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# Performance evaluation of a Wireless Sensor Network with Fiber Optic for Precision Agriculture

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**ABSTRACT:** This paper proposes a comparison between a Wireless Sensor Network (WSN) and a Wireless Sensor Network with Optic Fiber (WSNOF). The comparison is achieved through simulating the two scenarios using Opnet modeller 17.5. The network configuration used is the Wi-Fi standard IEEE 802.11g. The aim of this paper is to ascertain the efficiency of a WSNOF to perform real time monitoring with reference to throughput and end-to-end delay. The two network parameters of both the WSN and WSNOF are simulated and compared in order to ascertain a suitable design to be implemented for real time monitoring. Thus network performance in this research is predicated/premised on the throughput and end-to-end delay parameter values. Both the WSN and WSNOF are created in OPNET modeller to obtain the results. Real time monitoring and surveillance requires networks with good network delays and acceptable throughput. Optical Fiber cables are included in the (WSNOF) to enhance the design. From the simulation results, the Wireless Sensor network with Optic Fiber showed a 25% improvement in both the throughput and the end-to-end delay resulting in a significant improvement network performance. Hence, the Wireless Sensor Network with Optic Fibre network design provided is best suited for real time network monitoring and video surveillance

**KEYWORDS:** Fibre Optic, Precision Agriculture, Throughput, Delay, Sensor Networks.

## I. INTRODUCTION

Fiber Optic networks have transformed data transportation in the Information and Communication Technology (ICT) sector. [1]. Increased data demands for video applications has forced service providers, utility companies to use Fiber mainly for its bandwidth and immunity to electromagnetic interference and low loss [1]. Research shows that most of the monitoring networks used are WSN [2]. These WSN's are designed to monitor and collect raw static data, with less focus on real time implications [3]. However, very few researches have been done on deploying networks with real time monitoring. Khan [4] worked on a wireless network for water well management. However, this was not a real-time monitoring network. A WSNOF is an intelligent private network comprised of sensor nodes [5] detecting various parameters and connected via Fiber Optic cable to a cloud server. A WSN is equally simulated to investigate the throughput and delay based 802.11g standard. The objective of this paper is to demonstrate that the WSNOF has a better throughput and reduced end-to-end delay as compared to the conventional WSN through simulation. There are different simulation tools for Wireless sensor networks, these are: OMNET++, OPNET, NS-2, J-SIM, SENSE TOSSIM [6] Here we used OPNET Modeller to implement the simulations. The paper is organised in the following manner; section 1 constitute related work, followed by the system architecture and simulation modelling in section 2, then the methodology used in section 3. Section 4 explains the results of the simulation. Results are then discussed in section 5. Finally the Conclusion is given in section 6.

## II. RELATED WORK

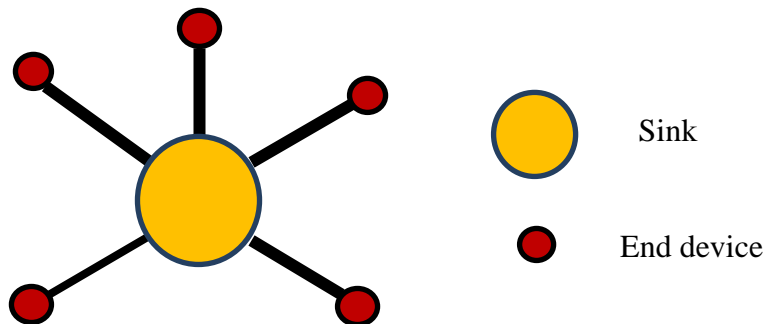
Wireless sensor networks date back to 1980. Umeh et al [7] analysed throughput and delay performance in IEEE 802.11 WLAN's using different tools with a view to establish the effects of varying the number of work stations against the network performance in a real WLAN environment. However, only wireless networks were compared and no Fiber Optic cables were present in the networks. Meir M [8] proposed a Fiber wireless broadband network enhanced by Fiber Optic cable for smart grids however, he focused on usage of these networks in smart grid to reduce carbon emissions and no comparisons of any network parameters. In paper [9] wireless sensor networks were implemented in which two topologies were compared. Throughput and delay were compared in the two topologies with the sole purpose of ascertaining the most efficient topology. However, none of the networks included Optic Fiber cables. In another

research[10] a performance analysis was carried out on a Wi-Fi video surveillance; the tree and the star topologies are compared in terms of their throughput packet loss, delay and jitter were considered for implementation in a video surveillance application. However the research had no fiber optic cables in the network under consideration. Maier[8] proposed a Fiber wireless sensor network(WiFi) for smart grid communications in order to increase the energy efficiency and reduce carbon dioxide greenhouse emissions.

### II.I.Wireless Sensor Networks

Wireless Sensor Networks play a very important role in agriculture monitoring. Buratti et al, 2009[5] defines a wireless sensor network (WSN) as a network of devices, denoted as nodes, which can sense the environment and communicate the information gathered from the monitored environment (e.g., an area or volume) through wireless links [1–9]. The data is forwarded, possibly via multiple hops, to a sink (sometimes denoted as controller or monitor) that can use it locally or is connected to other networks (e.g., the Internet) through a gateway.

The nodes can be stationary or moving. They can be aware of their location or not. They can be homogeneous or not. WSN's has been an area of research for sometime. Nakanishi[11] did a generative wireless sensor network as a framework for agriculture use. Pievannelli et al [12] implemented remote monitoring of workers exposed to hazards in a construction site using WSN, although the most of the research focused on the design of the actual sensors so that they could be portable, compact and wearable. Wireless Sensor Networks (WSN) are based mainly on two standards first the IEEE 802.15 and the IEEE 802.11a/b/g[13]. These may either be implemented in the star, mesh or ring topologies. Below is an example of the star topology network.



It is worth mentioning that most of the networks implemented in the field of WSN use the IEEE 802.15.4 standard and very few WSN are deployed used the IEEE 802.11g. Karviniad in paper [3] implemented a smart irrigation based on the 802.15 standard and using the Zigbee network. Paper [14] discusses real time monitoring of soil nutrient monitoring and it also uses the Zigbee network based on the 802.15 standard. However, Sahota in paper [9] employs an IEEE 802.11g for precision agriculture by comparing between Grid and random topology.

### II.II.Optic Fiber

Optical Fiber offers bandwidth capabilities[15]. Technological changes and high demand for bandwidth has resulted in the proposition of certain service implications[1] such as cable Television and consumer electronics applications in Fiber to the home (FTTH) networks. Fiber is a thin strand of glass or plastic made from silica having the core and the cladding on the outside and transmits light through it by the process of total internal reflection. Below is the diagram of a cross section of an Optical fiber cable. They are two basic types of Optical fiber cables single mode and Multimode. Single mode is the type that has a smaller core diameter that allows it to transmit a single ray of light as coherent light in the core of the fiber. This type of Fiber Optical cable has greater bandwidth than multimode and is normally used in trunks as well as access networks[15]. It also has the advantage of less attenuation as compared to Multimode. This is because this type of Optical fiber cable suffers less from chromatic dispersion.

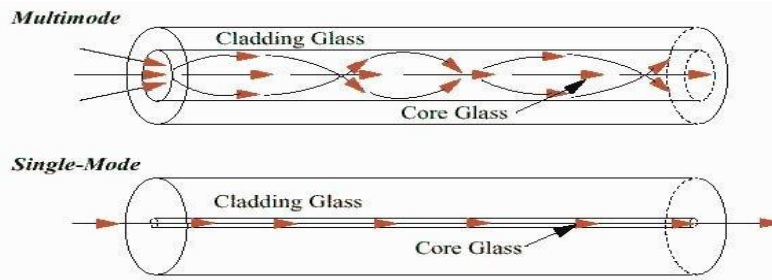


Figure 1: Multimode and Singlemode

### II.III. Precision Agriculture

Precision agriculture(PA) is a type of agriculture that provides the means for monitoring, determining and managing agriculture through automation of agricultural practices [13].Beekeeping in [16]has been proposed as one of the variants of precision agriculture.Note that the networks used in the monitoring and implementation of PA are WSN's. The challenge for most of the wireless networks is the delay and throughput short comings that seem to characterise these networks[17]. In order to reduce the delay and have a better throughput for real time monitoring we proposed a wireless sensor network enhanced with Optical Fiber (WSNOF).

### II.IV Proposed System Architecture

WSNOF and WSN generally consist of devices such as sensors spread in an environment for the purpose of monitoring and managing the network based on the specific physical phenomena [9]. In our case the system covers: detection, identification of detected parameters as well as transportation of data from the crop field to a control location. Note that the WSN has the same design layout as the proposed WSNOF except for the cables used. Thus we can make appropriate decisions for each zone of the farm. The sensors in the environment can be programmed to record measurements such as temperature, humidity etc. All the data collected from the sensors is transmitted via a hybrid WSNOF as shown below.

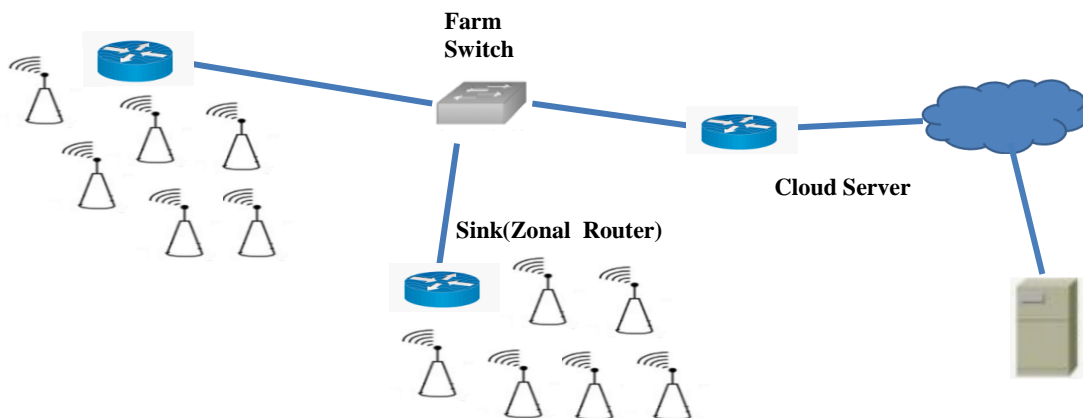


Figure 1. Proposed WSNOF System Architecture

### III. METHODOLOGY

We simulated the above proposed architecture using OPNET simulation tool. In our simulation we considered 2 hectares of farm land with 12 sensors. Each hector represents a zone(Sink) in which, 6 six sensors are used[18]. The sensor nodes interact with the crop conditions in the farm zones in which they are placed.Their job is to detect crop conditions in the farm zones. The sensors have specific properties as shown in table 1. The twelve (12) sensors are sufficient to cover the requisite area. The sensors around each router in Opnet represent a physical distance of 1hectare of land. In Opnet Modellerall the data iswirelessly transmitted to the zonal access point (router). 10GB links were used

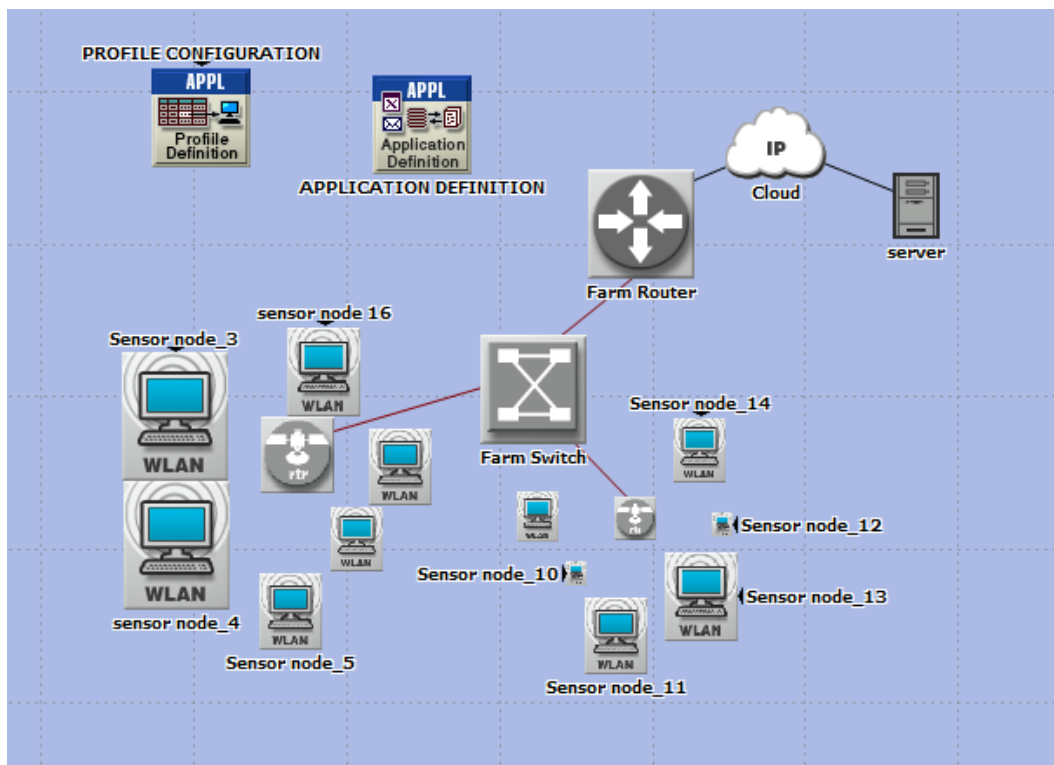


in interconnecting the zonal router to the Switch, and from the switch to the farm Router. From the farm Router to the cloud, a PPP point-to-point link was used. Note that the 10GB links used in the simulation are links which in this case represents Fiber Optical links. The application configuration and profile configuration were accordingly added to provide data with video applications running on the profile configuration to mimic or emulate drones capturing real time videos on the farm. The data is then routed through the network by way of simulation.

**Table 1: Sensor and Antenna Specifications**

Sensor specification	Model	Protocol	Frequency	Tx Power	sensitivity	Range
	WI-FI	IEEE802.11G	2.4GHZ	100mw	-20dBm	500m
Antenna specification	Type		Gain	Dimensions		
	Omni directional			224 2mm		

Similarly, the conventional WSN was also simulated as shown in figure 3. Both simulations were run the throughput and end-to-end delay results were compared accordingly. Figure 2 and 3 displays the proposed network and conventional WSN respectively as configured in Opnet modeller.



**Figure 2: Fibre-Optic wireless Sensor Networks (WSNOF)**

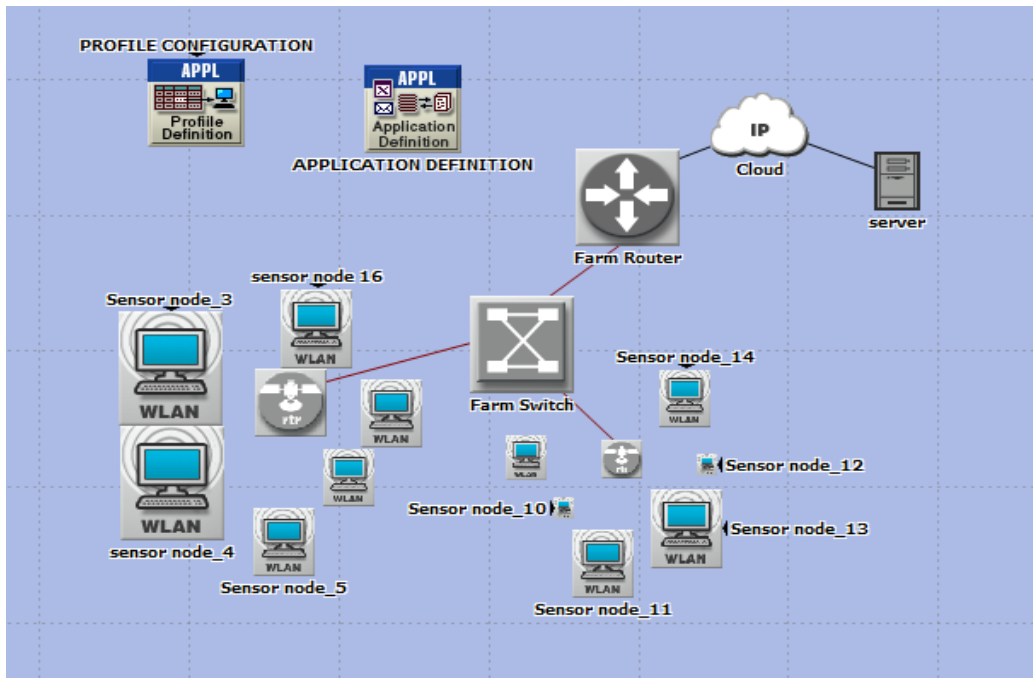


Figure 3: Ethernet Wireless Sensor Network (WSN)

#### IV. EXPERIMENTAL RESULTS

Comparing the results the Figures 5,6,7 below. The end-to-end delay in the WSN is 0.025 seconds(25ms) where as it is 0.02seconds (20ms) in a WSNOF. The maximum throughput for WSN is about 10Mb/sec with a sharp increase in the jitter for the entire simulation period of 600seconds. This produces a flatter graph for the WSNOF than the WSN. The improvement translates into over a 25% network improvement in the two performance metrics. The two performance metrics under consideration can be defined as: Throughput: is defined as the total number of data bits transmitted from source to destination usually measured in bits/second[19]. The throughput of the network is the sum of the throughputs of all destinations[9]. End-to-End Delay: is a measure the total time taken to send the data from source to destination [10].

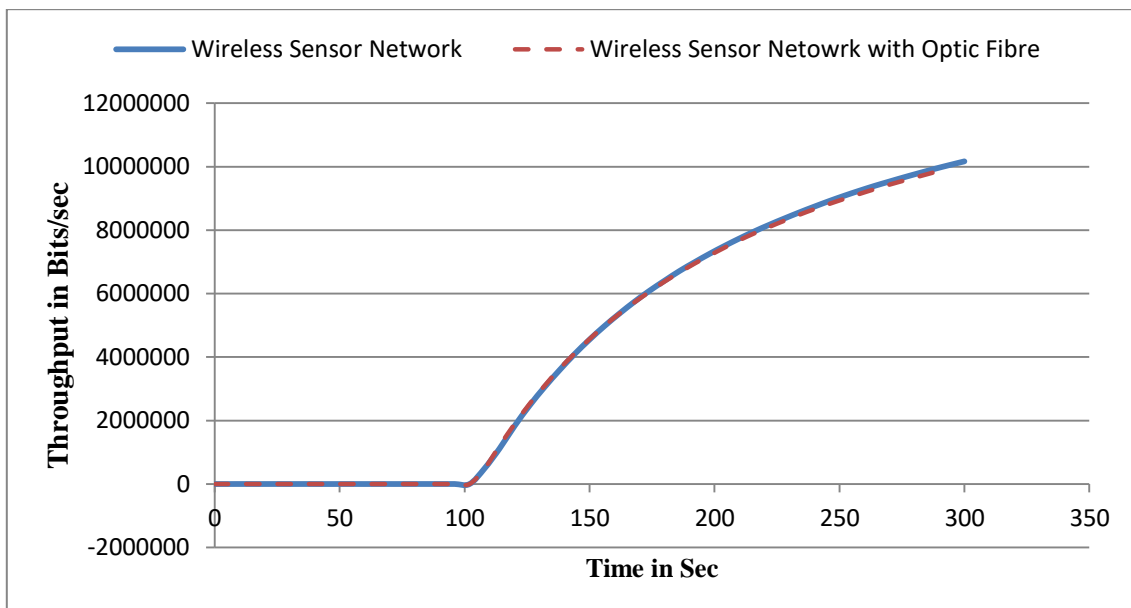


Figure 5: Average Throughput in WNOF & WSN



Figure 6 displays the result for the time average packet end to end delay of the two networks under consideration. From the diagram it can be clearly seen that the end to end delay in the WSN is higher than the WSNOF. The values show that the End-to-end delay is 0.02 in a WSNOF and 0.025 in a WSN this increase translates into a 25 % reduction in the network delay. This means that the WSNOF outperforms the WSN with respect to delay.

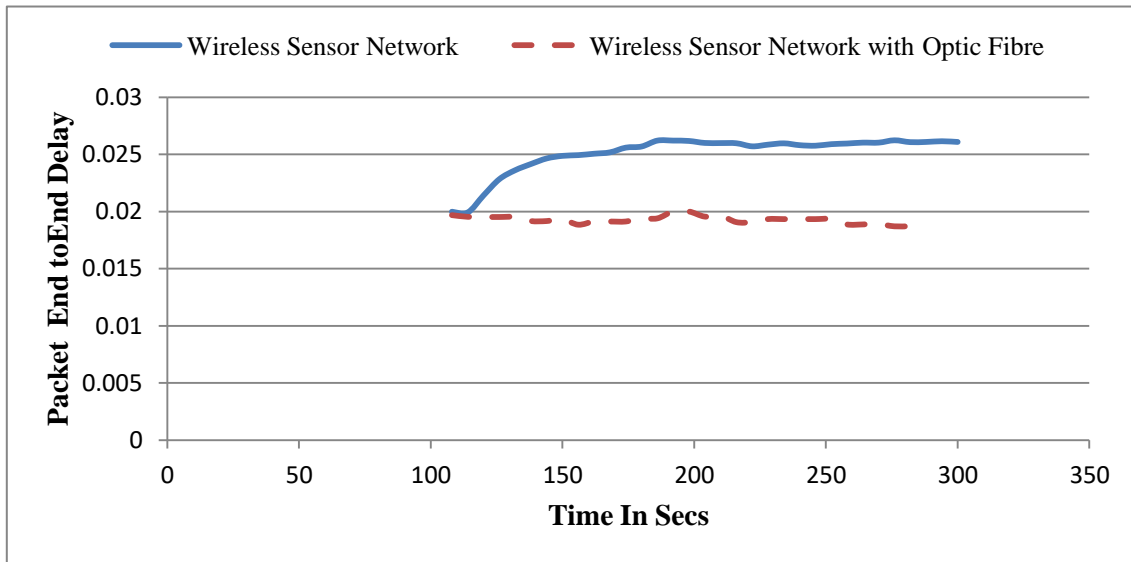


Figure 6: End to End Delay in the WSNOF & WSN

The figure below is a the output graph for the jitter results. The results are not in themselves the end but were collected to substantiate the delay values in the two networks. The purpose is to give a broader picture of the two network performance metrics. Jitter is essentially defined as the network inconsistencies or simply the short delays in the networks[10]. It is evident from the graph shown below that the jitter is higher in the WSN than the WSNOF. This therefore accounts for a higher delay in the WSN causing the cumulative delay to be higher than in the WSNOF.

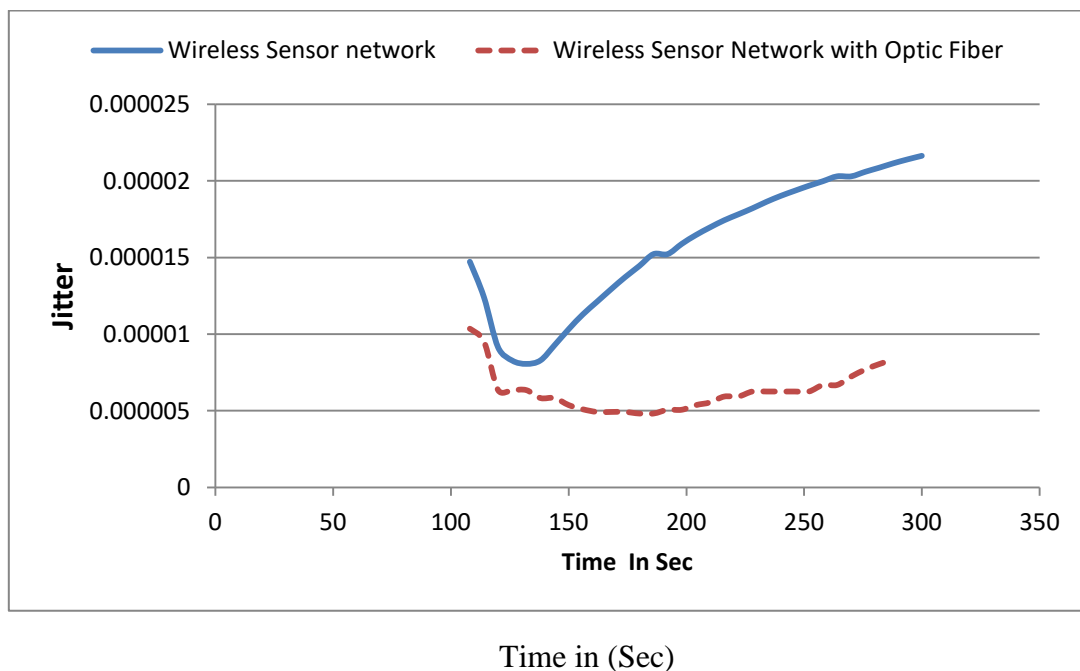


Figure 7: Packet Delay variation (Jitter) In WSN & WSNOF

The diagram below shows the load results increased from 26Mb/sec to 28Mb/sec in the WSNOF compared to WSN without corresponding latency issues arising. This result entails an increase or improvement in the available packets for transmission. In our case, the improvement could only be attributed to the replacement of the low capacity cables with the high capacity Optical cables. Despite the increase in the load, there is no corresponding increase in the end-to-end packet delay as should be the case. However; the throughput result essentially remains almost the same. Thus the increase in the load for the WSNOF is offset, by the proportionate increase in the cable capacity as the fiber optical cables were used in the proposed design. This means that there was an increase of 25% in the network throughput for the WSNOF (assuming that there is 100% packet delivery). This is further substantiated by the jitter results in figure 7, which shows a reduction for the proposed WSNOF case. It is also important to note the reduction in the end-to-end delay for the WSNOF as compared to the WSN. Thus therefore the network throughput and delay performance metrics shows a significant improvement in the proposed WSNOF.

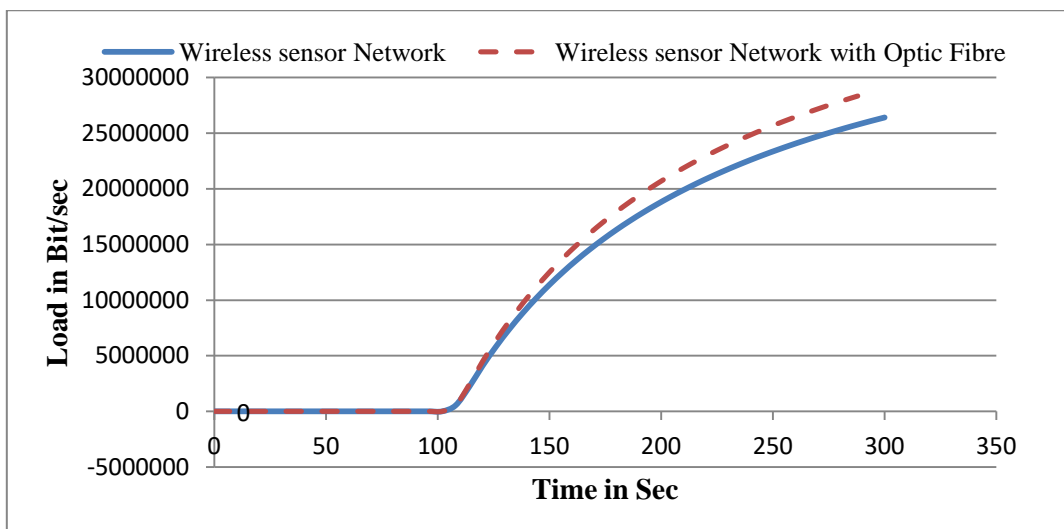


Figure 8: Load in WSNOF & WSN

### V. CONCLUSION

Precision agriculture requires networks with a good throughput and reduced delay to allow for real time automation and control [2]. General quality of service (QoS) in the throughput, jitter including other network parameters are crucial to the improvement of the network performance. Real-time quality video streaming monitoring requires delays of less than 150ms end-to-end one way [20]. The end-to-end delays in the designed WSNOF network reduced by 5ms (from 25ms to 20ms). The reduction in the end-to-end delay enhances the transmission of data in real time and this has the effect of reducing the time delay of packets from source to destination allowing networks to be vestile to different data types. Therefore, this improvement in network performance in the throughput and corresponding reduction in delay enhances the quality of service (QoS) by 25%. Although we concentrated on two performance metrics (throughput and delay), we also considered jitter and load. The improvements in the proposed network design, are evident as the jitter and load results in graphs 7 and 8 reveal these improvements. The jitter or network inconsistencies in the blue line are higher than the red dotted line. This implies that the improvements in the network are not only in the throughput and delay dimensions but also in the jitter and the load results. The results are a clear attestation to the fact that the designed WSNOF outperforms the WSN in the chosen performance metrics. This therefore means that that this new design is better and suitable for real time network monitoring and video surveillance due to the reduced delay and better throughput. The values obtained as a result of the improvements, are far below the minimum threshold for real time data transmission.

### REFERENCES

- [1] M. Charbonneau-Lefort and M. J. Yadlowsky, "Optical cables for consumer applications," *J. Light. Technol.*, vol. 33, no. 4, pp. 872–877, 2015.
- [2] X. Li, Y. Deng, and L. Ding, "Study on precision agriculture monitoring framework based on WSN," *2nd Int. Conf. Anti-counterfeiting, Secur. Identification, ASID 2008*, pp. 182–185, 2008.



- [3] G. Kavianand, V. M. Nivas, R. Kiruthika, and S. Lalitha, "Smart drip irrigation system for sustainable agriculture," *Proc. - 2016 IEEE Int. Conf. Technol. Innov. ICT Agric. Rural Dev. TIAR 2016*, no. Tiar, pp. 19–22, 2016.
- [4] S. Khan, "Wireless Sensor Network based Water Well Management System for precision agriculture," *26th Int. Telecommun. Networks Appl. Conf. ITNAC 2016*, pp. 44–46, 2017.
- [5] C. Buratti, A. Conti, D. Dardari, and R. Verdone, "An overview on wireless sensor networks technology and evolution," *Sensors*, vol. 9, no. 9, pp. 6869–6896, 2009.
- [6] H. S. Kim, J. S. Han, and Y. H. Lee, "Scalable network joining mechanism in wireless sensor networks," *RWW 2012 - Proc. 2012 IEEE Top. Conf. Wirel. Sensors Sens. Networks, WiSNet 2012*, pp. 45–48, 2012.
- [7] U. A. A. O. N, and E. C, "Throughput and Delay Analysis in a Real Time Network," *Int. J. Eng. Appl. Sci.*, vol. 2, no. 12, p. 257775, 2015.
- [8] M. Maier, "Fiber-wireless sensor networks (Fi-WSNs) for smart grids," *Int. Conf. Transparent Opt. Networks*, pp. 1–4, 2011.
- [9] H. Sahota, R. Kumar, A. Kamal, and J. Huang, "An energy-efficient wireless sensor network for precision agriculture," *Proc. - IEEE Symp. Comput. Commun.*, vol. 3, no. 1, pp. 347–350, 2010.
- [10] S. C. Lubobya, M. E. Dlodlo, and G. De Jager, "Performance evaluation of the wireless tree Wi-Fi video surveillance system," *Proc. - UKSim-AMSS 16th Int. Conf. Comput. Model. Simulation, UKSim 2014*, pp. 511–516, 2014.
- [11] T. Nakanishi, "A Generative Wireless Sensor Network Framework for Agricultural Use," no. November, pp. 205–211, 2014.
- [12] E. Pievanelli, A. Plesca, R. Stefanelli, D. Trincherro, and P. Torino, "Dynamic wireless sensor networks for real time safeguard of workers exposed to physical agents in constructions sites," pp. 55–57, 2013.
- [13] G. Sahitya, N. Balaji, C. D. Naidu, and S. Abinaya, "Designing a wireless sensor network for precision agriculture using zigbee," *Proc. - 7th IEEE Int. Adv. Comput. Conf. IACC 2017*, pp. 287–291, 2017.
- [14] S. N. Shylaja, "Real- T ime Monitoring of Soil Nutrient Analysis u sing WSN," *2017 Int. Conf. Energy, Commun. Data Anal. Soft Comput.*, pp. 3059–3062, 2017.
- [15] K. Hogari, S. Tetsutani, J. Zhou, F. Yamamoto, and K. Sato, "Optical-Transmission Characteristics of Optical-Fiber Cables and Installed Optical-Fiber Cable Networks for WDM Systems," vol. 21, no. 2, pp. 540–545, 2003.
- [16] A. Zacepins, A. Kviesis, P. Ahrendt, U. Richter, S. Tekin, and M. Durgun, "Beekeeping in the future - Smart apiary management," *Proc. 2016 17th Int. Carpathian Control Conf. ICC 2016*, pp. 808–812, 2016.
- [17] A. Mateen, "with W ireless M ultimedia S ensor N etworks," *2017 IEEE Int. Conf. Power, Control. Signals Instrum. Eng.*, pp. 80–83, 2017.
- [18] W. Bingfang, M. Jihua, Z. Feifei, D. Xin, Z. Miao, and C. Xueyang, "Applying Remote Sensing in Precision Farming-a Case Study in Yucheng," vol. 86, no. 10, pp. 1–6.
- [19] S. Pandi, S. Wunderlich, and F. H. P. Fitzek, "Reliable Low Latency Wireless Mesh Networks - From Myth to Reality," pp. 1–2, 2018.
- [20] F. Ongaro, E. Cerqueira, L. Foschini, A. Corradi, and M. Gerla, "Enhancing the Quality Level Support for Real-time Multimedia Applications in Software-Defined Networks," pp. 505–509, 2015.



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