Design of Scenarios for Service Life Estimator Battery Model using QualNet 5.0

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Abstract— **Mobile ad hoc network nodes can be in any of states-receive, transmit, idle and sleep mode. They consume energy in all these modes, which leads to depletion of finite energy and minimizes network lifetime. Many types of battery models are available in market for a variety of applications. We have studied, analyzed and compared energy and performance related issues of reactive routing protocols for Service Life Estimator battery model – Duracell AA. We have created a scenario involving 11 nodes with CBR traffic for AODV, DSR and DYMO protocols implementation for Service Life Estimator Battery Model – Duracell AA by defining Simulation Area of 1500 x 1500 mt.^{2} in QualNet 5.0 simulator and varying simulation time between 10 minutes to 60 minutes. To take into account the energy dissipation due to various activities, we have defined values for our own energy model. DSR protocol gives highest throughput at cost of increased Average Jitter and end-to-end delay followed by DYMO and AODV. For DSR protocol, energy consumption at Transmit mode and Receive mode is maximum followed by DYMO and AODV. Energy consumption at Idle Mode is highest for AODV followed by DYMO and DSR.**

Keywords- AODV;DSR ; DYMO; MANET; QUALNET; Battery Model.

I. BATTERY MODEL

Dynamic nature and mobility characteristics impose several challenges to MANET routing protocols working under different Battery Models. In literature, we find variety of battery models for different application areas [1]. Under energy constrained operations, it is ideal to optimize energy use for extending network lifetime. Transmission, reception and overhearing activities lead to depletion of energy in Batteries continuously [2]. Depletion of energy in intermediate nodes may disrupt communication resulting in modification of the network topology. Battery models are used to predict the behavior of real life batteries under various conditions of charge/ discharge, proving useful tools for battery driven system design approach. These models enable analysis of the behavior of battery under different design choices without wasting time.Service Life Estimator Battery Model estimates the total service life of the Battery (i.e. the time it takes the battery charge to reach zero from the start of the simulation). This battery model is a modular approach for enhancing event-driven simulator with precise high battery level which can accurately estimate service life of a battery-operated device with a given time-varying load. Residual Life Battery Model estimates the remaining service life of the battery at any time in the simulation. One important characteristic of the battery is that some amount of energy will be wasted when the battery is delivering the energy required by the circuit. Linear Battery Model is based on Coulomb counting technique to dissipate the Coulombs from the beginning of the discharge cycle and estimates the remaining capacity based on the difference between the accumulated value and a pre-recorded full charge capacity.

The state of charge of batteries attached to a battery-operated node is periodically checked and if the battery is out of charge, the node is shut down. For the battery model specification, the input parameters must be configured initially for a given battery type from a battery manufacturer. In QualNet, we can found pre-computed and stored parameters and specifications for several types of batteries including DURACELL (AA and AAA) and ITSY. Therefore, for DURACELL (AA and AAA) and ITSY battery types the specifications can be loaded from battery library in case of Residual Life Battery Model and Service Life Battery Model. The following assumptions are made in the implementation of the battery models: 1) The output voltage of the battery is considered to be constant during the operation of the battery. Output voltage of a battery decreases as depth of discharge (ratio of remaining charge to full charge) increases. 2) The effects of temperature and cycle-aging have not been captured in any of the model which has been currently implemented in the simulator.

We include the parameter -‘SERVICE-LIFE-ACCURATE’ in the scenario configuration (.config) file to specify the Service Life battery Model. A load utility table file for battery types can be found in QUALNET_HOME/data/battery. The name of the file for the DURACELL-AA-MX-1500 is DURACELL-MX2400.utl. To configure the battery model parameters, we select ‘Battery Model’ from Node–Configuration tab of Default Device Properties Editor. Statistics for the Battery Model can be collected at the global and node levels. File statistics in form of Residual battery capacity (in mAhr), Total charge consumed (in mAhr) and Battery is dead at time (sec) are provided as output to the statistics (.stat) file at the end of the simulation.

II. RELATED WORK

We are providing the surveys conducted for different energy saving techniques. [3] proposed power-efficient, cost-efficient and power-cost efficient routing algorithms. Conditional Max Min Battery Capacity Routing (CMMBCR) [4] suggest considering both the total transmission energy consumption of routes and the remaining power of nodes. When all nodes in some possible routes have sufficient remaining battery capacity, i.e. above a threshold, route with minimum total transmission power among the routes is chosen. Since less total power is required to forward packets for each connection, the load for most of the nodes must be reduced, and thereby lifetime extended. But, if every possible route have nodes with low battery capacity i.e. below the defined threshold, a route including nodes with lowest battery capacity must be avoided to extend the lifetime of these nodes.

Realistic consumption model [5] is used for calculation of energy cost, using channel quality as parameter for ensuring successful delivery of packet. Power-aware routing metrics are proposed [6] select routes around congested areas, extend time for network partition and reduce the variance of hosts power levels and adjust the cost function. Energy Based Routing algorithm (EBRA) [7] was developed to integrate Dynamic Source Routing (DSR) protocol for ensuring minimum energy consumption rate. The proposed scheme consist of three phases: nodes energy consumption is limited with high mobility; the effect of malicious behavior is reduced to avoid the replaying of packets and the unauthenticated node is identified using the digital signature verification. Efficiency of protocols is evaluated [8] for energy consumption indicating their usage of node's energy , taking into consideration nodes density and mobility.

A new approach for optimizing power consumption in MANETs has been proposed and implemented [9] by introducing a threshold value on each node and transmitting the equal length of packet on the route. Llama [10] is Battery Monitoring and Power Management System for Windows Mobile 5 Platform. [11,12,13,14] analyzed and compared MANET protocols based on numerous performance issues under varying constraints of mobility, size, energy model, battery model and simulator used. [15] developed battery charging and cell balancing mechanism for monitoring cells in a battery pack, to optimize the available energy utilization. [16] surveyed different models for radio energy, battery, propagation, antenna and mobility which have in-built libraries built in QualNet for easy implementation.

In [17], authors have proposed a routing technique which considers a cost metric being function of battery. Residual power and energy consumption rate of participating nodes for path computation, along with minimization of over-utilization of participating nodes simulated through QualNet 4.5 for achieving higher performance in terms of network lifetime and energy consumption. Authors in [18] proposed a link quality-aware Maximum Lifetime Reliable Broadcast Tree (MLRBT) Algorithm to build a broadcast tree for extending network lifetime in MANETs.

A model based on mobile agent concept is proposed [19] for design of connectionless routing protocol for wireless ad hoc networks selecting reliable paths between source and destination for maximum throughput and minimum control packets flow over network. To cope with problems of congestion, route failures and battery energy drain, authors in [20] proposed a Cross Layer Design spanning Transport and Network Layer by reducing packet dropping rate and energy consumption. [21] proposes a power-based routing protocol to restrict data transfer costs and transmission energy consumption, comprising of two phases : resource selection and resource allocation. [22] developed a Petri-net based simulation model covering reliability aspects of wireless communication to study behavior of QoS metrics in MANETs with varying distance of transmission and other requisite model parameters. [23] presented methods for analyzing results generated by discrete event simulations. In [24], three different mobility models have been selected, where each of them is highly distinctive in terms of nodes movement behavior.

III. SIMULATION ENVRIONMENT

We have chosen QualNet version 5.0 over Windows platform [25] for our simulation studies. In our simulation model, there are 11 nodes in a subnet. The terrain condition we have set as 1500 x 1500 mt.^{2} (flat area). The battery model considered in our simulation is Duracell AA. The number of CBR connections are five (from node2 to node 1, node 7 to node 8, node 3 to node 4, node 9 to node 10, node 5 to node 6), which is depicted in diagram by CBR . CBR means Constant Bit Rate (CBR) traffic generator. In canvas, green labeled CBR is used to represent CBR applications graphically.

The simulation is conducted to study throughput performance and energy consumption (of MANET Protocols under study) for Duracell AA battery model [26] for varying number of simulation times from 10 minutes to 60 minutes. In content of paper, figures and tables, we have used 'M' to denote minutes. for eg. AODV 10 M means AODV protocol is run for simulation time of 10 minutes. Six simulation scenarios are run for each protocol and results are averaged, by extracting results from the statistics file generated from each scenario simulation. Fig. 1 shows diagrammatically representation of simulation scenario. Table 1 lists the parameters to configure the Service Life Battery Model. The various parameters of simulation are revealed in Table 2. In [27] authors have proposed a routing technique which considers a cost metric being function of battery residual power. [28] developed a Petri-net based simulation model covering reliability aspects of wireless communication to study behavior of QoS metrics in MANET.

Table 1 Parameter to configure Service Life battery model

Parameter	Properties of Parameters Used	
	Value	Description
BATTERY-CHARGE-MONITORING-INTERVAL Optional	Time Range: ≥0s Default: 1M	This parameter specifies the interval in which the state of charge of the battery is monitored once. In case the battery is out of charge, the node is shut down.
BATTERY-PRECOMPUTE-TABLE-FILE Required Scope: Global, Node	Filename	This parameter specifies the file that contains the pre-computed table for the specified battery type. Note: A pre-computed table file for each of the battery types can be found in QUALNET_HOME/data/battery. The names of the files for the different battery models are :DURACELL -- AA: duracell-aa.pcm, DURACELL – AAA: duracell-aaa.pcm

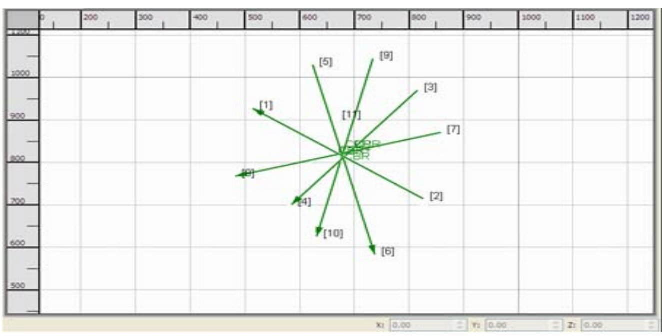

Fig1. Scenario applying CBR Traffic in QualNet Simulator 5.0

IV. RESULT ANALYSIS

Results of 18 cases under study are shown in this section in Tables (3-8) and Figure (2-7) for analysis of results in better way. We are discussing these results one by one for each Simulation Parameter under study:

A. *Average Jitter(s):*

On individually observing, maximum jitter value of 0.0191562 is observed for AODV 10 M corresponding to node id-2. Minimum jitter value of 0.00849833 is observed for DYMO 60 M corresponding to node id-10. Sum of average jitter (s) values observed for AODV 10 M is 0.07973376 which is highest. Sum of average jitter(s) values observed for AODV 60 M is 0.06393678 which is lowest. A total value of average jitter(s) for DSR (0.45536192) is observed which is highest followed by DYMO (0.41543907) and AODV (0.41050238). Sum of average jitter value at node id-4 is highest (0.293776) and is lowest for node id-10 (0.168432).

B. *Average end-to-end delay:*

On individually observing, maximum average end-to-end delay value of 0.0401417 is observed for AODV 10 M corresponding to node id-2. Minimum average end-to-end delay value of 0.0192714 is observed for AODV 10 M corresponding to node id-4. Sum of average jitter (s) values observed for DYMO 10 M is 0.1847551 which is highest. Sum of average end-to-end delay values observed for DYMO 60 M is 0.1714237 which is lowest. A total value of average end-to-end delay for DSR (1.06699) is observed which is highest followed by DYMO (1.06394) and AODV (1.053656). Sum of average end-to-end value at node id-2 is highest (0.61736) and is lowest for node id-4 (0.38123).

C. *Throughput (bits/s):*

On individually observing, maximum throughput value of 4098 is observed for DYMO 10 M corresponding to node id-6. Minimum throughput value of 3911 is observed for AODV 10 M corresponding to node id-2. Sum of throughput values observed for DSR 10 M is 24579 which is highest. Sum of throughput (bits/s) values observed for AODV 10 M is 24235 which is lowest. A total value of throughput(bits/s) for DSR (147451) is observed which is highest followed by DYMO (146797) and AODV (146563). Sum of throughput values at node id-8 is highest (73729) and is lowest for node id-2 (73074).

D. *Energy Consumption in Transmit Mode (mJoule):*

On individually observing, maximum energy consumption value of 0.618451 is observed for AODV 60 M corresponding to node id-3. Minimum energy consumption value of 0.000401 is observed for DYMO 10 M corresponding to node id-11. Sum of energy consumption values observed for DSR 60 M is 2.427545 which is highest. Sum of energy consumption values observed for AODV 10 M is 0.395973 which is lowest. A total value of energy consumption for DSR (8.48298) is observed which is highest followed by DYMO (8.190547) and AODV (8.064592). Sum of energy consumption values at node id-3 is highest (3.84215) and is lowest for node id-10 (0.9344).

E. *Energy Consumption in Receive Mode(mJoule):*

On individually observing, maximum energy consumption value of 1.72467 is observed for DSR 60 M corresponding to node id-4. Minimum energy consumption value of 0.213688 is observed for DYMO 10 M corresponding to node id-1. Sum of energy consumption values observed for DSR 60 M is 17.89724 which is highest. Sum of energy consumption values observed for AODV 10 M is 2.919021 which is lowest. A total value of energy consumption for DSR (62.5379) is observed which is highest followed by DYMO (60.36785) and AODV (59.45375). Sum of energy consumption values at node id-10 is highest (17.560349) and is lowest for node id-3 (15.386862).

F. *Energy Consumption in Idle Mode(mJoule):*

Maximum energy consumption value of 28.8729 is observed for AODV 60 M corresponding to node id-11. Minimum energy consumption value of 4.79998 is observed for DSR 10 M corresponding to node id-8. Sum of energy consumption values observed for AODV 60 M is 317.5897 which is highest. Sum of energy consumption values observed for DSR 10 M is 52.80383 which is lowest. A total value of energy consumption for AODV (1111.332) is observed which is highest followed by DYMO (1110.66) and DSR (1109.07). Sum of energy consumption values at node id-5 is highest (302.83019) and is lowest for node id-1 (302.81601).

G. *Total Energy Consumption:*

Total energy consumed in Transmit Mode is 24.7381 (mJoule), energy consumed in Receive mode is 182.36 (mJoule) whereas energy consumption when nodes are in idle state is maximum i.e. 3331.06 (mJoule) respectively. For Routing Protocol AODV, from AODV 10M to AODV 60 M energy consumption in Transmit Mode (for all nodes) keeps on constantly increasing from value of 0.395973 in AODV 10 M to highest value of 2.29185 at AODV 60 M. In case of energy consumption in Receive Mode, we observe that energy consumption value at AODV 10M is 2.919021 which is minimum, and reaches to 16.89669 at AODV 60 M which is highest. Lowest energy consumption value observed for Idle Mode is at AODV 10 M i.e. 52.85598 and highest value is observed for AODV 60 M i.e. 317.5897.

We see for all cases under study (i.e from AODV 10 M to AODV 60 M) the value of energy consumption at Idle Mode is always greater than energy consumed at Receive Mode which is again greater than energy consumption at Transmit mode i.e. for AODV 10M, energy consumed at Transmit Mode is 0.395973, Energy consumed at R. Mode is 2.919021 and at Idle Mode is 52.85598 and similar trend is observed for all cases of AODV under study. From DSR 10m to DSR 60 M energy consumption in Transmit Mode (for all nodes) keeps on constantly increasing from value of 0.405576 in DSR 10 M to highest value of 2.427545 in DSR 60 M.

Energy consumption at Receive Mode and Idle Mode follows similar pattern. In case of energy consumption in Receive Mode, we observe that energy consumption value at DSR 10M is 2.990057 which is lowest, and value reaches to .89724 at DSR 60 M which is highest. Lowest energy consumption value is observed for Idle Mode is at DSR 10M i.e 52.80383 and highest value is observed for DSR 60 M i.e. 316.8547. In case of DSR Protocol, we see for all cases under study (i.e from DSR 10m to DSR 60 M) the value of energy consumption at Idle Mode is highest followed by Receive Mode and Transmit Mode respectively i.e Transmit Energy consumed at DSR 10 M is 0.405576, Receive Mode energy consumption is 2.990057 and Idle Mode energy consumption is 52.8038 and similar trend is observed for all cases of DSR under study. From DYMO 10 M to DYMO 60 M, energy consumption in Transmit Mode keeps on constantly increasing from value of 0.398334 in DYMO 10 M to highest value of 2.318696 in DYMO 60 M.

In case of energy consumption in Receive Mode, we observe that energy consumption value at DYMO 10 M is 2.935292 which is minimum and value reaches to 17.09239 at DYMO 60 M which is highest. Lowest energy consumption value observed for Idle Mode is at DYMO 10 M is 52.84398 and highest value is noted for DYMO 60 M i.e. 317.4457. In case of DYMO protocol, we observe that for all cases under study (ie from DYMO 10 M to DYMO 60 M) the value of energy consumption at Idle Mode is highest followed by Receive Mode and Transmit Mode respectively. eg. Transmit Mode energy consumption at DYMO 10 M IS 0.398334 , Receive Mode energy consumption is 2.935292 and Idle mode energy consumption is 52.84398 and similar trend is observed for all cases of DYMO under study.

Table 2. Simulation Parameters

Constraint	Value
Antenna Model	Omni directional
Radio Type	802.11b
Number of Nodes	11 (Fig. 1)
Item Size	512 Bytes.
Channel Frequency	2.4 GHz
Traffic Generator	CBR
Property for CBR	Item to send –infinite Interval = 1s
Battery Model Type	Service Life Estimator (If battery model is set to Service Life Estimator, we have to set the dependent parameters- Battery Type, Battery Charge Monitoring Interval and Service Life Estimator Table.)
Protocols	AODV, DSR and DYMO.
Battery Charge Monitoring Interval	10 s
Battery Type	DURACELL AA
SLE Table	Duracell-aa.pcm
Energy Model	User Specified
Transmission current load(mAmp)	20
Reception Load(mAmp)	15
Idle Current Load(mAmp)	10
Supply Voltage Interface load(volt)	3.0
Performance Metrics	Average Jitter(s), End-to-End Delay(s), Throughput (bits/s), Energy consumed (mJoule) in Transmit, Receive and Idle Mode.
Simulation Time	10 minutes to 60 minutes
Seed	1

V. Conclusion

The study has evaluated three routing protocols for same battery model in physical and application layer of network. There is no single protocol qualifying all the performance metric. From simulation results, it has been observed that DSR provides maximum throughput followed by DYMO and AODV with modest difference in other quantifying parameters. The overall energy consumption at Idle mode is highest, followed by energy consumed in Receive mode and Transmit mode. In Future, we could somehow reduce the duration of nodes being in idle mode, this can be one of alternative for optimal utilization of energy in addition to selection of appropriate battery model.

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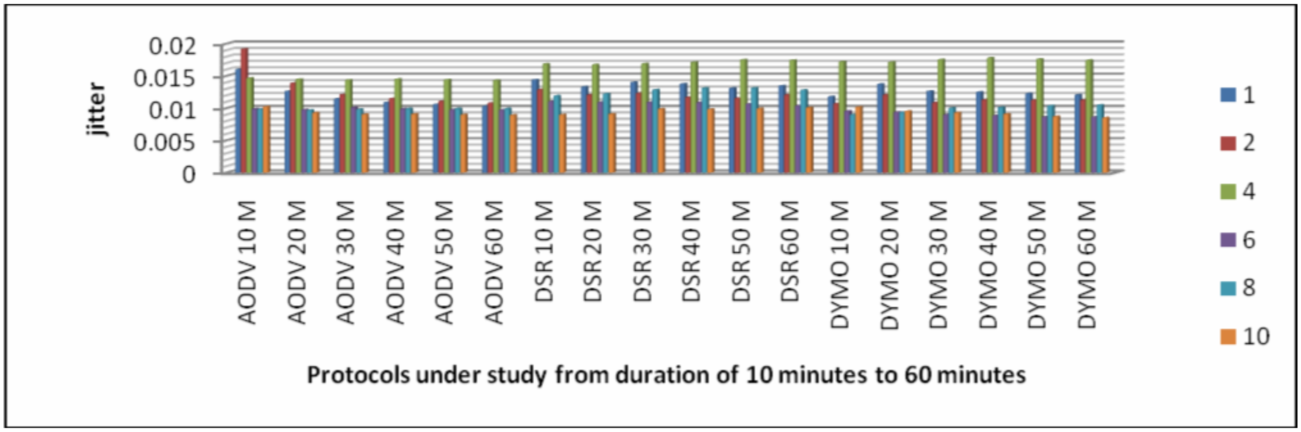

Fig. 2 Comparison of average jitter values

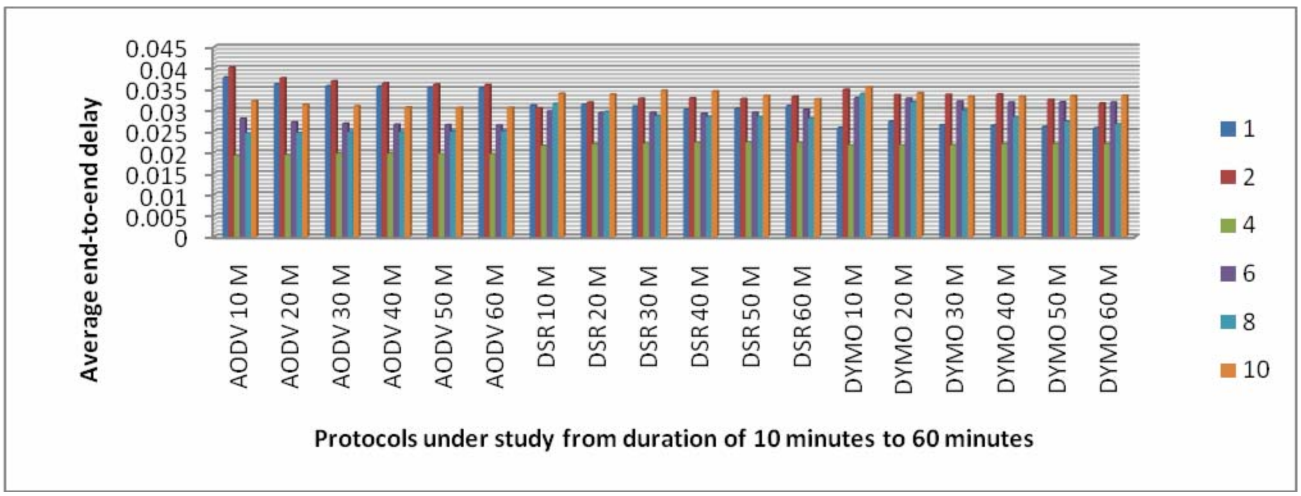

Fig. 3. Comparison of Average end-to-end delay values.

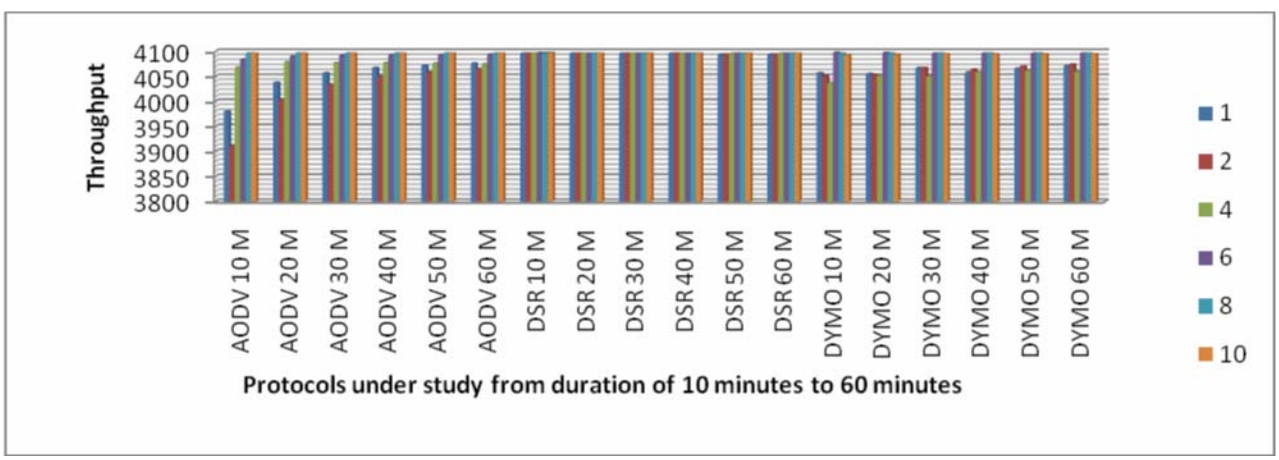

Fig 4. Comparison of Throughput values.

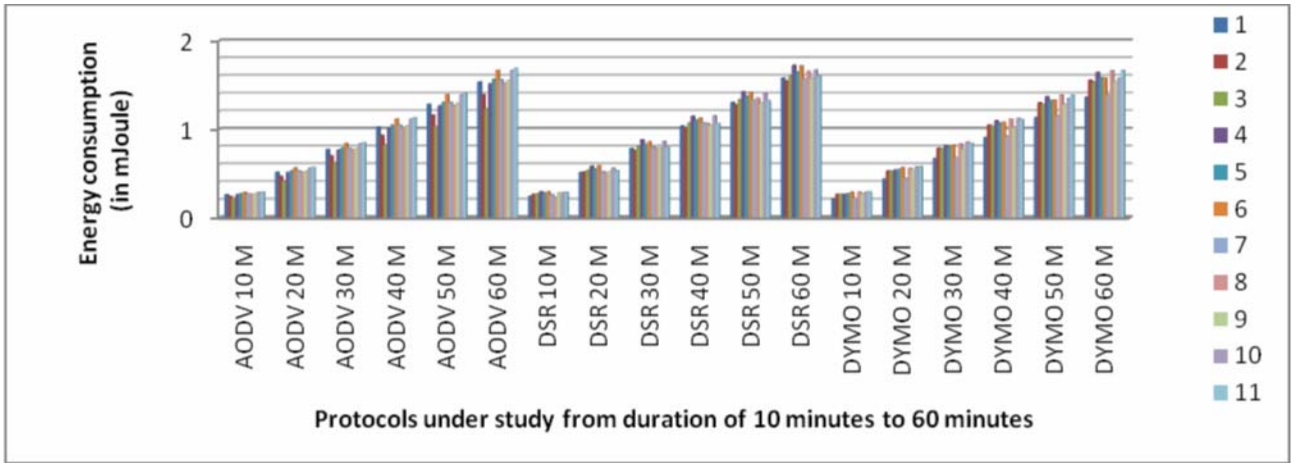

Fig 5. Energy consumed in Receive Mode

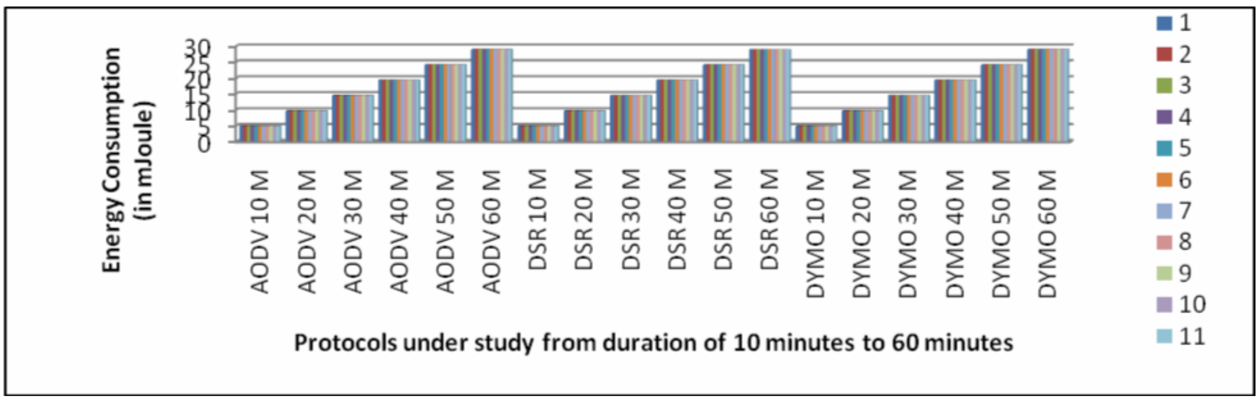

Fig 6. Energy consumed in Idle Mode

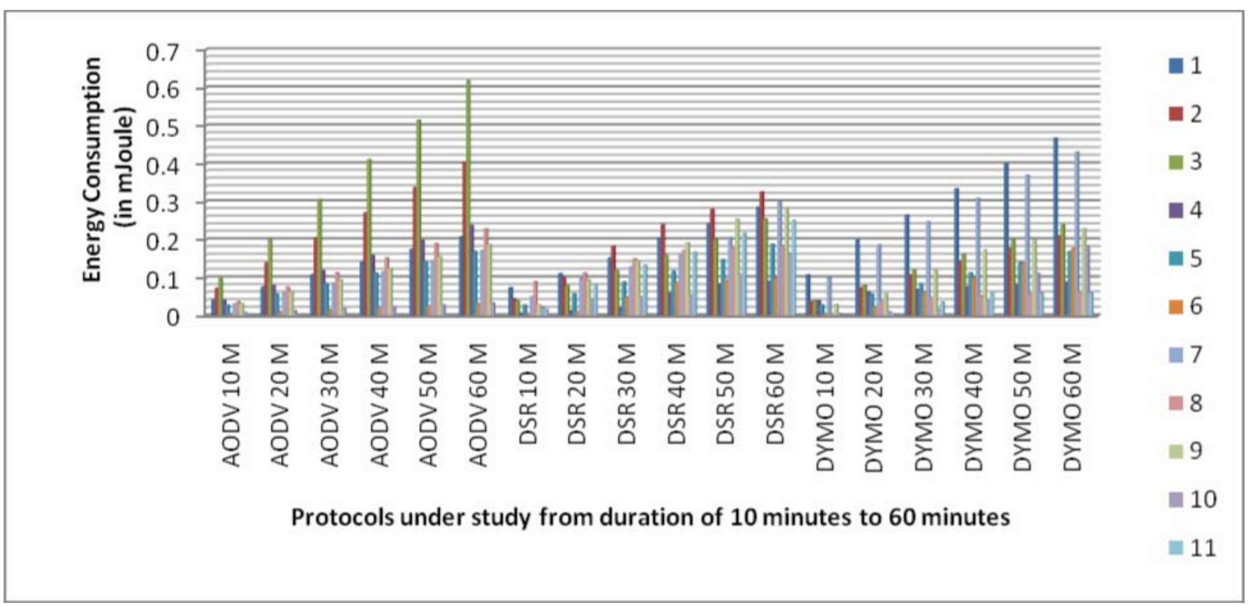

Fig 7. Energy consumed in Transmit mode

Table 3. Average Jitter values for CBR servers (in s)

	Node Id -1	Node Id- 2	Node Id -4	Node Id- 6	Node Id- 8	Node Id – 10
AODV 10 M	0.0160101	0.0191562	0.0146359	0.00987417	0.00984079	0.0102166
AODV 20 M	0.0126071	0.0138767	0.0144702	0.00975211	0.00968695	0.00927061
AODV 30 M	0.0114435	0.0120946	0.0143427	0.010095	0.00979919	0.00900891
AODV 40 M	0.0108809	0.0114833	0.0144881	0.00988925	0.00991418	0.00907076
AODV 50 M	0.0105548	0.0110625	0.0143873	0.0097561	0.00992866	0.00896842
AODV 60 M	0.0103219	0.0107823	0.0143006	0.0097119	0.00991385	0.00890623
DSR 10 M	0.0143801	0.0128813	0.0168515	0.0110259	0.0118968	0.00896525
DSR 20 M	0.0132871	0.0120435	0.0167425	0.0108999	0.012225	0.00908535
DSR 30 M	0.0139884	0.0123065	0.0168801	0.0109	0.012832	0.00987566
DSR 40 M	0.0137442	0.0116727	0.0171152	0.0108615	0.0131109	0.00981112
DSR 50 M	0.0130992	0.0115303	0.0174768	0.0106425	0.0131292	0.00993814
DSR 60 M	0.0134538	0.0120752	0.0174126	0.0103557	0.0127904	0.0100756
DYMO 10 M	0.0117676	0.0107009	0.0172076	0.00953415	0.00898609	0.010164
DYMO 20 M	0.0137119	0.0120861	0.0171336	0.00937806	0.00934144	0.00952178
DYMO 30 M	0.0126126	0.0108569	0.0175132	0.00897801	0.00999894	0.00927959
DYMO 40 M	0.0124796	0.0112664	0.0177912	0.0088339	0.0101112	0.00908344
DYMO 50 M	0.0122646	0.0112358	0.0176006	0.00862079	0.0103709	0.00869211
DYMO 60 M	0.0120586	0.0112439	0.0174265	0.00862464	0.0104641	0.00849833

Table 4. Average end-to-end delay - CBR servers (in s)

	Node Id- 1	Node Id-2	Node Id-4	Node Id-6	Node Id-8	Node Id-10
AODV 10 M	0.037791	0.040142	0.019271	0.02803	0.024594	0.032154
AODV 20 M	0.036227	0.037641	0.019429	0.027156	0.024654	0.031331
AODV 30 M	0.035777	0.036878	0.019746	0.026835	0.024841	0.030972
AODV 40 M	0.035674	0.036422	0.019764	0.026614	0.024841	0.030699
AODV 50 M	0.035403	0.036115	0.01964	0.026516	0.024929	0.030631
AODV 60 M	0.03527	0.035966	0.019623	0.026421	0.025009	0.030648
DSR 10 M	0.03118	0.030539	0.021593	0.029778	0.031565	0.033912
DSR 20 M	0.031365	0.03189	0.021984	0.029407	0.02963	0.03374
DSR 30 M	0.030919	0.032802	0.022095	0.029433	0.028728	0.034659
DSR 40 M	0.030133	0.032854	0.022298	0.029196	0.028488	0.034501
DSR 50 M	0.030404	0.032715	0.022418	0.029435	0.028455	0.033423
DSR 60 M	0.031055	0.033245	0.022308	0.030094	0.02809	0.032662
DYMO 10 M	0.025849	0.034877	0.021698	0.032947	0.033871	0.035514
DYMO 20 M	0.027388	0.033651	0.021688	0.032758	0.03193	0.034061
DYMO 30 M	0.026507	0.033728	0.02174	0.032132	0.02997	0.033246
DYMO 40 M	0.026396	0.033787	0.021967	0.03185	0.028473	0.033269
DYMO 50 M	0.026057	0.032495	0.021999	0.031909	0.027391	0.03337
DYMO 60 M	0.025778	0.031615	0.021965	0.031876	0.026706	0.033485

Table 5. Comparison of Throughput for CBR Servers (in bits/s)

	Node Id-1	Node Id-2	Node Id-4	Node Id – 6	Node Id – 8	Node Id -10
AODV 10 M	3980	3911	4068	4084	4096	4096
AODV 20 M	4038	4004	4079	4090	4096	4096
AODV 30 M	4057	4034	4077	4092	4096	4096
AODV 40 M	4067	4050	4077	4093	4096	4096
AODV 50 M	4072	4059	4076	4093	4096	4096
AODV 60 M	4076	4065	4075	4094	4096	4096
DSR 10 M	4096	4096	4096	4097	4097	4097
DSR 20 M	4096	4096	4096	4096	4096	4096
DSR 30 M	4096	4096	4096	4096	4096	4096
DSR 40 M	4096	4096	4096	4096	4096	4096
DSR 50 M	4094	4094	4096	4096	4096	4096
DSR 60 M	4094	4094	4096	4096	4096	4096
DYMO 10 M	4057	4051	4037	4098	4096	4093
DYMO 20 M	4056	4053	4052	4097	4096	4094
DYMO 30 M	4067	4067	4051	4096	4096	4095
DYMO 40 M	4058	4064	4059	4096	4096	4095
DYMO 50 M	4066	4070	4062	4096	4096	4095
DYMO 60 M	4071	4074	4060	4096	4096	4095

Table 6. Energy consumed in Transmit Mode (in mJoule)

	Node Id-1	Node Id-2	Node Id -3	Node Id-4	Node Id- 5	Node Id 6	Node Id- 7	Node Id- 8	Node Id- 9	Node Id - 10	Node Id - 11
AODV 10 M	0.042059	0.071969	0.097609	0.039985	0.028824	0.005647	0.030659	0.036791	0.032058	0.007859	0.002513
AODV 20 M	0.075274	0.138441	0.20185	0.079392	0.056888	0.010824	0.058703	0.075156	0.062901	0.013019	0.002513
AODV 30 M	0.108424	0.204971	0.306382	0.118831	0.085003	0.015992	0.086904	0.113562	0.093996	0.018179	0.002513
AODV 40 M	0.14169	0.271424	0.411111	0.158386	0.113067	0.021165	0.115069	0.151867	0.124719	0.023339	0.002513
AODV 50 M	0.174891	0.337903	0.514152	0.197778	0.141126	0.026338	0.143454	0.190292	0.155755	0.028499	0.002513
AODV 60 M	0.208109	0.404327	0.618451	0.237289	0.169134	0.031506	0.171673	0.228508	0.186665	0.033667	0.002521
DSR 10 M	0.074003	0.044635	0.038347	0.006653	0.028864	0.00554	0.050775	0.089614	0.02881	0.021613	0.016722
DSR 20 M	0.111248	0.100645	0.079112	0.013592	0.057887	0.011138	0.098655	0.112498	0.094201	0.043698	0.08243
DSR 30 M	0.152609	0.182251	0.118692	0.020248	0.088743	0.049594	0.128397	0.149874	0.143463	0.04916	0.132988
DSR 40 M	0.205308	0.240151	0.159106	0.059388	0.11751	0.088335	0.159054	0.172279	0.192004	0.054669	0.167286
DSR 50 M	0.242251	0.280093	0.200884	0.083386	0.147991	0.094306	0.206288	0.178607	0.254333	0.108308	0.217198
DSR 60 M	0.286403	0.325706	0.254767	0.090192	0.188308	0.09984	0.299386	0.184458	0.283773	0.164286	0.250426
DYMO 10 M	0.107871	0.036517	0.039678	0.039288	0.028358	0.005398	0.099913	0.006029	0.02918	0.005701	0.000401
DYMO 20 M	0.198892	0.073644	0.079802	0.062001	0.056724	0.023607	0.186604	0.038155	0.057545	0.011138	0.005022
DYMO 30 M	0.265361	0.107785	0.120356	0.068603	0.084656	0.062236	0.247741	0.047431	0.119311	0.016363	0.036234
DYMO 40 M	0.334169	0.143874	0.161354	0.075477	0.112873	0.100662	0.309048	0.053066	0.172912	0.040127	0.059859
DYMO 50 M	0.400637	0.176959	0.200597	0.081882	0.140919	0.139013	0.370257	0.058226	0.200944	0.111592	0.059859
DYMO 60 M	0.467355	0.210082	0.239903	0.088338	0.168941	0.177355	0.431291	0.063394	0.228999	0.183179	0.059859

Table 7. Energy consumed in Receive Mode(in mJoule)

	Node Id-1	Node Id- 2	Node Id-3	Node Id -4	Node Id-5	Node Id-6	Node Id-7	Node Id-8	Node Id-9	Node Id-10	Node Id-11
AODV 10 M	0.26088	0.2387	0.2195	0.26254	0.27058	0.28799	0.26922	0.26489	0.26817	0.28635	0.29021
AODV 20 M	0.5158	0.46895	0.42158	0.513	0.52921	0.56382	0.52786	0.51609	0.52473	0.56219	0.56976
AODV 30 M	0.7714	0.6998	0.62407	0.76407	0.78844	0.84029	0.78703	0.7679	0.78174	0.83867	0.84996
AODV 40 M	1.02671	0.93048	0.82621	1.01484	1.0475	1.11654	1.04601	1.01958	1.03881	1.11493	1.12994
AODV 50 M	1.2811	1.1602	1.02865	1.26478	1.3056	1.39185	1.30387	1.27021	1.29469	1.39024	1.40897
AODV 60 M	1.53626	1.39073	1.23093	1.5154	1.56452	1.66792	1.56263	1.52177	1.55144	1.66632	1.68877
DSR 10 M	0.24428	0.26605	0.27059	0.29438	0.27766	0.29518	0.26138	0.23281	0.2777	0.28326	0.28677
DSR 20 M	0.51129	0.51914	0.53484	0.58401	0.55066	0.58578	0.52039	0.51059	0.5237	0.56162	0.53266
DSR 30 M	0.78389	0.76188	0.80864	0.88251	0.83098	0.86066	0.80152	0.78629	0.79033	0.86098	0.79846
DSR 40 M	1.03898	1.01309	1.07268	1.14779	1.1037	1.12621	1.07284	1.06397	1.04838	1.15118	1.06718
DSR 50 M	1.30553	1.27741	1.33549	1.42408	1.37493	1.41585	1.33164	1.35334	1.29598	1.40546	1.32411
DSR 60 M	1.57825	1.54907	1.60087	1.72467	1.65041	1.71735	1.56797	1.65462	1.57953	1.66954	1.60496
DYMO 10 M	0.21369	0.26663	0.26413	0.2647	0.27256	0.28981	0.21947	0.28935	0.27196	0.28959	0.29341
DYMO 20 M	0.43734	0.53026	0.52537	0.53915	0.54258	0.56758	0.4462	0.55679	0.54197	0.57683	0.58115
DYMO 30 M	0.67044	0.78736	0.77755	0.81681	0.80416	0.82145	0.68315	0.83243	0.77845	0.85548	0.84041
DYMO 40 M	0.90499	1.04618	1.03256	1.09742	1.0687	1.07862	0.92313	1.11394	1.02414	1.12354	1.10846
DYMO 50 M	1.13421	1.30018	1.28184	1.37135	1.32633	1.32882	1.15616	1.38876	1.28178	1.34917	1.387
DYMO 60 M	1.36354	1.55443	1.53136	1.64552	1.58426	1.57932	1.38959	1.66386	1.53968	1.575	1.66583

Table 8. Energy consumed in Idle Mode(in mJoule)

	Node Id-1	Node Id-2	Node Id-3	Node Id-4	Node Id-5	Node Id-6	Node Id-7	Node Id-8	Node Id-9	Node Id-10	Node Id-11
AODV 10 M	4.80505	4.8049	4.8049	4.805	4.8052	4.8052	4.8052	4.805	4.8052	4.8052	4.80527
AODV 20 M	9.6185	9.6182	9.618	9.6183	9.6188	9.6187	9.6187	9.6184	9.6187	9.6187	9.6189
AODV 30 M	14.4315	14.431	14.431	14.431	14.432	14.432	14.432	14.431	14.432	14.432	14.4321
AODV 40 M	19.2447	19.244	19.244	19.244	19.245	19.245	19.245	19.244	19.245	19.245	19.2454
AODV 50 M	24.0585	24.058	24.057	24.058	24.059	24.059	24.059	24.058	24.059	24.059	24.0594
AODV 60 M	28.8718	28.871	28.87	28.871	28.872	28.872	28.872	28.871	28.872	28.872	28.8729
DSR 10 M	4.80014	4.8003	4.8004	4.8004	4.8005	4.8004	4.8004	4.8	4.8005	4.8004	4.80046
DSR 20 M	9.60352	9.6036	9.6039	9.6039	9.604	9.6039	9.6038	9.6034	9.6038	9.6037	9.60368
DSR 30 M	14.4011	14.401	14.402	14.402	14.402	14.401	14.402	14.401	14.401	14.401	14.4012
DSR 40 M	19.2047	19.205	19.205	19.205	19.205	19.205	19.205	19.205	19.205	19.205	19.2049
DSR 50 M	24.0085	24.008	24.009	24.009	24.009	24.009	24.009	24.009	24.009	24.009	24.0087
DSR 60 M	28.8046	28.804	28.805	28.805	28.806	28.805	28.805	28.805	28.805	28.805	28.8048
DYMO 10 M	4.80361	4.804	4.8041	4.8039	4.8041	4.8041	4.8037	4.8041	4.8041	4.8041	4.80419
DYMO 20 M	9.60899	9.6097	9.6099	9.6096	9.6099	9.6098	9.6092	9.6097	9.6099	9.6099	9.61006
DYMO 30 M	14.4204	14.421	14.422	14.421	14.422	14.421	14.421	14.421	14.421	14.422	14.4216
DYMO 40 M	19.2296	19.231	19.231	19.231	19.231	19.231	19.23	19.231	19.231	19.231	19.2311
DYMO 50 M	24.0435	24.045	24.045	24.045	24.045	24.045	24.044	24.045	24.045	24.045	24.0454
DYMO 60 M	28.8573	28.859	28.859	28.859	28.859	28.858	28.858	28.859	28.859	28.858	28.8595