Performance Analysis of AODV, DSDV and ZRP Routing Protocols in WSN using Qualnet

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Abstract: A sensor network is a system that consists of thousands of very small stations called sensor nodes. The communication among nodes is done in a wireless fashion, and thus, the name of wireless sensor networks. Wireless sensor networks (WSN) have generated tremendous interest among researchers in recent years because of their potential usage in wide variety of applications. Nodes in WSN communicate with each other using different routing protocols. A variety of routing protocols have been proposed for wireless sensor networks in the past. Based on update mechanisms, they are classified into reactive, proactive and hybrid routing protocols. The performance of these protocols varies depending on the simulation environment. Many researchers have been working in this direction to evaluate the performance of these protocols in different simulation environments. The main aim of this paper is to compare the performance of three different protocols- AODV (Ad-hoc on demand distance vector routing), DSDV (Destination-Sequenced Distance-Vector Routing) and ZRP (Zone Routing Protocol) which constitutes a good combination of on-demand (reactive), table-driven (proactive) and hybrid protocols respectively. It is taken into account that these protocols are the best protocols in their respective domains due to their low overhead. The performance of these protocols will be analyzed in two ways. Firstly, by keeping no. of CBRs constant and varying nodes from 10 to 50. Another way is by keeping no. of nodes constant and varying no. of CBRs from 1 to 7. The evaluation is done by considering the performance metrics - throughput, jitter and average end to end delay. The simulator used is Qualnet 7.3.

Keywords: WSN, Routing protocols (AODV, DSDV, ZRP), Qualnet 7.3, nodes, CBR.

SECTION I – INTRODUCTION

A Wireless sensor network (WSN) is the collection of homogenous, self-organized nodes called sensor nodes. These nodes have the capabilities of sensing, processing and communication o data with each other wirelessly using radio frequency channel. The basic task of sensor networks is to sense the events, collect data and send it to their requested destination. The main problem in wireless sensor networking is the efficient transmission of data packets to the mobile nodes. Hence, proper routing in wsn is the challenge to the designers.

To identify and select best routing protocol for an application, it is required to understand the strict demands of that application first and then to select the appropriate protocol to be implemented and simulated. There are several routing protocols developed for WSNs. All these routing protocols have different competing features and qualities. Therefore, the selection of correct routing protocol is vital. Based on the route selection classification, WSN protocols can be categorized in three parts i.e. proactive, reactive and hybrid. Many routing algorithms have been proposed for proactive and reactive approach and as well as for hybrid approach [1]. In proactive routing approach it continuously evaluates the path of the network, so whenever it needs to send the packets in the network the routes is already known and can send immediately. Reactive routing protocol invokes the route only when it is required. So route determination required more time as compared to proactive protocol. Because of larger delay and control traffic it is not applicable to the real-time system. Hybrid routing is the combination of proactive and reactive approach and it make use of proactive to determine the early routes in its internal zone whereas uses the reactive approach in its intra-zone, that is communicating between inter-zone of the network. ZRP uses the hybrid routing approach.

The performance comparison for all the approaches is presented in this paper. Routing protocol DSDV is for proactive, AODV is for reactive and ZRP for Hybrid are well-known approaches in their respective domains. The parameter throughput, end-to-end delay and jitter are examined for each of the approaches Finally, the simulation results of protocols implemented on Qualnet 7.3 are concluded here.

The rest of the paper is organized as follows: section- II gives a brief description about classification of various routing protocols. Section III consist of Simulation setup and environment which gives a detailed description of our proposed work. Section IV gives the description of various Performance Metrics used in our work. Then, Section V is Results and Discussion in which all the results are provided in the form of graph. Finally, conclusion and future scope are presented in section VI.

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SECTION II - CLASSIFICATION OF WSN ROUTING PROTOCOLS

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Routing is a method to choose the best path from source to destination to send data packets in a network. The WSN routing protocols can be classified into large number of routing protocols based on different criteria's. Based on the routing information update mechanism, there are three different types of routing protocols namely- Proactive or table driven routing protocol, Reactive or on-demand routing protocol and Hybrid routing protocol.[2] This classification of protocol is based on how the source node finds a route to a destination node. Classification based on Route selection or routing information update mechanism is shown below in figure 1.
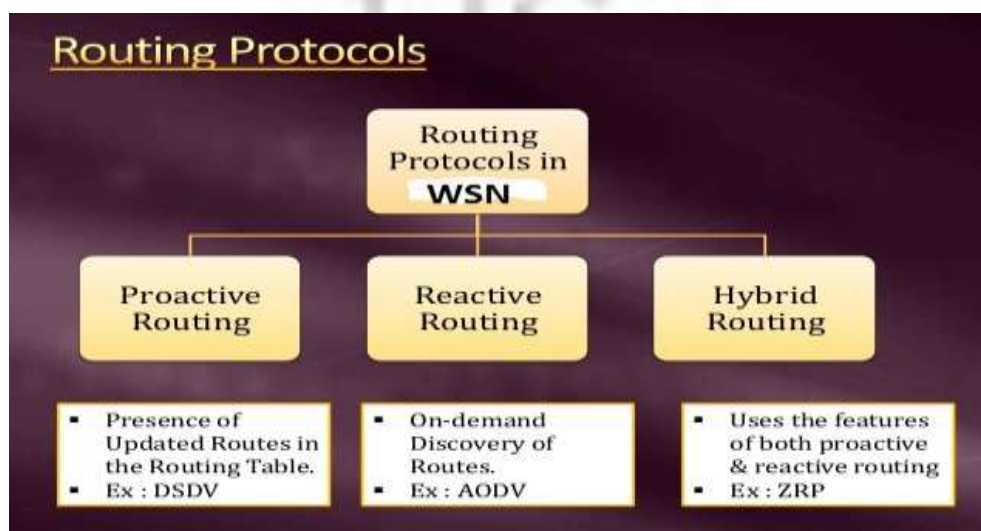

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Figure 1 : Classification of Routing Protocols

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1) **Proactive Protocol**: Proactive routing protocols are also known as table driven protocols.Here each node maintains a routing table for keeping the updated route information of others nodes [3]. This routing information is flooded in the whole network. Whenever the network topology changes, the corresponding update needs to be done throughout the network. This category of protocols has large bandwidth and more memory requirements making them more suitable for wired networks only. Destination Sequenced Distance-Vector Routing protocol (DSDV), Optimized Link State Routing Protocol(OLSR*),* Fisheye State Routing(FSR), and Source- Tree Adaptive Routing protocol (STAR) are some examples of proactive protocols. The chosen protocol in this category is DSDV.

DSDV

DSDV (Destination Sequenced Distance-Vector Routing protocol) is an enhanced version of the distributed Bellman-Ford algorithm, where each node maintains a table that contains the shortest distance and the first node on the shortest path to every other node in the network. It incorporates table updates with increasing sequence number tags to prevent loops, to counter the count-to-infinity problem and for faster convergence. As it is table driven routing protocol, correct route to any node in the network is always maintained and updated. The tables are exchanged between neighbors at regular intervals to keep an up to date view of the network topology. The tables are also forwarded if a node finds a significant change in local topology. This exchange of table imposes a large overhead on the whole network. To reduce this potential traffic, routing updates are classified into two categories.

The first is known as "full dump" which includes all available routing information. This type of updates should be used as infrequently as possible and only in the cases of complete topology change. In the cases of occasional movements, smaller

"incremental" updates are sent carrying only information about changes since the last full dump. Each of these updates should fit in a single Network Protocol Data and thus significantly decreasing the amount of traffic. Table updates are initiated by a destination with a new sequence number which is always greater than the previous one. Upon receiving an updated table a node either updates its tables based on the received or holds it for some time to select the best metric received from multiple versions of the same information update from different neighbors. The availability of routes to all destinations at all times implies that much less delay is involved in the route setup process.[4] The mechanism of incremental updates with sequence number tags makes the exiting wired network protocols adaptable to mobile ad hoc networks. Hence, an existing wired network protocol can be applied to mobile ad hoc networks with fewer modifications. DSDV suffers from excessive control overhead that is proportional to the number of nodes in the network and therefore is not scalable in mobile ad hoc networks. Another disadvantage is stale routing information at nodes.

2) **Reactive protocol:** It is also called On Demand routing because it establish a route to destination whenever a node has something to send thus reducing burden on network. In this case protocols do not maintain network topology information. When a source wants to send data to the destination, it invokes the route discovery mechanisms to find a path to the destination. Hence the routes are created on demand and table updating is not required here. [5]This type of protocols is more suitable for ad hoc network as they do not have large memory and bandwidth. In comparison to Table Driven routing protocols the routing delay in this case is quite high since the routes are created when required. Some examples of reactive protocol are Dynamic State Routing protocol (DSR), Ad hoc On-Demand Distance Vector Routing protocol (AODV), associativity-based routing *(ABR)* and Location-Aided Routing *(LAR)* . The protocol taken into consideration is AODV.

AODV

The AODV (Ad hoc On-Demand Distance Vector Routing protocol) uses on-demand approach . Periodic exchange of routing information does not take place in this protocol. Here neighbour nodes store the route information of its next hop neighbour only. This protocol is based on two mechanisms i.e. route discovery and maintenance. AODV nodes use four types of messages to communicate among each other. Route Request (RREQ) and Route Reply (RREP) messages are used for route discovery. Route Error (RERR) messages and HELLO messages are used for route maintenance. The destination sequence number is used to make this routing protocol loop free and identify the most recent path. When route for destination is not available, the source floods the Route Request packet in the network. It consists of source identifier, destination identifier, source and destination sequence number, broadcast identifier and time to live field.[6] When a node has to send data and wants a path to the destination, it sends Route Request message to the next neighbour node. The node which receives this message either forwards it to the next node or sends a Route Reply message if it has a path to the destination. AODV does not repair the broken links locally. When a link breaks between any two nodes, they send a Route Error message to inform the end nodes about the link break and this link is removed from the table of the end nodes. Once again the source starts the path finding process with a new broadcast ID and old destination number.

The main advantage of AODV protocol is route is discovered and identified on demand. The count- to-infinity and loop problem is solved with sequence numbers. The disadvantage of AODV is poor scalability and unnecessary bandwidth consumption, due to periodic beaconing [7].

3) **Hybrid Routing Protocol:** These protocols use the best features of both the reactive and proactive routing protocols. Here the network is divided into small clusters or zones [8]. Within a particular zone the proactive routing scheme is used whereas the reactive routing scheme is used outside the zone. Some examples of this protocol are Zone Routing protocol (ZRP) and Zone-Based Hierarchical Link State Routing Protocol (ZHLS). ZRP is chosen in this category.

ZRP

ZRP combines the best features of both Table driven and on-demand routing protocol. The Zone Routing Protocol (ZRP) divides the network into zones. A zone of a node has all the nodes lying within a certain zone radius which is defined in hops. ZRP consists of two sub-protocols [9], a proactive routing *i.e.,* the intra zone routing protocol (IARP) is used inside the zone; while the reactive routing protocol *i.e.,* inter-zone routing protocol (IERP) is used outside the zone.
Each node, using IARP, maintains the information about routes to all nodes within the routing zone by exchanging route update packets periodically. Larger the zone, higher is the update control traffic. The IERP finds path for nodes not within the routing zone by using information of every node's routing zone. If a packet has to be sent from a source to destination where both belong to the same zone, the packet can be sent directly. Else if the destination is not inside the zone, then the source bordercasts Route Request message to the peripheral nodes. If the destination is within the zone of the peripheral nodes, they add their address to it and send back the Route Reply packet to the source. Otherwise they resent Route Request

packet to the peripheral nodes of their zone. This process continues till the destination node is not found. Once the source receives the Route Reply packet along with the path given, it uses this path to send the data to the destination. Hence ZRP reduces control overhead by avoiding unnecessary flooding of Route Request packets. The disadvantage is the lack of route optimization. Decision of zone radius is also an important factor for efficiency.

SECTION III - SIMULATION SETUP AND ENVIRONMENT

The analysis and comparison of protocols can be done by testbed, real world experiments or simulation. Since simulation is cheaper and feasible so most research work of Wireless Sensor Networks is conducted using simulation software. It eliminates the need for time consuming and costly real world experiments. The simulator used in my analysis is Qualnet-EDU 7.3 that predicts wireless, wired and mixed platform network and networking device performance. The reason for choosing this software is its accuracy, speed and portability.

The main motive of this paper is to compare the performance of AODV, DSDV and ZRP in different simulation environments. The comparison was made by varying the node density and the simulation environment one at a time and keeping all the factors to be constant. The simulation was carried on an area of size 1500*1500 sq units. The node density was varied from 10 to 50 nodes. In the scenario UDP (User Datagram Protocol) connection was used and data traffic of Constant bit rate (CBR) was applied between source and destination. The multiple CBR applications were applied varied from 1 to 7 CBR. Each simulation was carried out for 30 seconds. The performance metrics used for comparison were throughput, end- to-end delay, and jitter. Various parameters and their description is summarized below in the table given:

Table 1 : Table for Simulation Parameters

PARAMETERS	DESCRIPTION
Network Simulator	Qualnet 7.3
Protocols Studied	AODV,DSDV,ZRP
Size of region	1500*1500 sq.units
Shape of region	Square
Mobility Model	Random Waypoint
No. of Nodes	10,20,30,40,50
Placement of Nodes	Random
Antenna Model	Omnidirectional
Traffic Source	CBR(Constant Bit Rate)
No. of CBR	1,3,5,7
Packet Size	512 bytes
Simulation Time	30 sec.
Radio Type	802.11b
MAC Protocol	802.11
Channel frequency	2.4 GHz
Data Rate	2 Mbps

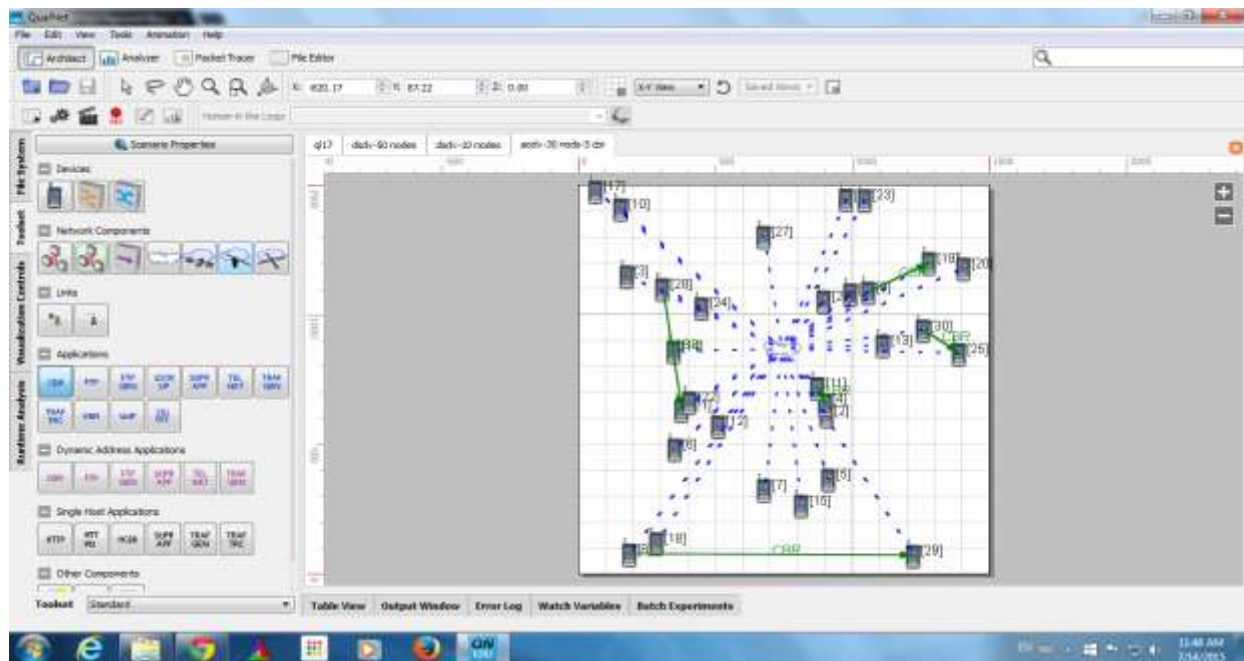The **snapshot of the simulation** keeping 30 nodes and 5 CBR is shown below.

Figure 2 : Simulation Scenario

SECTION IV - SELECTED PERFORMANCE METRICS FOR EVALUATION

In order to check the protocols performance in terms of its effectiveness there are different metrics to be used. In our study, we use Throughput, Jitter and End-to-End delay for protocols evaluation. The metrics that we selected for performances evaluation are as follow:[10]

i) **Average End-to-End Delay (AED):** Average End-to-end delay refers to the time taken for a packet to be transmitted across a network from source to destination. A data packet may take longer time to reach to the destination due to queuing and different routing paths.[11] Formula for AED –

$$AED = \frac{\sum_{i=0}^{n} Time\ Packet\ Received_i - Time\ packet\ sent_i}{Total\ Numbe\ of\ Packets\ Received}$$

ii) **Throughput**: Throughput is the average rate of successful message delivery over a communication channel. The throughput is usually measured in bits per second (bit/sec), and sometimes in data packets per second or data packets per time slot. High throughput is always desirable in a communication system.
It can be expressed mathematically:

$$Throughput\ (bytes/sec) = \frac{Number\ of\ delivered\ packets * Packet\ size * 8}{Total\ Duration\ of\ Simulation}$$

iii) **Jitter**: Jitter is the variation in delay by different data packets that reached the destination and can seriously affect the quality of audio/video and thus an unwanted parameter. Jitter should be small for a routing protocol to perform better.[12]

SECTION V - RESULTS AND DISCUSSION

The Qualnet 7.3 network simulator is used to analyze the performance of AODV, DSDV, and ZRP. The animation of nodes mobility and transmission of data of one of the scenario is shown in Figure 3.
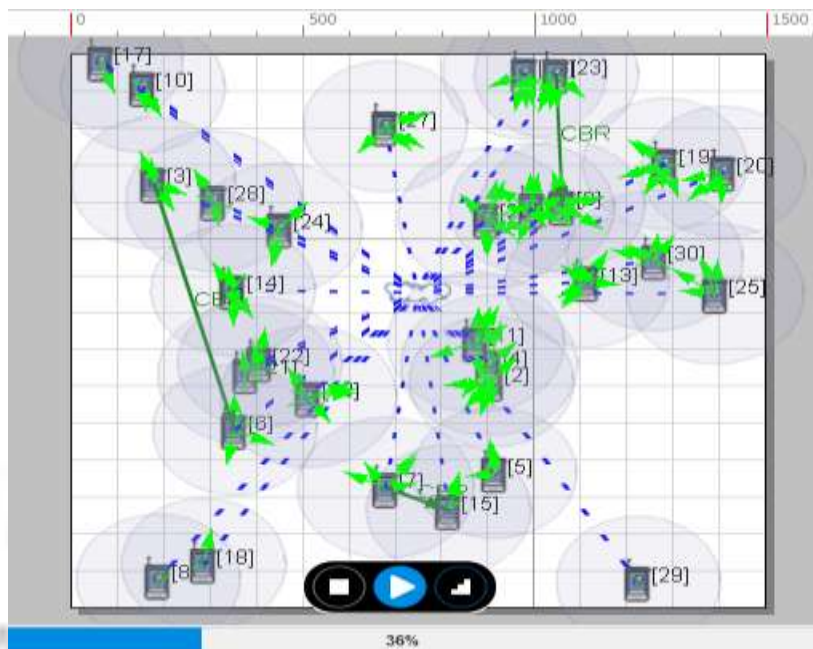

Figure 3.   Running Simulation Scenario

Our study is divided in two conditions. Acc. to first condition, no. of nodes are varied keeping CBR constant and in second condition, no. of CBR's are varied keeping nodes constant.

Condition 1 - CBR CONSTANT AND NODES VARIED

In this experiment, no. of CBR remains constant i.e. 3 CBR but nodes are varied from 10 to 50. Various results are obtained by comparing all the three protocols. Different Scenarios are created by firstly taking 10 nodes then, 20 nodes, then 30 and upto 50 nodes.

After the simulation of all the scenarios which has been created by varying the no. of nodes from 10 to 50 and keeping CBR constant, various results are obtained. All the results are analysed and briefed in the form of graphs given below.
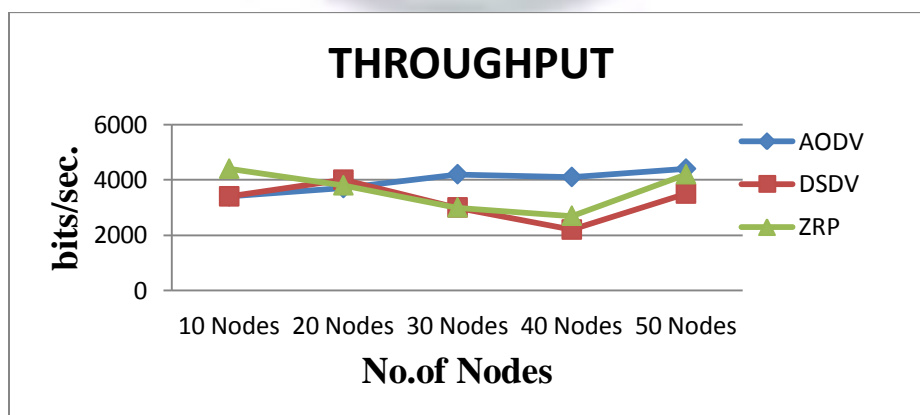
Throughput-

Here, we notice that as the no. of nodes increases, value of throughput for AODV also goes increasing but in case of DSDV and ZRP throughput decreases as the no. of nodes decreases except when nodes are 50. So, overall we can say that AODV is the most preferred routing protocol for larger networks in terms of throughput.

AED and Jitter-
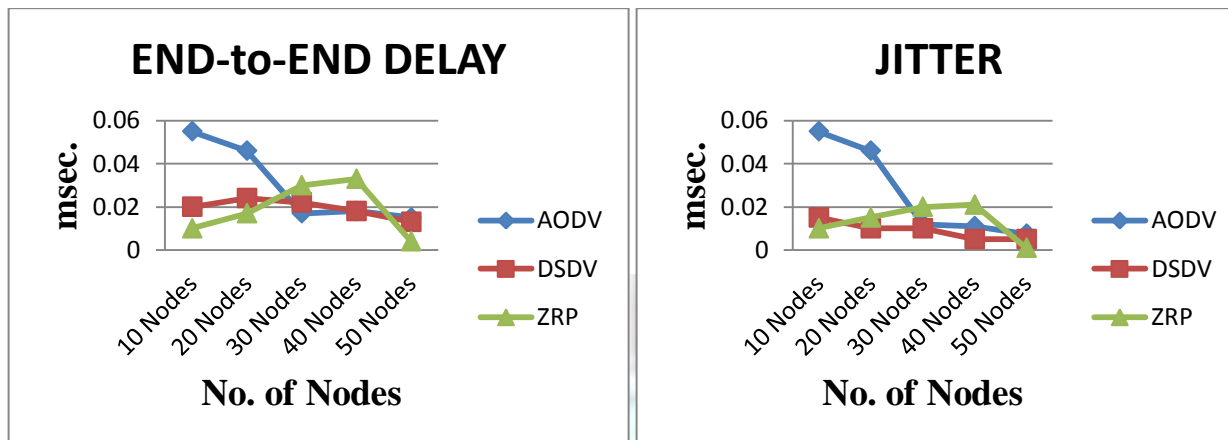
Here, we notice that as the no.of nodes increases, value of AED and Jitter for AODV and DSDV goes decreasing but in case of ZRP, these parameters increases as the no. of nodes increases except when nodes are 50.This behavior of ZRP is due to its hybrid nature because for smaller no. of nodes, it behave as a Proactive Routing Protocol but for larger networks, it distributes the nodes into different zones and hence, due to IERP effect, it behave as a Reactive Routing Protocol. So,overall we can say that AODV is the most preferred routing protocol for larger networks in terms of AED and Jitter because its these parameters decreases more sharply than DSDV.

Condition 2 - NODES CONSTANT AND CBR VARIED

In this experiment, no. of nodes remains constant i.e. 30 nodes but no. of CBR are varied from 1 to 7. Various results are obtained by comparing all the three protocols. Different Scenarios are created by firstly taking 1 CBR then, 3 CBR then, 5 CBR and at last 7 CBR

After the simulation of all the scenarios which has been created by varying the no. of CBR's from 1 to 7 and keeping nodes constant, various results are obtained. All the results are briefed in the form of graphs given below.
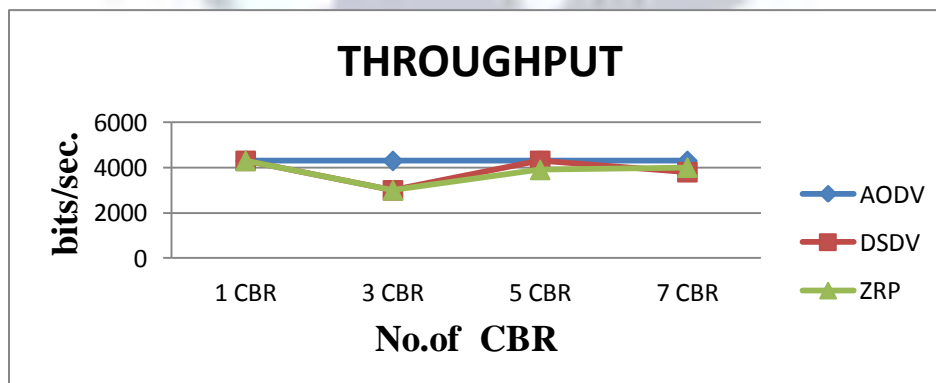
Throughput-

Here, we notice that value of throughput for AODV remains constant as the no. of CBR increases but in case of DSDV and ZRP throughput show many variations i.e. sometimes it decreases and sometimes increases but through deep analysis, we can also notice that despite constant behaviour of AODV, its value for throughput always remain on the top in comparison to DSDV and ZRP. Hence we can conclude that AODV is the best protocol in terms of throughput. It does not depend on the no. of CBR's.

AED and Jitter-
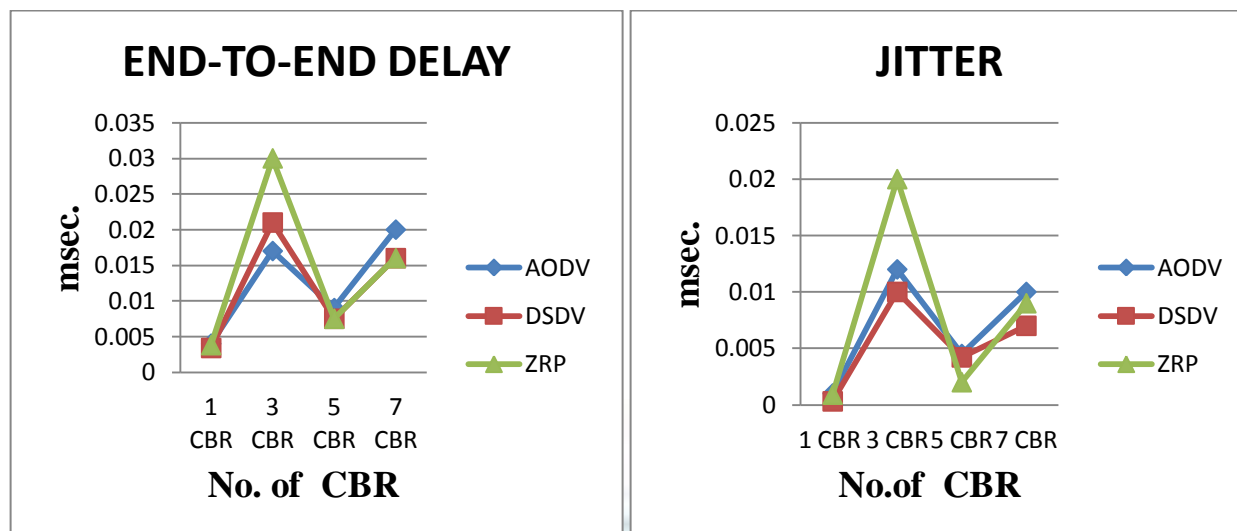
In case of AED and Jitter, value of these parameters varies frequently as we change no. of CBR's. For each protocol, value of AED and Jitter increases in case of 3 CBR, decreases in case of 5 CBR and it again increases as the no. of CBR's increases from 5 to 7. So, it seems very hard to find any conclusion but by doing deep analysis of graphs, we notice that ZRP has highest AED and Jitter in comparison to AODV and ZRP. Hence, ZRP is worst protocol in this case.

SECTION VI - CONCLUSION AND FUTURE SCOPE

On the basis of our results, we analyzed and proved that AODV is more reliable protocol in terms of delay and throughput than DSDV and ZRP. Network size has no considerable effect on AODV performance with respect to throughput but it does affect ZRP. In some scenarios, Routing protocol DSDV has also performed good even than AODV. However, not all of these protocols are efficient enough to fulfill all desired features of WSNs applications.

From the conducted study on selected protocols, we conclude that no one protocol is superior with respect to overall performance. The performance of one protocol may be far better in terms of delay other may be superior in terms of throughput. Secondly, network type and size of network also matters for protocols performance. Therefore, choice for selecting particular routing protocol will depend on application type (expectation from network) and intended use of network

Future Scope

Wireless Sensor Networks is rather an emerging and hot concept in wireless communication which means that a lot of research is going on and many issues are subjected to be investigated in this field. Due to the time limitations, our focus was only on some of the routing protocols during our study. Though, there are many other routing protocols that are still that need to be analysed. There are different design issues in WSN, like node deployment, heterogeneity, localization and synchronization which need to be explored further. Also, Protocols security should be investigated with respect to various natures of attacks to which wireless communication is considered as an attractive target.

REFERENCES

[1].   S. Gobriel. "Energy-efficient design of ad-hoc and sensor networks", M.Sc, University of Pittsburgh, 2008.
[2].   M. N. Elshakankiri, M. N. Moustafa and Y. H. Dakroury. "Energy Efficient Routing Protocol for Wireless Sensor Networks," in International Conference on Intelligent Sensors, Sensor Networks and Information Processing, Dec. 2008, pp. 393 – 398.
[3].   Jorjeta G.Jetcheva and David B. Johson, "A Performance Comparison of On-Demand Multicast Routing Protocols for Ad Hoc Networks," school of computer science, computer science department, Pittsburgh, December 15, 2004.
[4].   M.N Sree Ranga Raju and Dr. Jitendranath Mungara," Enhanced ZRP Protocol for Mobile Ad-hoc Networks", International Journal of Wireless & Mobile Networks (IJWMN) Vol. 3, No. 4, August 2011.

[5]. Elizabeth, Royer, Chai-Keong, Toh: A Review of Current Routing Protocols for Ad Hoc Mobile Wireless Networks, April 1999, IEEE Personal Communications

[6]. Perkins, C. E., Bhagwat, P.: Highly Dynamic Destination-Sequenced Distance-Vector Routing (DSDV) for Mobile Computers, October 1994, Computer Communications, pp. 234-244

[7]. Perkins, C. E., Royer, E. M.: Ad-hoc On-Demand Distance Vector Routing, February 1999, Proc. 2nd IEEE Workshop on Mobile Computer Systems and Applications, pp. 90-100.

[8]. Pearlman, Marc R., Haas, Zygmunt J.: Determining the Optimal Configuration for the Zone Routing Protocol, August 1999, IEEE Journal on Selected Areas in Communications, Vol. 17, No. 8.

[9]. G. GELETA, "Performance Evaluation of Wireless Sensor Network Routing Protocols for Critical Condition Monitoring Applications," Department of Computer Engineering, Addis Ababa University, Oct, 2007.

[10]. F.L. Lewis, "wireless sensor network," Technologies Protocols and Applications, New York, 2004

[11]. Neha Rathi, Jyoti Saraswat and Partha Pratim Bhattacharya," A Review On Routing Protocols For Application In Wireless Sensor Networks", International Journal of Distributed and Parallel Systems (IJDPS) Vol.3, No.5, September 2012.

[12]. Shio Kumar Singh, M P Singh, and D K Singh," Routing Protocols in Wireless Sensor Networks – A Survey", International Journal of Computer Science & Engineering Survey (IJCSES) Vol.1, No.2, November 2010.