PERFORMANCE EVALUATION OF WIRELESS AD-HOC NETWORK

ABSTRACT

This paper has investigated the performance of a wireless Adhoc network in an indoor and outdoor environment. The performance metrics used to assess the network are throughput, packet loss, packet latency and packet delivery ratio (PDR). Two measurement locations were chosen for the experimentation; location 1 (an indoor) and location 2 (an outdoor). At each of these locations, data packets were deployed in successions across the network and the network responses were observed at the server's node in real-time mode. Results 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 with location 1. It was thus inferred that the outdoor 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.

1.0. 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. Each device in the network serves as both a host and a router, passing data packets between other devices. They are utilized in many different applications, including military, disaster response, and emergency communication due to their ability to rapidly deploy data packets to multiple mobile users with full autonomy [1]. The techniques are also employed in situations where there is no fixed infrastructure, such as in distant locations or poor countries, with the goal of establishing survivable, efficient, and dynamic communication [2]. However, the implementation and design usually present various obstacles such as: limited resources,device mobility, and the necessity for efficient routing algorithms. Therefore, due to these challenges, Adhoc Network is now attracting growing 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. Multiple computing and communication devices, such as laptops and mobile phones, currently possess the necessary characteristics in terms of cost, portability, and usability, and in the context of an ad hoc network. As technological advancement continues, these characteristics will be increased even further. Generally, in an adhoc network, nodes are organized into various small clusters, utilizing the hierarchical structure [3]. 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 [17,18]. The kind of architecture used in an adhoc network plays a major factor in the power consumption, cluster layering, and re-clustering of nodes [4].

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Another very important feature in adhoc network is the routing. Routing plays a critical role 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 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). In all, routing plays an essential role in Adhoc Network for effective and efficient data flow in the system.

2.0 Methods.

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 [5]. It is a graphical user interface (GUI) for the network performance measurement tool known as Iperf, which is run 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 [6,7]. 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..

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

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2.1. Measurement Details.

Measurements were conducted at 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 was being deployed and data logged in at the receiving node accordingly. Location 2is an outdoor environment that is made up of a flat terrain with line of trees which forms a 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 Figures 1to 4

3.0. Results and Discussion

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

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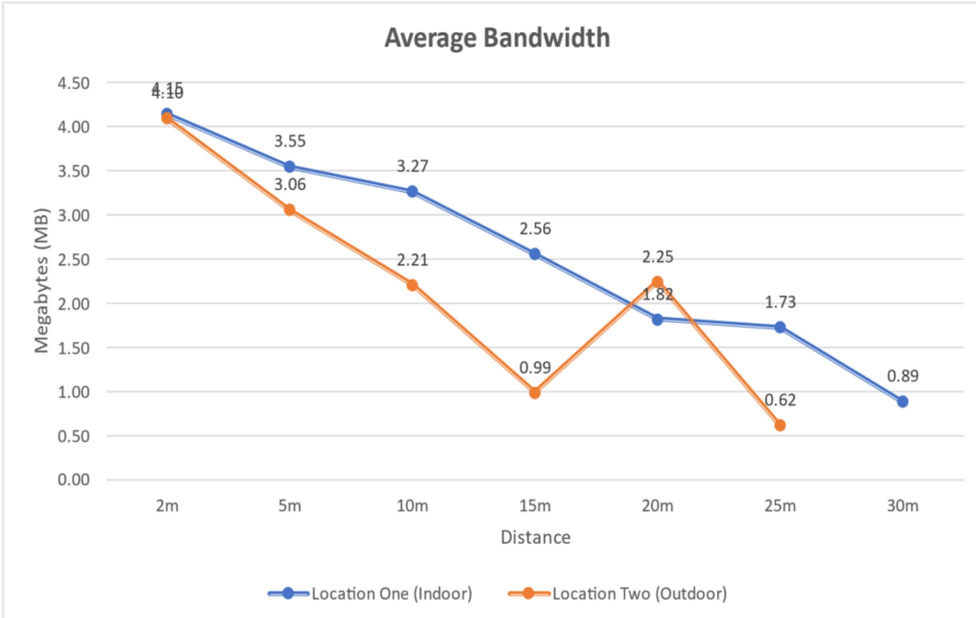

Figure 1. Plot comparing the average bandwidth between the two locations

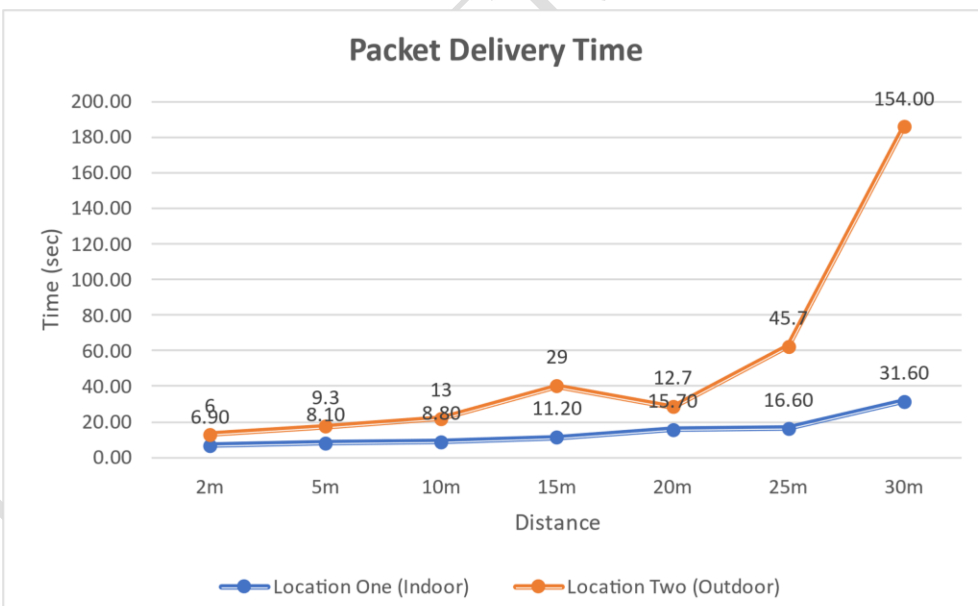

Figure 2.. Plot comparing Packet delivery time between the two locations.

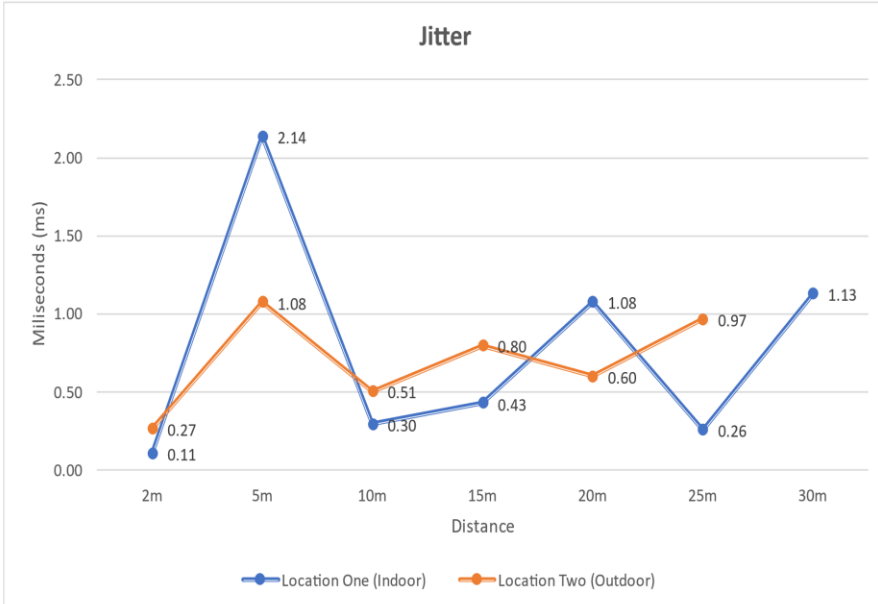

Figure 3. Plot comparing the jitter between the two locations

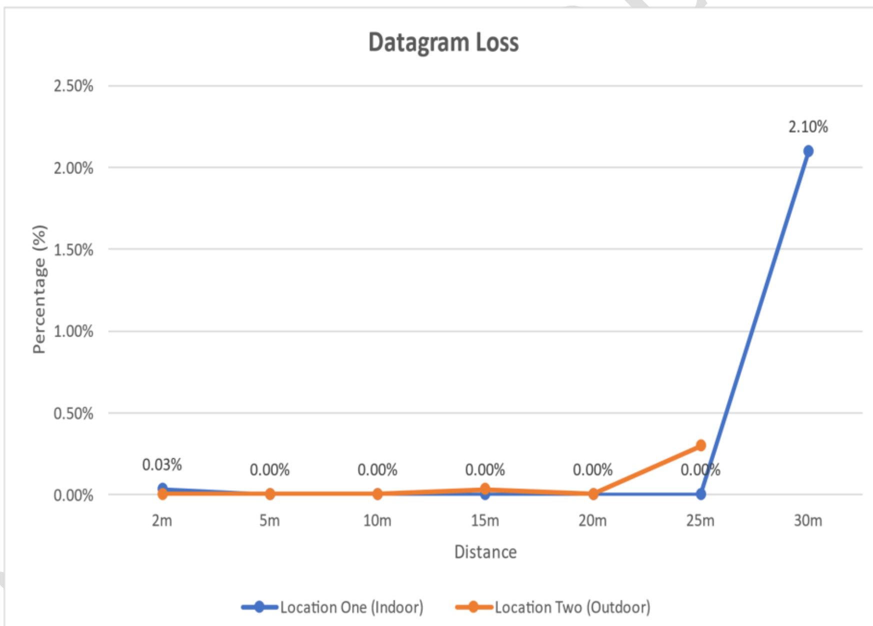

Figure 4. Plot comparing the datagram loss between the two locations

From the plots above, figure 1shows 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 transmit node. Also, as distance increases, a reduction in data transfer rate was seen at the two locations. This clearly indicate a drop in signal strength as it moves from transmit to receive node. In addition, total failure (packet loss) was recorded at 30m for outdoor case. Also in terms of packet transfer rate, L1 (indoor) shows a better performance than L2 (outdoor). It is seen that on the overall average, L1 recorded 2.56Mbytes/sec across the entire link while L2 shows 2.20Mbytes/sec across the link. The obvious reason for this is the other associated losses with outdoor environment. Figure 2. shows the plot of packet delivery time across the network at both locations. The trend shows an increasing time in packet delivery across the network. On the overall average, it took L2 (outdoor)

38.53sec to deliver a 28.6Mbytes of data packet across the network. The same network has taken 14.13sec to transfer same data packet size in an indoor environment. This clearly suggest that the network performs fairly well in an indoor environment.

Figure 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 as the distance between the transmitting and receiving nodes increases. At a distance of 5m, the jitter value increases to 1.076ms, indicating slightly greater variation in packet delivery time than at a distance of 2m. The jitter value at 10 metres is 0.506ms, indicating a moderate increase in jitter compared to the 2-meter and 5-metre distances. In addition, at 15m, the jitter value increases to 0.798 milliseconds, indicating increased packet delivery time variability. At 20m, the jitter value is measured to be 0.601ms, which is significantly lower than the 15m value, indicating a modest improvement in jitter performance. At 25m, the deviation value rises to 0.969 milliseconds. This suggests a greater variation in packet delivery time compared to shorter distances, which may have an effect on real-time applications that require precise and consistent data delivery.

4.0. 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 receiving node gets far apart from the sending node. Delay in packet delivery was observed, though at higher distances. However, this is not pronounced in the indoor investigation. 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.

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