy applications and services with greater flexibility, scalability and reliability in AWS. The application for this research work is deployed in US-East.

3.3.4 Amazon Elastic Compute Cloud (Amazon EC2)

Amazon EC2 [42] is a web service that provides the change of platform for the developers in the cloud. EC2 is a new way of introducing web hosting by allowing the flexible increase or decrease of the number of servers according to the service required within minutes. EC2 is a simple web service interface allows obtaining and configuring the capacity so that the applications can run easily in the cloud. Amazon EC2 allows you to pay for how much you have utilized. Various features like Amazon Elastic load balancing, Auto scaling and an Amazon cloud watch are provided for monitoring the developer tools. EC2 has different instances, images, security groups, SSH keys, Elastic IPs and placement. They are configured as per the requirements.

The following steps are performed using Amazon EC2

- Select a pre-defined template if it is available in the market. Then import it and run immediately or create an own image according to the application requirements, install libraries, data and some configuration settings.
- Set up security and network approach on an EC2 instance.
- Decide whether to run the application in different zones or locations.
- Pay as per use for what you actually take, like per hour charges or the data transfer.

3.3.5 EC2 Instances

The instances for planning, purchasing and maintaining hardware, which costs more and this set up provides a low cost. It offers both 32 bit and 64 bit instance types. Choose according to the application requirement. Some of the applications need high performance network interconnects along with a high-performance CPU then use cluster compute instances.

SSH Keys

Before launch of deployment, an image is launched and will specify Secure Shell key to link that image. It is better to create own SSH Key from the rightscale dashboard. The SSH key is

passed into the new instance to allow root login access to your instance via SSH. This is an acceptable and secure way to communicate your instances.

Security Groups

Amazon has developed security groups and essential firewalls for EC2 servers. The traffic is filtered based on the IP address, packet types and ports. Security groups are essential to provide firewalls for EC2 servers. It assigns incoming ports opened in the Amazon for the interconnection to instance. At the launch of EC2 server at least one security group needs to be assigned. Security groups are usually required if you have multiple deployments that require different levels of accessibility. All security groups must have port 22 open in order to support root level access the machine via SSH.

Elastic IPs

Once an instance is launched, the Elastic IP to the running instances is associated. So that the application will link to that EIP address. For example you can see the page with the help of that IP address.

3.3.6 Amazon Simple Storage Service (Amazon S3)

Amazon S3 is simple storage for internet. It provides a web service interface to store and recollect any amount of data at any time and from anywhere in the world using the web. Each data is stored in a bucket and can collect through developer-assigned key. A bucket can be stored at one of the zones. When the objects are stored in particular region then they store in that region unless you change the region. Authentication is required to ensure that data is kept secure. It gives the developer to access for highly scalable, reliable, secure, fast inexpensive infrastructure that Amazon uses to run its own global network of websites [43].

3.3.7 Jw Player

Jw Player version 5.8 is an open source embedded video player [46] that supports both audio and video formats. With the help of a Jw player script a video application is deployed in the cloud. Jw Player works in every browser on both old and new device. Its embedded script supports both Flash application and JavaScript application using html. This work focuses on .mp4 file for streaming video from the cloud.

3.3.8 TShark tool

The Tshark (version: 1.6.5) is a command line oriented version of the Wire shark. The Tshark is a network protocol analyzer. It is designed for capturing and displaying packets in the terminal. The Tshark native capture file format is pcap which is supported by the TCP dump and other tools [45]. The Tshark is installed in the cloud for collecting traces at the server side in the form of pcap files. The command used for collecting pcap file is

i.e.: tshark –i –w *filename*.pcap

The traces are then downloaded to the local machine using secure copy of SSH.

i.e.: scp *filename*.pcap root *@ipaddress*:*/home/path*

3.3.9 Wireshark tool (1.6.5)

Wireshark is an open source network packet analyzer [45]. Wireshark is a validated tool to capture network packets and display data. Wireshark is cross platform using a GTK+ tool kit to user interface and using pcap to capture packets. It runs on various operating systems and it's free software available in the market. Wireshark is installed in laptops and traces are collected through various browsers like opera, Firefox and chrome. The captured files are in pcap format.

3.3.10 Network Time Protocol (NTP)

NTP is a protocol designed and software for the synchronization of the computer clock over packet switched variable via a network. The pool.ntp.org project consists of a huge number of time servers providing easy to use NTP service for a large number of clients. NTP application is available in the android market for android mobile. Laptop 1, 2 and smart phone are in sync with the NTP servers. The command ntpd –p, peers is used before conducting every experiment. In smartphone clock sync application has been installed and set the atomic time and system time to sync from internet via NTP.

3.3.11 Mobile Browsers

HTC Desire smart phone with android version 2.2.1 is used. Five browsers are considered to conduct the experiments. They are an android in build browser, opera, x-scope, dolphin and Firefox browsers [47].

3.3.12 Super User and Shark Root

Super user is an application available in the android market [47]. Super user has the functionality to access sudo su. su has permission to modify any data in android devices. The super user in conjunction with shark root tools helps to capture network packets. Sharkroot is a traffic sniffer tool works for both 3G and Wi-Fi it is similar to Wireshark. The shark tool monitors all the network activity in android mobiles. The captured information is placed in a .pcap format. For validating the tool different experiments are performed. Traces are collected at both the server and client side. In another experiment, an android mobile is made as router and connected WI-Fi to laptop. Now Wireshark is used to collect traces in the laptop then a comparison is made of both the traces and validated the tool.

3.4 Results and Analysis

.Pcap files are used to perform the analysis of network performance metrics.

3.4.1 PCAP to text conversion

From the inbuilt libraries of Tshark conversion from the .Pcap file to text is performed for convenience and easy analysis.

The command used in Tshark is: *tshark -<file.pcap> file.txt.*

3.4.2 Jitter Calculation

Jitter (J_n) is calculated as the difference of the inter arrival times of the consecutive packets of the captured packets of [14]. Jitter is calculated from the obtained traces after the three-way

handshake SYN, ACK until the last packet FIN, ACK from the server. Filtering process is done using IP to IP for calculation of jitter using TCP packets. $T_{R,n}$ is the time when the n^{th} packet is received and $T_{R,n-1}$ is the time when the $(n-1)^{th}$ packet is received. The equation for the calculation of jitter is

$$\Delta T_{R,n} = T_{R,n} - T_{R,n-1}$$

$$J_n = \Delta T_{R,n} - \Delta T_{R,n-1}$$

3.4.3 MATLAB and graph analysis

MATLAB (MATtrix LABoratory) (version 7.12.1) is a tool for visualization and numerical computation. MATLAB is a convenient tool for analyzing the statistics. A script that can perform the functions like reading text files, filter process using IP to IP address, packet's size and calculation of jitter is done. In order to validate the script, the metrics first calculates the result theoretically and compared the result with MATLAB output and then different graphs like jitter with respect to sequence number, packet size, semi log and CDF is plotted.

3.5 Results

To analyze the results, experiments are repeated for 25 times with each browser of Smartphone and laptop. All experiments are done during different time of the day in BTH. Before the start of every experiment in Smartphone and laptop caches are removed and then capture of traces is collected through packet capture tools.

The Fig 6 represents the CDF graph of packet size. Here, experiments are repeated with various browsers in HTC Desire and Toshiba Laptop. From the obtained traces, it is observed that most of the packet sizes are 1514 bytes (approx 99% of packet size is 1514 bytes) which are obtained from server cloud to the client Smartphone and laptop.

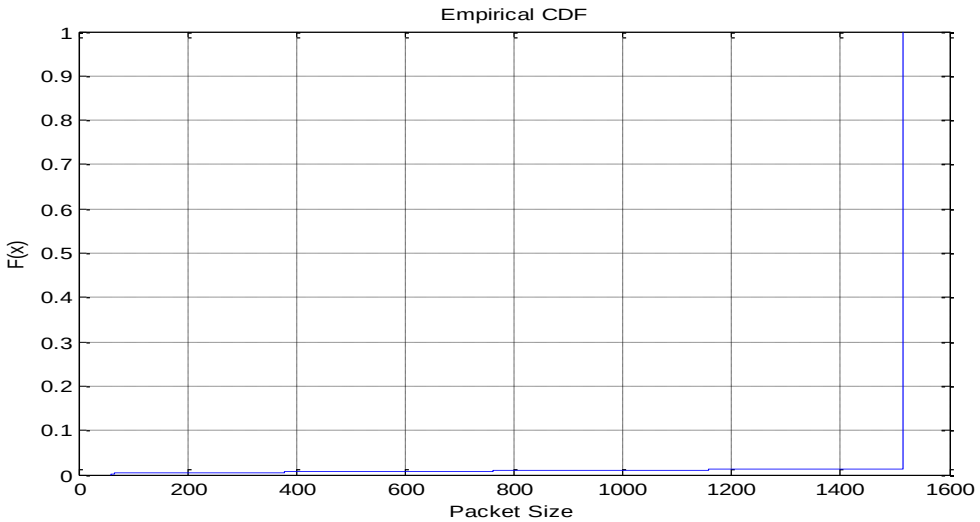

Fig. 6 CDF graph of Packet Size.

3.5.1 Jitter performance in Smart Phone Browsers

The experiments were performed on the top five browsers available in android market. They are Android browser, xScope, Firefox, Opera and Dolphin browsers of android mobile. The experiments were repeated for 25 times individually with each browser. The traces are collected using shark root in HTC Desire mobile. From the obtained traces, IP to IP address filter has done for the TCP flow and then jitter is calculated as shown in section 3.4.2. Performance of video application depends upon the network and browser. With the help of jitter values of various browsers, the semi logs CDF graph is plotted as shown in Fig. 7 Opera browser performs better jitter performance compared to other browsers. Due to less number of Retransmission of packets that are generated in capture packets of Opera browser but in other browsers, the transmissions of resets are more. Opera browser performs well due to network performance for jitter. Detailed graphs of jitter for various browsers and zoom version of graphs are also placed in Appendix.

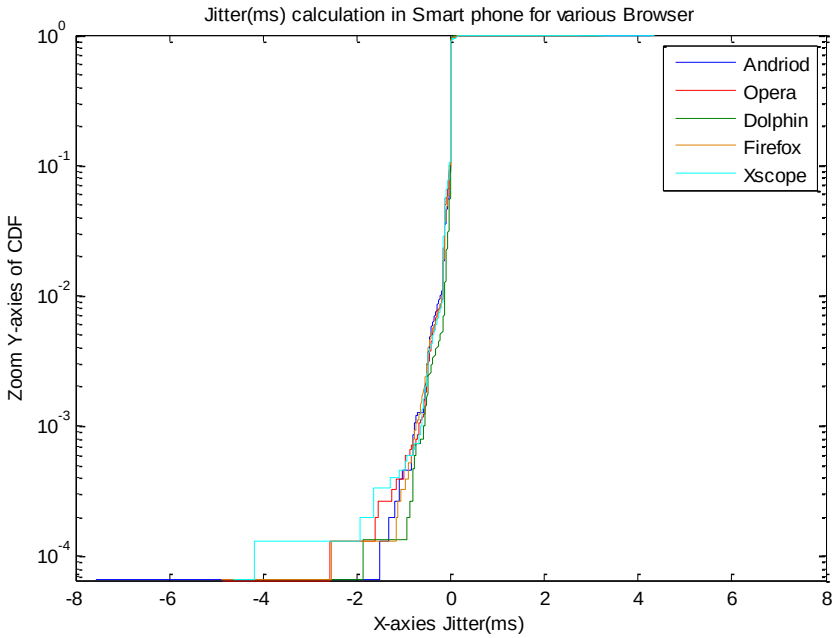

Fig. 7 Semi-log graph for the calculation of jitter in Smart phone for various Browsers.

3.5.2 Jitter Performance in Laptop Browsers

The experiments were performed in laptop with three browsers they are Chrome, Firefox and Opera browsers. The experiments were repeated for 25 times individually with each browser. The traces are collected using wireshark in Toshiba Laptop. From the obtained traces IP to IP address filter has done for the TCP flow and then jitter calculation has shown in 3.4.2. With the help of jitter values of various browsers, the CDF graph of zoom version of Y axis is plotted as shown in fig. 8. From the graph Firefox shows the best browser performance for video application in the cloud. To show the graphs clear a zoom version of X-axis and Y-axis graphs are placed in Appendix.

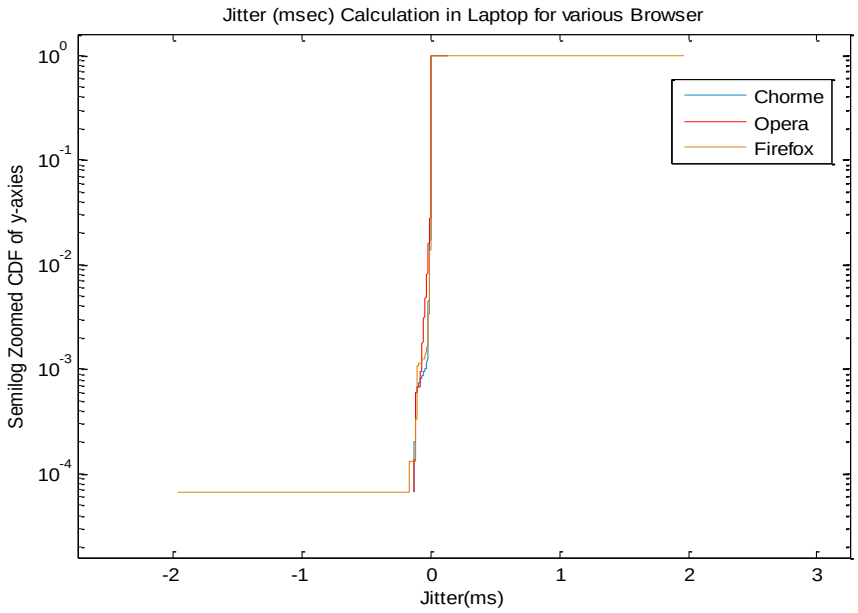

Fig. 8 Semi-log graph for jitter calculation for various browsers.

4. Experimental Setup for Local Server

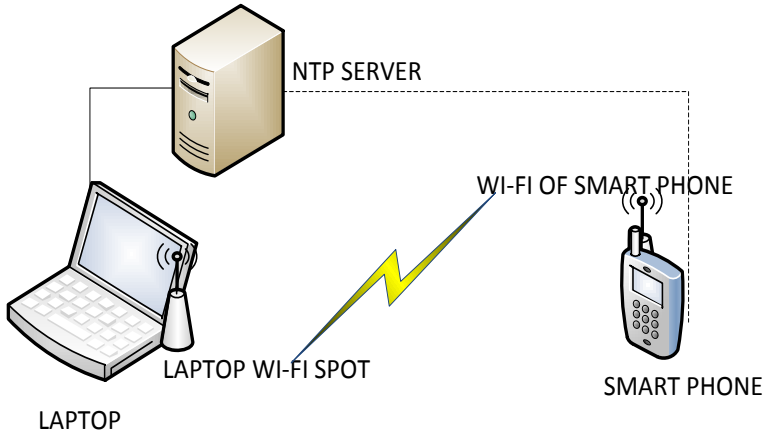

Fig. 9 Experimental setup for Local Server.

The experimental setup for Local server is as shown in Fig 9. For this experiment HP laptop of windows7 64 bit, Intel core i3 processor with 4 GB RAM will act as a server. Wamp Server (version 2.2) or Nginx server (version 1.1.13) is installed in the laptop to act as a local server. First, in the Apache server video application is deployed, and Wi-Fi hot spot has done in laptop. Now, the laptop will act as a router for smart phones. Wi-Fi Access point encrypted (WPA2) security is used in laptop for connecting smart phone. The smart phone gets access through the laptop Wi-Fi hotspot. Both laptop and smart phone synchronizes to NTP server. The pcap files are captured using shark root while accessing a video streaming application through smart phone. Experiments are repeated for 25 times on different times of day for various browsers available in the smart phone. With the captured traces page loading time and Round Trip Time are calculated for local server on various browsers. As for cloud server, the experimental setup is explained clearly in 3.1.

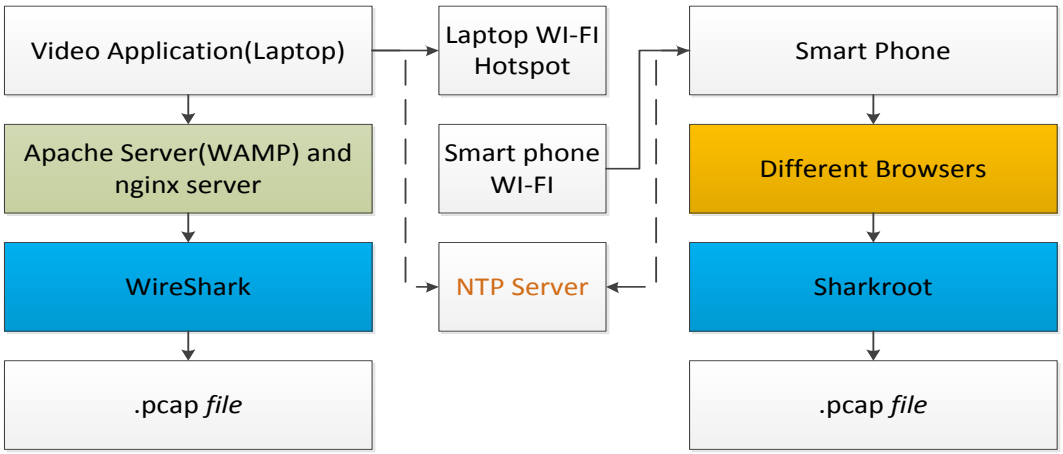

Fig. 10 Block Diagram for Local Server.

Using two different servers experiments are conducted in local server. They are as shown in fig. 10.

Wamp Server

Wamp server (2.2C) is a freely available open-source software and easy to configure. Wamp server manages Apache and Mysql services [61]. Apache is a freely available source for web server platform.

Nginx Server

Nginx Server is open-source software with high-performance HTTP server. Nginx provides high performance, reliability, scalability, security, and it is consistently efficient. The version number of Nginx used is 1.1.13 of [62].

Some tips are considered before conducting the experiment.

- Page weight is important for page loading time for mobile browsers. So, here in the script unnecessary comments, white space, timeline is eliminated. Video file, CSS, JavaScript into other extra files is considered.
- To reduce the time required for the request to be sent and response to receive and minimizing the page size is considered by this HTTP Look up will be reduced. For every time the caches are cleared. If caches are present, it displays from a last modified content page.
- The embedded JavaScript player is considered to display fast appearance of webpage for the quick response to the user.
- Experiments are repeated to know the better performance of the browser for the page loading time and round trip time.

4.1 Round Trip Time (RTT)

Round trip time is the time taken for the response from the server when the request is sent by the user. Round trip time is most important parameter in cloud computing. To know how round trip time varies with the local server. RTT is the time between SYN, SYN ACK packets of a three way handshake. The time between SYN, SYN ACK predicts minimum RTT. The estimating time between SYN, SYN ACK shows the average RTT. The time between the SYN, SYN ACK is a poor prediction of the maximum RTT of [11, 12]. The network monitor tool is placed in both server and client side to capture the TCP packets. From the captured packets, RTT can be calculated using SYN, SYN ACK.

4.2 Results

4.2.1 RTT for cloud server

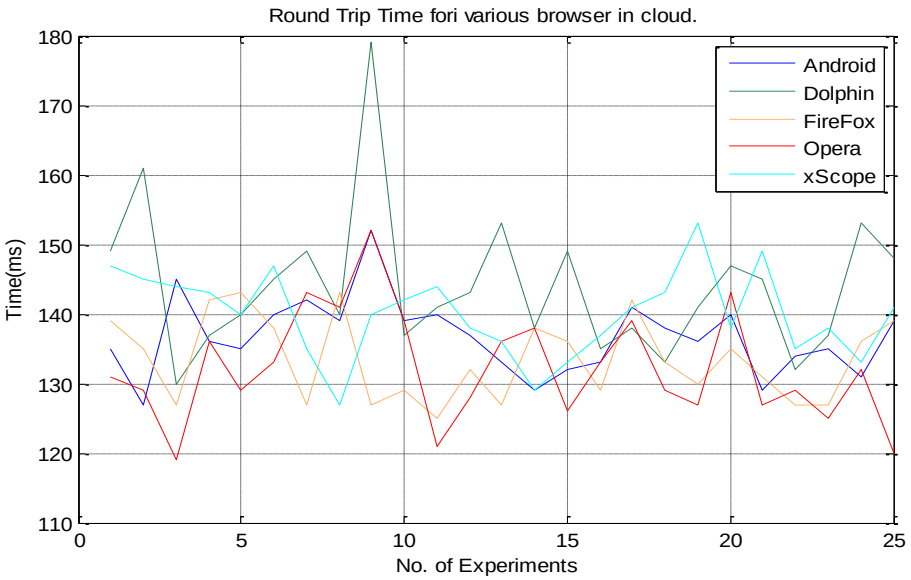

Fig. 11 Round trip time for various browsers in Cloud.

The above experiment is done to calculate Round Trip Time from the cloud server. Packets are collected for 25 times using various browsers of smart phone. From the captured packets of SYN, SYN ACK is called Round Trip Time. The Fig. 11 shows the RTT for five browsers while accessing a video from the cloud server. X-axis represents number of experiment and y-axis represents time in milliseconds. For every browser RTT value looks similar so from the analysis RTT does not depend on the mobile browsers. Experiments are conducted in a controlled environment to minimize network latency. To know the browser performance experiments are conducted in two different local servers, they are Apache and Nginx server.

4.2.2 RTT for Apache Server

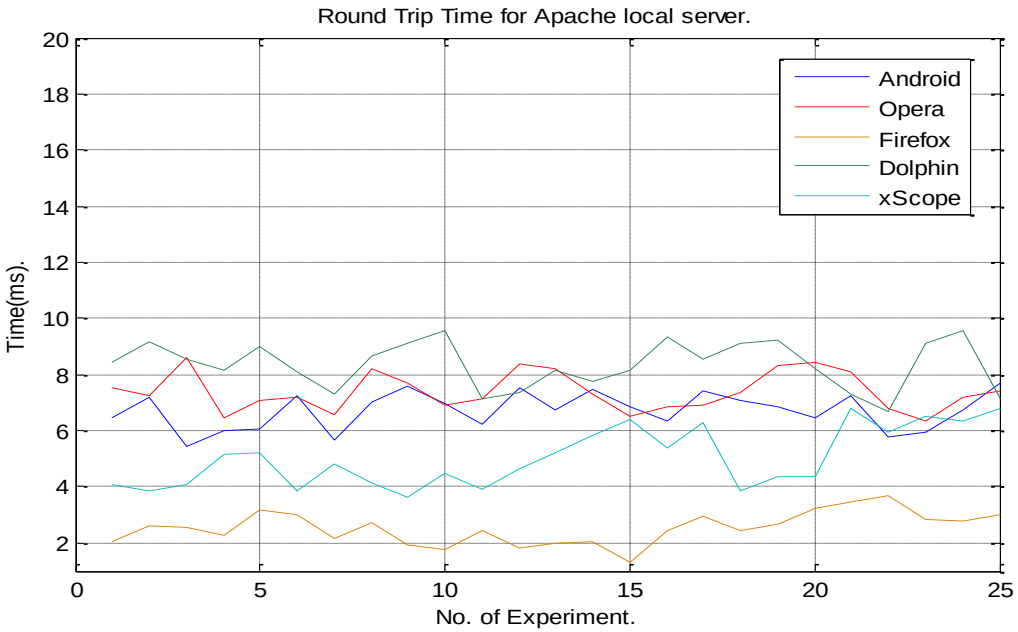

Fig. 12 Round Trip Time for Apache local server.

From Fig. 12, it shows the results of various browsers of smart phone. When video is deployed in Apache server and accessed through smart phone. The packets are collected at both client and server side. From the captured packets RTT can be calculated from SYN, SYN ACK packets. The experiment is conducted for 25 runs on each browser by clearing the caches for every experiment. From the RTT values of Apache server Firefox shows better performance compared to other browsers of smart phone.

4.2.3 RTT for Nginx Server

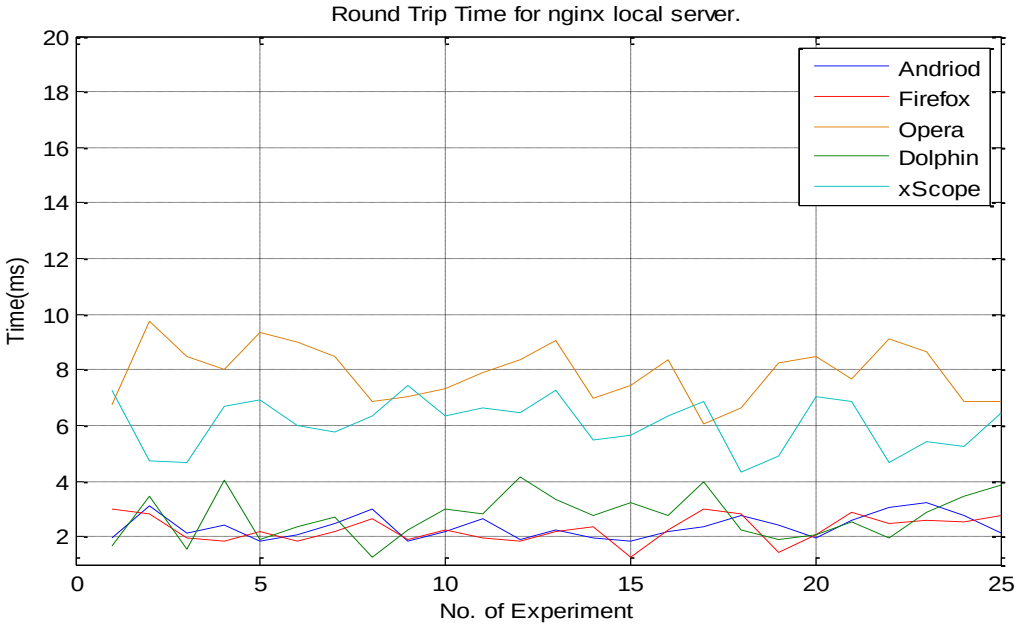

Fig. 13 Round trip time for nigix local sever.

The experiment is conducted same as Apache server. Here, the Apache server has been replaced with Nginx Server to know whether browsers depend on RTT. The video is deployed in Nginx server and accessed through smart phone using various browsers. From the calculated RTT for Nginx server Firefox shows least browser performance compared with other browsers in fig 13.

From 4.2.2 and 4.2.3, the same Firefox browser shows the best performance in Apache server and least performance in Nginx Server for RTT. So, by this analysis RTT does not depend on browsers and it mostly depends on the server response time.

4.3 Page Loading Time

The Page loading time [18, 19] is defined as the time taken to load the web page from the server through mobile browser or laptop browser. Page loading time is calculated from the first HTTP GET request packet from smart phone or laptop to the last FIN ACK response from the cloud server to the smart phone or laptop while accessing the video from the cloud server. The Page loading time of a mobile browser also depends upon hardware, software, server response time, on the network and bandwidth. Mobile browsers play a vital role in smart phones, PDAs, tablets etc. Mobile browsers are also known as mini browser, micro browser or wireless internet browser. Mobile browser helps to display the content of the web page.

Mobile browsers are designed based on hardware, operating system, and low power consumption and even on the low Band width to display the content. To increase the performance of the mobile browser the development of hardware was increasing rapidly. A mobile browser specifies a data services platform which is provided by the mobile operators for the end user.

For an end user mobile browser should perform fast, effective, reliable and secure. The performance of mobile browser depends on User Interface, browser engine, Java script interpreter, networking, subsystem, XML parser, UI back end and Data persistence subsystem.

- The User Interface provides the features like display of content, toolbar, page load and downloads option.
- Browsers Engine is software that takes a URL and displays forward, backward, reload of the browser actions. It loads and displays the web page content on the screen.
- The rendering engine displays the given URL and also displays the HTML and XML documents with CSS are the result for features of web browser design or architecture.
- Networking carries out file transfer protocols such as HTTP and FTP. It is used to transfer data cache of recently retrieved resources.
- The Java script interpreter is Java script which is embedded in web pages. Java script is an object oriented programming language developed by Netscape (Netscape, 2008).
- XML parser translates an XML document to an XML DOM object.
- Display backend subsystem mainly depends on the operating system, and on the user interface widgets.
- Data persistence is to store data of various browser sessions. It stores all types of data such as cookies, bookmarks and toolbar settings, etc.

Performance of mobile browser not only depends upon page loading time moreover on the performance issues like network latency, server response time and hardware. To avoid the network latency experiments are conducted in controlled environment as well as experiments are conducted on two different servers they are Wamp server and Nginx server.

Experiments are conducted in both local servers and cloud server for the page loading performance. Page loading time is calculated for both local servers and in the cloud server. A video application is deployed on all the servers. That video is accessed through various browsers available in android mobile and in laptop. The time taken for the video to load and play from the server to smart phone or in the laptop through various browsers is the page loading time performance for the research work. The traces are collected in Smartphone and laptop.

4.4 Results

4.4.1 Page Loading Time for cloud

Performance for page load time is the total time taken for the web browser to display the whole web page content after the request is sent by the user to the server. Page loading time is calculated from first HTTP GET request packet from smart phone to the last FIN ACK response from the cloud server or the local server to the smart phone while accessing a video. The video length is 322 seconds.

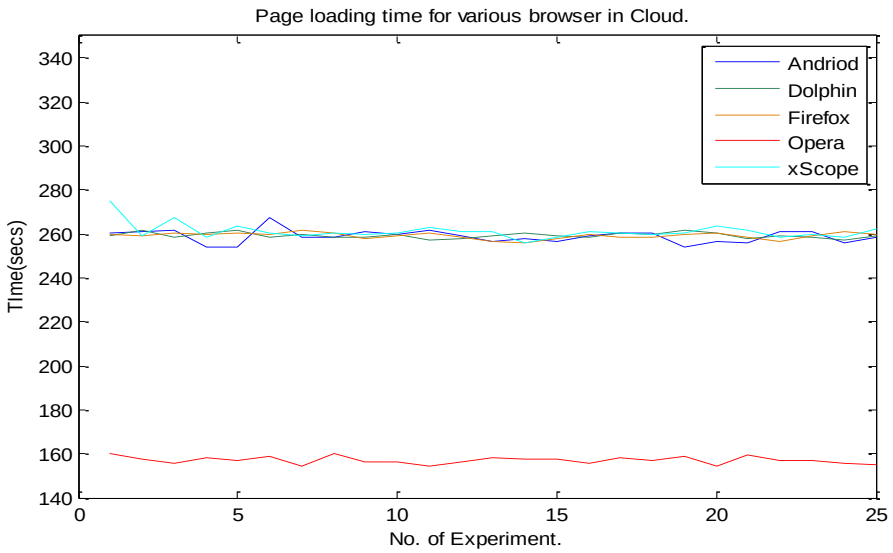

Fig. 14 Page loading time for various browsers in cloud.

From fig. 14, page loading time for various browsers while accessing the video from the cloud server. The experiments are repeated for 25 times on each browser. X-axis represents number of experiments and Y-axis represents the time it takes for the video to load and play with each browser of an android mobile.

Opera browser is the best browser compared to other browsers for the page loading time. From the obtained traces of various browsers, opera browser performance is better due to less retransmission of packets occurred due to TCP window size full. To reduce the impact of network and also to identify the role of browsers in page load time, the experiments are repeated in an isolated and controlled environment. We observe that opera browser takes less time to load the video page.

4.4.2 Page loading time for Apache Server

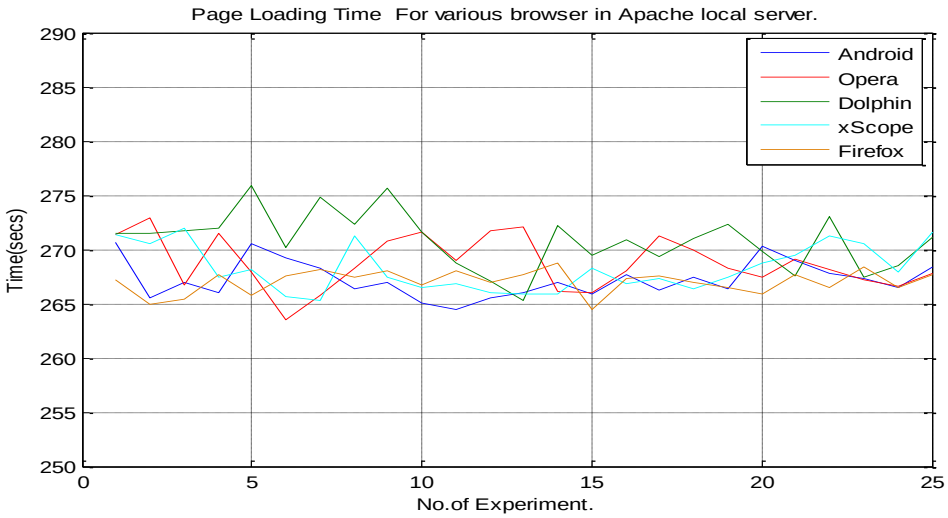

Fig. 15 Page loading time for various browsers in Apache local server.

The experiments are conducted in a controlled environment to calculate page loading time for Apache server. The experiments are repeated for 25 times on five browsers while accessing a video application in the smart phone. The time taken for various browsers is shown in the above graph in fig 15. The Mean (average) and variance for page load time on various browsers are shown in the below table 5. Every time caches are cleared to know the exact time to load the video page content. Fig 15 shows page load time for android, opera, dolphin, xscope and firefox browser. We observe that opera browser takes less time to load the video page.

4.3.3 Page loading time for Nginx Server

The experiments are repeated on Nginx server similarly as like Apache server as shown in Fig 16. Before every experiment, all caches are removed; browser history and saved cookies are removed. Fig 16 shows the page load time for video page in android, opera, firefox, dolphin and xscope browsers. Experiments are repeated for 25 times on each browser independently. From the mean values and variance we observe that opera browser takes less time to load the video page content in Nginx server.

Fig. 16 Page loading time for various browsers in nginx local server.

Browsers	Mean value of Apache server	Mean value of Nginx server	Variance for Apache server	Variance for Nginx server
Android browser	267.265	266.017	2.742	0.785
Opera	266.118	265.730	1.107	0.254
Firefox	267.033	266.639	3.581	0.839
Dolphin	270.084	266.954	6.479	1.442
xScope	268.241	266.778	4.423	1.337

Table 5 Mean (Average) and variance for Page Loading time in local servers.

The performance of Mean (average) and variance for page load time on two different servers is shown in table [5]. From the obtained results, page loading time for both Apache server and Nginx server are approximately equal. Type of server used has no much influence on page load time. Among them opera browser takes less time to load the video page in both Apache and Nginx server.

Conclusion

The thesis can be summarized by answering research questions on the basis of SLR and experimental results.

1. What are the performance issues that are influencing cloud infrastructure?

Ans: A Systematic Literature Review on the performances of Cloud Infrastructure in Cloud Computing. To answer research question one a SLR is conducted on cloud infrastructure to observe the cloud performance. The related papers give the detailed issues on security, hardware, power consumption and network for cloud infrastructure.

2. How does jitter vary in laptop and Smartphone while accessing a video application in the cloud?

Ans: To answer the second research question, a video application is deployed in the cloud and the jitter performance is calculated while accessing web page content with video is load and play in smart phone and laptop for various browsers. Jitter calculation is shown in section 3.4.2. On the basis of measurement results (section 3.5.1) Opera browser in smart phones shows better performance for jitter compared to android, dolphin, xscope and firefox browsers from the cloud. Firefox shows best browser performance for jitter in laptop compared to opera and chrome browsers as shown in section 3.5.2.

3. Does Round Trip Time (RTT) depend on type of mobile browser?

Ans: To answer the third research question, it focuses mainly based on the performance of mobile browser while accessing a video application in a cloud for Round Trip Time. It shows similar results as shown in the graph. So RTT is analyzed for various browsers and can conclude with the help of these results, RTT does not depend on mobile browsers.

Then the experiments are conducted in a controlled environment on two local servers (fig 12 and 13) Apache server and Nginx server. Firefox performs better and worst performance in two local servers. Hence from these experiments we can conclude RTT does not depend on mobile browsers. It depends on the server response time. To see the performance of mobile browser we have done page load time for both the servers.

4. How page loading time varies with various browsers in the Smartphone?

Ans: To answer the fourth research question, the time took to load the whole web page content with video to display on the screen. Page loading time is conducted on three servers one is cloud server, and two other servers are local server with the smart phone. Experiment is conducted using android, dolphin, opera, firefox and x-scope browsers. In the page loading time experiment (fig 15 and 16) from table 5 we observe that opera browser performs better in both the local servers. On the basis of measurement results (section 4.4.1) we observe opera browser takes less time to load the web page content with video this is due to the less number of retransmission of packets from the cloud sever.

Future Work

During the course of work this can be extended in many ways.

Firstly, it can be linked to QOE (Quality of Experience). The Measuring different parameters like throughput, packet loss, CPU processor and memory utilization. Experiments can be done in different smart phones. See the same performance issues how it works in 3G.

It would be interesting to compare the Performances of various cloud providers. By increasing loads, scalability in different cloud provider's performances can be analyzed. Browser performance can be performed on advanced hardware and smart phones. Cloud Network performance also increases by different Algorithms.

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APPENDIX

Wireshark	Version 1.6.5
Tshark	Version 1.6.5
Type	Android 2.2
Model • Processor • RAM • Operating system	HTC desire. 1Ghz. 576 MB. Android 2.2.
Android : ➢ Browsers(layout): • Dolphin(webkit) • Firefox(Gecko) • Opera (persto) • Xscope (webkit)	 Version 7.3.0 Version 9.0 Version 11.5.3 Version 6.50
Band width for client • Laptop (Application: http://speedtest.net/) • Smart phone	 • ~10mbps/sec. • ~10mbps/sec.
Jw player with embedded player	Version 5.8
WI-FI	Wi-fi 802.11g
Video type	MP4
MP4 ➢ Video • Length • Frame width • Frame height • Data rate • Total bit rate • Frame rate ➢ Audio • Bitrates • Channels • Audio sample rate	 ➢ Video • 05.22 • 480 • 368 • 429kbps • 537kbps • 29frames/second ➢ Audio • 108kpps • 2(stereo) • 44khz
Apache server for Cloud	Wampserver 2.2A P1 (32 bits)Apache 2.2.21 Php 5.3.8 Mysql 5.5.16 XDebug 2.1.2 XDC 1.5 PhpMyadmin 3.4.5 SQLBuddy 1.3.3 webGrind 1.0.
Apache server for local sever	Version 2.2
Nginx server for local server	Version 1.1.13

HP Laptop • OS • RAM • Processer	• Windows 7. • 4GB. • Intel core i3.
Toshiba Laptop • OS • RAM • Processor	• Windows 7 • 3GB. • Intel core 2 duo(32bit).
Cloud • Zone • Server Template • Image • Bit • Configuration	Amazon aws EC2 • US East • Rightscale TLC Apache/PHP Micro • Ubuntu_10.04_i386_ micro[rev1] • 32bit • SSH, Security ,Elastic IP's,S3
MATLAB	Version 7.0.12.

Table 6 Specification table for experiments.

Database	Search string
IEEE	(("Abstract":"cloud infrastructure") AND ("Abstract":performance OR "Abstract":practice OR "Abstract":operation OR "Abstract":efficiency) AND ("Abstract":issue* OR "Abstract":risk* OR "Abstract":challenge* OR "Abstract":problem*))
E-VIILLAGE	+(((({cloud infrastructure}) WN AB) AND (English WN LA) AND (2008-2012 WN YR)) AND ((((((($performance) WN AB) OR (($practice) WN AB)) Osearch R (($efficiency) WN AB)) AND (English WN LA) AND (2008-2012 WN YR)) OR ((($OPERATION) WN AB) AND (English WN LA) AND (2008-2012 WN YR)))))) AND ((((((($issue) WN AB) OR (($risk) WN AB)) OR (($challenge) WN AB)) AND (English WN LA) AND (2008-2012 WN YR)) OR ((($problem) WN AB) AND (English WN LA) AND (2008-2012 WN YR)))))
SCIENCE DIRECT	(("Abstract":"cloud infrastructure") AND ("Abstract":performance OR "Abstract":practice OR "Abstract":operation OR "Abstract":efficiency) AND ("Abstract":issue* OR "Abstract":risk* OR "Abstract":challenge* OR "Abstract":problem*))

Table 7 SLR Search string.

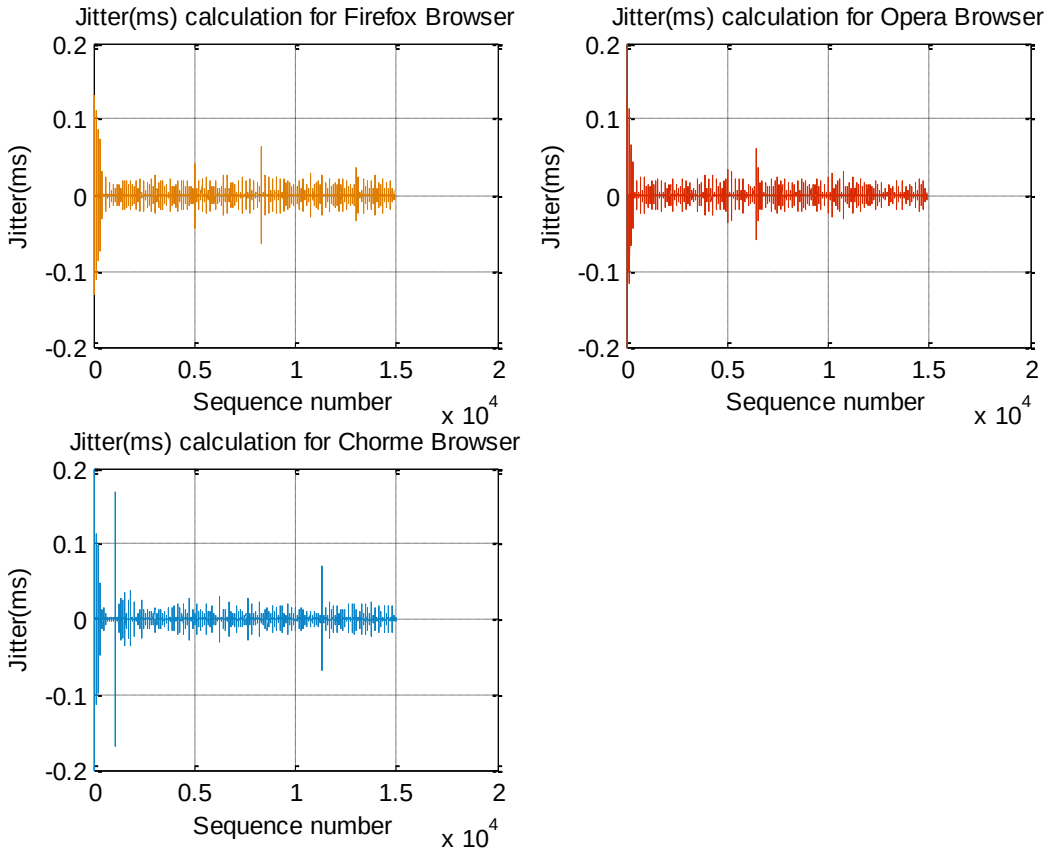


Fig. 17 jitter calculation for various browsers in Laptop.

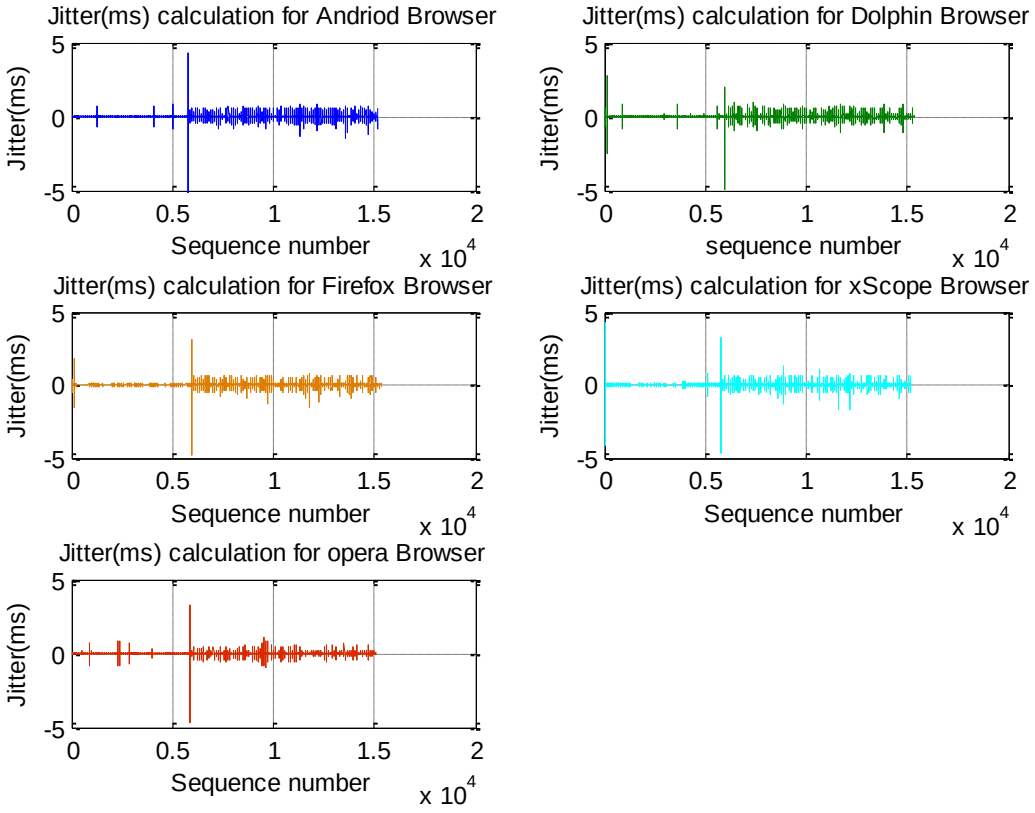
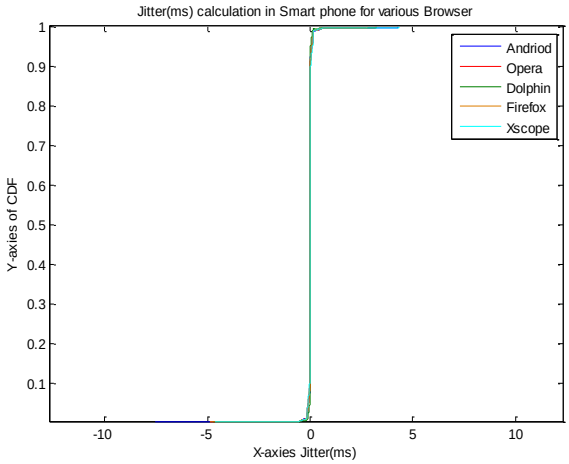
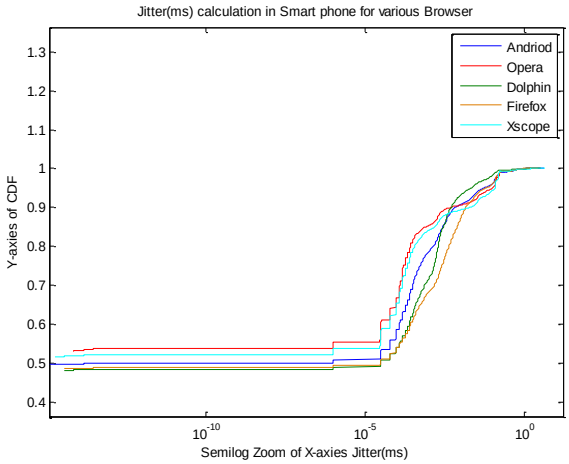
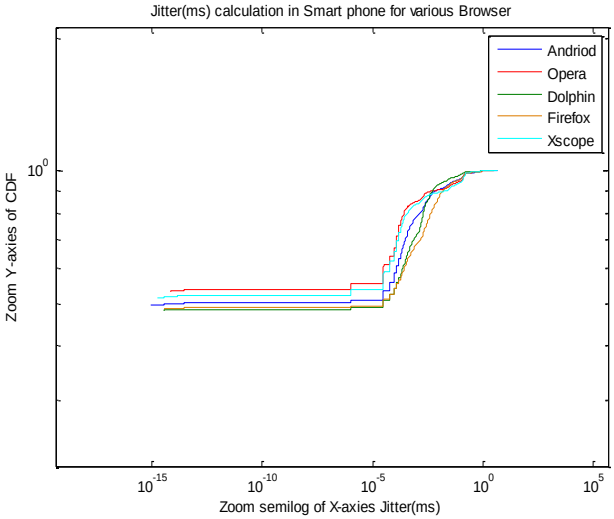
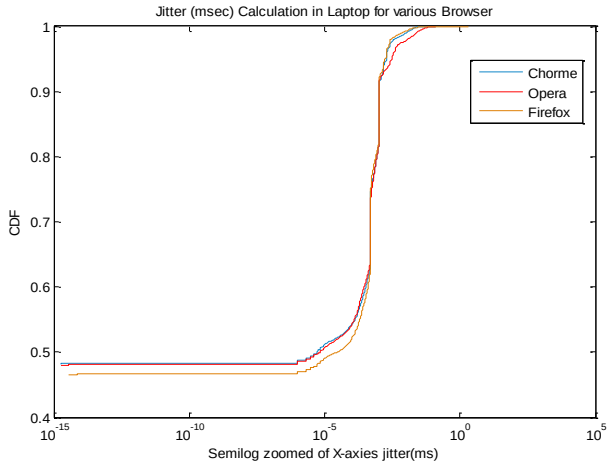


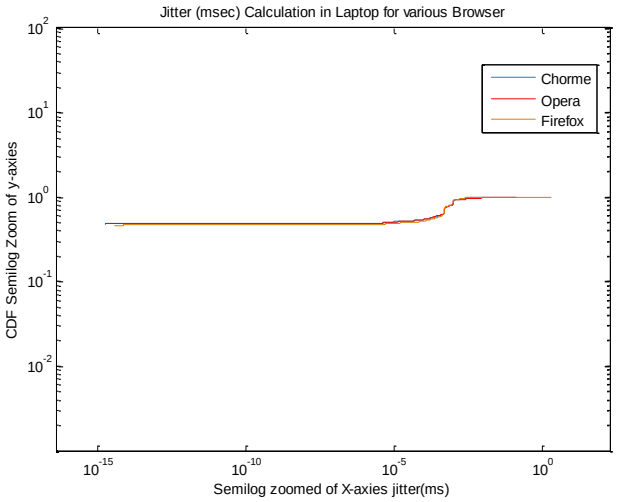
Fig. 18 jitter calculation for various browsers in smart phone.




Jitter(ms) calculation in Smart phone for various Browser
Andriod
Opera
Dolphin
Firefox
Xscope
Y-axies of CDF
1.3
1.2
1.1
1
0.9
0.8
0.7
0.6
0.5
0.4
10^-10
10^-5
10^0
Semilog Zoom of X-axies Jitter(ms)


Jitter(ms) calculation in Smart phone for various Browser
Andriod
Opera
Dolphin
Firefox
Xscope
Zoom Y-axies of CDF
10^0
10^-15
10^-10
10^-5
10^0
10^5
Zoom semilog of X-axies Jitter(ms)


Jitter (msec) Calculation in Laptop for various Browser
Chorme
Opera
Firefox
CDF
1
0.9
0.8
0.7
0.6
0.5
0.4
10^-15
10^-10
10^-5
10^0
10^5
Semilog zoomed of X-axies jitter(ms)


Jitter (msec) Calculation in Laptop for various Browser
CDF Semilog Zoom of y-axies
Semilog zoomed of X-axies jitter(ms)
Chorme
Opera
Firefox
10^2
10^1
10^0
10^-1
10^-2
10^-15
10^-10
10^-5
10^0