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Research paper

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

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Abstract

Ad hoc network is a network which is decentralized in nature that organizes its network, transmission and delivery of message is executed by nodes themselves. The concept of cloud is getting popular because of the idea of the use of the online information, software and hardware. The utilization of these non-dedicated infrastructures can be increased using a framework known as Ad hoc cloud. Popularity of these networks makes its performance evaluation is of vital importance. This paper is twofold, study is done to identify the most effective performance metrics, factors and parameters that effect the performance evaluation of these networks and then Ad-hoc On-demand Distance Vector (AODV) routing protocol is implemented and analyzed using OPNET Modeler.

Keywords: *Ad hoc network, cloud, ad hoc cloud network, cloud computing, performance metrics, performance parameters.*

1. Introduction

A wireless network without any need of centralized architecture is known as Ad Hoc network [1]. The network is ad hoc as in this type of network each node acts as a router and forward data for the other nodes. In the wired networks router is needed to perform the task of routing whereas in ad hoc network each node acts as a router for other node and it is determined dynamically which node forwards data. Ad hoc network is also different from the managed wireless network that needs access point to manage data communication among the nodes. Ad hoc network is explained via a simple example as shown below in Fig. 1.

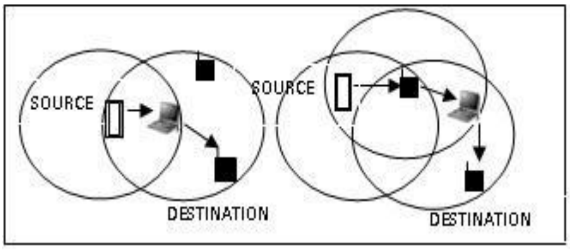

Fig.1: Ad Hoc Network [2]

The computer network diagram as shown in the Fig. 2 represents the internet as a cloud is the origin of the concept of cloud computing [3]. NIST defines cloud computing as a model that empower easy, on-demand network access to share various applications, computer resources, networks, services, storage etc., with minimum management effort that can be provided to the user.
Ad hoc cloud computing is a concept that allows to run cloud services on existing heterogeneous hardware [4]. This can be explained in simple term as running cloud services on ad hoc network. This concept helps in increasing utilization of hardware devices and general purpose computers. Ad hoc cloud structure is shown in Fig. 3.

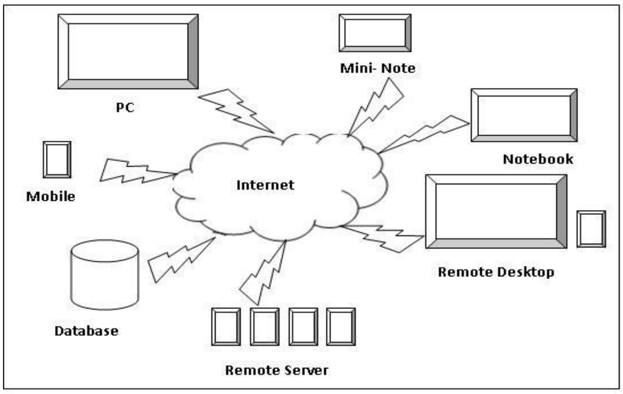

Fig.2: Computer network diagram that represents cloud computing. [2]

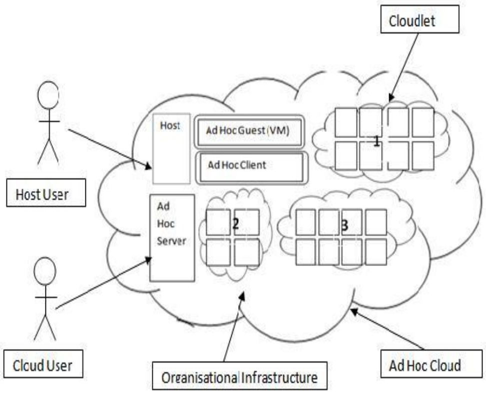

Fig.3: Ad Hoc cloud Architecture. [2]

There are various advantages of adopting ad hoc cloud such as:-

- Less number of machines are to be purchased
- Hardware as well as Infrastructural costs are reduced
- Lesser Overall power consumption is required
- Easy Data management
- Easy disaster management and data recovery

2. Performance metric and parameter/ factors in Ad Hoc, cloud and Ad Hoc cloud network

There are various performance metric, parameter and factors in ad hoc and cloud network that is mentioned in Table 1 and Table 2 below respectively and it also shows the summary of analysis of various papers. These are also same for Ad hoc cloud network as according to the concept of ad hoc cloud discussed in above section.

Table 1: Summary of papers [1], [5] to [12] on the basis of simulator, protocol, performance metrics and parameters of Ad Hoc Network

Authors Name	Simulator	Protocols	Performance Metric	Performance Parameters
Jyoti Raju, J. J. Garcia-Luna-Aceves (2000) [5]	NS 2	DSR,WSR-Lite	Packet delivery ratio, Control packet overhead, Hop Count, End to End Delay	Mobility model, Simulation time, Number of nodes, Simulation Area, Speed, Pause time, Traffic type, Packet Size
Dmitri D. Perkins, D. Hughes Herman, B. Owen Charles (2002) [6]	GloMoSim	AODV, DSR	Average Throughput, Average Routing Overhead, Power Consumption	Mobility model, Simulation time, Number of nodes, Simulation Area, Speed, Pause time, Traffic type, Packet Size, Rate, No. of traffic source, Routing
J-M Choi and Y-B Ko (2004) [7]	QualNet	LAR, OLSR,DSR,AODV	Packet delivery ratio, Average End to End Delay, Control Packet Overhead, average energy consumption.	Mobility model, Simulation time, Number of nodes, Simulation Area, Speed, Pause time, Traffic type, Packet Size, Rate
HuiYao Zhang, John Homer, Garry Einicke, Kurt Kubik (2006) [8]	NS 2.28	DSDV,DSR,AODV,TORA	Packet delivery ratio, End to End Delay	Mobility model, Simulation time, Number of nodes, Simulation Area, Speed, Pause time, Traffic type, Packet Size, Rate
Abdul Hadi Abd Rahman, Zuriati Ahmad Zukarnain (2009) [1]	NS-2	AODV, DSDV, I-DSDV	Packet delivery ratio, End to end delay, Routing overhead	Mobility model, Simulation time, Number of nodes, Simulation Area, Speed, Pause time, Traffic type, Packet Size, Transmission range
Ahmed A. Radwan, Tarek M. Mahmoud and Essam H. Houssein (2011) [9]	GloMoSim	AODV, FSR, LAR	Routing Message Overhead, Average End-to-End Delay, Throughput	Mobility model, Simulation time, Number of nodes, Simulation Area, Speed, Pause time, Traffic type, Packet Size, Rate
G. Kioumourtzis, C. Bouras and A. Gkamas	Bonnmotion-1.4 software	OLSR,DSR,AODV	Packet delivery ratio, Normalized routing, Normalized MAC, Average	Mobility model, Simulation time, Number of nodes, Simulation Area, Speed, Pause time,

(2012) [10]			End to End Delay	Traffic type, Packet Size, Rate, Number of connections
Vikas Goya, Shaveta Rani, Paramjit Singh (2013) [11]	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, Network Size, Technology used, Number of Mobile nodes, Traffic type, Simulation Time, Physical characteristics, Data rate
Gayatree Rana, Bikram Ballav, Binod Kumar Pattanayak (2015) [12]	NS 2.35	AODV, AOMDV, DSR, PAAODV, DSDV	Packets delivery ratio, energy conservation, throughput and average delay	Channel type, Radio-propagation model, Network interface type, Interface queue type, Link layer type, Antenna, Maximum packet, Area, Number of mobile nodes, Simulation time, Source type, MAC type, Initial Energy

Kirby et. al. [17] suggested and discussed ad hoc cloud model and sketched the major challenges of implementation and one approach to tackle them. This approach privileges the potential for the firm to reduce information technology costs; to obtain the advantages of cloud computing in new application areas and to reduce net energy consumption by information technology activities.
A trusted algorithm was recommended and developed by Jaime Lloret et. al.[18], to create spontaneous ad hoc mobile cloud computing network. Castalia Simulator was used to simulate and create such network. The result of simulation showed that their proposal presents good efficiency and network performance even by using high number of node.
McGilvary et. al. [4] proposed Ad hoc cloud computing as a solution after discussing the problems in the first half of their work. In second half based on BOINC they also outline their architecture.

3. Methodology and simulation environment

The performance metrics that are considered for this paper are: Throughput; Network Load; Delay; Data Dropped and Load.
OPNET (Optimized Network Engineering Tool) modeler 14.5 has been used as a simulation tool to implement the network and protocols. OPNET is a provider of planning and operations, network engineering, network research and application performance management and that are used to provide solutions for managing applications and networks. It is commercial discrete event driven simulator used to network modelling and simulation. Object oriented approach is used to graphically create and map the network. It can be used to design and study the communication networks, application and network devices with a high degree of flexibility. Network and network components clear view is provided by its graphical editors. One
reason for choosing OPNET is as a result of its key attributes such as integrated GUI based Debugging, customizable and scalable wireless simulation and modelling. [19]
In this work there are four subnets located at different locations as shown in Fig. 4. Subnets are named as subnet_Tokyo, subnet_Sydney, subnet_Bangkok and India_Head_office. Among these subnet, India_Head _office contains five dedicated servers named FTP server, Email Server, Database Server, HTTP Server And Cloud printer as shown in Fig. 5. Dedicated applications run on each server and all these servers' runs on cloud. Rest three subnets consist of fifty wireless ad hoc mobile nodes as shown in Fig. 6.

Table 2: Summary of papers [3], [13] to [16] on the basis of simulator, performance metrics and parameters and performance factors or issues of Cloud Network

Authors Name	Simulator	Performance Metric and parameters	Performance Factors or issues
Ashraf Zia and Muhammad Naeem Ahmad Khan (2012) [13]	-	-	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) [14]	CloudSim	System resources utilization and allocation metrics, workload and CPU contention	-
Niloofar Khanghahi , and Reza Ravanmehr (2013) [15]	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
John O'Loughlin and Lee Gillam (2014) [16]	-	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) [3]	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).	-

Fig. 4: Simulation Environment

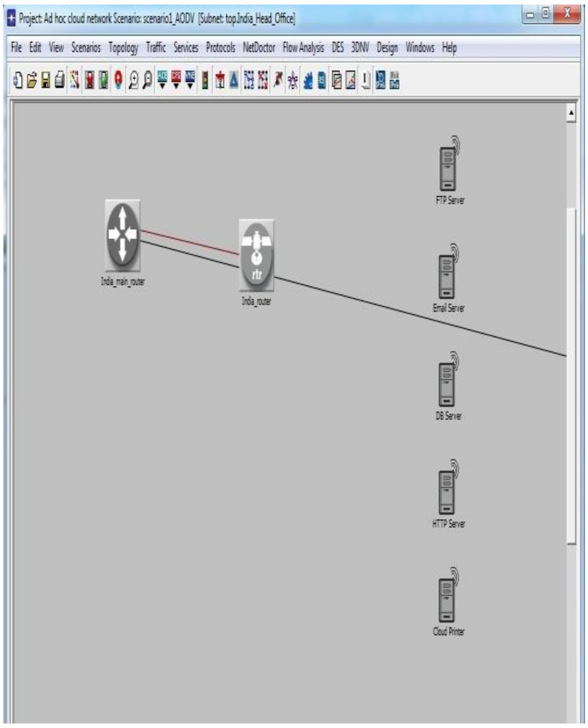

Fig 5 Ad Hoc Cloud Server in India_Head _office subnet

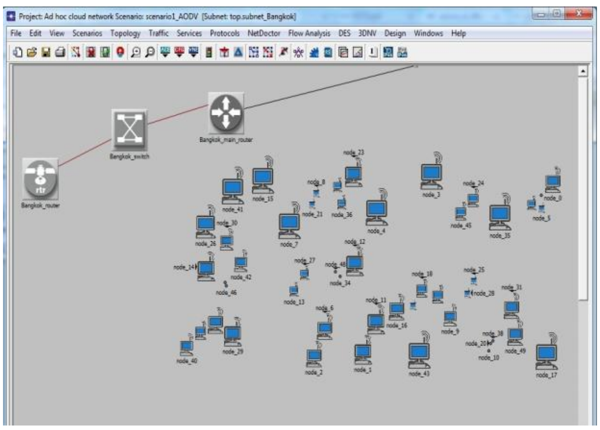

Fig 6: Wireless mobile nodes in subnets

Fig. 7, 8, 9 and 10 shows wireless LAN parameters, simulation configuration, simulation speed and simulation message respectively.

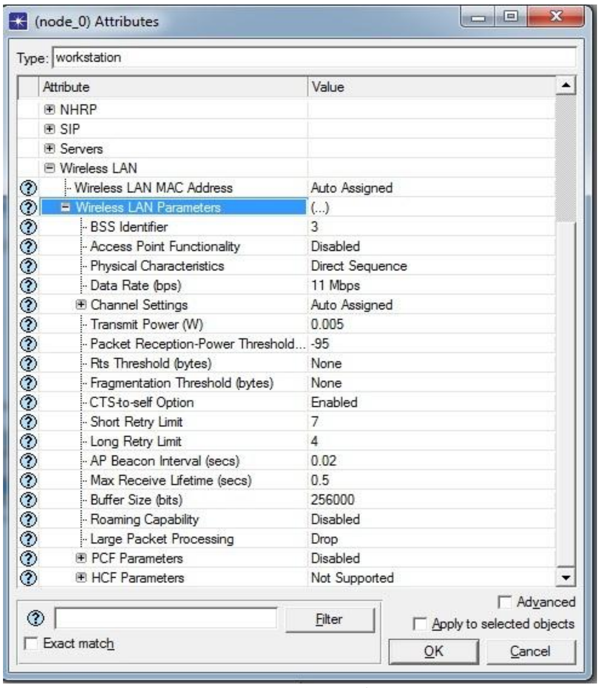

Fig 7: Wireless LAN parameters for nodes in subnet

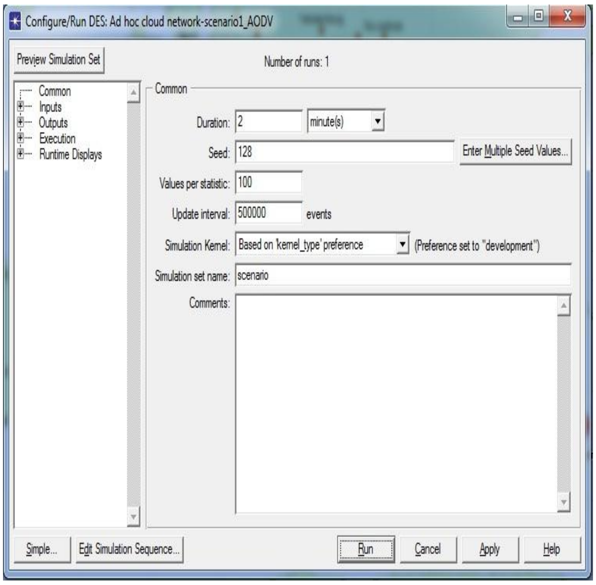

Fig 8: Simulation configuration

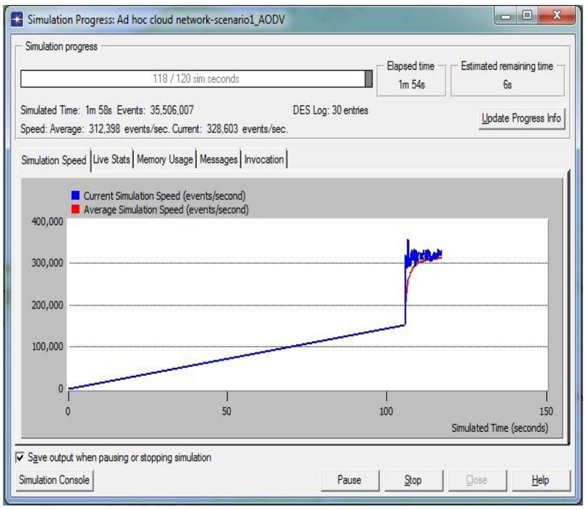

Fig 9: Simulation speed

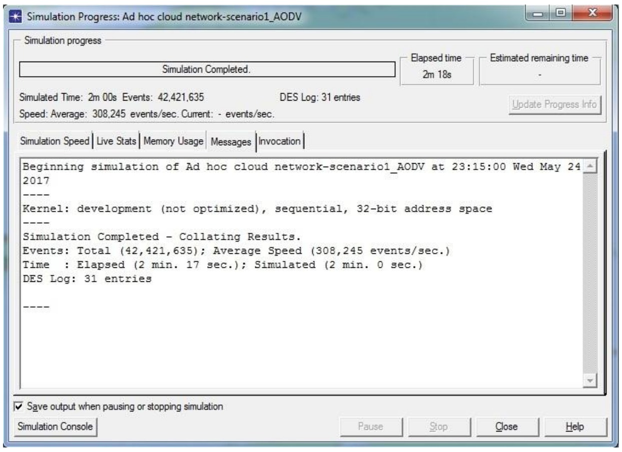

Fig 10: Simulation message

4. Experiment and Result

4.1. Throughput

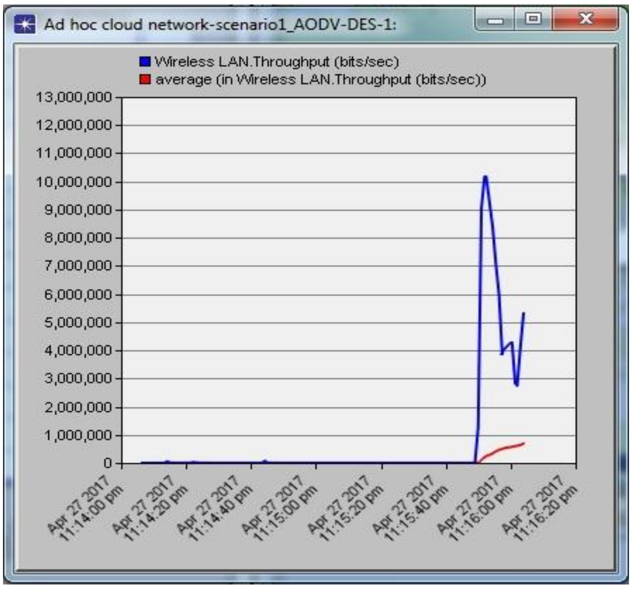

Fig 11: Wireless LAN throughput and average Wireless LAN throughput for AODV

According to the definition, the total number of bits sent from wireless LAN layers to higher layers in all Wireless LAN nodes of the network is throughput. Fig. 11 shows the Wireless LAN throughput and average Wireless LAN throughput for AODV routing protocol. Average throughput for the wireless LAN is 695,174 bits/sec however maximum value is 10,220,080 bits/sec.

4.2. Network load

Network Load is a statistic that measures the network load separately for each Basic Service Set (BSS). The total data traffic (in bits/sec) received by the entire WLAN BSS from the higher layers of the MACs that is accepted and queued for transmission is also represented by this statistics.

As shown in Fig. 12 maximum network load for BSS1, BSS2, BSS3, and BSS4 are 1280.0, 1280.0, 692640 and 1280.0 bits/sec respectively however their average are 29.9, 27.7, 73591 and 27.7 bits/sec.

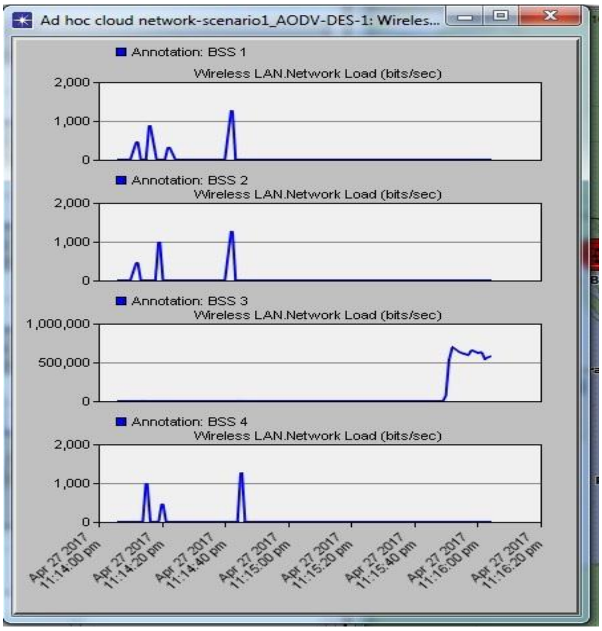

Fig.12: Network Load (bits/sec) of Wireless LAN of AODV for BSS1, BSS2, BSS3, and BSS4

4.3. Delay

According to the definition, the end to delay of all the packets received by the wireless LAN MACs of all wireless LAN nodes in network and forwarded to the higher layer is known as wireless LAN delay. According to Fig. 13 maximum delay of wireless LAN is 2.6231 sec however average delay is 1.0353 sec.

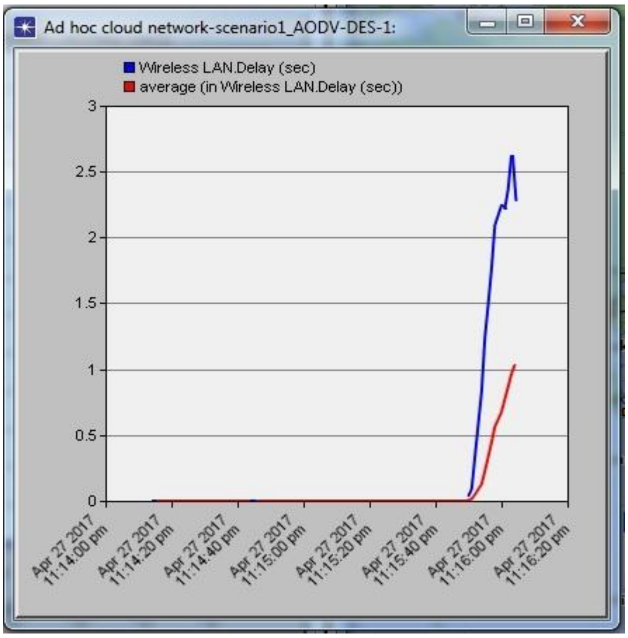

Fig 13: Wireless LAN delay and average Wireless LAN delay of AODV

4.4. Load

According to definition, wireless LAN load is the total load (bits/sec) in all WLAN nodes of the network submitted to wireless LAN layers by all higher layers.
As shown in Fig. 14 average wireless LAN load is 54,318 bits/sec however maximum wireless LAN load is 552,587 bits/sec.

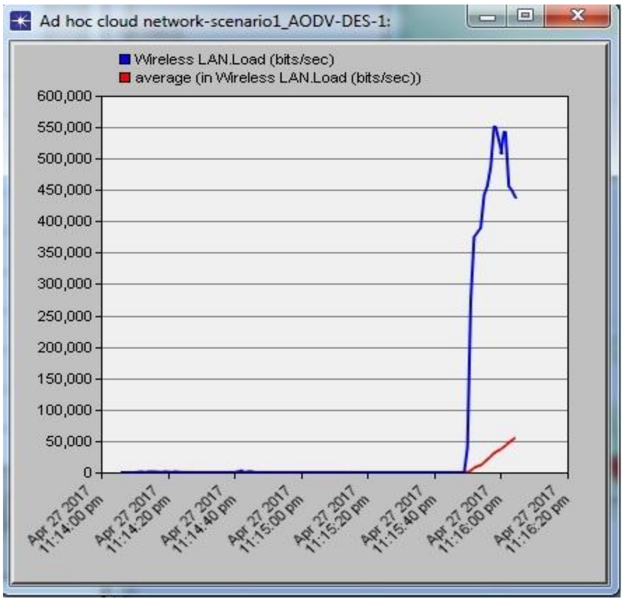

Fig. 14: Load (bits/sec) of Wireless LAN and average Load (bits/sec) of Wireless LAN of AODV

4.5. Data Dropped

According to the definition, data dropped in terms of Buffer Overflow is the total size of higher layer data packets (bits/sec) dropped by all the WLAN MACs in the network due to full data buffer of higher layer, or the size of the higher layer packet, that is greater than the maximum allowed data size defined in the IEEE 802.11 standard.

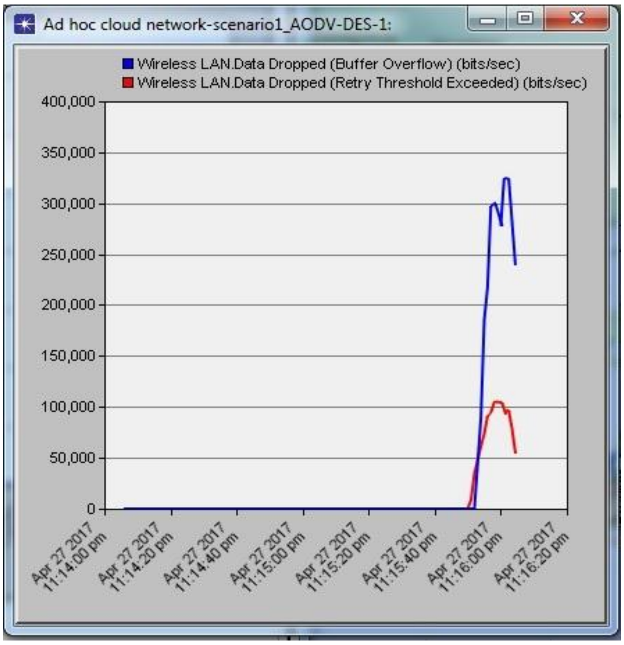

Fig 15: Data Dropped (Buffer Overflow) (bits/sec) and Data Dropped (Retry Threshold Exceeded) (bits/sec) of Wireless LAN and average Load (bits/sec) of Wireless LAN of AODV

Data Dropped (Retry Threshold Exceeded) is defined as total higher layer data traffic (in bits/sec) dropped by the all the WLAN MACs in the network as a result of consistently failing retransmissions. According to Fig. 15 average wireless LAN data dropped (Buffer Overflow) is 25,407 bits/sec however maximum wireless LAN data dropped (Buffer Overflow) is 324,480 bits/sec. Average wireless LAN data dropped (Retry Threshold Exceeded) is 9,020 bits/sec however maximum wireless LAN data dropped (Retry Threshold Exceeded) is 105,040 bits/sec.

5. Conclusions

In this article, first a comprehensive study is performed on the performance metrics, parameters and factors of Ad hoc network, cloud network and Ad hoc cloud network. Due to popularity of these networks, performance evaluation is of vital importance and this article can help users to make proper decision. . Based on this comprehensive study, the main observations of the study are listed below in Table 3.

Then implementation of AODV is performed on Ad hoc cloud network using performance factors and metrics namely data dropped, load, throughput, delay and network load. Table 4 list the summary of simulation result of this paper.

Table 3. Performance Metric, Parameter, Factors and Issues of Ad Hoc Network

No	Most effective performance metrics	Important parameters that highly influence the performance	Most effective factors and issues
1	Throughput	Traffic type	Storage capacity
2	Network Load	Traffic received/ sent (packets/s, bytes/s)	Security
3	Wireless LAN Delay	Response time	Workload
4	Routing message overhead	Application	Scalability
5	End to End Delay	Number of nodes	Location
6	Packet delivery ratio	Mobility type	Network bandwidth

Table 4: Summary of Simulation Result

Statistic	Average	Maximum	Minimum
Wireless LAN Data Dropped (Buffer Overflow) (bits/sec)	25,407	324,480	0
Wireless LAN Data Dropped (Retry Threshold Exceeded) (bits/sec)	9,020	105,040	0
Wireless LAN Delay (sec)	1.0353	2.6231	0.0003
Wireless LAN Load (bits/sec)	54,318	552,587	0
Wireless LAN Network Load (bits/sec)	29.9	1,280.0	0.0
Wireless LAN Network Load (bits/sec)	27.7	1,280.0	0.0
Wireless LAN Network Load (bits/sec)	73,591	692,640	0
Wireless LAN Network Load (bits/sec)	27.7	1,280.0	0.0
Wireless LAN Throughput (bits/sec)	695,174	10,220,080	0

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