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Performance Evaluation of A Peer-to-peer Wireless Ad-hoc Network

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

This paper has investigated the performance of a peer-to-peer wireless Adhoc network in an indoor and outdoor environment. The objective is to assess the network performance using metrics such as throughput, packet loss, packet latency and packet delivery ratio (PDR). In the investigation, two measurement locations were chosen; Location 1 (an indoor) and Location 2 (an outdoor). At each of these locations, data packets of 28.6MB was deployed in successions across the network and the responses were observed at the client's node in real-time mode. Results of the experimentations at both locations show packet losses across the network which is more pronounced at Location 2 (outdoor). Also, higher packet latency was recorded at Location 2 compared to Location 1. The investigation results were compared with similar research works to validate the accuracy of our work. It was thus inferred that between the two locations, the outdoor

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environment shows a low level of reliability in terms of network performance. A knowledge of these performance metrics is essential for network administrators, engineers and researchers for proper network planning, design and deployment.

Keywords: Wireless adhoc networks; performance; packet loss; packet delay; packet; throughput.

1. INTRODUCTION

Wireless Adhoc Network is a set of self-organizing nodes that are connected together without the typical network infrastructure equipment and a central server. The nodes are linked together in a decentralized manner, without the requirement for a central access point or infrastructure. They are usually temporary networks that are not suitable for long term operations. Each device in the network serves as both a host and a router, passing data packets between other devices. They are used in many different applications, including military, disaster response, and machine to machine (M2M) communication due to their ability to rapidly deploy data packets to multiple mobile users with full autonomy [1,2,3]. The techniques are also employed in situations where there are no fixed infrastructures, such as distant locations or poor countries, with the goal of establishing survivable, efficient and dynamic communication [4,5,6]. However, the implementation and design usually encounter some challenges such as, limited resources, device mobility and the necessity for efficient routing algorithms. Therefore, due to these challenges, Adhoc Network is now attracting growing research interests in the field of computer networks.

Advances in wireless technologies in recent years have resulted in the creation of new types of ad hoc networks, such as mobile ad hoc networks (MANETs), vehicular ad hoc networks (VANETs), and wireless sensor networks (WSNs). But these networks have different characteristics and requirements. Generally, in an adhoc network, nodes are organized into various small clusters, utilizing the hierarchical structure [7,8,9]. This clustering has several advantages such as reducing signaling overhead, abstracting the network topology into a simpler form, and providing efficient load management and load balancing. In a cluster-based scheme, the cluster head gathers data from the member nodes and acts as a fusion center. Data is gathered at the cluster head level and forwarded to the destination by multi-hop communication. Each cluster head maintains a virtual backbone for the network, which reduces communication time and enhances network performance. Clustering can also handle situations where multiple nodes may try to access the same spectrum or data simultaneously, which may lead to collision and deadlock. The kind of architecture used in an adhoc network plays a major role in term of power consumption, cluster layering and re-clustering of nodes [10]. Another very important feature in adhoc network is the routing. Routing plays a critical role in network system as it involves the sending of packets by making logical and intelligent decisions. It normally guarantees efficient and reliable communications among the nodes. Three major types of routing protocols have been proposed by researchers in the field, these are proactive, reactive and hybrid. In a proactive routing protocols, routing table information is being updated periodically and consistently. Examples of this protocol include Destination Sequenced Distance Vector (DSDV), Optimised Linked State Routing (OLSR) etc. For a reactive protocol, the routing will be initiated only on demand. Typical example is Adhoc On-Demand Distance vector (AODV). Hybrid is a combination of both reactive and proactive routing protocols. It is designed to reduce control overhead caused in proactive routing protocols and also to reduce latency in reactive routing protocols [11]. In all, routing plays essential role in Adhoc Network for effective and efficient data flow in the system.

2. REVIEW Of PAST WORK

Several researchers have investigated the performance of wireless mobile Ad-hoc networks and VANET with regards to various metric parameters. [12] Evaluated the performance of the internet protocol version 6 (IPv6) based routing protocol for low power and lossy networks (RPL) used in static networks like, wireless sensor networks (WSN) and internet of things (IoT). They implemented the (RPL) in mobile networks, like vehicular ad-hoc network (VANET) and mobile ad-hoc network (MANET) and compared their performance with the static network. They observed that the (RPL) performance rely mostly on number of sender nodes, sink nodes and introduction of mobility to the nodes. [13] Evaluated the performance of Destination Sequence Distance Vector routing (DSDV) and ad-hoc on Demand Vector protocol (AODV) of mobile Ad-hoc network, based on packet delivery, end to end delay and throughput with varying numbers of nodes. Their findings showed that the AODV performed better in terms of bandwidth utilization, less overhead, support high speed mobility and stable throughput than the DSDV. [14,15] Evaluated the performance of IEEE 802.11p, enhanced distributed channel access (EDCA) mechanism, using node speed and node density. They adopted two scenerios, the highway and the rural roads. Various tools such as openstreetmap and simulated Urban mobility (SUMO) that gives real life traffic. The generated traffic was exported to simulator (NS.3.31) for the IEEE802.11p performance evaluation and compared the performance with IEEE802.11a. Their results showed that 1EEE 802.11p performed better. A two types of single user models was developed in [16] for predicting transmission control protocol (TCP) downstream throughput in IEEE 802.11g wireless local area networks, for different signal to noise ratio (SNR) categories. They used Tamosoft throughput test tool to collect different SNRs in open corridor, free space and small offices. Their first model was developed without data categorisation, using SNR and the second model by categorizing the field data into different signal categories (strong, grey and weak signals).

3. METHODOLOGY

A simulation tool called jperf has been used to implement this research work. Jperf is a tool that allows users to measure the performance of a network connection between two nodes by using either the TCP or UDP protocols [17]. It is a graphical user interface (GUI) for the network performance measurement, the Iperf tool, which is run directly from the command line. Jperf has a user interface that is easier to navigate and it makes the process of configuring and running network tests, less complicated [18,19]. The tool is capable of measuring a variety of crucial metrics such as bandwidth, throughput, jitter, and packet loss. In addition, it is also capable of generating a wide variety of traffic, such as single-stream, multi-stream, and bursty traffic. The network was configured to form a peer-to-peer (p2p) arrangement. The network parameter settings for the experimentation is as indicated in Table 1.

3.1 Measurement Details

Measurements were conducted in two different locations. Location one (L1) is an indoor environment that consists of a lobby within a complex. The lobby is measured 52m long and 4m in width. It has a flat terrain and devoid of any physical obstructions along the established line of sight. Measurements were taken at different points along this lobby up to 30m length.At each observation point, a packet size of 28.6Megabytes were deployed and data logged in at the client's node accordingly. Location 2 is an outdoor environment that is made up of a flat terrain with shrubs planted at both sides of the pedestrian pathway. Similar experimental procedure was repeated here, which covers a length of 30m. At each observation point, data was logged in and compared with the indoor scenario. The results are as presented in Tables 2,3 and Figs. 1 to 4.

Table 1. Experimental parameter settings

Parameter	Value
Packet size	28.6 Megabytes
Number of nodes	2 (Server and client)
Architecture	Peer to peer
Distance	2m, 5m, 10m, 15m, 20m, 25m, 30m
Protocol used	User datagram protocol (UDP)
Standard	IEEE 802.11
Software	Jperf application
Output format	Megabytes
Report interval	1 sec

4. RESULTS AND DISCUSSION

From the plots above, Fig. 1, shows the average recorded bandwidth with distance at both locations. Generally, highest value of data transfer rate (bandwidth) was recorded at 2m being the closest distance to the server's node. Also, as distance increases, a reduction in data transfer rate was seen at the two locations. This indicates a drop in signal strength as it moves from server to client's node. In addition, total failure (packet loss) was recorded at 30m for outdoor case. Also in terms of packet transfer rate, the indoor environment shows better performance than the outdoor. It is seen that on the overall average, indoor recorded 2.56Mbytes/sec across the entire link while outdoor measures 2.20Mbytes/sec across the link. The obvious reason for this is the other associated losses with outdoor environment.

Fig. 2, shows the plot of packet delivery time across the network at both locations. The trend shows a slight progressive increase in packet delivery time with distance across the network. On the overall average, it took 38.53sec to deliver a 28.6Mbytes of data packet across the network in an outdoor environment. However, it has taken 14.13sec for the same data packet size (28.6MB) to be transferred across the network in indoor environment. This is suggesting that the network performs fairly well in an indoor environment.

Fig. 3, is the plot for observed jitter which indicates variations in the packet transmission latency. At a distance of 2m (for outdoor), the jitter value measured is 0.2670ms. This low jitter value indicates that the arrival latency of data packets at their destination is exceptionally stable and consistent. In other words, there is minimal variation in the time required for each transmission to reach its destination, resulting in a predictable and consistent network behaviour. As seen, Jitter values tend to rise inconsistently, as the distance between the communicating nodes increases. At a distance of 5m, the jitter value increases to 1.076ms, indicating a slightly higher variation in packet delivery time, than at a distance of 2m. The jitter value at 10m measures 0.506ms, which is slightly lower than the measured value at 5m. Also, at 15m, 20m and 25m, the measured values are 0.79ms, 0.601ms and 0.969ms respectively. This clearly shows a wobbling pattern of measured jitter on the plot. But on the average, it could be said that the plot shows a slowly increasing jitter with time. The findings here are in total agreement with [13,16].

Table 2. Measurement result for location 1 at different observation points

Distance (location Indoor)	Interval (sec)	Transfer (28.6MBytes)	Average Bandwidth (Mbytes/sec)	Jitter (ms)	Datagram Loss (%)
2m	6.90	28.6	4.15	0.107	7/20409 (0.034%)
5m	8.10	28.6	3.55	2.139	0/20409 (0%)[356]
10m	8.80	28.6	3.27	0.295	0/20409 (0%)[356]
15m	11.20	28.6	2.56	0.431	0/20409 (0%)
20m	15.70	28.6	1.82	1.077	0/20409(0%)
25m	16.60	28.6	1.73	0.259	0/20409 (0%)
30m	31.60	28.6	0.89	1.13	424/20409 (2.1%)

Table 3. Measurement result for location 2 at different observation points

Distance (location Outdoor)	Interval (sec)	Transfer (28.6MBytes)	Average Bandwidth (Mbytes/sec)	Jitter (ms)	Datagram Loss (%)
2m	6	28.6	4.12	0.267	1/20410 (0.0049%)
5m	9.3	28.6	3.06	1.076	1/20410 (0.0049%)
10m	13	28.6	2.21	0.506	1/20410 (0.0049%)
15m	29	28.6	0.99	0.798	7/20410 (0.034%)
20m	12.7	28.6	2.25	0.601	1/20410 (0.0049%)
25m	45.7	28.5	0.62	0.969	2/20410 (0.3%)
30m	154.00	failed	failed	failed	failed

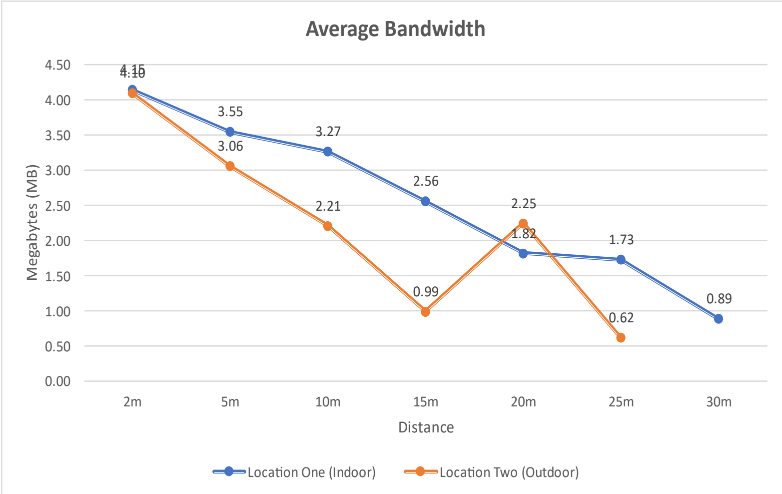

Fig. 1. Plot comparing the average bandwidth between the two locations

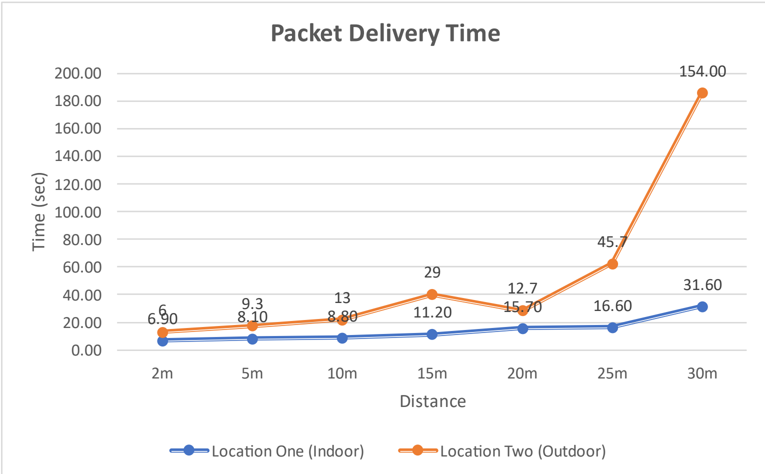

Fig. 2. Plot comparing Packet delivery time between the two locations

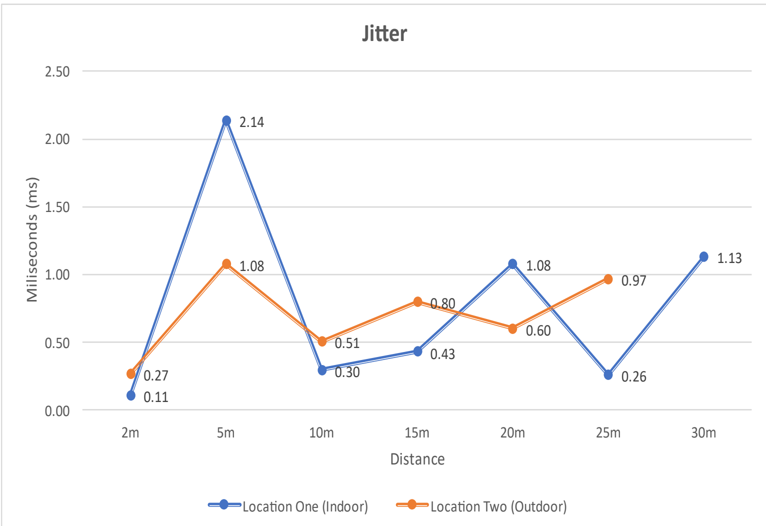

Fig. 3. Plot comparing the jitter between the two locations

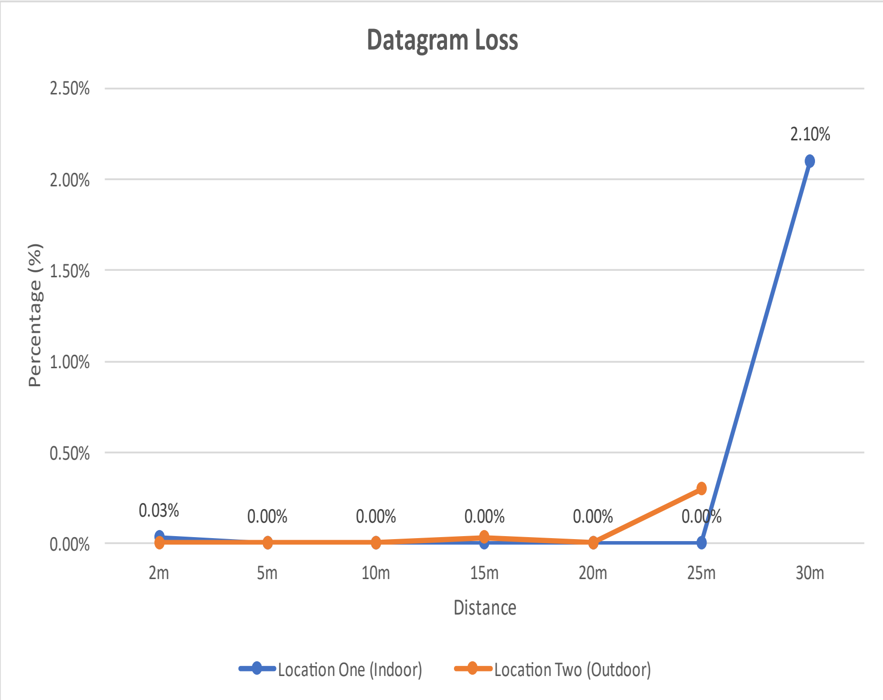

Fig. 4. Plot comparing the datagram loss between the two locations

5. CONCLUSIONS

This work has investigated the performance of a peer-to-peer Adhoc network using a simulation tool called jperf. The essence is to assess the network performance metrics such as throughput, packet delay, packet loss, jitter etc. In addition, the dependencies of these metrics against measurement locations were also investigated.

For the distances considered, a minimal packet loss was recorded. However, the bandwidth (data transfer rate) shows varying degrees of values at each observation point and is location dependent. For instance, the indoor environment has shown a high performance rate compared with the outdoor. Also, the bandwidth gets reducing as the client's node gets far apart from the server. Delay in packet delivery was observed, though at higher distances. However, this is not pronounced in the indoor environment.

In conclusion, this study has provided valuable insights into the behaviour of a P2P wireless ad hoc network in various locations and casts light on the performance variations and challenges presented by various environments. Taking cognizance of these observations, network administrators and researchers can then make informed decisions regarding network design, deployment strategies, and performance optimisation techniques to improve the reliability and efficiency of P2P wireless ad hoc networks in real-world scenarios.

6. RECOMMENDATION

For further research, the various protocols of the MANET and VANET Adhoc network performance, should be study individually.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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