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SIMULATION AND COMPARISON OF AODV ROUTING PROTOCOL WITH DSDV ROUTING PROTOCOL OF SMART GRID USING NS-2 SIMULATOR "APPLICATION FOR RENEWABLE ENERGY PRODUCTION SYSTEMS"

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ABSTRACT

The demand for energy rises as the population increases, creating many issues with the network. Moreover, the use of traditional energy has become a threat to the ecosystem and to humans. In this scenario, by incorporating a smart grid to better control energy usage, the renewable energy would be very advantageous. This paper describes the foundations of the smart grid, its architecture, the simulation of the smart grid, and its various applications, in particular at the level of large businesses and from one country to another. The main objective of this paper is to simulate and compare the performance of two routing protocols (AODV and DSDV) in terms of power consumption, end-to-end delay, transmission rate of packets, and energy costs of the network. The results based on simulation and data analysis show that the AODV protocol is more efficient in terms of overall performance compared to the DSDV protocol for smart electricity grids.

Keywords Renewable energy, smart grid, AODV, DSDV, DSR, Routing, NS-2, Simulation, Performance Comparison.

1. INTRODUCTION

It is well known that electricity grids have remained in their original state and have undergone few modifications. However, the increasing needs for applications that concern these grids have progressively led to considerable changes to satisfy the increasing demands and performances [1, 2]. The development of smart grids is the solution.
The modernization of electricity networks is an absolute necessity for the national and international objectives in terms of energy saving.

Smart electricity grids allow the user to interact with the electricity system and have real-time data whether in terms of energy consumption, power or price. They are also opening up a new area for technologies using their concepts such as electric vehicles, which require a dedicated infrastructure [3, 4].

Such a digital smart grid requires energy and power to be tightly integrated with digital data and big data to enable an open and real-time market. The smart grid is a compromise of energy resources and communication technologies in an electricity grid. The main intelligent components are sensors; smart meters, a security system, and data management systems, which control the flow of information between the different parts [3, 5]. It represents a network of computers, switches, routers, smart meters, wireless sensors, control applications, renewable energy resources. Smart grid applications must communicate between heterogeneous environments and therefore must use routing protocols to accomplish their work. The AODV routing protocol was developed initially for Mobile Ad Hoc Networks (MANETs) [3]. It was, then adopted by smart grid applications to select the best path between smart grid sensors to exchange reliable data.

In MANETs, the communication between mobile nodes still needs routing over multi-hop paths [6]. Since the mobility of the node can cause frequent connection failures, we proposed that the nodes are fixed (smart homes).

The main objective of this work is to make a comparison between two routing protocols, DSDV and AODV to find out which one fits best in the smart grids environment. To achieve this, we proceed as follows: We start by giving generalities on this innovative network, by giving the definitions, characteristics, basic principles and the different types of the smart grid all over the world. We develop the architectures deployed in the smart grid network as well as their operation. To get a good idea of the topic, we discuss the protocols, algorithms and routing techniques used in smart grids. Finally, we present the simulation of the DSDV and AODV protocols under the NS-2 simulator for a smart grid network, aimin for a concrete comparison.

2. SMART GRID

Smart grids originate from the English expression "power grid" which refers to the electricity distribution network. The word smart emphasizes the "intelligence" brought by computers to the electricity distribution network. The notion of “smart grid” can thus be translated as “intelligent electricity grid”. This type of network is also called a "smart electricity distribution grid". The Smart Grid integrates electrical and IT technologies between any point of production and any point of consumption.

The International Energy Agency (IEA) defines “A Smart grid is an electricity grid that uses advanced digital technologies to manage the transmission of electricity from all sources of generation to meet the demands of energy users, minimizing costs and environmental impacts while maximizing the reliability, resilience and stability of the system [7].

The scope of the smart grid extends to all interconnected power systems, from centralized generation to distributed generation, from low voltage transmission systems to high voltage distribution systems.

2.1 Smart Grid Characteristics

A Smart Grid employs innovative products and services together with control, monitoring, and intelligent communication.

2.1.1 Provides the power quality for the range of needs

Not all customers or companies need the same quality of energy. A smart grid provides different qualities and prices of electricity. Advanced control methods monitor critical components, enabling rapid diagnosis and solutions to events that affect switching overloads, line faults and power quality.

2.1.2 Enables new products, services and markets
Correctly, developed and managed markets effectively provide customers with an ability to select between competing services. Power, power, location, time, rate of change and quality are some of the independent grid variables that must be specifically controlled. Markets may play a major role in these variables being controlled [4].

2.1.3 Enables informed participation by customers
By changing the way they use and buy power, customers help balance supply and demand, and maintain reliability. These improvements come because customers have options that motivate various buying habits and actions. These options include new technology, new electricity consumption information, and new types of pricing and incentives for electricity [4].

2.1.4 Provides resiliency to disturbances, attacks and natural disasters
Resilience refers to a system's ability to react by isolating problem elements to unusual events while the rest of the system is returned to normal operation. Such self-healing steps contribute to reduced customer service disruption and help service provider better control the distribution infrastructure.

2.1.5 Accommodates all generation and storage options
A smart grid accommodates the increasing array of distributed energy resources located by customers. The incorporation of these services, including renewables, small-scale combined heat and power, and energy storage, from manufacturers to marketers to consumers, would increase rapidly across the value chain [4, 5].

2.1.6 Scalability of the system and devices
To promote data sharing and interoperability by using open standards for devices and applications, ensuring flexibility for broader implementation through network management systems.

2.1.7 Optimizes asset utilization and operating efficiency
To maximize the use of its energy, a smart grid applies the latest technologies. For example, with dynamic ratings, optimized capacity can be achieved, allowing assets to be used at higher loads by continuously sensing and rating their capacity. To minimize losses and remove congestion, system-control systems can be modified. By choosing the least-cost energy-delivery system available via these types of system-control devices, operational efficiency improves [5, 8].

2.1.8 Upgrades to the grid may be delayed or avoided
Quick and cheap solutions are available for new connections and provide a continuous grid to meet the highest safety and reliability requirements [5].

2.2 Home energy management system
In a smart grid system, the generation, distribution and consumption of three major components have different functionalities, as follows:

a. Power generation
Different types of generators (gas, wind turbines and solar power) are used to produce power. A generator measures the cost, power demand and power prices provided by other generators to adjust the power generation strategy (price and quantity of power supplied over a certain period) competitively or cooperatively to achieve maximum benefit while meeting demand, energy and reliability constraints [9, 10].

b. Power distribution
Generators supply electric power and distribute it to consumers through distribution stations and transmission lines. Given the limitations on the capacity of the transmission line and the amount of power transmitted, power delivery must be optimized so that transmission losses and costs are reduced. On the generator and consumer side, the distribution can be adaptive [9, 11].

c. Power consumption
Consumption consists of various types of consumers of power. It is important to evaluate the power demand of customers so that the allocation of power supply and distribution can be done optimally.
Smart meters are deployed to efficiently and reliably capture power usage data in order to accomplish such a goal. To estimate the power demand, this data can be used. In a smart grid, the HEMS focuses on the electricity consumer side, where home appliances can be tracked and operated by a control center with smart meters to maximize power supply and usage [2, 12].

3. ROUTING PROTOCOLS

We will provide an overview of routing protocols and coordination hierarchy in the smart grid to understand the idea of our application. In order to compare AODV and DSDV routing protocols for performance metrics that include various comparison variables, such as fraction of packet transmission and energy consumption, parameter throughput, we select the network simulator (NS2) as an environment.

3.1 Classification of ad hoc routing protocols
Whenever a packet is sent by intermediate nodes from the source node to the destination node, it is the duty of the routing protocol to find paths from the source node to the destination node. These protocols for routing are listed as follows:

3.1.1 On-demand Routing Protocols
The routes are defined according to need in this group. Whenever it wants to submit data towards the destination node, the node starts a route discovery process. The process of exploration is regarded as complete when a route or routes are identified. The route maintenance process, which preserves valid routes and removes invalid routes, is followed when routes are established [7, 13].

AODV is a protocol for on-demand routing. Until a route is needed, the discovery process is OFF. The source node, which requires the path, broadcasts a request packet to its neighbors upon request. When an intermediate node receives a request packet and it has an entry corresponding to the destination node address in its routing table, the reply packet is returned to the source node via the reverse path; otherwise, the request packet is rebroadcast to its neighbors [14, 15]. This process continues until the intermediate node is able to return a reply packet to the source node via the reverse route, or the request packet enters the destination node and the destination node returns the reply packet via the reverse path. First, a new path is recognized by the source node and transmits its data to the destination node along this path.

AODV (Ad hoc On-Demand Distance Vector) is a routing protocol designed for mobile networks ad hoc is a routing algorithm. Both unicast and multicast routing are AODV capable. It is an on-demand algorithm, which means that it only builds routes between nodes as requested by the source nodes.

It keeps these paths for as long as the sources need them. Additionally, AODV forms trees that connect members of the multicast community. Trees consist of the members of the group and the nodes needed to link the members. Sequence numbers are used by AODV to keep routes fresh [15, 16]. It is loop-free, starts automatically and adapts to large numbers of network nodes

3.1.2 Table-Driven Routing Protocols

This protocol category includes routing information from each node to any other network node, regardless of whether or not these routes are needed. Each node in the network contains a table, referred to as a routing table, where routing information is retained and nodes are supported in obtaining route information and creating a path. Different table-driven routing protocols consist of Optimized Link State Routing (OLSR), DSDV, etc. [10].
For building ad hoc networks with a limited number of nodes, DSDV is suitable. As there is no formal specification of the algorithm. DSDV needs frequent updating of its routing tables, which, even when the network is idle, consumes power and a small amount of bandwidth. A new sequence number is needed before network reconvergence each time the network topology changes, so DSDV is not suitable for highly dynamic networks. This does not interrupt traffic in areas of the network, which are not affected by the topology update, as in all distance vector protocols [16, 17].

3.3 Scenario of smart homes simulation

The smart home incorporates several strategies from a centralized management and control network. House intelligence devices enables owners to arrange their house according to their will and thus enhance their lifestyle.

A smart house is capable of managing operations that enable energy delivery, including solar panels and wind turbines, in addition to energy management.

In terms of supervision, modification and energy loading, it supports the smart grid infrastructure.

In the sense of smart grid management, as shown in Figure. 1, AMI is primarily responsible for transmitting messages from utilities for each home, long-distance transmission power or wired means of communication.

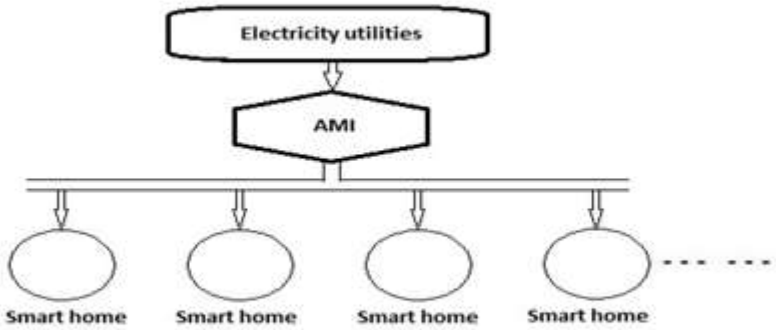

Fig 1. Scenario of delivering messages through AMI to smart homes in smart grid

A smart meter deployed by the applications (the municipality) keeps track of the original message in an intelligent building, via AMI, and cooperates with the home control center to regulate the use of energy for the various applications based on residents' choice and pre-configuration.

The control center selectively changes the energy supplement and use, directed according to the usage in a home, when receiving messages received by the smart meter [5, 9].

First, accessibility to the current energy generation and storage facility is required.
These facilities would be able to service the households automatically, at any order, without the control center interfering with the power grid as an additional complement.
If the electricity surcharge needs to be decreased, the controller instantly sends a warning message to the machines in each house based on the complex price, plug-ins often or simply cut off the path of a couple of machines if appropriate [5].

3.4 Routing across network

Data transmission in the implementation of DSDV or AODV is typically classified into two phases, the establishment of routes to destination nodes and the forwarding of data packets, as shown in the organigram sequence below:

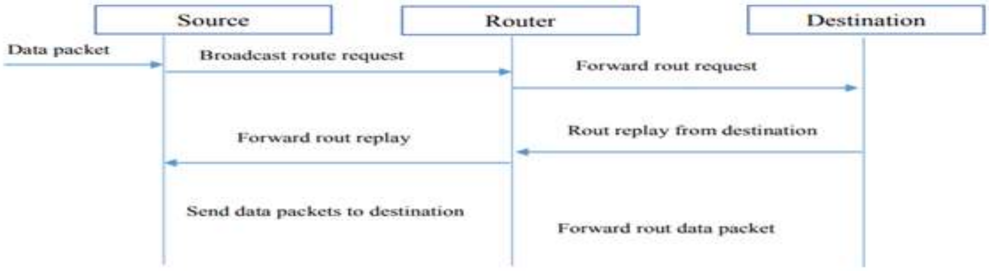

Fig 2. Sequence organigram of data transmission

4. SIMULATION ANALYZES AND DISCUSSION

In this part, we focus mainly on analyzing the results of the simulation in an effort to assess whether and how dynamic factors influence the network model in terms of performance indicators, oriented towards different protocols, and the routing strategies of our implementation.

4.1 Nodes deployment and network parameters

An individual network occupies the smart house. In our case, we take 16 houses a few meters away, which play the role of smart main meters, and each house is equipped with a secondary meter that will communicate directly with the main meter. The nodes are placed in a grid mode to ensure that each node participating in the associated network is able to receive packets via the wireless link according to the network deployment model as shown in the figure 3.

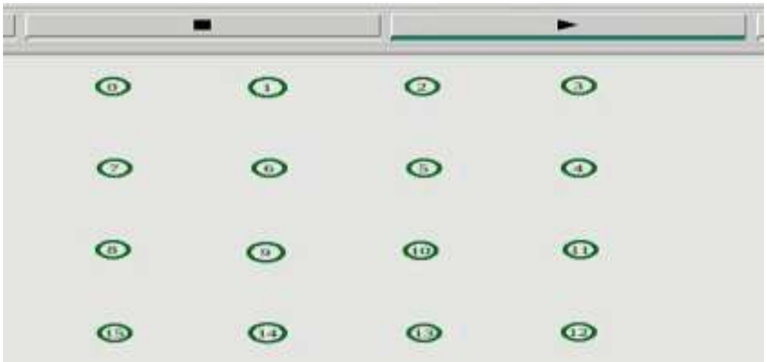

Fig 3. Deployment model

Given the fixed transmit power preconfigured for each node at the wireless interface in the hose; the network deployment allows the nodes to transmit packets to neighboring nodes along the grid path over the wireless link. Data packets, outgoing from the central controller (base station), could reach transmission in the house at a relatively low data rate per hop, regardless of node density. In this case, the packets could reach the distant wireless nodes by several hops, via the wireless link. In the default simulation scenario, the communication between the nodes is done as shown in figure 4.

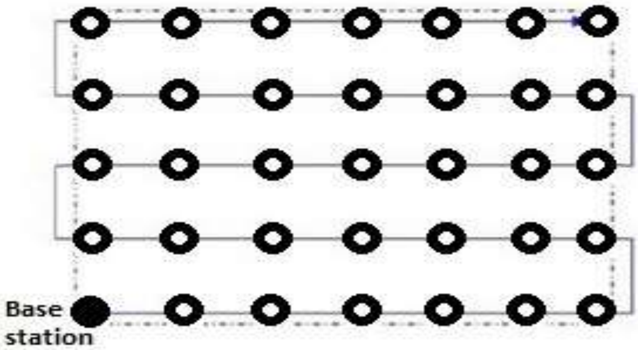

Fig 4. Wireless communication by several hops between nodes.

The network parameters are summarized in the table 1.

Table 1. Simulation configuration

X dimension of topography	**956**
Y dimension of topography	600
Routing protocol	AODV /DSDV
Number of nodes	16
Time of simulation end	25.0s
Channel type	Wireless channel
Antenna model	Antenna/OmniAntenna
Link layer type	LL
Interface queue type	Queue/Droptail/Queue

To understand the scenario and the configuration taken in our case, we summarize everything in the following points:

- To better coverage of our smart grid network, we take a large topology in our case (1Km^2).
- Transmit power is promoted to 3W to ensure that all messages arrive at all nodes in the network.
- The transmitter, taken in our case, is capable of transmitting packets without errors with a high probability reception of 99%. In our simulation, the transmitter must be high enough to send packets successfully, over RBDS channels, to all buildings at different heights.

The scenario will be taken in two cases: in the first case, we will replace the basic operation explained in figure.4 by the AODV routing protocol, and in the second case, we will use the DSDV protocol.To evaluate our contribution, we take three simulation metrics (energy consumed, Pdr, throughput).

4.2 Metrics and Performances

A group of measures used in the analysis of the data produced in the simulations, is selected in our work to assess the performance of the associated network.

4.2.1 Energy Consumed

The energy consumption of communication systems is becoming a fundamental issue among all sectors; wireless access networks are largely responsible for the increase in consumption. It is very essential to develop a technology to reduce energy consumption in wireless networks in general and smart grids in particular.

4.2.2 Packet Delivery Ratio (PDR)

The ratio of number of packets delivered in total to the total number of packets sent from source node to destination node can be measured in the network. It is desired that maximum number of data packets have to be reached to the destination. As the value of PDR, increases the performance of the network also increases [18, 19].

4.2.3 Throughput

In network throughput can be termed as number of successfully transmitted packets from source to destination per second. For good designed network, the value should be high and if it is attacked by any attack the value of throughput considerably decrease [18, 20].

5. RESULTS AND ANALSIS

In this work the performance analysis is carried out in an adhoc network with three deferent metrics (pdr, energy, throughput) while keeping other parameters constant. Two protocols AODV and DSDV are considered for the comparison purpose on the above performance.

5.1 Energy Consumed

The main objective of the energy colt is to explore the power consumption situation for all battery-powered nodes with a wireless interface.

The cost of network energy configured with the AODV protocol in a smart home is illustrated in figure.5 and that configured with the DSDV protocol is illustrated in figure 6.

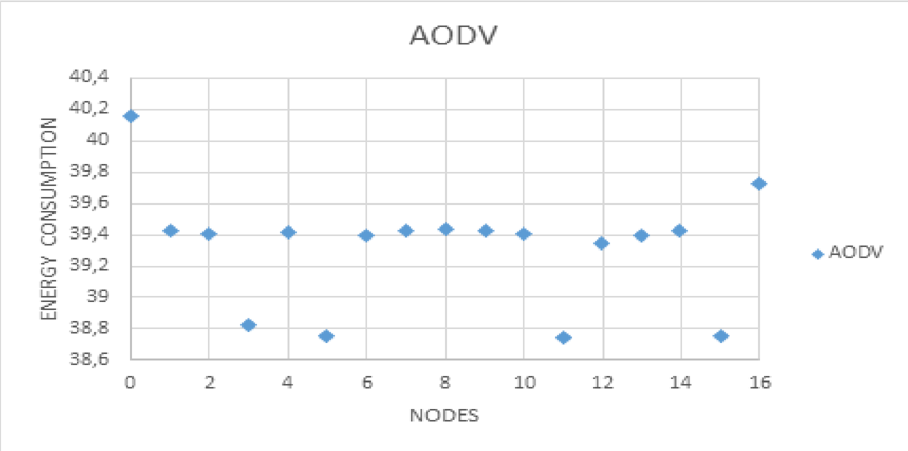

Fig 5. Energy consumption vs nodes by the AODV

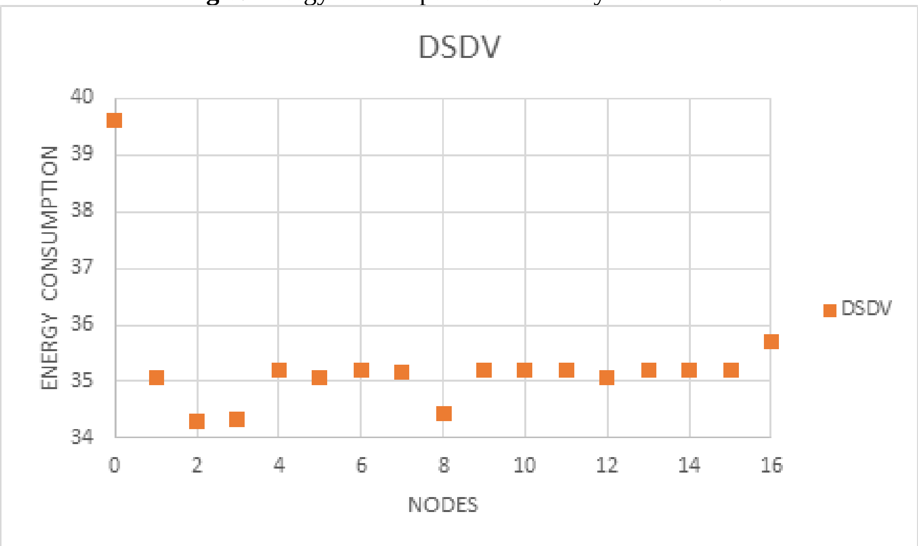

Fig 6. Energy consumption vs nods by the DSDV

The figure 7 shows traces of the residual energy in each node according to simulation time.in both graph. It is very important to note that by using the protocol AODV, the node are consumed energy more less than DSDV protocol.

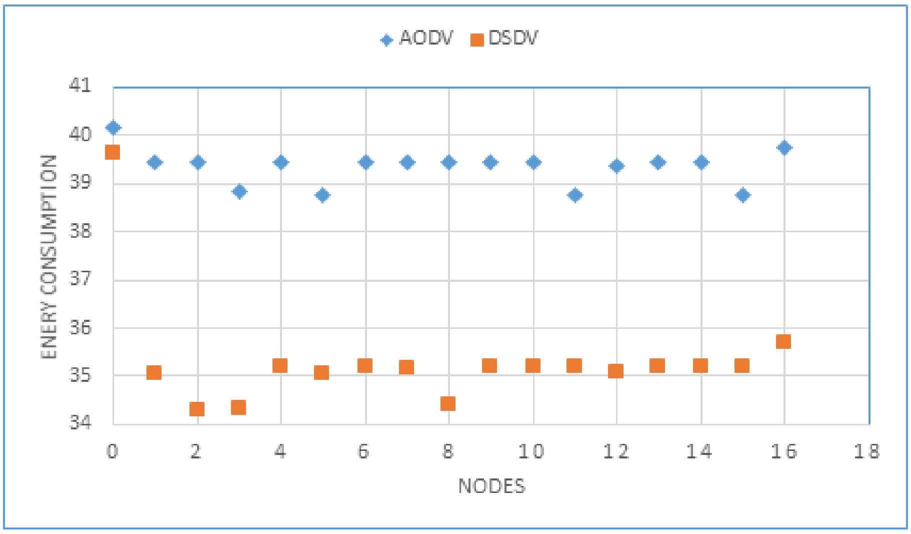

Fig 7. Comparison between energy consumption of AODV vs DSDV

5.2 Packet Delivery Ratio (PDR)

A comparison shown in figure 8 is made with AODV and DSDV in the network. It is observed that the AODV outperforms the DSDV in terms of PDR by increasing the total data bits received.

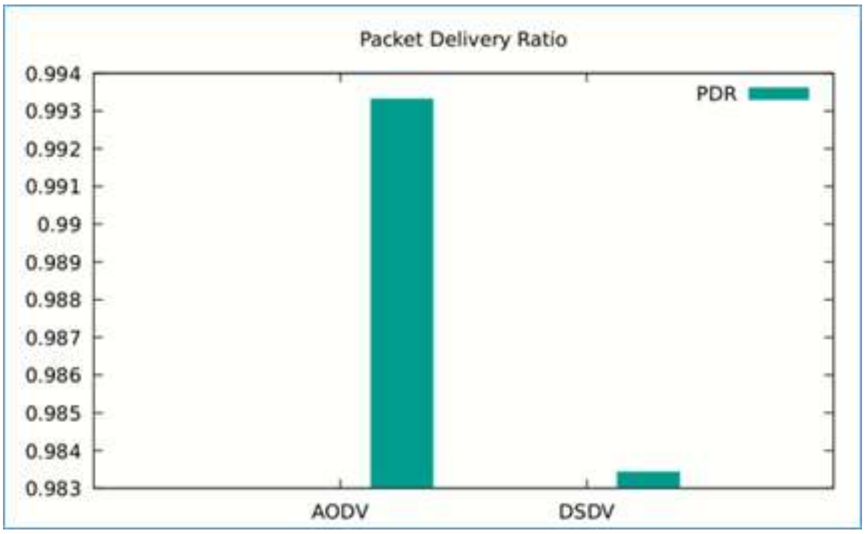

Fig 8. Comparison of packet delivery ratio between AODV and DSDV

5.3 Throughput

The comparison shown in figure.9 indicates that the performance metrics obtained from analysis of trace file and study of graph generated by simulation of DSDV and AODV routing protocols, states that: For 10 nodes, AODV performs best in comparison to DSDV and for the nodes from 10 to 16 DSDV performs better compare to AODV.

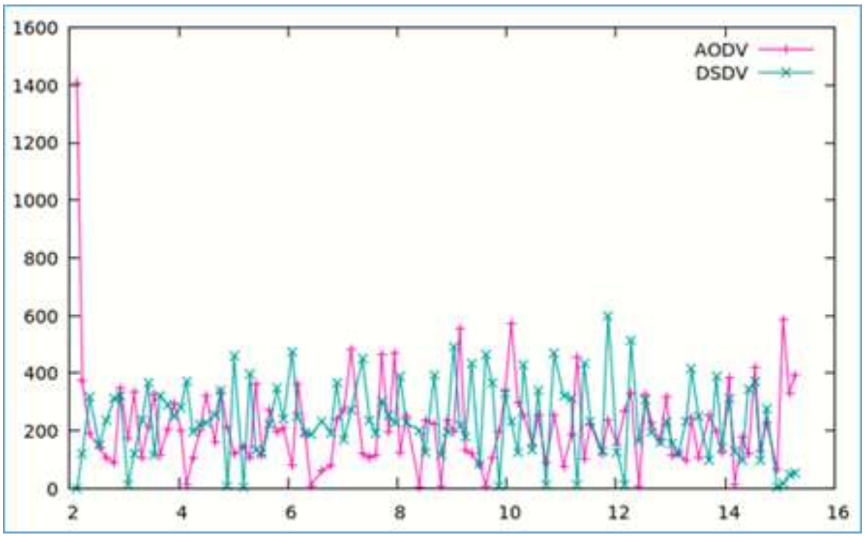

Fig 9. Comparison of throughput between AODV and DSDV

Moreover, in term of throughput thus, it states that in case of higher node density, DSDV performs well and is more scalable, but for lower node density, AODV performs well.

5.4 Network Energy Cost

The main focus of the cost of power is to explore the power consumption situation for all battery-powered nodes with a wireless interface, and how the distance increasing between nodes affects the energy cost of the entire network. To estimate the cost of energy, the node's transmit power is set to be the same at the three node densities (the transmit power equal to 3.0W could reach nodes within a radius of 6 meters).

The cost of network energy configured with AODV protocol in a smart home is shown in figure 10 and that configured with DSDV protocol is shown in figure 11.

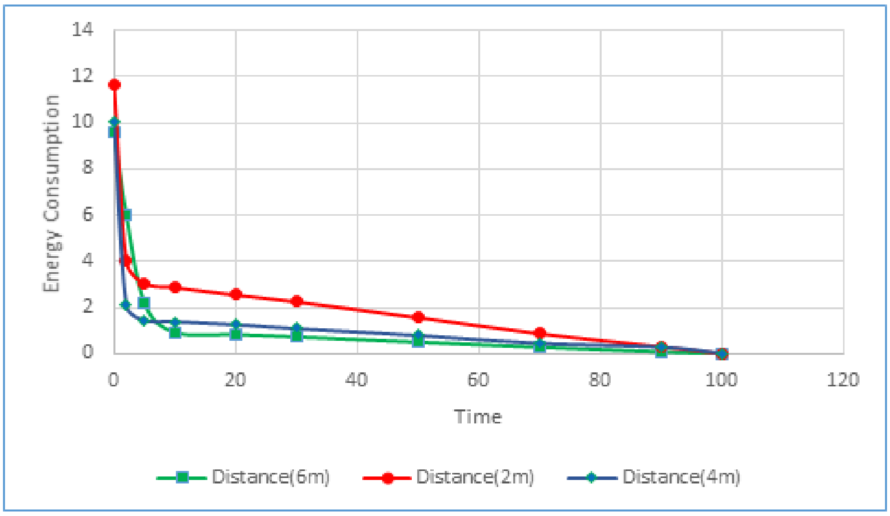

Fig 10. Energy consumption vs time pause by the AODV

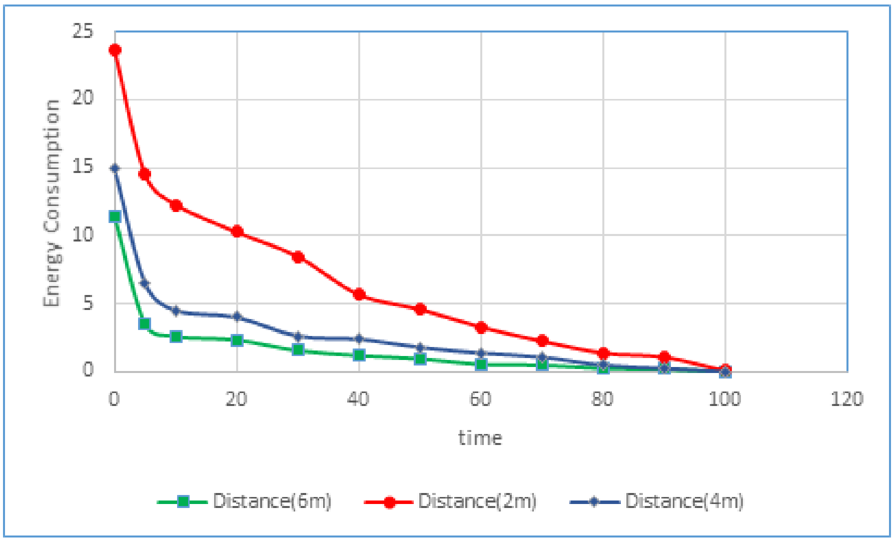

Fig11. Energy consumption vs time pause by the DSDV protocol

Figures 10 and 11 show plots of energy consumption as a function of simulation time. In both figures, we notice that there is an energy drop between 0 and 9 seconds, this is due to the necessary transmission time, taken by the Radio Broadcast Data System (*RBDS*), to the central controller node; since the simulation parameters only take smart homes into consideration, so between 0 and 9 seconds, since the smart homes are not powered, there is a fairly high consumption of energy. Once the house is powered by the external source, we notice that the more the distance (2m, 4m and 6m) between the main meter and the secondary nodes (meters) increases, the more energy consumed is also greater. The AODV protocol provides slightly reduced energy consumption compared to the flooding protocol; this is due to the optimized routing of the information to be transferred, which influences the overload of the network. However, the time distribution remains similar.

6. CONCLUSION

Smart grids currently represent production and distribution networks for electrical energy, integrating new information technologies. These systems information can improve overall energy efficiency by managing both production of electricity than its storage, distribution, and consumption, so effective [21].

Smart grids are therefore at the intersection of three sectors: energy, information systems, and telecommunications. This requires the installation of ICT systems in houses, apartments, offices, but also in energy production plants, etc [2, 9].

In this work, we presented the performance comparison between Ad hoc On-demand Distance Vector Routing (AODV) as reactive routing protocols and Destination Sequenced Distance Vector (DSDV) as a proactive routing protocol to precisely determine which protocol is more effective Network Simulator (NS-2) has used to evaluate the performance of these protocols in terms of the performance measures. Each protocol is having its own advantages and disadvantages and may be well suited for certain scenarios. In the term of energy consumption and average PDR, the protocol AODV is the best, and in term of throughput Thus, it states that in case of higher node density, DSDV performs well and is more scalable, but for lower node density, AODV performs well.

In our work, we studied an architecture based on fixed nodes, which represent smart homes and the routing protocols used. It would be ambitious to study architecture integrates mobile nodes representing, for example, electric vehicles.

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