The Performance Analysis of Wireless Distribution System Using Point to Multipoint Network Topology

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Abstract. Current information technology development continues to evolve along with the needs in obtaining data or information either audio, images or a combination of both which is growing rapidly. Therefore information technology must be able to provide services that could fulfill user expectations in terms of both quality and quantity. One of the prominent changes in information exchange field is the use of wireless technologies, including its network configurations. Besides having to function optimally, the performance of the wireless technology is also needed to be maintained. This research is about the technology performance of Wireless Distribution System (WDS) with point to multi-point network configuration using 802.11g access point. The research was conducted in two phases. The first phase was building a WDS network model using four access points that are connected to each other. The second one was examining WDS network performance on server side. Based on the results obtained seen throughput on each segment WDS tested in gradual decline and the sharpest occurred in the last segment. On the other side the value of jitter increased from WDS-1 to WDS-2 and WDS-3 in a normal number, as well as the value of packet loss which increased in a very good category. The results obtained indicate good quality and generally very appropriate WDS technology to expand wireless access.

1 Introduction

The development of information device technology continues to increase along with the needs of users in communicating and using data communication applications. The growth of users who switch to communication with IP based services needs to be accompanied by good service quality. To maintain data transmission requirements, equipment integrated in the network must be designed according to the desired expectations. The need to give satisfaction in accessing the internet is what motivates the motivation of this research.

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Nowadays, computer network infrastructure technology shows remarkable development on wireless networks compared to wire networks. Various variants of wireless network technology with the 802.11 standards are now starting to dominate with the 802.11n variant. Although the 802.11n variant offers a 2.4 GHz and 5 GHz frequency band, it turns out that hardware manufacturers have even installed network cards on the latest computer products by adopting the most recent variant, 802.11ac. However, all installed hardware wireless network is intended to provide optimum results but with network configuration and unpredictable traffic conditions, can produce an impact value from the output that is beyond expectations.

Wireless Distribution System (WDS) is a coordination technology for wireless network (WLAN) networks to optimize the use of network resources and service area coverage. The use of WDS in network implementation can expand the coverage area and provide flexibility and mobility for users. Limitations of service coverage of a network by using only single Access Points have been solved. Although the problem of coverage is resolved, the use of WDS as a system also has drawbacks, namely a decrease in capacity. In terms of capacity, the increasing number of a node according to users, the traffic collision, the channel utilization rate, the total throughput is among the research focus in system performance.

Network performance issues have provided challenges for researchers to conduct studies and provide solutions. The research conducted by Jeong [1], which proposed a new medium access scheme, showed that the results of throughput performance were better than the existing schemes. Sung, et al. have studied about signal quality and packet delivery and purposed an algorithm name Node Degree Algorithm for achieving throughput performance [2]. Another research which done by Tahar using multiple interfaces per participating Access Point (AP) in order to improve the end to end performance[3].

This paper is focused on network performance and describes an implementation of Wireless Distribution System point to multi point network in AP 802.11g. The purpose of the implementation is to figure out the performace of the network at the client site by evaluating the parameter of throughput, jitter, and packet loss of the WDS network that is connected to APs. The rest of this paper is organized as follows: section two explains the literature review; section three describes the research method; section four discusses the data analysis; and finally, the conclusion is summarized in section five.

2 Literature Review

Wireless Local Area Network (WLAN) is a wireless technology that uses air as a propagation medium to transmit data from the sender to the receiving device. In the operation of equipment, WLANs with 802.11 standards use frequencies allocated for Industrial, Scientific, and Medical (ISM) purposes that get exemption from usage permits or are identified with unlicensed bands. Equipment that works and meets the designation of the ISM band is free to be used by anyone. In addition to the impact on this simplification of convenience for users and increasing popularity, on the other hand it provides opportunities and challenges for researchers to get better results. In its development, various types of 802.11 standards try to provide high data transmission speeds in order to provide satisfying services for users.

To connect between 802.11 WLAN devices so that they can deliver information between interconnected entities, network topology needs to be planned. Theoretically, there are two topologies in a wireless network which are Ad-Hoc topology and infrastructure. Following is the short explanation of the topology:

a. Ad-hoc mode

Ad-hoc mode is a simple mode of the WLAN network. Ad-hoc topology is similar to peer to peer network, where the network is built only by applying the component of wireless device. Ad hoc wireless networks, consisting of a collection of wireless nodes, all of which may be mobile, dynamically create a wireless network among themselves without using any such infrastructure or administrative support [4] The drawback of this mode is the computer is unable to communicate with the computer in the wired network.

b. Infrastructure mode

A more complex topology of the wireless network is the network topology with Basic Service Set (BSS) infrastructure mode. This configuration places the AP as a device that functions as data traffic in forwarding information in the network. As the agent, AP in addition to serving connected nodes also plays a role as a bridge with conventional networks that are physically connected via UTP cable.

2.1 Wireless distribution system

Wireless Distribution System (WDS), which is also named as Wireless Repeater, is a system to develop a wireless network without using cable as the media of data transfer but applying the wireless path of each AP equipment. It is very contrast to conventional communication network, where the media of distribution system is cable (wired LAN). All of the base stations in WDS have to be configured using the same radio channel, the same encryption methode (without encryption, WEP, or WAP), and the same encryption keys. And the connection is a configuration using different Service Set Identifiers (SSID) on each user identity [5].

WDS allows the interconnection of each AP equipment in a wireless environment. By applying WDS, the connection in a wireless network can be expanded using some APs or base station without the requirement of backbone cable network. WDS can be applied in two features/modes connectivity between APs, which are:

a. Wireless Bridging; where the communication between APs in the WDS network is limited and does not allow other wireless client or station (STA) to access the network.
b. Wireless repeater; where AP can communicate with each other and to the wireless Station (STA).

Zikri conducted a research using 2 APs for Wireless Distribution System (WDS) [6]. In this research, *throughput, jitter, packet loss and Signal to Noise Ratio (SNR)* are used as evaluation parameters to measure the quality of the test network. The results obtained on the receiving-end from the test network throughput obtained showed that the average results decline of 51.3% from the maximum bandwidth. In the measurement of other parameters, indicating that the value of the jitter that occurs on average 1.95 ms and the number of packet loss of 0.1%. Another research evaluation showed that accessing a network with WDS system by a variation of client number might reduce the number of channel allocation that may be used by the client [7]. The calculation uses the same client that exists in the network with the WDS system. In the initial stages of testing with 1 client, it was known that the channel allocation in throughput degraded 40.3%. This percentage gradually decreased to 21. 2% on the test with clients, and increased again to 25.2% on the test with 12 clients. The last, the research conducted by using 3 APs with WDS technology [8]. As for the use of such research, WDS technology produces an average percentage decline in the value of the throughput generated by using one client on the AP-2 (WDS-1) is 31.27%, while the average percentage of the throughput on the AP-3 (WDS- 2) is 54.92%. Tests were performed using point-to-point network topology with the distance between the AP range of 20 meters conducted in open space. The results show a gradual decrease in throughput for each AP used.

2.2 Network performance

2.2.1 Throughput

Throughput is the real capability of a network in sending data. Throughput is always related to bandwidth even in some context it is also called bandwidth. The principal different is on their nature, while bandwidth is static of fixed, throughput, on the other hand, is dynamic. Globally speaking, through put is a measure of data traffic in a communication, with the unit of megabit per second (mbps). The higher the value, the better the network performance. Actual throughput will vary. Network conditions and environmental factors, including the volume of network traffic, building materials and construction, and network overhead, lower the actual data throughput rate.

2.2.2 Jitter

Jitter is a delay variation due to time difference or interval of the arriving of receiving the packet. In data communication, packets delivered are varied and traffics that occur in the network are very dynamic in accordance with the volume of the data transaction. The amount of jitter that occurs is dependent on the number of collisions between packets that pass through in the network. The number of jilter in a reasonable tolerance is between *0* to *100 ms* as shown in Table 1. As jitter indicates the package collision in the internet protocol, the heavier the traffic load, the bigger the possibility that collision will occur. This will have an impact on the value of the jitter will become larger.

Table 1. Jitter criteria [9]

Category	Peak Jitter
Excellent	0 ms
Good	0-75 ms
Poor	76-125 ms
Worst	126-225

2.2.3 Packet loss

The failure in the transmission of a data packet on its way to the destination is called packet loss. There are some factors that may cause the packet loss, including collision, congestion, error transmission of physical media, and the failure at the receiving side which may due to overflow on the buffer. Attempts to minimize the number of packet loss are a challenge that must be faced and very difficult to avoid. Therefore, if the smaller value of packet loss in a network the better the performance of the network. Performance categories of the packet loss are shown in Table 2.

Table 2. Packet Loss Criteria

Category	Packet Loss
Excellent	0 %
Good	1-3 %
Poor	4-15 %
Worst	16-25 %

3 Research Methodology

In this research, four APs have been configured using point to multipoint topology approach to test their WDS performances. All APs placed in open space and examine their capabilities to deliver a message to the client under three scenarios as listed in Table 3. We propose throughput, jitter and packet loss as the parameters to measure their performances by using the jperf software. Fig. 1 shows the tested topology model in this research.

Table 3. Testing scenarios

Skenario	AP-1 (*main*)	AP-2 (WDS-1)	AP-3 (WDS-3)	AP-4 (WDS-4)
1.	*Server*	*Client*	-	-
2.	*Server*	-	*Client*	-
3.	*Server*	-	-	*client*

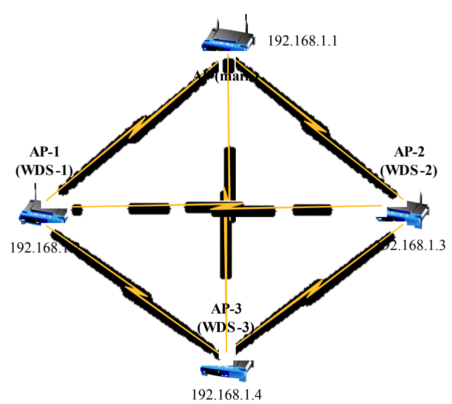

Fig. 1. The model of topology

4 Discussion

This section discusses the result from the average value of throughput, jitter, and packet loss during the test. The average value from every result test will be compared with the result from throughput, jitter, and packet loss on WDS network that using point to multipoint topology.

4.1 Throughput

This test uses one client for every AP-2 (WDS-1), AP-3 (WDS-2), AP-4 (WDS-3) and 1 server for AP-1. Port used for every client is 5001 (WD-S-1), 6001 (WDS-2), and 8001 (WDS-3).

As shown in Fig. 2, throughput measurements are carried out involving 3 APs that work together as a WDS network. From the resulting test, it is found that the average throughput value of WDS-1 is 6360.06 Kbps, WDS-2 is 6281.54 Kbps, and WDS-3 is 5535.04 Kbps. In aggregate, there is a decrease in throughput when data traffic passes between APs gradually

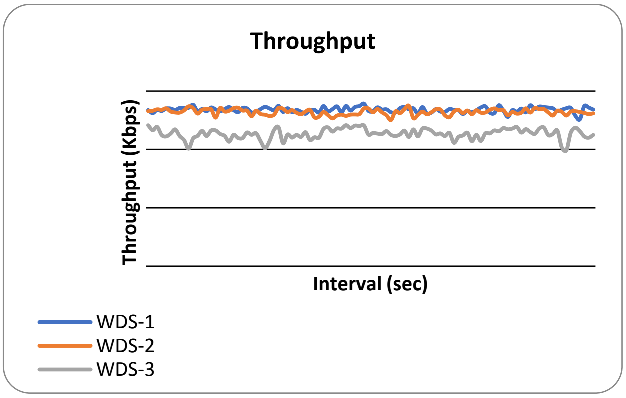

Fig. 2. Throughput average value

4.2 Jitter

The results of Jitter's measurement are shown in Fig. 3. The result shows that WDS-1 is 2,215 ms for its average value and the highest value is 4,574 ms. On WDS-2, its average jitter value is 3,417 ms and the highest value is 3,966 ms. On WDS-3, its average value is 3,897 ms with the highest value is 5,660 ms. Unlike the results of throughput for each WDS stage, jitter measurement shows a gradual increase between each WDS.

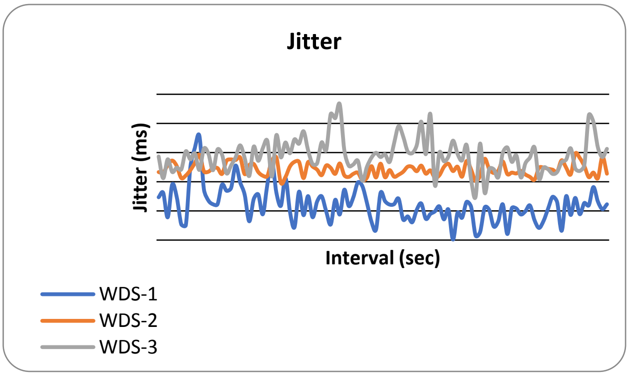

Fig. 3. Jitter average value

4.3 Packet Loss

The amount of packet loss on every WDS client is figured out in Fig. 4. The percentage of packet loss resulted from WDS-1 is 0,15%, WDS-2 is 0,18%, and WDS-3 0,35%. From this data, it can be seen that the amount of the packet losses is greater for every distance addition.

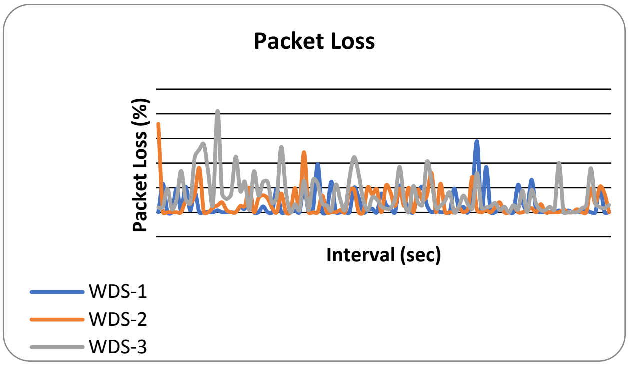

Fig. 4. The graphic of packet loss average value

4.4 Data Analysis

4.4.1 Throughput Comparison

Fig. 5 shows that the average value of WDS-1 is 6360,05 Kbps, WDS-2 is 6281,54 Kbps, and WDS-3 is 5535,04 Kbps. The percentage of decreasing value from WDS-1 to WDS-2 is 1,23%, from WDS-2 to WDS-3 is 11,88%, and from WDS-1 to WDS-3 is 12,97%.

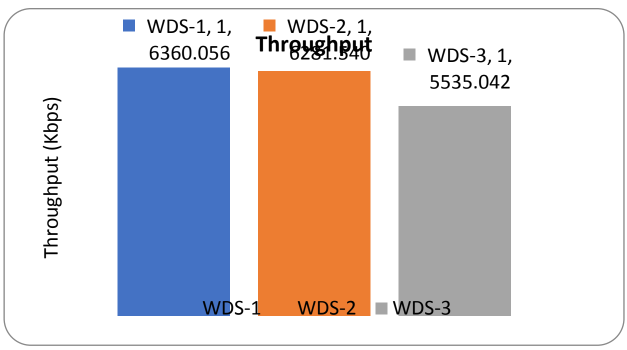

Fig. 5. The comparison result of throughput average value

4.4.2 Jitter Comparison

Fig. 6 shows that the average value of jitter on WDS-1 is 2.215 ms, WDS-2 is 3.417 ms, and WDS-3 is 3.897 ms. The percentage of jitter average value on the WDS-1 network is 1,20%, WDS-2 is 0,47%, and WDS-3 is 1,68%. The highest jitter value is found on WDS-3, it is because there is packet queueing during data distribution process. All the jitter results are still categorized as good according to ITU-T G.8251, 2001 standard where the maximum value of allowed jitter is 75 ms.

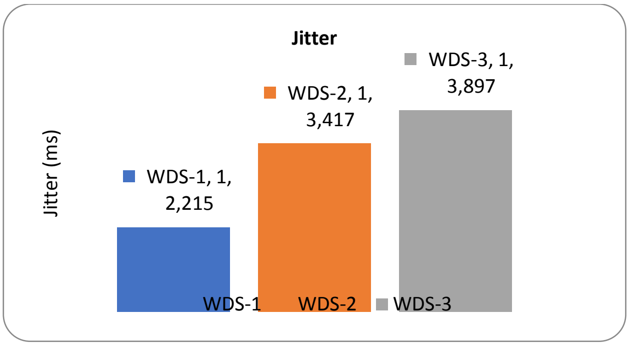

Fig. 6. The comparison result of jitter average value

4.4.3 Packet loss average value

Fig. 7 shows the percentage of packet loss average values on WDS-1 is 0,15%, WDS-2 is 0,18%, and WDS-3 is 0,35%. The losses percentage occured during the test between WDS-1 and WDS-2 is 0,03%, WDS-2 and WDS-3 is 0,17%, and WDS-1 and WDS-3 is 0,20%. But according to ITU TIPHON, 1998 standard, above losses are still categorizing good. The losses amount of data packet is influenced by throughput and jitter value on the network. The greater packet loss resulted from the low throughput value and the high jitter value.

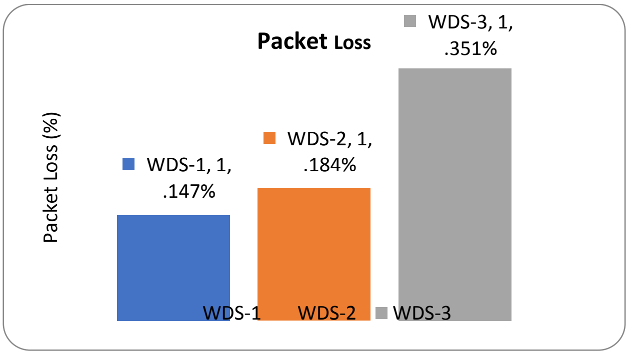

Fig. 7. The comparison result of packet loss average value

5 Conclusion

This research has shown the evaluation of throughput, jitter, and packet loss based on *point to multi point* topology and the WDS network. The results obtained indicate good quality and generally very appropriate WDS technology to expand wireless access.

References

1. J. Jeong, W. Lim, and Y. Suh, "Throughput Enhancement for WDS-Based WLANs," *22nd International Conference on Computer Communication and Networks (ICCCN)*, Nassau, pp. 1-6 (2013).

2. Sung, T.-W. *et al.* An Algorithm for Improving Network Throughput of Wireless Distribution System. in *2016 Third International Conference on Computing Measurement Control and Sensor Network (CMCSN)* 178–181.
3. R. Tahar, A. Belghith, and R. Braham, "Performance evaluation of IEEE 802.11 multi-interface based wireless distribution system (MI-WDS)," *2009 IEEE/ACS International Conference on Computer Systems and Applications*, Rabat, pp. 764-770 (2009).
4. J. Haas et al. , "Guest Editorial," IEEE JSAC, Special Issue on Wireless Networks, vol. **17**, no. 8, (1999).
5. Sulistyo, W., Bayu, T. I., & Sathibi, A. (2012). Implementasi Dan Analisis Penggunaan Dd-Wrt Firmware Untuk Membangun Jaringan Wireless Distribution System Pada Jaringan Hotspot (Studi Kasus : FTI UKSW), *2012*(Snati), 15–16.
6. K. Zikri, "Analisis Performansi dan Kualitas Penerimaan Sinyal Pada Multi Access point Menggunakan Wireless Distribution System (WDS) Pada Jaringan WLAN IEEE 802.11g. Skripsi. Universitas Syiah Kuala, (2012).
7. Putra, D. L. A., and Subhan, A. "Analisa Kinerja Implementasi Wireless Distribution System Pada Perangkat Access Point 802.11g Menggunakan OpenWRT". EEPIS Final Project (2011)..
8. R. Munadi, R. Wahyudi, Fardian, Ardiansyah, Analisis Kinerja Jaringan Wireless Distribution System Menggunakan Access Point 802.11g, Konferensi Nasional ke-7 Fortei (2013).
9. Sugeng, W., Istiyanto, J. E., Mustofa, K., & Ashari, A. The Impact of QoS Changes towards Network Performance. *International Jurnal of Computer Networks and Communications Security*, *3*(2), 48–53. Retrieved from http://www.ijcncs.org/published/volume3/issue2/p5_3-2.pdf (2015).