

Simulating Environmental IoT Sensor Networks for Wood Moisture

Introduction: IoT is a technology which has become very popular over the years, with the development of smart homes and smart cities. IoT is an idea that many devices can be networked together to create a web of information that can be utilized for gathering data and using said data to monitor certain systems such as energy, lighting and even industrial machines. IoT uses mainly 2 types of technologies, the first being 802.15.4 also known as Zigbee. Zigbee boasts a low power, low bandwidth and low cost solution to IoT with no need for expensive infrastructure such as switches or routers it is quickly becoming the industry standard. The second technology being 802.11 or Wi-Fi is also very popular and is often used in businesses and homes for wireless networking. Wi-Fi boasts high bandwidth and performance but also high power consumption and IoT devices for this wireless technology seem to be more expensive[2]. For this project the author designed and simulated an IoT sensor network for monitoring wood moisture in timber framed buildings for a company which specialises in the construction of energy efficient structure using renewable materials and techniques. The author looked at 2 proposed technologies the first being an standard 802.15.4 ZigBee network and the second being an 802.11 wireless local area network.

Implementation: The author developed 2 simulations around the 2 proposed technologies, whilst following the design specifications set out by the project manager of Down to Earth. This topology can be seen in figure 1. The author implemented simulations with and without network interference to understand how both network would perform under these conditions. For traffic generation the author implemented 16 constant bit rate applications as seen in figure 2 that would send data to the Data Server continuously, this will simulation how the network will perform when data is being transmitted at the same time. Throughput, Delay and Packet Loss are metrics that were measured throughout this experiment. For the noise generation then author applied 3 main settings as seen in figure 3, the first being the indoor office model suitable for the indoor spaces with smaller distances, the second being the Rayleigh model of fading which is simulates the variation of signal strength experienced through the network and finally shadowing replicates the obstruction of the signal by things such as wall or other buildings.

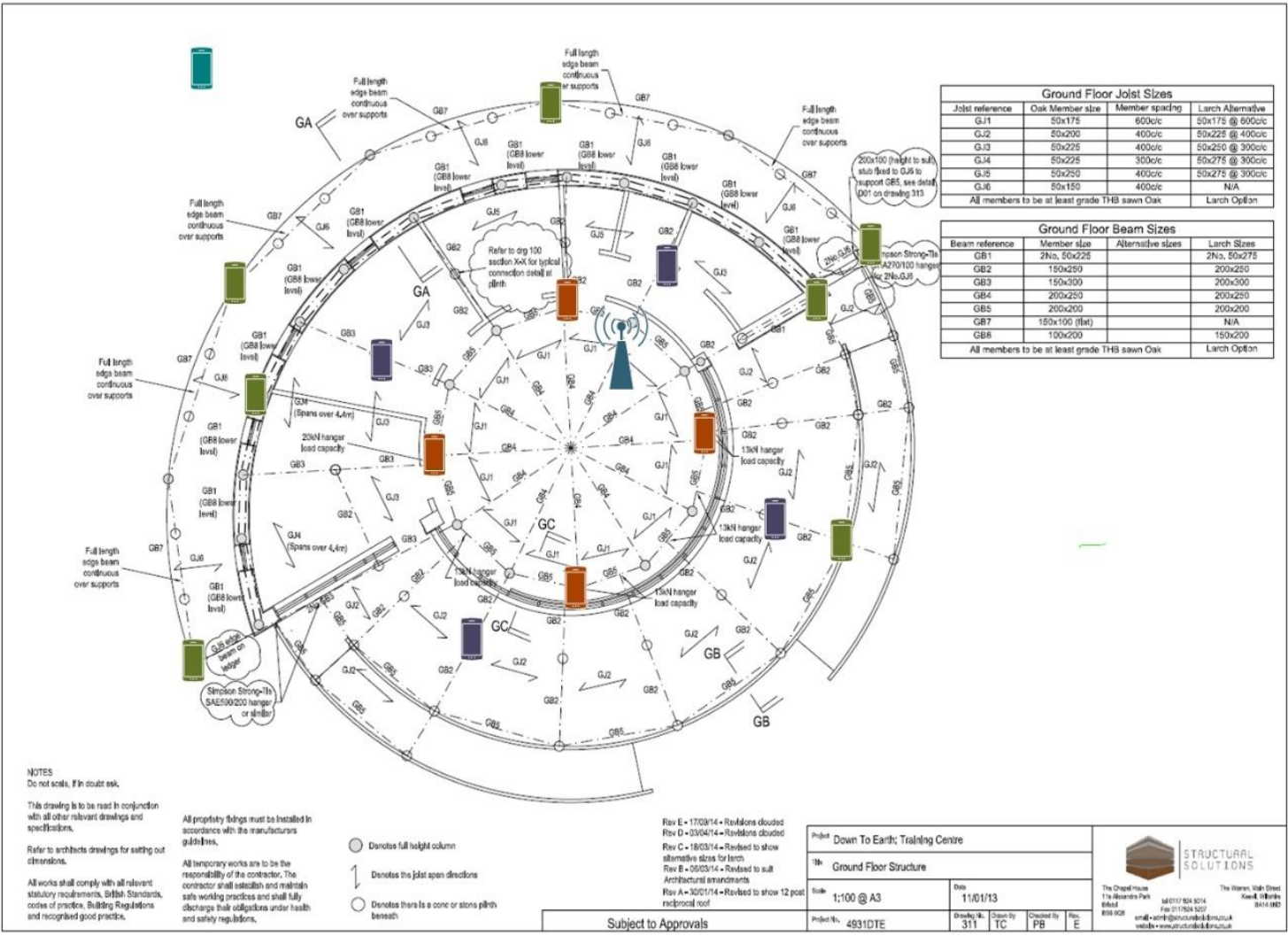


Figure 1 – Proposed Topology

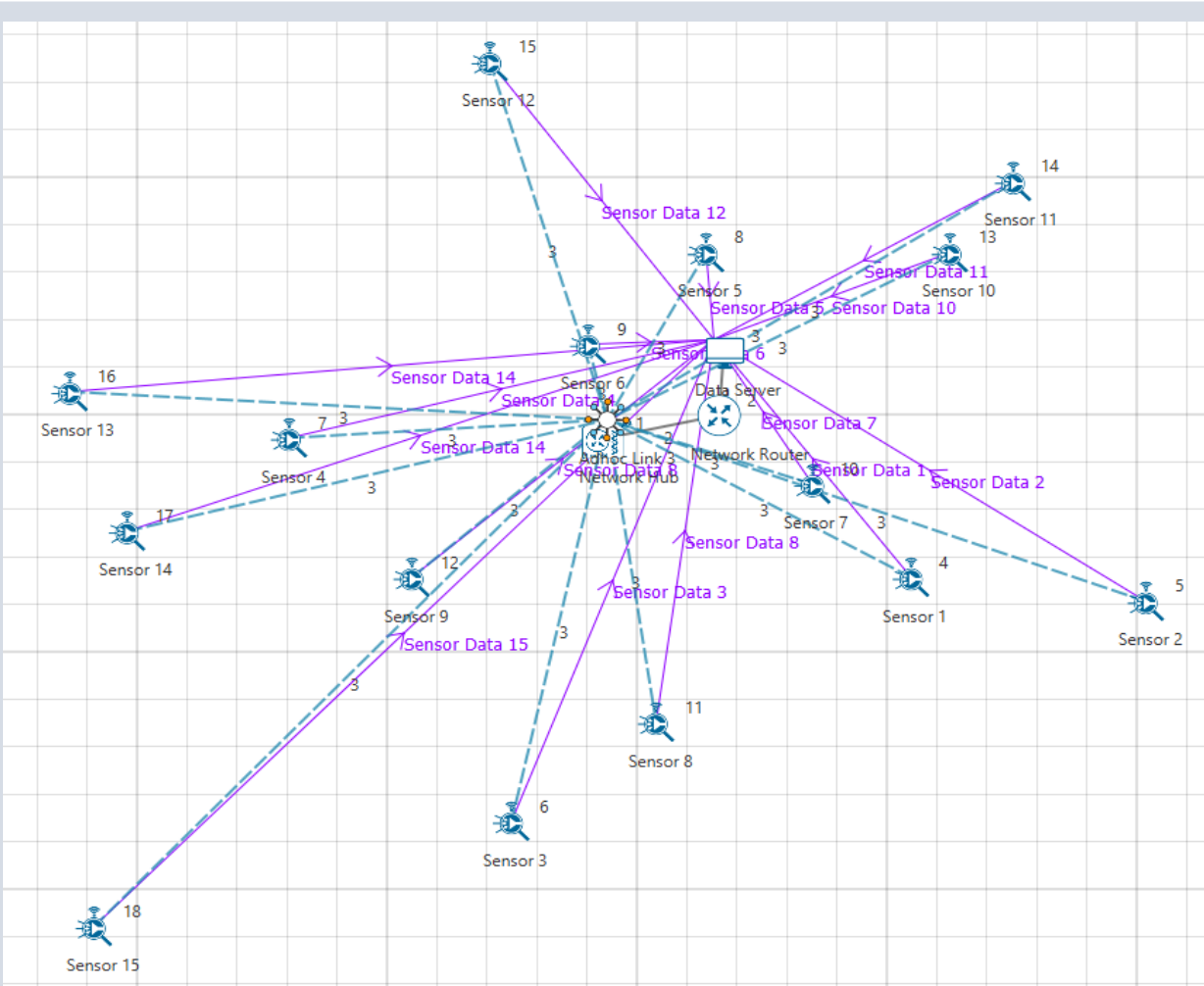


Figure 2 – Simulation Implemented Topology

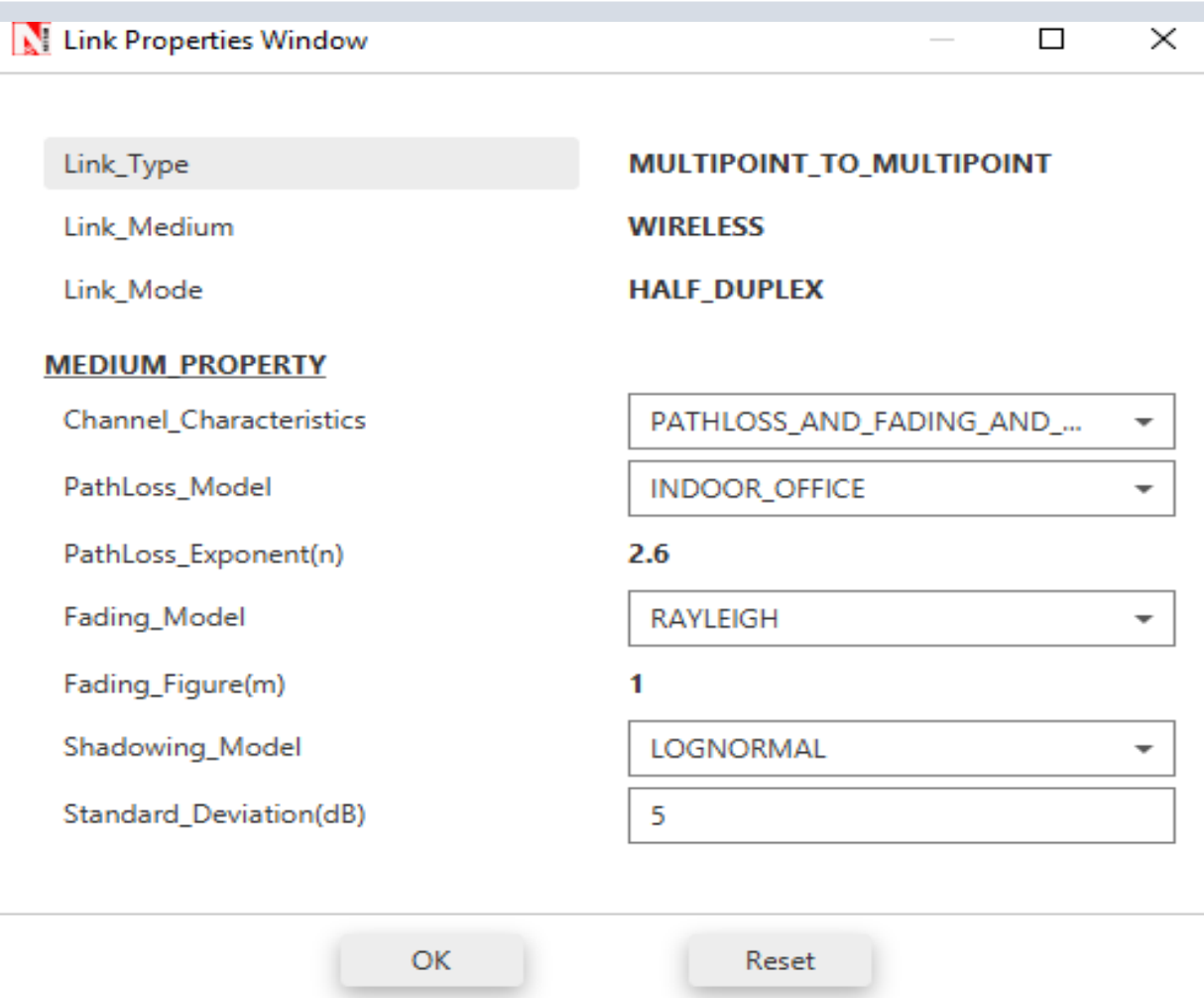
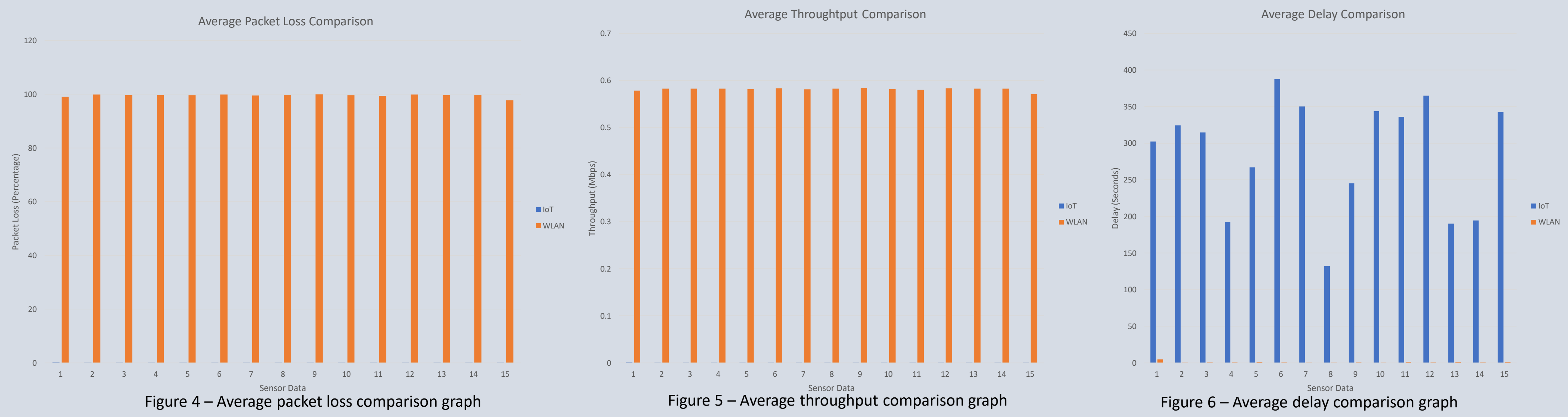


Figure 3 –Simulation Interference Settings

Results: To fully understand the result the author took the metrics both with and without noise and calculated an average for each node, this represents a good middle point of performance for the networks. As can be seen from Figure 4, it can be said that the WLAN network performed better in terms of packet delivery as almost all nodes on average maintained an almost 100% success rate, while the packet success is so low that it is un noticeable In comparison. When it comes to throughput as seen in Figure 5 a similar trend arises as once again WLAN is performing well at between 0.5 and 0.6 Mbps, the 802.15.4 network again has throughput so low that it doesn’t appear well on the charts. When Delay is considered it can be overserved in Figure 6 that the IoT (802.15.4) network experiences large amounts of delay even though it is varied. The WLAN on the other hand experiences so little delay that it is hardly noticeable. What the result from deeper analysis of the data show is that the simulation software has some issue as in some cases when noise was added to both network some nodes performed better than the experiments with noise. When considering range on this experiment it is clear that it doesn’t play a big part as some nodes which where further away performed better than those which were placed in close proximity to the hub.



Conclusion / Future Work: To conclude, the data gathered from both simulations show that with the best performing implementation of the network would come from a 802.11(WLAN) configuration this can potentially be a cost saving measure as it allows for the integration of the network with the pre-existing Wi-Fi already present at the site. Whilst 802.11 would be more power hungry than the energy efficient 802.15.4 due to the building being an enclosed space it is suitable for this network to be powered by means other than batteries. This work is further supported by the works of other researchers such as N. Ahmed et al in a paper titled “A comparison of 802.11ah and 802.15.4 for IoT”, which also showed that 802.11ah largely out performed 802.15.4 in terms of throughput, delay and association time but also stating that “802.15.4 demonstrates higher energy efficiency than 802.11ah”.In the future an implementation of the physical network will be undertaken, with careful consideration for the simulation results. The author would also like to explore the other technologies involved in IoT include LTE/4G/5G and LoRa, the author also would like to work more closely on the simulation of the end nodes and not just the network side. This would include simulating the boards, programming and power options of the system as the author research did not really touch upon the power consumption of the network.

[1] N. P. Mahalik, *Sensor Networks and Configuration*. 2007. [2] S. Banerji and R. S. Chowdhury, “On IEEE 802.11: Wireless LAN Technology,” *Orig. Publ. Int. J. Mob. Netw. Commun. Telemat.*, vol. 3, no. 4, 2013. [3] N. Ahmed, H. Rahman, and M. I. Hussain, “A comparison of 802.11ah and 802.15.4 for IoT,” *ICT Express*, vol. 2, no. 3, pp. 100–102, Sep. 2016.