Performance Metrics, Parameters and Factors of Ad Hoc, Cloud and Ad Hoc Cloud Network

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***Abstract*— ad hoc network is a decentralized network in which organization of network, message transmission and delivery is executed by nodes themselves. Cloud is the concept that is popular due to the idea of the use of the online information, software and hardware. Ad hoc cloud is a framework that provides a platform to increase the utilization of non-dedicated infrastructures (computer and hardware devices). Due to popularity of these networks, performance evaluation is of vital importance. This study is focused on the performance metrics, factors and parameters that effect the performance evaluation of these networks and this can help users to make proper decision.**

Keywords-Ad hoc network; cloud computing; ad hoc cloud network; performance metrics; performance parameters.

I. INTRODUCTION

Ad Hoc network [5] is a wireless network that does not need any centralized architecture. In this network each node acts as a router and forward data for the other nodes. Hence the network is ad hoc. Based on the network connectivity, it is determined dynamically which node forwards data. So it is very much different than the wired networks where router is needed to perform the task of routing. Also it is different from the managed wireless network where access point manages data communication among other nodes. Figure 1 shows simple examples of Ad hoc network.

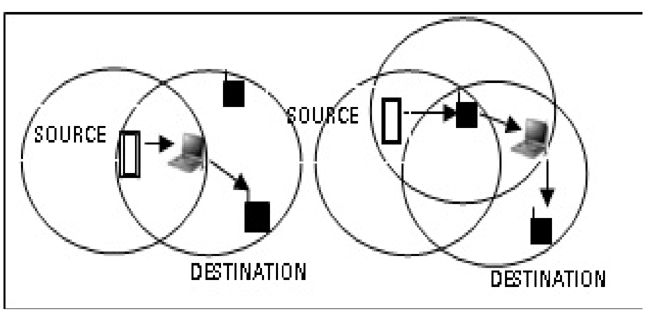

Figure 1. Ad Hoc Network

Cloud computing [20] is originated from the network diagram that represents the internet as a cloud. According to the NIST definition, cloud computing is considered as a model that enables easy ,on-demand network access to share various computer resources , application, services, networks, storage

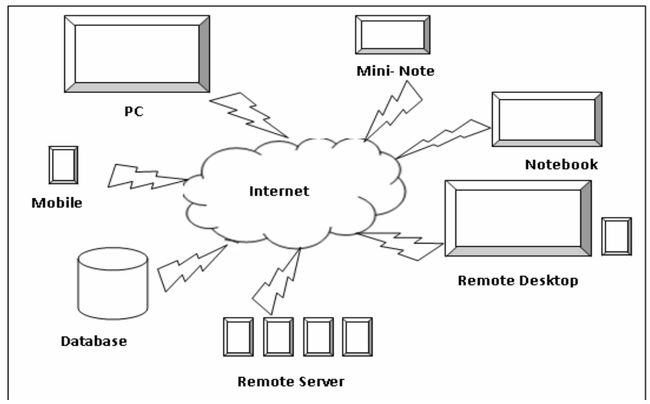

Figure 2. The term cloud computing seems to originate from computer network diagram that represents the internet as a cloud

etc. that can be provided to the user with minimum management effort. Figure 2 shows the computer network diagram that represent internet as cloud.

When cloud services are allowed to run on existing heterogeneous hardware, it is known as Ad hoc cloud computing [24]. It can also be termed as running cloud services on ad hoc network. General purpose computers and hardware devices utilization is increased by using this concept.

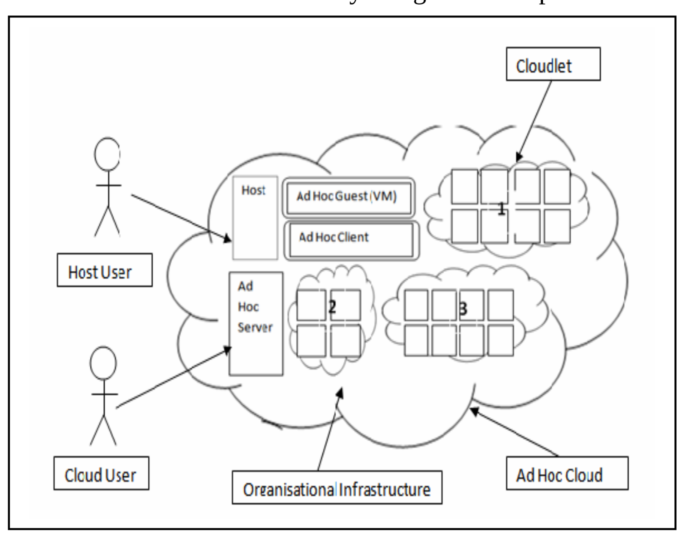

Figure 3. The Ad Hoc Cloud Architecture

It has various advantages as mentioned below:-

- Number of machines need to be purchased are reduced
- Hardware costs are reduced
- Infrastructural costs are reduced
- Overall power consumption is reduced
- Data are managed easily
- Data recovery and disaster management is easy

II. LITERATURE REVIEW

A. Performance Metric and Parameter/Factors in Ad Hoc

Georgios Kioumourtzis, Christos Bouras and Apostolos Gkamas that (2012) [1] have done performance evaluation that may be suitable for military communications based on quantitative and qualitative metrics both as recommended by RFC 2501 (1999) [27]. The protocol that was used for comparison in this article was Ad hoc On-Demand Distance Vector (AODV), Optimized Link State Routing (OLSR) and Dynamic Source Routing (DSR). First they have done study on both the metrics on various protocols. Then they selected the protocol and metrics that is best suited for military communications.

J-M Choi and Y-B Ko (2004) [2] had considered more realistic military scenario and did performance evaluation of four well known protocols named AODV, DSR, LAR and OLSR. Their simulation result shows that DSR and LAR performance is good compared to other protocols in military scenario.

Ahmed A. Radwan, Tarek M. Mahmoud and Essam H. Houssein (2011) [3] compares three protocols performance named AODV, Location-Aided Routing (LAR) and Fisheye State Routing (FSR) with respect to performance metric routing message overhead, end to end delay and throughput. According to their experimental results AODV has high throughput compared to other two protocol, LAR shows better end to end delay performance as compared to other two protocols and FSR protocol has low control overhead than the other two protocols.

Dmitri D. Perkins, D. Hughes Herman and B. Owen Charles (2002) [4] have analyzed five performance factors namely pause time, type of routing (source or distributed), node speed, network size, number of traffic size with respect to three performance responses namely average routing overhead, power and throughput. The protocols considered in their study are AODV and DSR.

Abdul Hadi Abd Rahman and Zuriati Ahmad Zukarnain (2009) [5] performed simulation to measure performance of AODV, Destination- Sequenced Distance Vector (DSDV) and I-DSDV with respect to performance metrics like packet delivery ratio, end to end delay and routing overhead in three different scenarios: node speed, pause time and number of nodes.

Gayatree Rana, Bikram Ballav, Binod Kumar Pattanayak (20150 [6] evaluated the performance of five network layer protocols namely AODV, Ad hoc On-Demand Multipath Distance Vector (AOMDV), DSR, Power Aware Ad hoc On-Demand Distance Vector (PAAODV), DSDV. The analysis was based on four performances metric such as Packets delivery ratio, energy conservation, throughput and average delay. According to their analysis result DSR gives better performance than other protocols with respect to end to end delay and packet delivery ratio, AODV gives better performance in terms of throughput, PAAODV has better performance in terms of residual energy.

Hui Yao Zhang, John Homer, Garry Einicke and Kurt Kubik (2006) [7] have presented performance evaluation of ad hoc routing protocols for establishing VoIP conversation session by mobile users in an ad hoc network scenario. In their work, they have analyzed four protocols namely DSDV, DSR, AODV, TORA in six different mobility levels and three different VoIP conversation sessions. Through this simulation based performance analysis they proposed that DSR is the best option for real time application such as VoIP conversation.

Madhavi W. Subbarao (1999) [8] in his document discussed and identified performance metric and critical networking features for estimating the behavior of an ad hoc network . The author has also outlined a strategy for computing the desired quantities and described implementation strategy for computing performance measure.

Jyoti Raju, J. J. Garcia-Luna-Aceves (2000) [9] have introduced a version of WRP named WRP-Lite and compared it with DSR. The performance metric considered were packet delivery ratio, control packet overhead, hop count, end to end delay. According to their evaluated result, performance of WRP-Lite is better than DSR. Also WRP-Lite had lesser control overhead than DSR.

Puneet Kumar Bhardwaj, Shipra Sharma, and Vandana Dubey (2012) [10] presented performance analysis of OLSR and AODV using OPNET 14.5 modeler based on performance metrics media access delay, network load (bits/sec or packet/sec), throughput. According to their performance evaluation analysis OLSR have better performance than AODV.

Mandeep Singh, Maninder Singh (2013) [11] had examined performance of two types of antenna, directional antenna and omnidirectional antenna. Also in their paper, they had presented simulation based performance analysis of three protocols namely AODV, OLSR and GPR. Based on this analysis they observed that directional antenna provides better performance than omnidirectional antenna. Also they observed that OLSR have better performance than AODV and GPR with respect to data dropped, delay and throughput.

Swati Dhawan and Vinod Saroha (2013) [12] paper was twofold study based paper in which they have done analytical study on category of routing protocol and its, their usage and importance of its selection of the category. The simulation study of this paper was based on use for retransmission attempt FTP traffic send and receives of three protocols namely GRP, DSR and OLSR. Based on the analysis it is concluded that OLSR performance is outstanding in delay and throughput and GRP performance is good in network load. Also GRP performance is better than DSR in delay, network load and throughput.

Muhammad Shaffatul Islam, Md. Adnan Riaz, Mohammed Tariqu (2012) [13] simulated AODV, DSR, TORA, OLSR and GRP protocols for video transmission in MANET and evaluated their performance based on performance metrics namely Packet delay, packet end-to-end delay, throughput, and Wireless LAN delay. Their simulation shows that routing protocol performance changes depending on the network scenario and types of video traffic used. According to their simulation TORA is the best performing protocol for video transmission and performance of DSR is poor.

Gagangeet Singh Aujla and Sandeep Singh Kang (2013) [14] have presented comprehensive simulation based analysis and study on AODV, DSR, TORA, OLSR and GRP protocols. The performance of these protocols is evaluated on the basis of throughput, delay, load, and data dropped. According to the simulation result with video conferencing

Ms. Sunita Sharma and Ms. Shruti Thapar (2015) [15] identified a suitable routing protocol to meet the specified network conditions and the targeted goals by evaluating the performance of routing protocols namely AODV, DSDV and OLSR with respect to performance metrics such as network throughput, end to end delay and packet delivery ratio . According to their analysis OLSR is a good choice for large and dense networks.

Vikas Goya, Shaveta Rani, Paramjit Singh (2013) [16] have performed performance evaluation of routing protocol GPR and TORA based on Database and Voice Data. Their analysis result declares that TORA is best performance routing protocol in terms of performance parameters: Network load, Jitler, Packet Delay Variation, Voice Traffic Received, Voice Traffic Sent and Data Dropped and GRP is best in terms of performance parameter: Throughput.

Muhammad Asif Mehmood, Ahmed Mateen Buttar, and Muhammad Ashraf (2014) [17] considered various quantitative performance metric such as throughput, network load, media access delay and retransmission attempts by varying physical characteristics, nodes speed, pause time and number of nodes and based on these metrics and parameters , performance comparison of routing protocols namely OLSR, TORA and GRP is done in this research. According to the result of this comparison study it is concluded that performance of OLSR is outstanding with respect to pause time, network density and network speed in throughput. TORA performance in retransmission attempt regarding nodes speed is better than OLSR and GRP. TORA performance in media access delay scenario is also better than OLSR and GRP.

Adel Aneiba and Mohammed Melad (2016) [18] analyzed performance evaluation of routing protocols namely AODV, DSR, OLSR and GRP under two different scenario (20 and 80 mobile nodes). The performance metric considered in this work are delay and throughput under FTP traffic condition and parameters considered are number of nodes, simulation time, simulation area, mobility model, data rate and application. The result of simulation indicate that OLSR perform better than AODV, GRP and DSR with respect to delay and throughput under heavy FTP traffic.

B. Performance Metric and Factors in Cloud

John O'Loughlin and Lee Gillam (2014) [19] explore the kinds of performance measures that Cloud service Brokers (CBSs) should use for performance discovery or to present transparent price per unit performance comparisons. They have also discussed Bad and Good metrics for performance of cloud.

Abdullah Sinan Yildirim and Tolga Girici (2014) [20] simulated two networks, cloud and LAN model and compared their performance in HTTP, E-mail and FTP traffic. According to this simulation result cloud model shows better performance in all three traffic type. In second part, performance improvement is gather in cloud model in all three traffic conditions by assigning QoS profile to the cloud model.

Ashraf Zia and Muhammad Naeem Ahmad Khan (2012) [21] discussed performance issues and parameters at the three basic layers of cloud namely Platform as a Service (PaaS), Infrastructure as a Service (IaaS) and Software as a Service (SaaS). The paper also identified the key challenges in different areas for performance improvement and critically analyzed various QoS issues in order to point out their strengths and weakness.

Md Shamshoddin Altamash Prashant Y. Niranjan, and Bahubali P. Shrigond (2013) [22] explored various issues in performance modeling and analysis in resource management of virtualized systems and also described a new simulation framework built for virtual cloud computing infrastructures known as CloudSim.

Niloofar Khanghahi , and Reza Ravanmehr (2013) [23] highlighted different performance factors of cloud computing and also analyzed and evaluated cloud performance in different scenarios with respect to these factors. In their study two methods for evaluation are used: evaluation based on criteria and characteristics and evaluation based on simulation.

C. Performance Metric and Factors in Ad Hoc Cloud

Gary A. McGilvary Adam Barker, and Malcolm Atkinson (2015) [24] discussed the problems for which Ad hoc cloud computing is the solution. They also outline their architecture that is based on BOINC.

Graham Kirby, Alan Dearle, Angus Macdonald and Alvaro Fernandes (2010) [25] proposed ad hoc cloud model and outlined the major challenges of implementation and one approach to tackle them. The approach claims the potential for the organization to reduce IT costs; to obtain the benefits of cloud computing in new application areas and to reduce net energy consumption by IT activities.

Jaime Lloret ,Raquel Lacuesta, Sandra Sendra and Lourdes Peñalver (2014) [26] proposed and developed a trusted algorithm to create spontaneous ad hoc mobile cloud computing network. To simulate and create such network, they used simulator Castalia. The simulation result show that even by using high number of nodes, their proposal presents good efficiency and network performance.

The performance summaries of papers are listed in Table 1, Table 2, Table 3 and Table 4.

Table 1: Summary of papers [1] to [6] on the basis of simulator, protocol, performance metrics and parameter

Authors Name	**Simulator**	**Protocols**	**Performance Metric**	**Performance Parameters**	
				Parameter	**Value**
G. Kioumourtzis, C. Bouras and A. Gkamas (2012) [1]	Bonnmotion-1.4 software	OLSR,DSR ,AODV	Packet delivery ratio, Normalized routing, Normalized MAC, Average End to End Delay	Mobility model	RPGM
				Simulation time	200s
				Number of nodes	50
				Simulation Area	2000mX1000m
				Speed	Min=2.0m/s; Max=7.0 m/s
				Pause time	5.0s
				Traffic type	Constant bit rate(CBR)
				Packet Size	512 bytes
				Rate	10 packets/s
				Number of connections	10,20,30,40
J-M Choi and Y-B Ko (2004) [2]	QualNet	LAR, OLSR,DSR ,AODV	Packet delivery ratio, Average End to End Delay, Control Packet Overhead, average energy consumption.	Mobility model	Random way point
				Simulation time	200s
				Number of nodes	100 to 200
				Simulation Area	12X22 km^2
				Speed	1,5,9,13,17,21,25 m/s
				Pause time	20s
				Traffic type	CBR
				Packet Size	512 Bytes
				Rate	1 packet/s
Ahmed A. Radwan, Tarek M. Mahmoud and Essam H. Houssein (2011) [3]	GloMoSim	AODV, FSR, LAR	Routing Message Overhead, Average End-to-End Delay, Throughput	Mobility model	Random way point
				Simulation time	300 s
				Number of nodes	100,200,300
				Simulation Area	1500X2000, 2000X1500, 3000X2000 m^2
				Speed	Min=0.0m/s; Max=10.0 m/s
				Pause time	0 to 300 s
				Traffic type	CBR
				Packet Size	512 bytes
				Rate	4 packets/s
Dmitri D. Perkins, D. Hughes Herman, B. Owen Charles (2002) [4]	GloMoSim	AODV, DSR	Average Throughput, Average Routing Overhead, Power Consumption	Mobility model	Random way point
				Simulation time	200 s
				Number of nodes	50, 80
				Simulation Area	1600X400 m^2
				Speed	5 m/s, 40 m/s
				Pause time	3 s, 30 s
				Traffic type	CBR
				Packet Size	1024 bytes
				Rate	4 packets/s
				No. of traffic source	10, 25
				Routing	Source, Distributed
Abdul Hadi Abd Rahman, Zuriati Ahmad Zukarnain (2009) [5]	NS-2	AODV, DSDV, I-DSDV	Packet delivery ratio, End to end delay, Routing overhead	Mobility model	Random way point
				Simulation time	400 s
				Number of nodes	5,10,15,20,25,30,35
				Simulation Area	1000X1000 flat area
				Speed	10,20,30,40,50 m/s
				Pause time	0,50,100,150,200,250,300,350,400
				Traffic type	CBR
				Packet Size	1400 bytes
				Transmission range	250 m
Gayatree Rana, Bikram Ballav, Binod Kumar Pattanayak (2015) [6]	NS 2.35	AODV, AOMDV, DSR, PAAODV, DSDV	Packets delivery ratio, energy conservation, throughput and average delay	Channel type	Wireless channel
				Radio-propagation model	Two ray round wave
				Network interface type	Wireless
				Interface queue type	Drop tail
				Link layer type	Logical Link
				Antenna	Omni Antenna
				Maximum packet	50
				Area	6400X6400 m^2
				Number of mobile nodes	10,20,30,40,50
				Simulation time	2060 s
				Source type	UDP, TCP
				MAC type	Mac 802.11
				Initial Energy	50 Joules

Table 2: Summary of papers [7] to [10] on the basis of simulator, protocol, performance metrics and parameter

Authors Name	**Simulator**	**Protocols**	**Performance Metric**	**Performance Parameters**	
				Parameter	**Value**
HuiYao Zhang, John Homer, Garry Einicke, Kurt Kubik (2006) [7]	NS 2.28	DSDV,DSR,AODV ,TORA	Packet delivery ratio, End to End Delay	Mobility model	Random way point
				Simulation time	300s
				Number of nodes	30
				Simulation Area	340X340 m^2
				Speed	0,1,5,10,15, 20 m/s
				Pause time	10 s
				Traffic type	CBR
				Packet Size	10 bytes
				Rate	50 packet/s
J-M Choi and Y-B Ko (1999) [8]	-	-	➢ Thread-Task Level Metric • Average Power Expended • Task Completion Time ➢ Diagnostic Packet Level Metrics • End to End Throughput • End to End Delay • Link utilization • Packet Loss ➢ Scenario Metrics • Nodal Movements/Topology Rate of Change-Average speed of nodes • Number of Network Nodes • Area Size of Network • Density of Nodes per Unit Area • Offered load and Traffic patterns • Number of Unidirectional Links	-	
Jyoti Raju, J. J. Garcia-Luna-Aceves (2000) [9]	NS 2	DSR,WSR-Lite	Packet delivery ratio, Control packet overhead, Hop Count, End to End Delay	Mobility model	Random way point
				Simulation time	200s
				Number of nodes	20
				Simulation Area	6.6X4.8Km
				Speed	20m/s
				Pause time	0, 30, 60,120, 300, 600 and 900 s
				Traffic type	Constant bit rate(CBR)
				Packet Size	64 bytes
Puneet Kumar Bhardwaj, Shipra Sharma, and Vandana Dubey (2012) [10]	OPNET Modeler 14.5	OLSR,AODV	Media access Delay, Network load (bits/sec or packet/sec) Throughput.	Mobility model	Random way point
				Simulation time	20mins
				Number of nodes	40
				Simulation Area	600X600 m
				Speed	30 m/s
				Ip	Ipv4
				Traffic type	FTP
				Packet Size	1024 Bytes
				Application Configuration	Default
				Mobile Configuration	Default
				DES Configuration	Duration: 20 mins Seed : 128 Update interval:500000 events
				Wireless Mac address	Auto assigned

Table 3: Summary of papers [11] to [16] on the basis of simulator, protocol, performance metrics and parameter

Authors Name	**Simulator**	**Protocols**	**Performance Metric**	**Performance Parameters**	
				Parameter	**Value**
Mandeep Singh, Maninder Singh (2013) [11]	OPNET Modeler 14.0	AODV, OLSR, GPR	Data dropped, Delay, Throughput	Trajectory	Vector
				Simulation time	120 s
				Number of nodes	40
				Environment size	500X500
				Physical characteristics	Extended rate PHY(802.11G)
				Antenna used	Directional, Omni-directional
				Directional gain	12 dBi
				Packet Size	1024 bytes
				Data Rate	54 Mbps
				Application	Video conferencing
Swati Dhawan, Vinod Saroha (2013) [12]	OPNET Modeler 14.5	OLSR, GPR, DSR	End to end packet delay, Network load(bits/s), Retransmission attempt(packets)Throughput	Operation Mode	802.11 a
				Simulation time	1200 s
				Number of nodes	50, 100
				Value per Statistic	100
				Seed	128
				Update Interval	50,000 event
				Simulation kernel	Based on ‘Kernel-Type preference
				Buffer Size	1024000
				Transmit power	0.10
				Bit Rate (mbps)	54
				Packet reaction –power threshold	-95
				Addressing Mode	IPV4
Muhammad Shaffatul Islam, Md Adnan Riaz, Mohammed Tariqu (2012) [13]	OPNET Modeler	AODV, DSR, TORA, OLSR and GRP	Packet delay, packet End to end delay, throughput, Wireless LAN delay	Mobility model	Random way point
				Simulation time	600 s
				Number of nodes	25, 85
				Network size	800X800m, 1600X1600 m
				Speed	Min.=5 m/s; Max.= 10 m/s
				Distance Threshold	300 m
				Initial placement	Placed in row and column based manner
				Communication Model	Selection by strict channel match
				Application name	Video stream
Gagangeet Singh Aujla, Sandeep Singh Kang (2013) [14]	OPNET Modeler 14.5	AODV, DSR, TORA, OLSR and GRP	Throughput, Delay, Load, Data Dropped	Simulation time	600 s
				Number of nodes	30, 60 and 90
				Simulation Area	1000 m X 1000 m
				Mobility model	Random way point
				Data Rate	11 Mbps
				Application Name	Video conferencing (high resolution) and e-mail(high load)
				Bandwidth	11 Mbps
Ms. Sunita Sharma and Ms. Shruti Thapar (2015) [15]	OPNET Modeler 14.5	AODV, DSDV and OLSR	Network throughput, End to end delay, packet delivery ratio	Mobility model	Random way point
				Simulation time	3600 s
				Number of nodes	50
				Node Speed	10 m/s
				Area of Network	1k m X 1k m
				Packet Size	512 to 1024 bytes
				Traffic type	TCP
Vikas Goya, Shaveta Rani, Paramjit Singh (2013) [16]	OPNET Modeler 14.5	GRP and TORA	Traffic sent, Traffic received, Jitler, Voice MOS Value, Packet Delay Variation, Data dropped, Network load and Throughput	Network Scale	Office type
				Network Size	2500X2500 m
				Technology used	MANET
				Number of Mobile nodes	85
				Traffic type	Database with high load and voice with GSM quality and Silence suppressed
				Simulation Time	500 s
				Physical characteristics	Direct sequence
				Data rate	11 bps

Table 4: Summary of papers [19] to [23] on the basis of simulator, performance metrics and parameter , factors or issues

Authors Name	Simulator	Performance Metric and parameters	Performance Factors or issues
John O'Loughlin and Lee Gillam (2014) [19]	-	• Bad Metrics- CPU clock rate, Theoretical Peak Performance, the maximum number of instructions a CPU could in theory execute per second, Millions of Instructions per second(MIPS), BogoMIPS and Floating Point Operation per second(FLOPS) • Good Metrics – Performance execution time, throughput, work done in a fixed time, response time	-
Abdullah Sinan Yildirim and Tolga Girici (2014) [20]	OPNET Modeler 14.5	Metrics-E-mail Traffic, web page response times, ftp download response time, Ethernet delay ,HTTP page response time Parameters – 10 manger profiles and 50 researcher profiles, two scenario were simulated based on real working hour (8 hrs./day), Application are Email(manager heavy, researcher low), VOIP(GSM, None), Web Browsing (manager low, researcher heavy),File Transfer (manager low, researcher heavy), Video Conferencing (manager heavy, researcher low).	-
Ashraf Zia and Muhammad Naeem Ahmad Khan (2012) [21]	-	-	Storage service, scaling, network services, scheduling, service level agreement templates, optimal location of data centers and software components, efficient SQL query processing, architecture and process improvement.
Md Shamshoddin Altamash Prashant Y. Niranjan, and Bahubali P. Shrigond (2013) [22]	CloudSim	System resources utilization and allocation metrics, workload and CPU contention	-
Niloofar Khanghahi , and Reza Ravanmehr (2013) [23]	CloudAnalyst	Average response time per unit, network capacity per second(Mbps), the number of I/O commands per second(IOPS) or unit time, Average waiting time per unit time, workload(requests) to be serviced per second or a unit of time, throughput(req./sec), average time of processing, percentage of CPU utilization, the number of requests executed per unit time, the number of requests per unit time buffer, the number of rejected requests per unit time	Security, recovery, service level agreement, network bandwidth, storage capacity, buffer capacity, disk capacity, fault tolerance, availability, number of users, location, data centers and their distance from a user's location, usability, scalability, workload, repetition or redundancy, processor power, latency

III. CONCLUSSION

This paper is comprehensive study on the performance metrics, parameters and factor of three popular networks namely Ad hoc network, cloud computing and Ad hoc cloud. The main observations of this study are:

- The most effective performance metrics are
  - Throughput
  - End to End Delay
  - Packet delivery ratio
  - Routing message overhead
- The important parameters that highly influence the performance of these three network are
  - Traffic type
  - Traffic received/ sent (packets/s, bytes/s)
  - Response time
  - Application
  - Number of nodes
  - Mobility type
- The most effective factors and issues are
  - Storage capacity
  - Security
  - Workload
  - Scalability
  - Location
  - Network bandwidth

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