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Toward an Appropriate Energy Efficiency Routing in Wireless Sensor Networks (WSNs) for IoT Applications

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Abstract:- In this current generation of increasing adoption of advanced computing and Internet of Things applications, Wireless Sensor Networks (WSNs) will attract an elevating role in supporting several IoT use cases and applications in real life. Such applications include weather monitoring, agriculture, health, security applications, among others. Since demand for such applications has increased, there is a need to study and implement WSN in such a way that will efficiently support implementation of IoT applications across locations including the world of inaccessible areas. Most of the sensor devices that support IoT application implementation are battery powered and always have limitations with energy optimization especially when they are installed in inaccessible areas. Due to this fact, energy optimization in WSN is attracting great attention. The applications of WSN have spanned across various environments, and several other challenges and constraints such as Network Performance, Delay, Energy Efficiency, Limited bandwidth, Node costs, and Complexity of Network protocols exist and all affect WSN performance hence greatly affecting IoT applications implementation. Several categories of Routing protocols exist ranging from reactive, proactive, hybrid among others but this research only concentrates on reactive and Proactive protocols of Dynamic Source Routing (DSR), Ad hoc On-Demand Distance Vector (AODV) and Optimized Link-state Routing (OLSR) in analyzing and studying energy efficiency in WSN. In this paper, we recount on experimental methodology to simulate mechanisms and draw conclusion on selected Routing protocols to determine one with a most efficient Energy optimization strategy in a WSN design.

Keywords:- *Wireless Sensor Networks, Data Transfer Rate, Energy Consumption, Packet Delivery Ratio, Sensor Node, Sink Node.*

I. INTRODUCTION

Today technology is quickly changing the world, many people are interested and are appreciating how the technology is shaping innovations and comes to the rescue of the ever-growing demand for facilities and services in the modern society. Wireless Sensor Network (WSN) and Internet of Things (IoT) are such technologies which improves various aspects of people's lives.

Recently, the field of IoT and WSN is significantly witnessing elevating research and development, systems that consist of objects like sensing objects and mobiles phones are increasingly becoming available for use with IoT Applications. These objects known as sensor nodes, are used to obtain data from the physical parameters of the environment, they have low computational power and battery life. This signifies why WSN are becoming increasingly important in today's computing space.

WSNs are composed of several tiny components called nodes, they are in most cases inexpensive because of their limited processing, storage, memory and computability, additionally power limitations are envisaged depending on several factors such as battery capacity, data transfer rates, routing protocol used, etc. Due to these multiple limitations with sensor nodes, the survivability and lifetime of devices in a WSN, the energy consumption attract the attention of researchers around the world.

There are several challenges [1], [2] that affect Wireless Sensor Networks, these factors range from design-related, topology-related to implementation-related challenges and some of them are listed here; Network Performance, Delay, Energy Efficiency, Limited bandwidth, Node costs, and Complexity of Network protocols. This paper concentrates on Energy Efficiency as a key highlighted challenge in discussion.

There are several factors that affect Factors that affect Energy optimization in WSNs, and these include Routing Protocols, Sensor network topology, Packet Delivery Ratio (PDR) and Data Packet Size (DPS). Several WSN Routing protocols exist as at [3], but this analysis only stops at the proactive and reactive Routing Protocols of Dynamic Source Routing (DSR), Optimized Link State Routing (OLSR) [4] and Ad Hoc On-Demand Distance Vector (AODV) [5] for analyzing Energy Efficiency.

This paper basically discusses energy efficiency analysis in WSNs based on several factors and presents the different approaches that need to be considered to deal with heavy transfer of data amongst nodes in the network.

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II. METHODOLOGY

The research was based on experimental research approach. In order to solve the issue statement, both proprietary and open-source Network Simulation tools were used. Only reactive and proactive protocols for energy efficiency in WSN for IoT applications were considered in the simulations. The model considered changing several parameters, including data packet size, data transmission rate, and number of sensor nodes.

There are several tools that exist for simulating Energy models in WSN, and the following are highlighted: OMNeT++, NS- NetworkSimulator-3 (NS-3), Cooja and NetSim.

A comparison of these tools is also summarized here:

Table 1 Comparison of Network Simulation Tools

Features	OMNET++	NS-3	Cooja	NetSim
License	Open Source	Open Source	Open Source	Licensed
Languages Supports	C++	C++/ Python binding	C/Java	Java/C
Scope	Network	Network	Network	Network
Environment	IDE based on the Eclipse platform. Supports both GUI and Command line	GUI and Command line	Windowing system and GUI	GUI
Mobility of Sink Node	Supported	Supported	Supported	Supported
Type of Events	Discrete-Event	Discrete-Event	Discrete-Event	Discrete-Event
Energy Simulations	Supported	Supported	Supported	Supported
Protocols supported (WSN)	DSR, AODV, OLSR	DSR, AODV, OLSR,	Standard RPL, CoAP, 6LoWPAN, and OPPCAST	DSR, AODV, OLSR, ZRP,

The summary above shows the comparison between common simulation tools and summarizing parameters that can be based on to choose the most appropriate too based on what simulation is needed. The Experiment Setup and Simulation model, NS-3 which is an open-source tool and NetSim Standard v14 which is a proprietary tool were used.

Table 2 and Table 3 show the parameters that were considered for simulation with NS-3 and NetSim tools respectively. These parameters were varied accordingly during the experiments to generate considerable data sets for further analysis tailored towards Energy efficiency.

Table 2 Summary of Simulation Parameters for NS-3

Parameter	Parameter Values
Number of Nodes	20,40,60,80,100,120,140,160,180,200 nodes
Simulations Area	600 x 600 square meters
Simulation time	300s, 600s, 900s
Sink Node Speed	5mps and 8mps
Mobility model	Random Way Point
Data Packet Size	1024 bytes and 2048 packets
Transmission Rate	8kbps
Initial Energy Source	3000 Joules
Routing Protocols	DSR, OLSR, AODV

This is a proprietary tool like already presented in section 6 above. It is simulation model in easier to adopt and implement. It only requires installation of the package on a Windows 8/10.11 computer. The simulations in Netsim were guided by the sequence of stages that included: Create a network model, Energy Parameters of Routing Protocols, Run Simulations and View and analyze Results.

The section presents below the Simulation parameters considered for the NetSim simulator.

Table 3 Simulation Parameters for NetSim

Parameters	Parameter Values
Number of Nodes	4, 9, 16, 25, 36, 49, 64 nodes
Simulations Area	600 x 600 square meters
Simulation time	300s, 600s and 900s
Device Placement Strategy	Random
Mobility Model	Constant Position Mobility model
Application Layer Settings	Open Flow, SDN
Congestion Control Algorithm	NEW_RENO
Medium Properties	Pathloss Only

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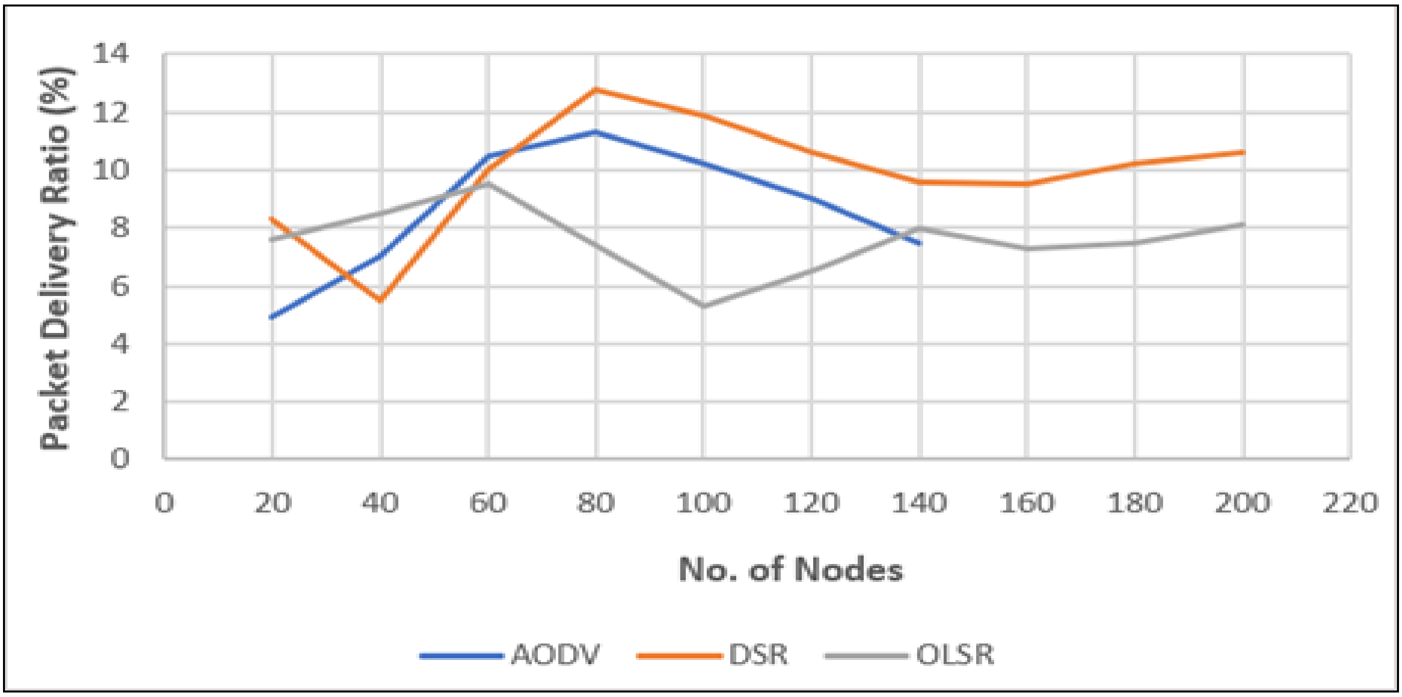
Pathloss model	Log Distance
Channel/Link medium	Wireless
Link Type	Multi Point to Mult Point
Energy Harvesting	Enabled
Initial Energy Source	Battery
Initial Energy Capacity	38888
Routing Protocols	DSR, OLSR, and AODV

III. RESULTS

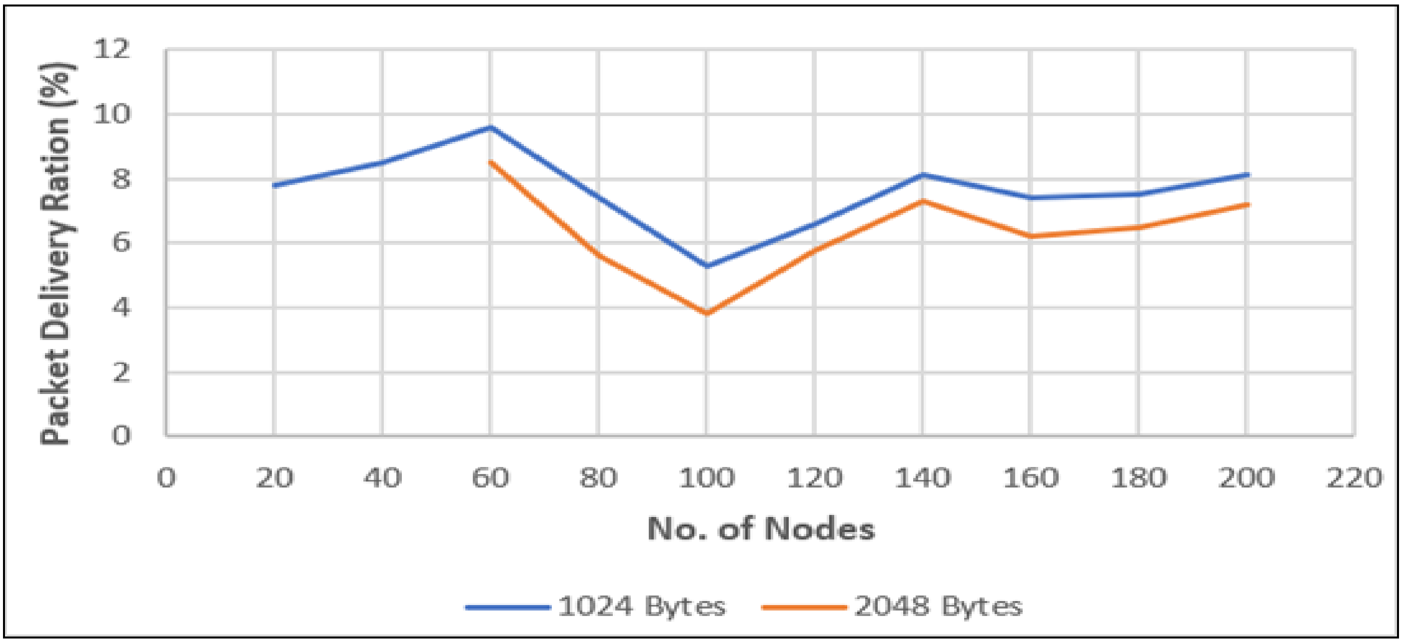
A. *Packet Delivery Ratio (PDR)*

Below we present some of the results that were obtained from the analyzed data.

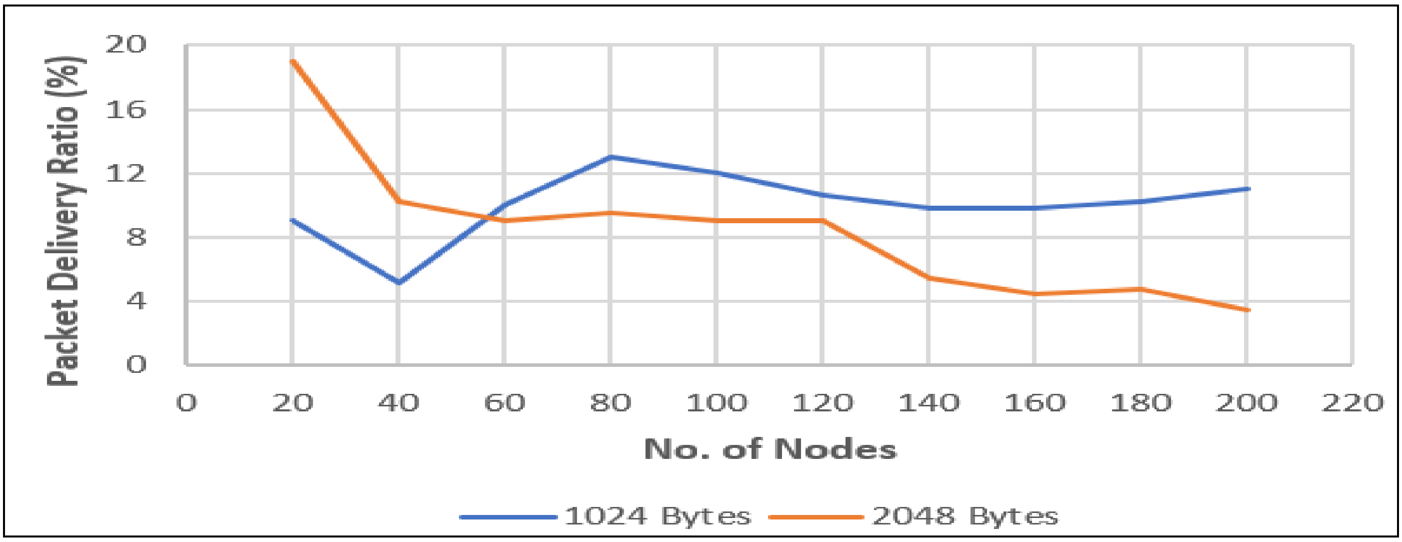
Graph (a) represents PDR for the selected protocols of AODV, DSR and OLSR, and how it varies with change in network size. Network size of 20, 40, 60, 80, 100, 120, 140, 160, 180 and 200 nodes as considered during the simulations with NS-3 tools. AODV stops at 140 and we could not get results after 140 nodes.



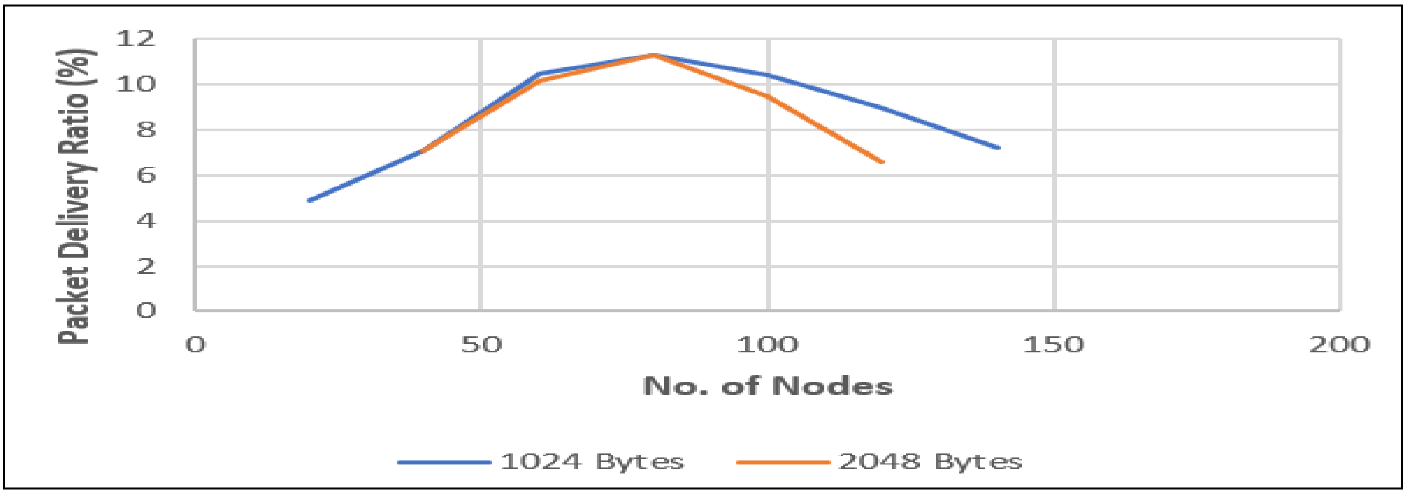
Graph 1 (a) PDR Comparison for Selected Protocols



Graph 2 (b) PDR Comparison of OLSR, Changing Data Packet Size



Graph 3 (c) PDR Comparison of DSR, Changing Data Packet Size

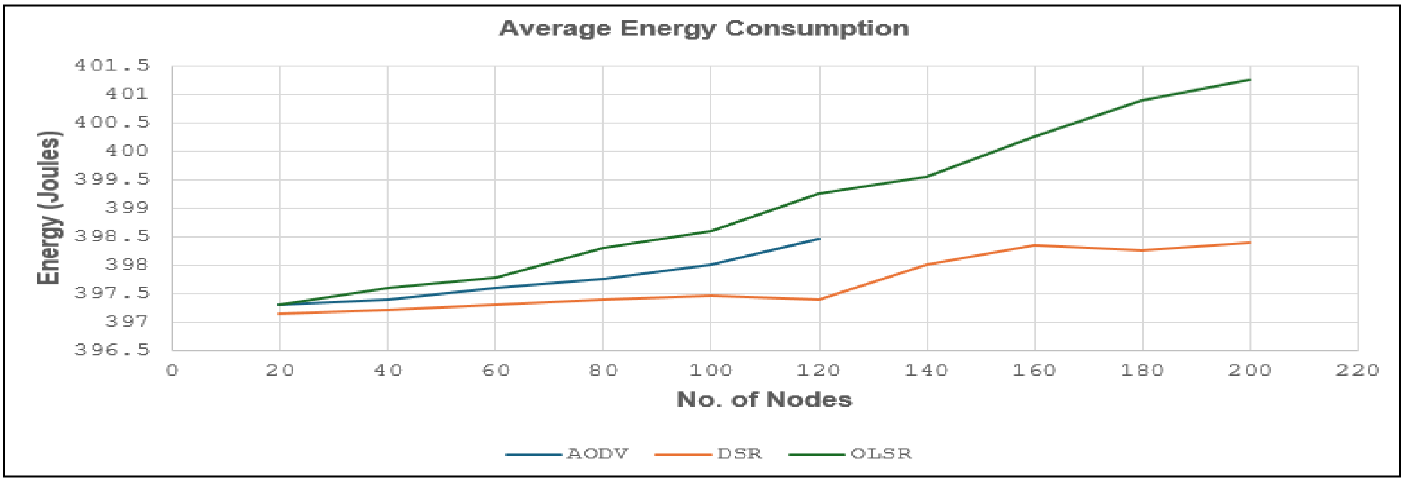


Graph 4 (d) PDR Comparison of AODV, Changing Data Packet Size

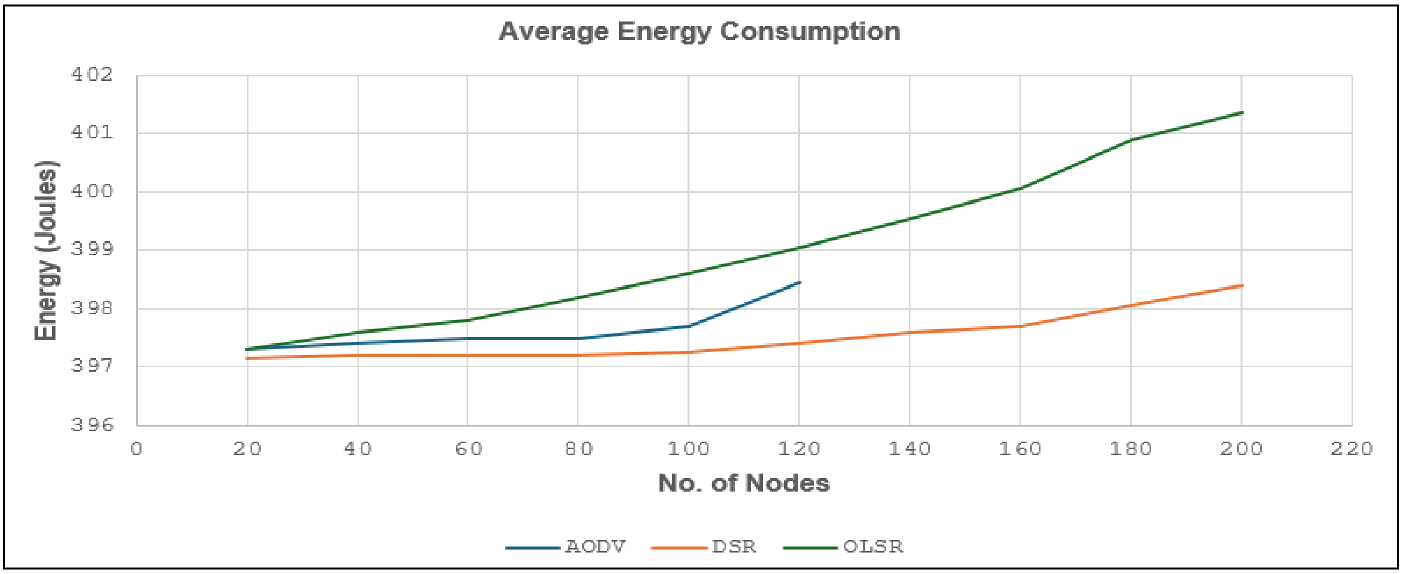
Graphs (b), (c) and (d) shows how each of the protocols of AODV, DSR and OLSR behave when the data size is varied between 1024 bytes and 2048 bytes, and we observed how change in data size affects the Packet Delivery Ratio.

B. Energy Efficiency

In order to draw conclusions regarding the energy efficiency of AODV, OLSR, and DSR, the simulation results are also examined in relation to energy-efficient routing by taking into account various situations, such as scaling network size (number of nodes), scaling packet size, and scaling data transmission rate.



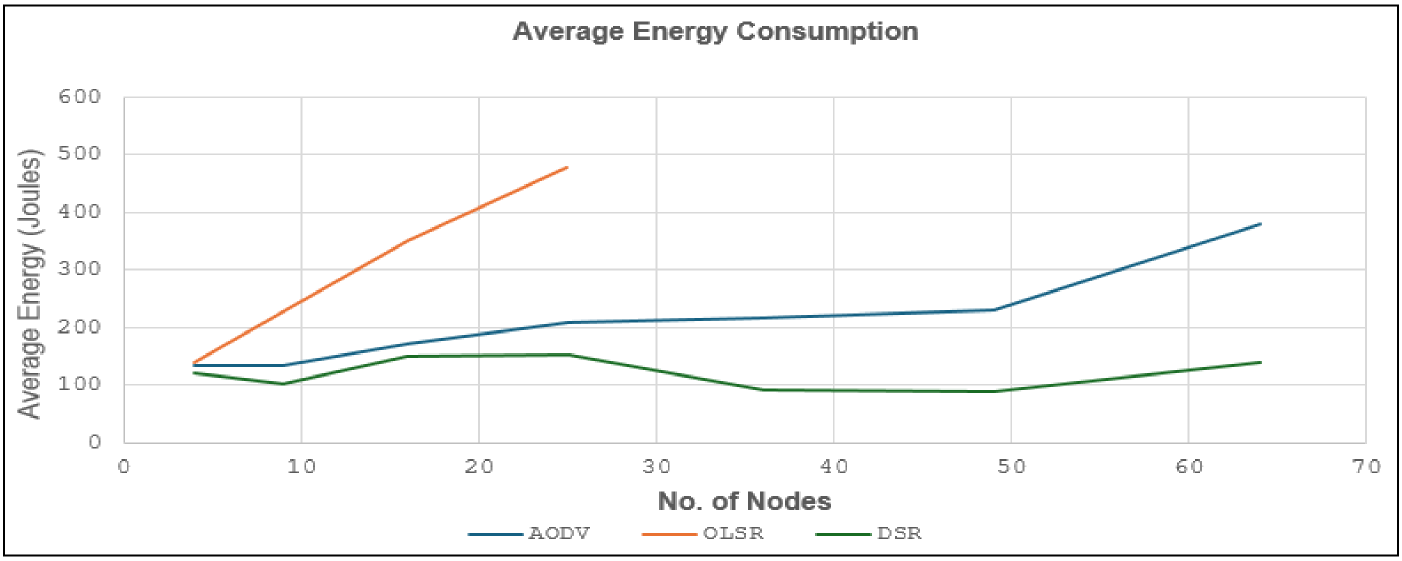
Graph 5 (e) Average Energy Consumption for DPS of 2048 bytes and TR of 8kbps



Graph 6 (f) Average Energy Consumption for DPS of 1024 bytes and TR of 8kbps

Graph (e) shows the Average Energy Consumption of protocols (AODV, DSR and OLSR) by varying the network size (number of nodes) in each case, considering a Data Package Size of 2048 bytes and Transmission Rate of 8kbps.

For graph (f), a Data Package Size of 1024 bytes and Transmission Rate of 8kbps as considered in simulating the results.



Graph 7 (g) Average Energy Consumption (with selected parameters for NetSim Standard v14)

NetSim Standard v14 (proprietary tool) was used to and its network topology considered square dimensions of 4, 9, 16, 25, 36, 64, etc. to simulate the same protocols of AODV, DSR and OLSR as experimented with NS-3. The graph (g) above represents the Average Energy Consumption for selected protocols.

IV. DISCUSSION

The purpose of this research was to assess energy-efficient routing in WSN for IoT applications and conclude the most less hunger Routing protocol for WSN. Two network simulator programs, NS-3 and NetSim Standard v14, were used in an experimental simulation to accomplish the energy-efficient data routing goal.

This paper starts by introducing the application concept of WSN and IoT, factors that affect WSNs and highlighting the challenges associated with key emphasis on Energy optimization, we also present the most common Network tools, and the different types of proactive and reactive protocols that have been considered in the study.

When analyzing and discussing the simulation findings for the chosen routing protocols—DSR, AODV, and OLSR—the validation of the energy-efficiency that emerges from the results is taken into account. We study and finish the case studies using two tools: NetSim and NS-3. As it is specified in table 1 and table 2, the simulation was spanning from 20 to 200 sensor nodes for NS-3 and 4 to 64 nodes for NetSim. Although we don't go into great detail about this problem, the simulation process stops in 140 nodes,

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particularly when using the AODV protocol. As a result, the graph ends at about 140 sensor nodes in the instance of the AODV protocol. Thus, simulation results are available up to 140 nodes in AODV.

According to graphs (a), (b), (c) and (d), it is clearly illustrated that as the packet size is varied between 1024 bytes and 2048 bytes, DSR shows a better performance. PDR was not the key parameter of study but contributed greatly to the research results. Graphs (e), (f) and (g), clearly show that as the network size changes (number of nodes on the network increases) the average energy consumption varies according to the network size, but still DSR performs better compared to the others. In conclusion, the reactive routing protocol DSR supports energy efficiency and increase network lifetime in a Wireless Sensor Network.

Compared to the results that were presented in their paper [5], DSR protocol performs better than AODV by a factor of 13% and OLSR by 40%, in medium scale network. This well coincides with findings in this research both for Packet Delivery Ratio and for Energy Efficiency.

Due to several bottlenecks that come with using different tools, the study highlights some of the limitations such as, for NS-3.41 simulations, the results for AODV stop in 140 nodes and hang, yet for DSR and OLSR, the simulations can run in up to 200 nodes that were considered. Topologies in NetSim are limited to only square numbers hence limiting choice for the researcher. All simulations were resource angry and needed machines with better specifications on top of GPUs that were unavailable.

For future researchers, the study realizes several data transfers that happen between the sensor nodes, and this arises security concerns that needs to be investigated to understand further a secure energy-efficient data routing for IoT applications in a WSN since this can help to stabilize the IoT applications as well as increasing user trust.

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