INDIAN JOURNAL OF SCIENCE AND TECHNOLOGY

RESEARCH ARTICLE

OPEN ACCESS

Received: 19-10-2022

Accepted: 03-02-2023

Published: 24-02-2023

Citation: Bharadwaj C, Barman U, Saha S (2023) Analysis of Latency and Bandwidth for Edge-Based Short Length in Edge Computing Devices for Short Ranges and Long Ranges. Indian Journal of Science and Technology 16(8): 531-539. https://doi.org/10.17485/IJST/v16i8.2051

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Funding: None

Competing Interests: None

Published By Indian Society for Education and Environment (iSee)

ISSN
Print: 0974-6846
Electronic: 0974-5645

Analysis of Latency and Bandwidth for Edge-Based Short Length in Edge Computing Devices for Short Ranges and Long Ranges

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Abstract

Objectives: To propose an IoT-based design in an edge computing environment for short ranges and long ranges of real-time data streaming to the client. **Methods:** Multimedia data is used in this work. Here we have used Opnet for creating a physical architecture and to analyze the quality-of-service parameters like delay, throughput, and jitter for different Ad-hoc routing protocols like Ad-hoc on-Demand Distance vector routing, Dynamic source routing, Optimized Link State Routing, Temporally ordered routing algorithm and Geographic Routing Protocol for edge-based short length in edge computing devices for short ranges and long ranges. Riverbed academic modeler (formerly known as OPNET) has been used as a simulation tool to analyze the latency and bandwidth for edge computing under the pre-configured set-up. The simulation is accomplished using MATLAB to find the fluctuation of the delay, throughput, and jitter for edge-based short length in edge computing devices for short ranges and long ranges by applying the datasets in the edge computing environment. **Findings:** The results we got through simulations from different routing protocols like AODV, DSR, OLSR, TORA, and GRP of delay, throughput, and jitter shows that the proposed system strengthens the existing cloud-based system, leading to greater QoS.AODV surpasses all other protocols with a minimal delay of 0.24 msec and OLSR achieves the best performance with an average delay of 0.3 msec, better throughput of 180 bits/sec, and a load of 1410 bits/sec for the three key parameters of latency, throughput, and jitter. **Novelty:** The study compares the performance of different routing protocols and shows a reduction in the delay of 0.24 msec with respect to time as compared to other existing works. The proposed research is designed for a media streaming application based on the mobile nodes regarded as an edge devices for different QoS parameters like throughput, delay, and load, and by comparing the existing work we found that AODV outperforms all other routing protocols with a minimum delay.

Keywords: Edge Computing; Cloud Computing; Latency; Bandwidth; Throughput; Jitter

1 Introduction

The consequential advancement in data propagation by the Internet of Things (IoT) devices, for instance, smartphones, sensors, antenna, microcontrollers, wearables, and media streaming devices and applications are increasing in a variety of fields daily to provide clients with anything, anytime, and anywhere network access. Real-time media streaming from a security camera or cloud-based servers is one such application. There is still a substantial demand for low latency, high bandwidth, high storage with high processing power, and high security in real-time IoT applications such as video streaming, media streaming, live updates, and so on. To reduce latency among data centers with restricted bandwidths for faster data transmission, appropriate fog, and edge computing remain important research areas.

One of the main obstacles to providing data from IoT devices is bandwidth restrictions through cloud application servers that are effectively delivered to consumers in real time. Near-real-time data transmission is however restricted by bandwidth limitations and network traffic congestion. Although a few existing cloud computing techniques aids in data storage and processing, it lags in terms of less storage with finite computation, high latency, low bandwidth, and limited security for real-time applications. A better method for addressing to improve efficacy, fog, edge, and cloud computing must be designed with low latency and a limited number of bandwidths. For that latency and bandwidth across computing, techniques must be analyzed. Increasing demand for Internet of Things (IoT) devices has been accompanied by an increase in the amount of data generated by them. Transferring data to cloud computing leads to the occurrence of bottlenecks in the data networks. Edge computing reduces the delay by executing the computing process close to the data source[1]. It also discussed the need for systematic research on edge computing-driven Internet of Things (ECDriven-IoT) and listed recent developments in this field[2]. MobileEdge Computing-enabled video streaming offers extraordinary improvement to support unique use cases. Separate sections are devoted to cutting-edge contributions in cooperative device-to-device (D2D) communication and machine learning. MEC-assisted video streaming is correlated and easily adaptable to the relevant use cases[3]. Insufficient uplink bandwidth is an important factor that influences the quality of live video transmissions. A novel flexible super-resolution-based video coding and uploading framework have been presented for FlexSRVC that includes a flexible video coding scheme, which compresses high-resolution key and non-key video frames to a lower bitrate[4]. HxL3 is a cutting-edge architecture for low-latency and QoE assurance in Low latency Live (L3) broadcasting at a large-scale Internet[5]. Fog computing extends cloud computing storage networking and computing capabilities to edge and backbone servers on the cloud for Internet of Things (IoT) devices[6]. A novel framework for stream query processing called Amnis that carefully distributes edge-located computing and network resources to maximize the performance of stream processing applications has been offered[7]. It also discussed a LE-STREAM framework for processing IoT data streams that uses edge computing to bring data processing closer to the data sources, reducing latency. Adaptive sampling in combination with a data prediction model reduces device energy consumption without compromising data accuracy[8]. A System-on-Chip (SoC)-based three-level edge computing architecture for low power consumption and extensible on-board computation had offered based on the results of studies performed on the simulation hardware of the Luojia3 satellite using simulation data and frame array sensor data[9]. An analysis of the state of the art has been displayed, when MEC is applied to streaming video. An application taxonomy for MEC-enabled video streaming is then categorized[10].

Utilizing multimedia services has greatly benefited from the use of mobile devices. The analysis of media streaming concentrated on mobile nodes and wireless LAN (WLAN), which were regarded as edge devices. Designing a media streaming data architecture based on fog computing and edge computing is the primary work behind this study. To do this, we put into practice Riverbed Academic Modeller is based on the Opnet network simulator and is designed to reduce latency and bandwidth for fog, edge, and cloud computing. To check the latency, we are doing this by utilizing the media services application, which is based on the mobile node following the trajectory path between the devices. Considering the motivations outlined in the prior section, we developed a proposed framework model for Fog, Edge, and Cloud Computing to reduce the delay period between the data center with the constrained bandwidths for quicker data transfer in real-time IoT applications. For that, we used Opnet and Riverbed Academic Modeller as simulator platforms for the services used in media streaming applications for measuring the latency and bandwidth. The data were analyzed in MATLAB to evaluate the proposed mechanisms for edge-based short length in edge computing devices for short ranges and long ranges to determine the latency, throughput, and jitter for different Ad hoc routing protocols for the media streaming application used in Fog, Edge, and Cloud Computing.

The main contributions of this paper are as follows:

- A systematic approach to generating real-time IoT applications of Fog, Edge, and Cloud Computing related to media streaming services.
- A simulator is set up by using Opnet and Riverbed Academic Modeller for the services used in media streaming applications to measure the latency and bandwidth.
- To determine the delay, throughput, and load for various ad hoc routing protocols utilized by the media streaming application employed in fog, edge, and cloud computing, we performed data analysis in MATLAB.

2 Methodology

A physical framework has been designed in Opnet to analyze the quality-of-service parameters like delay, throughput, and jitter for different Ad-hoc routing protocols like Ad-hoc on Demand Distance vector routing, Dynamic source routing, Optimized Link State Routing, Temporally ordered routing algorithm and Geographic Routing Protocol for edge-based short length in edge computing devices for short ranges and long ranges of the proposed model using the toolkit Riverbed academic modeler for interfacing the media streaming data using mobile nodes and Wireless Local Area Network that has been regarded as an edge device. The mobile nodes are arranged in the form of clusters among the group of nodes where the chief node will act as the cluster head for the node. Here, mobile nodes are utilized to stream data between devices while moving between nodes to analyze latency and bandwidth in edge computing devices for short ranges and long ranges under the pre-configured setup. The trajectory path is established when the mobile node is moving between nodes. The comparison between the different types of Ad- hoc routing protocols shows that there has been a variation in delay, throughput, and jitter when the mobile node is traveling along a trajectory path considering its near real-time movement. Data streaming between mobile devices has made it feasible to determine the delay and throughput (Figures 1 and 2).

3 Results and Discussion

A simulation environment is created in Riverbed academic modeler and analyses the data in MATLAB for edge-based short length in edge computing devices for short ranges and long ranges. Different routing protocols make the comparative analysis for the different QoS parameters like latency, bandwidth, throughput, and jitter to get the minimum delay with a limited number of bandwidths. In the Opnet architecture, media streaming devices are connected to the mobile nodes in a wireless network and the gateway router in a wired network, respectively. Mobile nodes and WLAN have both been recognized as edge devices. Here, mobile nodes are utilized to stream data between devices while moving between nodes to analyze latency and bandwidth. The trajectory path is established when the mobile node is moving between nodes. Figure 3 and Figure 4 indicate the network architecture and the positions and motions of mobile nodes in the simulation environment. Figure 5 (a), 5(b), 5(c), Figure 6 (a), 6(b), and 6(c) display the simulation results in MATLAB that have been done for finding the variation in delay transmission time as well as for the throughput and jitter utilizing datasets in the edge computing environment.

Figure 5 (a) observed that AODV outperforms all other routing protocols with a minimum delay of 0.26 msec followed by GRP protocol and OLSR protocol with an average delay of 0.3 msec which is below the threshold burst of packet drop. There is a spike and through in Figure 5 (a),5(b), and 5(c) respectively at 0.2 msec due to Mobile node handoff from one edge node

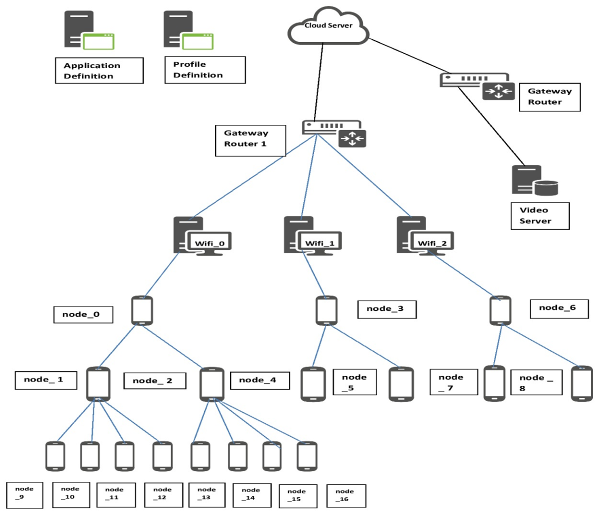


Fig 1. The proposed model for a media streaming application

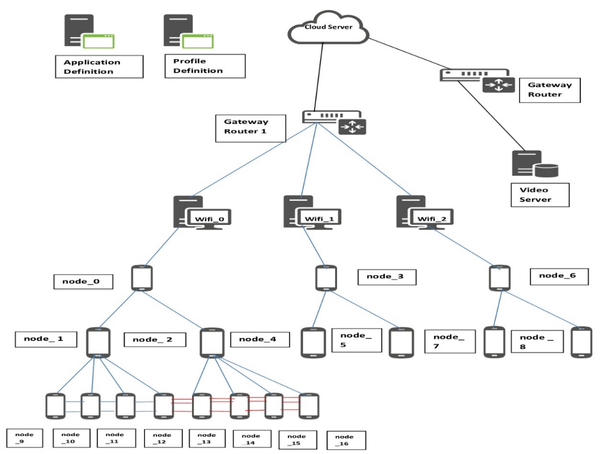


Fig 2. The proposed model of a media streaming application for setting the trajectory path between the mobile devices

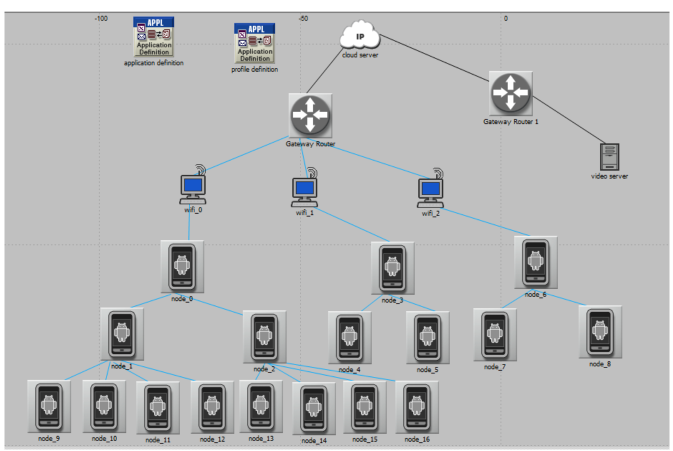


Fig 3. In Scenario 1, a mobile node's Opnet IoT simulation architecture is regarded as an edge device

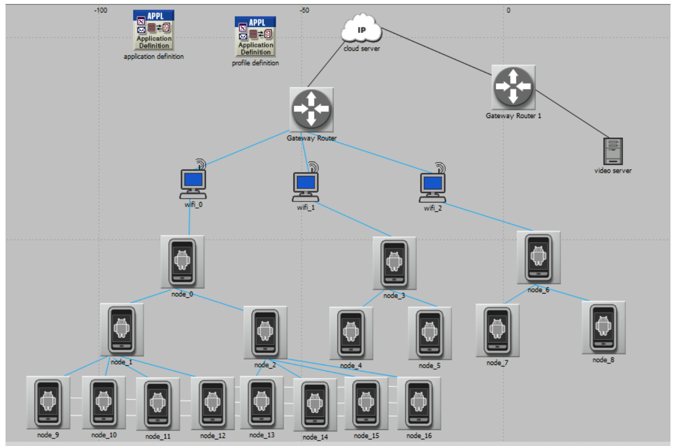
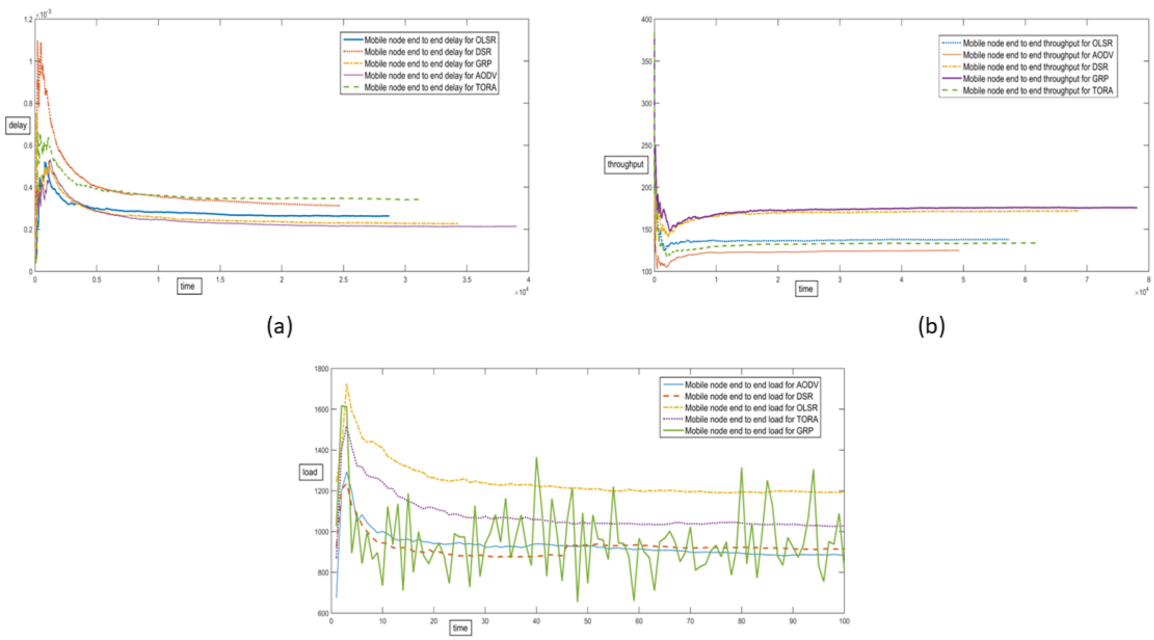


Fig 4. In Scenario 2, taking into consideration the mobile node as an edge device while determining the trajectory between the mobile devices.



(a) (b)

(c)

Fig 5. The average (a) packet transmission end-to-end delay time for AODV, DSR, OLSR, TORA, and GRP routing protocols of the networks when data is streamed to a Mobile node from a cloud server directly, (b) value end-to-end throughput for AODV, DSR, OLSR, TORA, and GRP routing protocols of the networks when data is streamed tothe Mobile node from the cloud server directly, (c) packet variation end-to-end load for AODV, DSR, OLSR, TORA, and GRP routing protocols of the networks when data is streamed to a Mobile node from a cloud server directly

Table 1. Parameters considered for the simulation

Parameters	Values
AD-HOC routing parameters	AODV
Route request retries	5
Route request rate limit(pkts/sec)	10
Active route Timeout(seconds)	3
Node Traversal Time(seconds)	0.04
Time out buffer	2
AD-HOC routing parameters	DSR
Maximum Buffer Size(packets)	50
Broadcast Jitter(seconds)	Uniform (0,0.01)
Minimum outcome	0
Maximum outcome	0.01
AD-HOC routing parameters	OLSR
Addressing mode	IPV4
Hello Interval(seconds)	2.0
TC Period (seconds)	5.0
Hold-time for neighbors (seconds)	6.0
Time for topology hold (seconds)	15.0
AD-HOC routing parameters	TORA
Transmit Interval OPT (seconds)	300 seconds
Timeout for IP Packet Discard (seconds)	10 seconds
AD-HOC routing parameters	GRP
Hello Interval(seconds)	Uniform (4.9,5.0)
Minimum outcome	4.9
Maximum outcome	5.0
Neighbor expiry time(seconds)	constant (10)
Distance moved(meters)	1000
Position Request Timer(seconds)	5.0
CPU Background Utilization	Null
CPU Resource Parameters	Single Processor
Advanced Server Configuration for the Server	Solaris, System, Sun Ultra 10 333 MHz: 1 CPU, 1 Core(s), 333 MHz
WLAN Physical Characteristics	Extended Rate PHY (802.11 g)
Data Rate(bps)	54 Mbps
Channel Settings	5 GHz Ch 153
Bandwidth	22 MHz
Minimum Frequency (MHz)	5.795
Transmit Power (W)	0.005 W
Simulation time	30 minutes
No. of nodes	17
Mobility	Fixed+ mobiles
Short Retry Limit	7
Long Retry Limit	4
Buffer size	256000
Cellular mobility in a building	5
Mobility across a geographical area	10

Table 2. Performance metric of proposed media streaming application for the various routing protocols of delay, throughput, and load when data is streamed to the mobile node from the cloud server directly

Routing Protocols	Delay (msec)	Throughput (bits/sec)	Load (bits/sec)
AODV	0.26	130	985
DSR	0.80	165	1000
OLSR	0.31	141	1350
TORA	0.43	135	1100
GRP	0.30	170	850

to another edge node. We have considered a delay, throughput, and jitter after the handoff period. GRP attains the maximum throughput after handoff whereas AODV attains minimum throughput. DSR throughput is close to the GRP throughput. But DSR has inconsistent out jitter with a load of 1000 bits/sec. Whereas OLSR has consistent jitter with a high load which is required for the edge node to enable video streaming applications. Considering the performance analysis of these three Figure 5 (a),5(b), and 5(c) it is evident that OLSR performs the optimum result concerning the three most significant parameters delay, throughput, and jitter. Though GRP has the maximum throughput and delay is also within the threshold region but it cannot be considered for live streaming just because of the most consistent delay as depicted through the jitter graph as shown in Figure 5 (c). The performance metric of the proposed media streaming application for the various routing protocols of delay, throughput, and load when data is streamed to the mobile node from the cloud server directly is given in Table 2 . From the table, it is found that AODV has got a minimum delay of 0.26 msec, GRP has got a maximum throughput of 170 bits/sec and OLSR has got a maximum load of 1350 bits/sec.

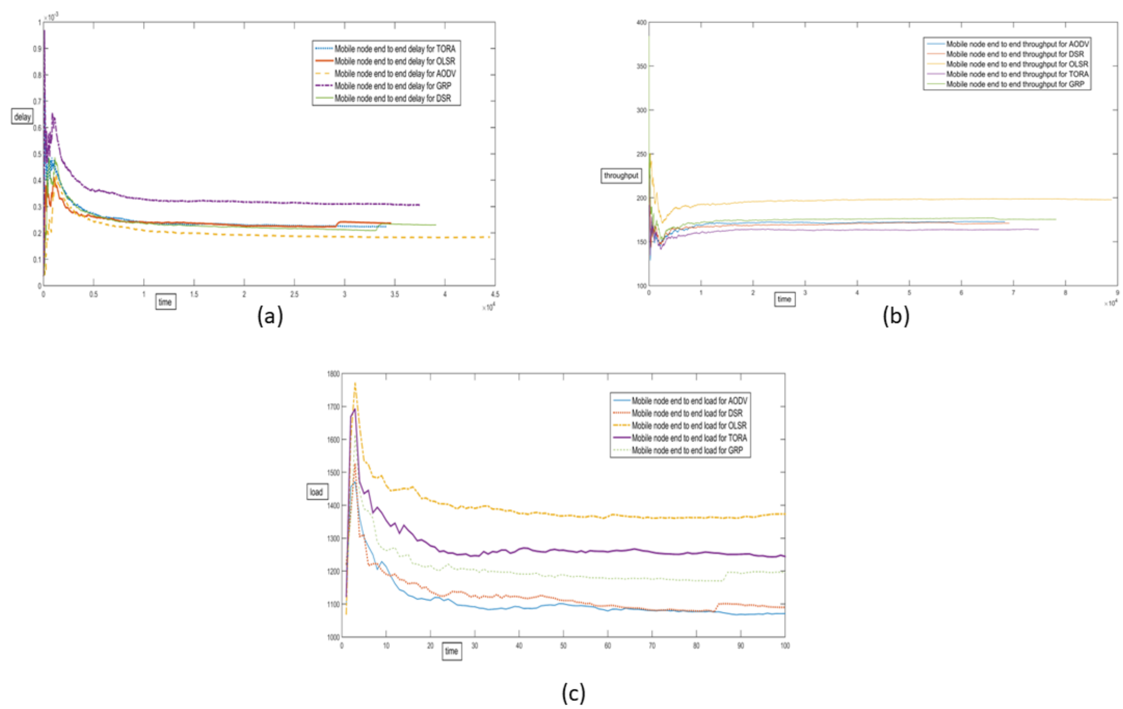


Fig 6. Shows the average (a) packet transmission end-to-end delay time for AODV, DSR, OLSR, TORA, and GRP routing protocols of the networks when data is streamed through the mobile edge devices, (b) value end-to-end throughput for AODV, DSR, OLSR, TORA, and GRP routing protocols of the networks when data is streamed through the mobile edge devices, (c) packet variation end-to-end load for AODV, DSR, OLSR, TORA, and GRP routing protocols of the networks when data is streamed through the mobile edge devices

Figure 6 (a) demonstrated that AODV surpasses all other routing protocols with a minimal delay of 0.24 msec, followed by the DSR protocol and TORA protocol, both of which have an average delay of 0.2 msec, which is below the threshold burst

Table 3. Performance metric of proposed media streaming application for the various routing protocols of delay, throughput, and load when data is streamed through the mobile edge devices

Routing Protocols	Delay (msec)	Throughput (bits/sec)	Load (bits/sec)
AODV	0.24	165	1080
DSR	0.26	164	1095
OLSR	0.31	180	1410
TORA	0.28	153	1250
GRP	0.37	170	1220

of packet drop. Figure 6 (a), 6(b), and 6(c) show a spike and through at 0.2 msec, which is caused by the handoff of a mobile node from one edge node to another edge node. After the handoff phase, we have taken into consideration latency, throughput, and jitter. OLSR achieves the highest throughput after handoff whereas TORA attains minimum throughput. The throughput of GRP is close to that of OLSR throughput. However, GRP exhibits inconsistent output jitter at a load of 1220 bits/sec. OLSR, on the other hand, lacks the constant jitter and high load needed for edge node-enabled video streaming applications. It is clear from the performance analysis of these three Figure 6 (a),6(b), and 6(c) that OLSR achieves the best performance for the three key parameters of latency, throughput, and jitter which has got the maximum throughput, maximum load, and delay also within the threshold region. Despite having the highest throughput, and a delay that is within the threshold range, OLSR can be used for live streaming since it has the most consistent jitter, with the pretty high load which is required for the edge node enable video streaming application as shown by the jitter graph in Figure 6 (c). The performance metric of the proposed media streaming application for the various routing protocols of delay, throughput, and load when data is streamed through the mobile edge devices is given in Table 3. From the table, it is found that AODV has got a minimum delay of 0.24 msec, OLSR has got a maximum throughput of 180 bits/sec, and a maximum load of 1410 bits/sec.

Some of the previous works stated that the AODV protocol outperformed DSR in terms of throughput, although at the cost of lower latency. GRP and OLSR achieve the least data dropping in a network with a throughput of 30945.16 bits/sec [11]. Since IEEE 802.11n 2.4GHz has the maximum data rate and the broadest coverage, it can display the highest throughput. IEEE 802.11b has the lowest data rate of 10 bits/sec with the broadcast coverage of any other routing protocols [12]. While AODV has significant overhead advantages and is well suited to decrease the packet loss ratio, it is constrained for real-time applications due to its higher jitter levels [13]. The simulation results revealed that the OLSR protocol has the highest throughput reaching 6000000 bits/sec among other protocols when implemented in small and big networks. The DSR protocol performed the best when compared to other protocols in terms of the network load [14].

Finally, we have made a comparative analysis of different QoS parameters like throughput, delay, and jitter and by comparing the previous work we found that AODV outperforms all other protocols in terms of delay of 0.24 msec, while OLSR outperforms all other protocols in terms of highest throughput and a better load of 180 bits/sec and 1410 bits/sec as demonstrated in this study.

Table 4. Performance Comparison between the Proposed method and other previously worked existing methods

Methods	Routing Protocols	Delay	Throughput	Load
Jammer [11]	AODV	10.576	1039841.8	177744.9
	DSR	22.504	355058.9	228688.4
	OLSR	0.0183	173982	2105.04
	GRP	0.019	30945.16	340
Flying ad-hoc Network [12]	AODV	0.022	3500000	33
	OLSR	0.015	3800000	25
Mobile ad-hoc Network [13]	AODV	0.224	14600	2250
	OLSR	0.190	14100	9150
	ZRP	0.022	12000	2700
OPNET [14]	AODV	4	2000000	225000
	DSR	5.3	50000	160000
	OLSR	2.6	6000000	51000
	TORA	2.1	50000	100000
	GRP	2.3	1000000	190000
Our Proposed System	AODV	0.24	165	1080
	DSR	0.26	164	1095

Continued on next page

Table 4 continued

OLSR	0.31	180	1410
TORA	0.28	153	1250
GRP	0.37	170	1220

Finally, we have made a comparative analysis of different QoS parameters like throughput, delay, and load and by comparing the previous work we found that AODV outperforms all other protocols in terms of delay of 0.24 msec, while OLSR outperforms all other protocols in terms of the highest throughput and a better load of 180 bits/sec and 1410 bits/sec as demonstrated in this study (Table 4).

4 Conclusion

In this study, we evaluated the performance of five routing protocols to achieve the least delay with the limited bandwidths, for various QoS parameters such as delay, throughput, and jitter. Opnet was utilized for the simulations. The simulation results for throughput, end-to-end delay, and load demonstrate that the OLSR protocol has a high throughput of 180 bits/sec, and the delay is also within the threshold region of 0.31 msec as compared to the other four routing protocols with increasing network size and mobility speed. AODV surpasses all other protocols with a minimal delay of 0.24 msec. DSR throughput of 164 bits/sec is close to that of GRP throughput of 170 bits/sec. TORA attains minimum throughput of 153 bits/sec.

The most consistent delay, as shown by the jitter graph in Figure 6 , prevents GRP from being used for live streaming even if it has the highest throughput of 170 bits/sec and the delay is also inside the threshold range of 0.30 msec.

We intend to expand our simulations to include a variety of other routing protocols for the minimum delay with better throughput and load. The current work of this research is quite promising and in the later part, when we put this into practice, it will come up with a better and more useful manner.

Acknowledgment

At this juncture, I would like to express my sincere gratitude to Assam Kaziranga University's authorities for giving me the opportunity to do the research and express my deep gratitude to all the respected teachers of the CSE Department, at Kaziranga University.

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