

Evaluating Energy Saving Techniques in Networks

Student ID: 001211278

BSc in Computer Science (Networking)

COMP1665: Advanced Networks

University of Greenwich

Old Royal Naval College

United Kingdom

Abstract—Energy consumption of internet connected devices is growing exponentially. This report investigates methods of reducing consumption on a simulated wired network. A network of 11 routers was simulated across three Scenarios using OSPF routing protocol. Scenario 1 provided a baseline of all routers awake. Scenario 2 placed only routers that saw no traffic in Scenario 1 to sleep. Scenario 3 slept the central routers of the topology meaning traffic was diverted around different routes. Scenario 2 saw a 0.32% reduction in energy consumption, Scenario 3 saw a 28% increase in energy consumption. These results demonstrated smart sleeping techniques are viable, but node selection is important.

Key words: *Energy Efficiency, Smart Sleeping, Wired Networks*

I. Introduction

As the number of devices connected to the internet each person possesses increases, so does the energy burden of the internet. The ICT sector is estimated to account for approximately 8% of worldwide energy consumption with network equipment contributing a significant portion of that figure (Cianfrani et al., 2012). As the demand for networking equipment and higher bandwidth continues to grow each year so does the importance of reducing energy wastage. Currently, ethernet is the dominant technology for LANs valued in 2020 at \$10.49 billion USD (Ashokkumar, 2025). This means that small reductions in energy consumption can contribute to a substantial global saving (Christensen et al., 2010).

This report aims to test energy usage on a network and examine what methods are possible to reduce energy usage when transmitting data.

II. Estimating Energy Consumption in wired networks

As the burden of energy consumption in networks continues to grow, research has increasingly focused on methods to reduce energy usage. This section reviews relevant work undertaken by researchers in this area, examining how energy consumption in wired networks has been estimated and what techniques have been proposed to reduce it.

A. Smart Sleeping

A proposed solution to the problem of increasing energy usage is a method named smart sleeping, this idea consists of sending networked routers, that are not actively sending or receiving a signal, to go to sleep, with the occasional refresh signal to maintain alignment in the network. (Christensen et al., 2010) explains the IEEE 802.3az, a standard approved in 2010, could save over approximately \$1 billion USD worldwide. More recent papers claim that a 70% reduction in energy usage can be achieved by incorporating the low-power idle mode. (Ashokkumar, 2025)

B. Energy Efficient Routing Protocols

OSPF routing as it stands is rigid, routers are either powered on, or off. This causes topology recalculations and can increase delays on a network. To mitigate this, (Cianfrani et al., 2012) proposed Energy Saving IP Routing (ESIR), an OSPF-integrated strategy where adjacent routers share Shortest Path Trees. However, more recent research has moved beyond OSPF. (Otten et al., 2023) demonstrated Segment Routing, a proactive method to steer traffic away from idle hardware. This was demonstrated to reduce energy consumption by 56%. Furthermore, (Saritha et al., 2025) experimented with a Software Defined Network based green energy aware routing protocol. This method also makes adaptive decisions leading to a 37.5% reduction when compared to similar OSPF systems.

III. Critical evaluation

This experiment consisted of a network with 11 Routers on an OSPF network, loosely inspired by GÉANT, with 4 wired nodes on the four corners of the network. Two of the nodes sent and received Constant Bit Rate (CBR) packets to each other through the network. Two different nodes were sending and receiving email packets to each other. The total network was then simulated for 420 milliseconds (ms) consisting of 30 ms intervals. The experiment ran three times, first the control where all routers were awake and in a ready state, followed by two more Scenarios consisting of different sleep patterns between the routers.

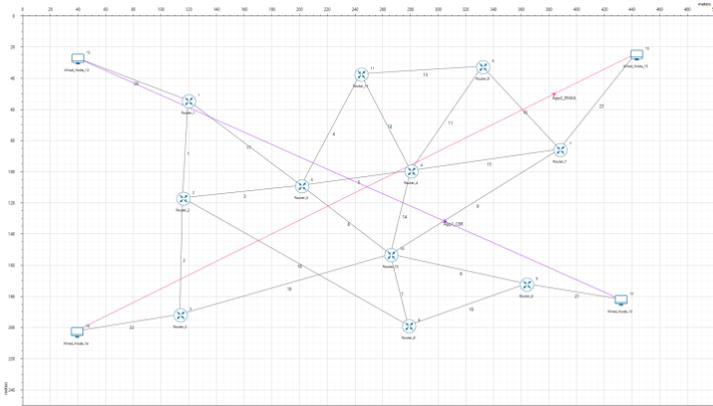


Figure 1: Map of the topology within Netsim.

Many studies on estimating energy consumption have been done, this report will cite (Texas Instruments, 2013). This report is data that was collected with the aim to provide accurate power consumption in typical Networks. Therefore, the paper defines, in a typical 100 Base-Tx Operating Mode, the energy consumption for a packet is 294.65 Milliwatt (mW), this paper will round this up to 295 mW per packet. Following this, this paper will define that a control packet will consume approximately half the energy as a packet 148 mW. (Texas Instruments, 2013) also defines the energy usage of idle routers as 285.81 mw, rounded to 286. Along with the energy usage for a powered down or sleeping router as 24.22, rounded to 24 mW.

Scenario 1 consists of running the experiment while all nodes are awake and in an idle position. This meant that the routers that saw no traffic for the whole simulation, however still used energy, this Scenario is expected to have the highest energy consumption. The delay found in Scenario 1 also sets the basis of an expected delay through the network.

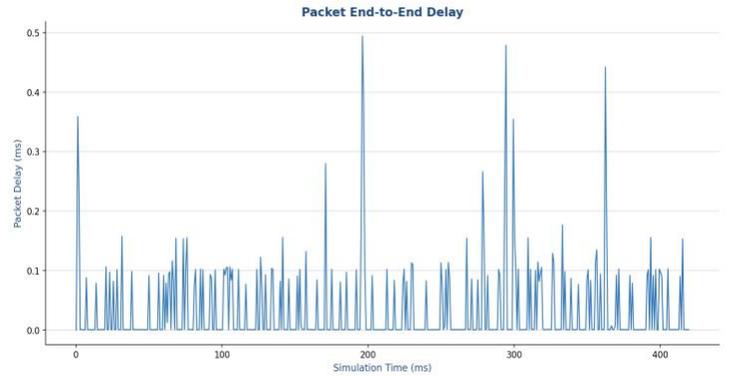
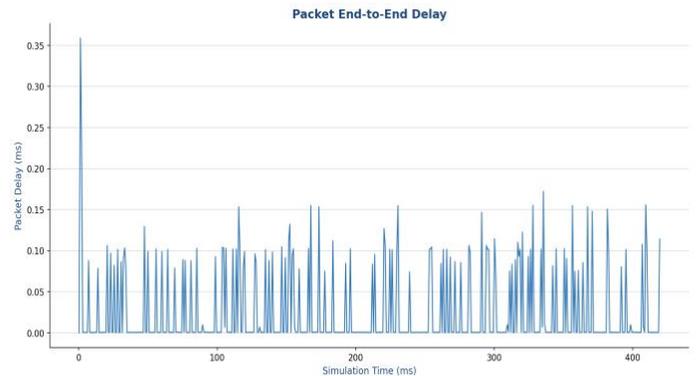


Figure 2: The packet end-to-end delay for Scenario 1, establishing a baseline for comparison.

In Scenario 2, routers 2, 4, 6, 9, and 11 were placed into a sleep state after the first 30ms interval, as these routers saw no traffic during Scenario 1. This meant that only the routers that needed to be awake to transfer data around the network were awake. This assumed that since these routers saw no traffic to begin with, they were not needed to transmit the packets within the simulation. Because of this drop in routers using energy, this Scenario saw a reduced energy consumption of 0.32% compared to Scenario 1. The energy saving is small due to the only difference being they are now asleep rather than idling like in the previous simulation. Delay found in Scenario 2 is mostly comparable to the delay found in Scenario 1, this is to be expected as the same routers are performing the same tasks. However, Scenario 2 sees less spikes throughout, this is likely because there were less routers, here are fewer competing routing paths, resulting in



more consistent packet delivery times.

Figure 3: The packet end-to-end delay for Scenario 2.

Finally in Scenario 3, the central nodes of routers 4 and 10 were put to sleep, meaning that any traffic had to be routed around the outside of the network. This Scenario had the assumption that rather than one router in the centre handling the most traffic, load would be shared across the outsides of the network. This however had the opposite effect, since traffic could no longer take the optimal route, there was a large energy increase of around 28% when compared to Scenario 1, this is because packets had a longer journey time in comparison to the previous Scenarios. The delay seen in Scenario 3, was a huge spike at the first 30 ms interval. This is likely as the packets must stop and find a completely alternative route. The delay after this seems to fall more consistent with previous Scenarios, however this spike alone makes it difficult to be a successful option.

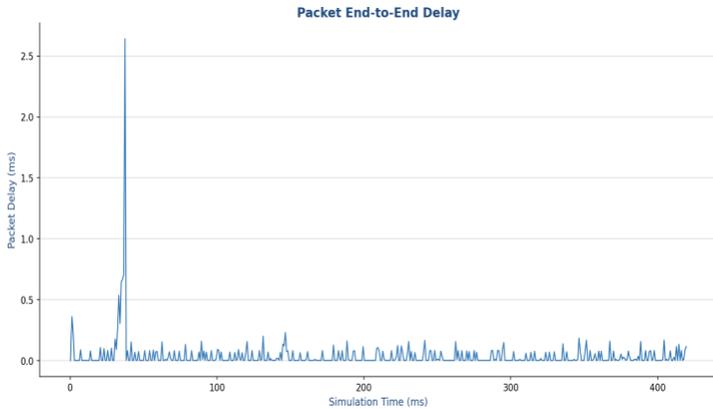


Figure 4: The packet end-to-end delay for Scenario 3. Showing huge spike as central routers sleep.

These findings are consistent with the literature reviewed in section II. The reduction observed in Scenario 2 aligned with the principles outlined by (Christensen et al., 2010). Whereby placing idle network devices in a sleep state can result in a reduction of energy. However as highlighted in (Cianfrani et al., 2012) the effectiveness of sleep strategy is entirely dependent on which nodes are selected as their ESIR approach specifically avoids sleeping central routing nodes. This can be seen demonstrated in Scenario 3 where the network saw a 28% increase in energy consumption. This suggests that in a real-world network, a more sophisticated approach such as ESIR would be necessary to maximise energy savings while avoiding the shortcomings observed in Scenario 3.

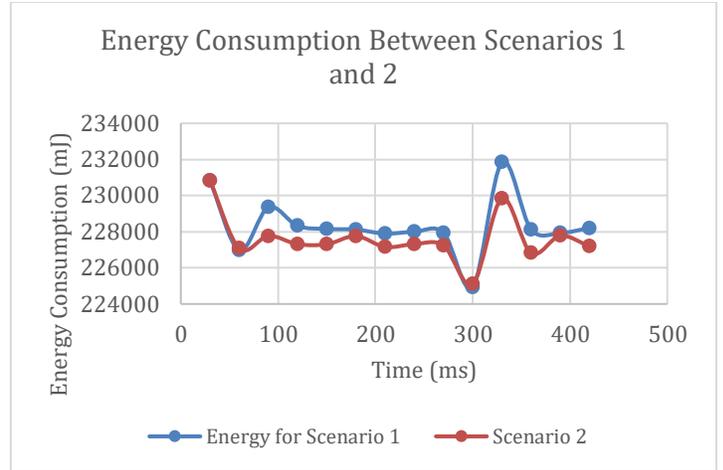


Figure 5: The energy consumption of Scenarios 1 and 2.

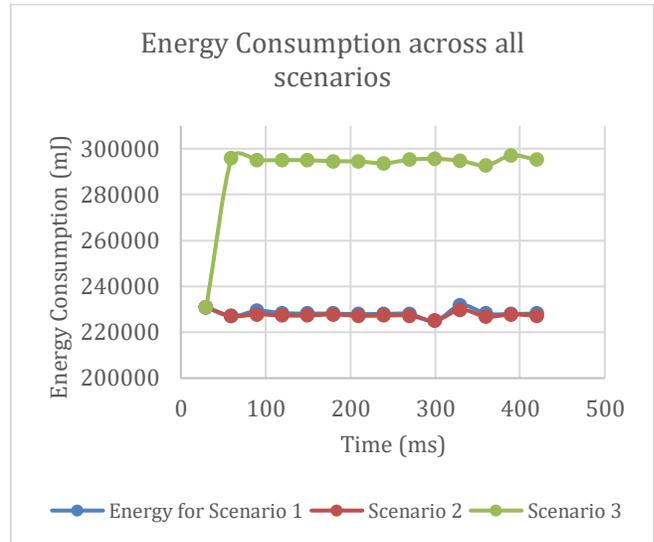


Figure 6: The energy consumption of Scenarios 1, 2, and 3.

IV. Conclusions

To conclude, this report evaluated the energy consumption and packet delay of a network in three separate Scenarios. Using Scenario 1 as a baseline, the subsequent Scenarios tested methods that could be used to reduce wasted energy. Scenario 2 found that just by placing routers 2, 4, 6, 9, and 11 into a sleep state, a small but measurable reduction of 0.32% in energy consumption could be seen, consistent with the findings of (Christensen et al., 2010). However, removing the central routers of a network forces packets to find an alternative, and likely longer path which greatly increased the energy usage and the packet delay like that observed in Scenario 3.

These results demonstrate that smart sleeping is a viable method of reducing energy consumption, however node selection is critical so that the maximum reduction can be achieved, as supported by (Cianfrani et al., 2012).

Future work could explore dynamic node selection strategies that identify which nodes can safely be slept based on current traffic distribution, avoiding the performance penalties observed in Scenario 3.

References

Ashokkumar, S. (2025) A Model-based Power Inference Mechanism for Energy-Efficient Ethernet Ports, In *2025 4th International Conference on Automation, Computing and Renewable Systems (ICACRS)*, IEEE, pp. 300–304, [online] Available at: <https://ieeexplore.ieee.org/document/11324258/>.

Christensen, K., Reviriego, P., Nordman, B., Bennett, M., Mostowfi, M. and Maestro, J. (2010) IEEE 802.3az: the road to energy efficient ethernet, *IEEE Communications Magazine*, 48(11), pp. 50–56, [online] Available at: <http://ieeexplore.ieee.org/document/5621967/>.

Cianfrani, A., Eramo, V., Listanti, M., Polverini, M. and Vasilakos, A. V. (2012) An OSPF-Integrated Routing Strategy for QoS-Aware Energy Saving in IP Backbone Networks, *IEEE Transactions on Network and Service Management*, 9(3), pp. 254–267, [online] Available at: <http://ieeexplore.ieee.org/document/6172595/>.

Otten, D., Brundiers, A., Schüller, T. and Aschenbruck, N. (2023) Green Segment Routing for Improved Sustainability of Backbone Networks, In *2023 IEEE 48th Conference on Local Computer Networks (LCN)*, IEEE, pp. 1–9, [online] Available at: <https://ieeexplore.ieee.org/document/10223317/>.

Saritha, Dr. K., Saheb, S. I., Praveen, K. N. R., Belwal, P., Gandhi, A. and Patra, Dr. B. (2025) Energy-Aware Protocol Design for Green Internet Architecture, *Journal of Internet Services and Information Security*, Innovative Information Science and Technology Research Group, 15(3), pp. 449–464, [online] Available at: <https://jisis.org/wp-content/uploads/2025/11/2025.I3.031.pdf>.