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Cross Layer Routing Protocol in WSN - Performance analysis

Lokesh S[1*], Yuvaraju B N[2]

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Abstract–Wireless Sensor Network (WSN) is a self-configuring network of small sensor nodes communicating among themselves using radio signals and deployed in quantity to sense, monitor and understand the physical condition. In this paper, much of interest is shown towards the design of WSNs by using cross layer Adaptive Dynamic Retransmission technique. The objective of the work is to compare the performance of the DSR (Dynamic Source Routing) and PSR (Proactive Source Routing) protocol with the proposed work. The DSR and PSR protocols consumes more energy, hence it is required to design an energy efficient routing protocol for WSN. The performance of above mentioned techniques is compared on basis of parameters such as Throughput, Packet Delivery Ratio, Packet Loss Ratio and End to End Delay. Mechanism of the proposed work is adapted to transmit power between two nodes and to utilize the transmitted energy efficiently by making use of adaptive Dynamic Retransmission technique.

Keywords–Wireless Sensor Networks (WSN), Cross Layer Protocol (CLP), Adaptive Retransmission, Dynamic Source Routing (DSR), Destination Sequenced Distance Vector (DSDV)

I. INTRODUCTION

A Wireless Sensor Network (WSN) is one of the most important technology in the present scenario all over the world. It consists of large number of low power, low cost, and multifunctional wireless sensor nodes with computational and wireless communication capabilities. Efficient design and implementation of WSN is required for applications as shown in Fig.1.1 such as medical monitoring, environmental monitoring, surveillance, home security, military operations and industrial machine monitoring. After getting the physical data from the mentioned applications was difficult or impossible by means of conventional ways. But WSN makes it easy.

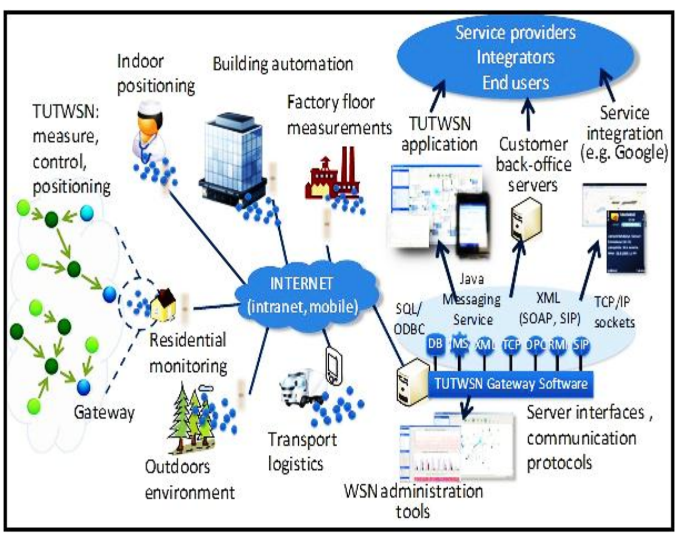

Fig.1.1 Applications of WSN

The working model of WSN node generally consists of sensor, microcontroller, transceiver and limited power source (battery). The microcontroller processes and stores the sensor output. The communication is established through transceiver commands from a central computer and transmits data to that computer. The communication system that is utilized to transmit the information between sensor nodes is a major functional block in every WSN. Practically communication system design is aided by well-defined conceptual framework called Open System Interconnection (OSI) reference model or TCP/IP protocol suit that shows the importance of layered architecture. However the layering architecture is not always suitable for WSN applications.

In this paper details of cross layer routing protocol using adaptive dynamic retransmission technique is presented. The WSN node senses the information from the environment and sends it to destination directly or with the help of intermediate nodes. If the destination node is in sensing range then source delivers the data packet directly otherwise delivers to intermediate node. During the data failure or intermediate node failure the previous node present in the route will recalculate the maximum number of retransmission and resend the data. The retransmission limit calculation is done by previous limit and the number of hops left to reach the destination.

In this paper the section I introduces the cross layer, section II discusses about the literature that referred in this work, section III explains the methodology used in the implementation of cross layer protocol design, section IV indicates the performance analysis of the cross layer protocols along with the PSR and DSR and section V gives conclusion.

II. LITERATURE REVIEW

There are many Energy Efficient Cross Layer Protocols are available in the market which can be used for implementation of WSN. Different Energy Efficient Cross Layer Protocols are used with their features and limitations.

1) Virtual MIMO and ETE (End to End) Quality of Service (QoS) Provisioning based Cross Layer Design[1] that improves energy efficiency, reliability and provides ETE QoS guarantee.
2) Adaptive Dynamic Retransmission Technique based Cross Layer Routing Protocol ADRTCLRP [2] which reduces energy consumption by saving energy and improves network lifetime and performance.
3) A Hop-by-hop Cross Layer Congestion Control Scheme [3] reduces Packet Loss Ratio, increases Throughput, stable source transmission rate, and increases energy efficiency.
4) Multi-hop cross layer design: Wise MAC, Minimum Delay Routing [4] achieve performance gains with respect to Throughput, Latency and Energy Conservation.
5) Adaptive Scalable Cross Layer Frame work for Multi-hop WSN [5] provide high resolution, improves energy efficiency and reliability.
6) A novel Dynamic Clustered and Cross layer Cooperative approach [6] shows energy efficiency is good in virtual clustering than real clustering.
7) Cross Layer Design for energy conservation in WSN: Joint Optimization [7] balancing the traffic inside the network efficiently and achieves energy conservation.
8) Energy Efficient Dynamic Source Routing Protocol [8] improves packet delivery ratio, throughput and reduces packet loss ratio.
9) PSR: A Lightweight Proactive Source Routing Protocol for Mobile Ad Hoc Networks increases the energy efficiency and security.

Out of many Cross Layer approaches Adaptive Dynamic Retransmission Technique is selected in this paper for increasing energy efficiency of WSN. This cross layer protocol is also compared with traditional PSR and EEDSR algorithms.

III.CROSS LAYER ROUTING PROTOCOL

In the ISO-OSI layering, the lower three layers such as PHY, MAC and routing are mainly responsible for data transmission between source and destination. The intermediate node is considered for retransmission and compute new limited number of adaptive retransmission method during route failure. All the nodes in a network are capable of receiving and transmitting packets from source to destination. Between source and destination a node with the largest distance from the source is selected as an intermediate node. There is no guarantee of delivering of the packets to the intended destination or receiver due to interference or noise problem. The loss of information also occurs due to packet collision. The protocol is designed to limit number of retransmission of the lost packets [2].

a. Tracking of destination location

In order to trace the exact location of the destination the source node (S) sends the Route_Request (RR) message to destination node (D), if destination node (D) is within the sensing range of Source node (S). If destination node (D) is ready to receive the data it sends back ACK to Source node (S). Then source node (S) sends the intended data to the destination node (D). When destination node (D) receives the data successfully, it sends back the data delivery confirmation ACK to source node (S). If destination node (D) is not in sensing range, Source node (S) waits destination node (D) to be in ready state. If source node (S) does not receive any ACK message with in the fixed time interval, it resends the Route_Request (RR) message. Within this time interval other nodes are kept in sleep state.

b. Finding the route of destination node

Source node (S) has a data to send to destination node (D) but, destination node (D) is not in the sensing range of source node (S). Then the source node (S) finds an intermediate node and issues a Route_Request (RR) message. Its length must be as small as possible. The intermediate node sends confirmation ACK message to source node (S). If the fixed time limit for receiving an ACK message gets over then source node (S) resends the Route_Request (RR) message. If two or more nodes have same maximum distance from source node (S) then it sends Route_Request (RR) message to all the nodes. After receiving the Route_Request (RR) message, all the nodes sends back an ACK message along with their power level information to source node (S). Now, the node with maximum energy has been selected as an intermediate node and receives the data from source node (S) and replies with ACK message to confirm the data reception. The nodes that are not involved in data transmission goes into sleep mode, thereby energy conservation can be achieved. Until the destination node (D) is found the above explained procedure must repeat. Fig.2 shows the graphical representation of tracking exact location and finding the route to destination node from source node.

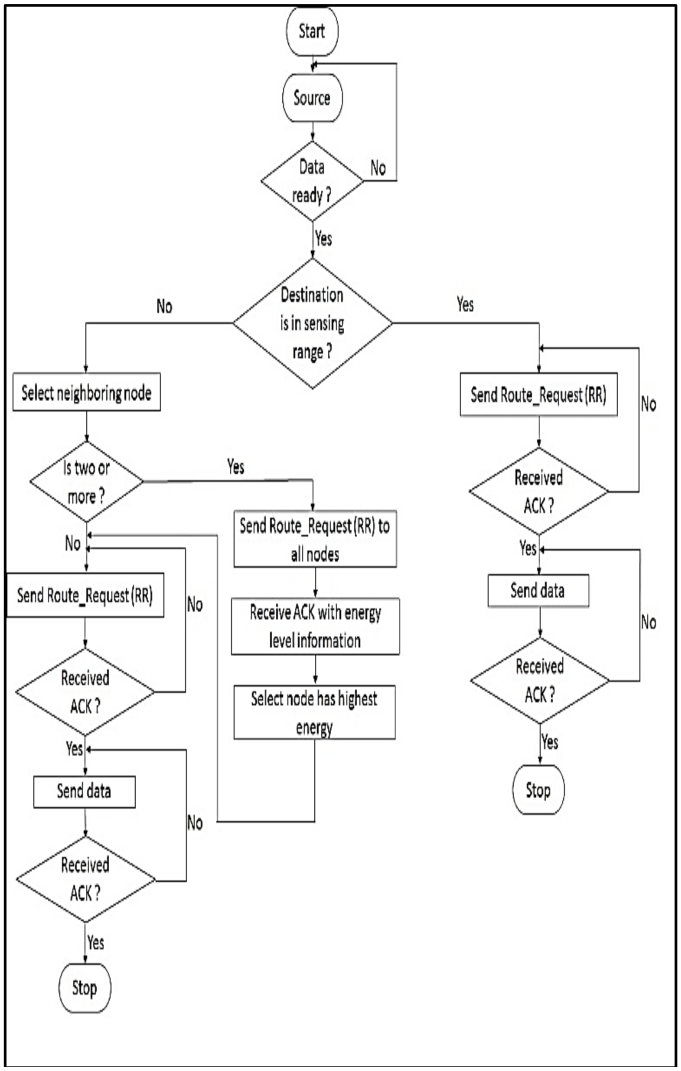

Fig.2. Finding the route to the destination node

c. Adaptive retransmission technique

Adaptive retransmission technique is based on information about destination route and number of hops to determine the frequency of retransmission. When the source node (S) sends data to destination mode (D), there is a possibility of loss of information due to collision in intermediate node. Now, source node (S) has to resend the data and required to check the number of hops to destination node (D). The maximum value is set and retransmission of the data would have done. If any of the intermediate node fails then, it has to recalculate the frequency of retransmission depending on its position from the source node and the number of hops left from the destination. In this technique more chance is given to the success of packets that had approached to the destination. Hence effective bandwidth utilization can be achieved by taking care of nodes nearer to the destination by considering following factors like link quality, transmission probabilities and number of neighbours. This makes the protocol flexible.

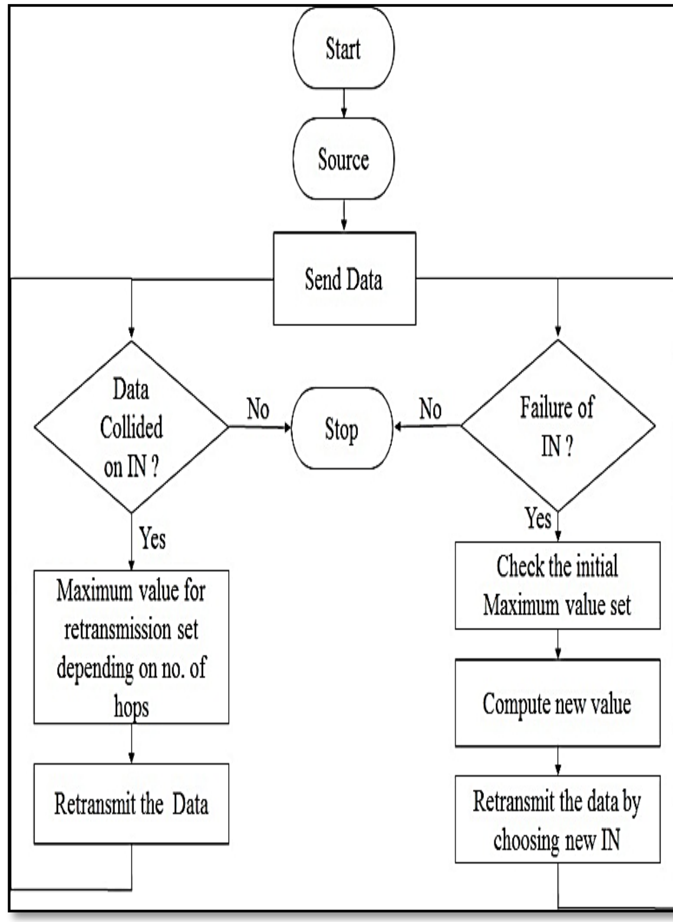

Fig.3. Flow Diagram of energy efficient cross layer protocol design under data collision

IV. PERFORMANCE ANALYSIS

a. Simulation Environment

The performance analysis of cross layer protocol with adaptive retransmission is presented in this section. NS2 simulator is an open source of ISI that is used to carry out the simulation experiments. NS2 is an object oriented, discrete event simulator for networking research. NS2 provides substantial support for simulation of TCP, routing and multicast protocol over wired and wireless networks. The NS2 simulator also supports simulation of energy-efficient protocol and helps to accurately model the power consumption by applications.

Simulation is carried out by deploying 60 nodes in simulation environment. The sink node is chosen in such a way that it should be far from the sensing range of source node after randomly chosen source node. Thus each simulation is run for around 15seconds. The results are averaged in 15 runs. The performance analysis is carried with the PSR and DSR routing protocols.

b. Simulation Parameters

There are a number of parameters that can become design metrics or performance parameters in Wireless Sensor Networks. Each and every parameters has its own significance. These design metrics are used to analyse the wireless routing protocols. The following parameters are considered as performance parameters in this work.

- Energy Efficiency
- Throughput
- Packet delivery Ratio
- Packet loss Ratio
- End-to-end Delay

The evaluation of design metrics/ performance parameters is done by considering duty cycle and number of sensing nodes with respect to routing protocols.

c. Simulation results and Analysis

The energy efficiency is the very important design metric among five parameters considered. The simulation is carried with all the three protocols like PSR, DSR and CLP to measure the total energy consumption of source nodes for successful data transmission.

Fig.4 shows the energy efficiency in each protocol v/s number of nodes. It also clearly indicates that the Cross Layer Protocol (CLP) utilizes less amount of energy than the PSR and DSR routing protocols. The cross layer protocol uses the cross layer information from MAC, routing layers and reduces the information exchange between the layers. All the protocols start losing the energy consistently, as the number of nodes increases. But, the cross layer protocol makes more nodes in sleep state that reduces the energy consumption. However, the PSR and DSR protocols continue to keep nodes asleep, fails to optimize the transmission energy, because it uses same transmission power in all communication links.

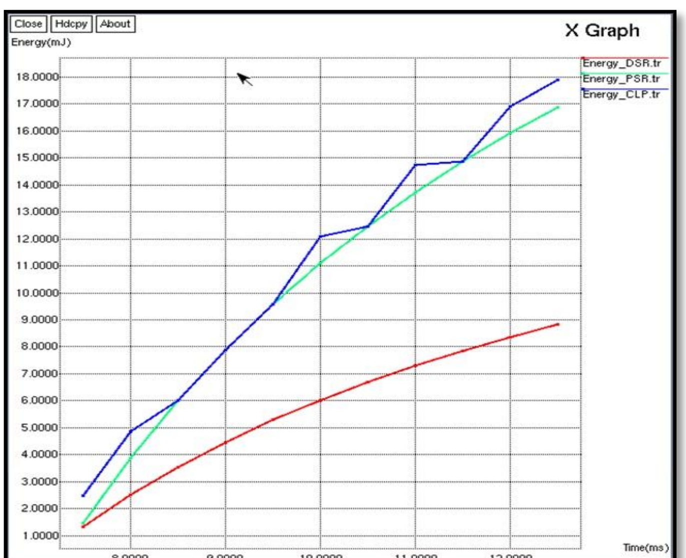

Fig. 4. Energy Efficiency analysis

In PSR protocol nodes create a routing table and updates for every interval, even if it hasn't any changes in the topology of the network. So, it requires more amount of energy to maintain. The DSR node wakes up from sleep mode even if the node hasn't any activity, because of fixed listening consumes more energy. Therefore the cross layer protocol effectively reduces the energy consumption than PSR and DSR protocols.

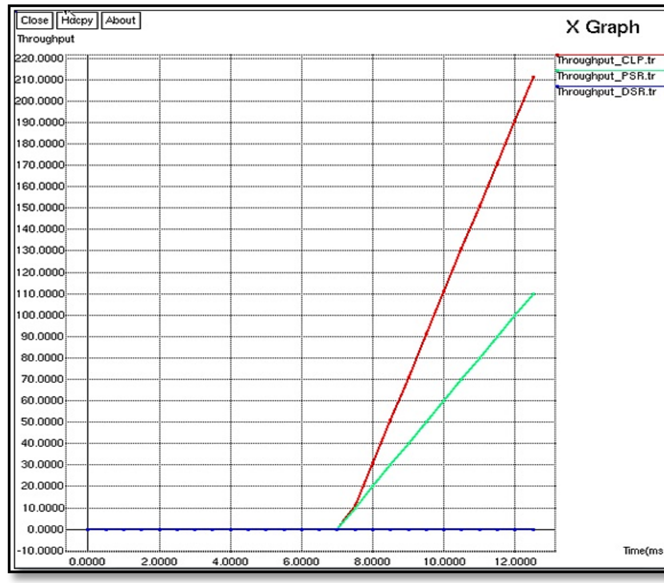

Fig. 5. Network throughput analysis

Another design metric used as a parameter to analyse the performance of the Cross Layer Protocol is Throughput. Fig.5 indicates that the Cross Layer Protocol has higher throughput than the other protocols PSR and DSR.

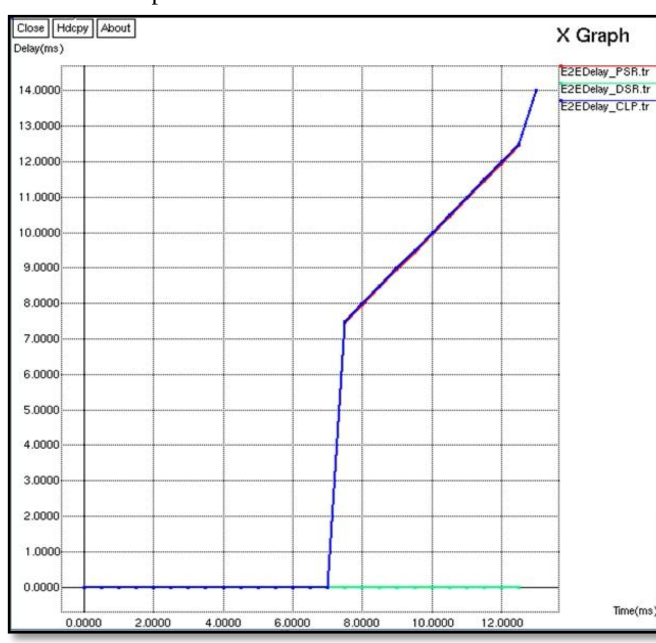

Fig. 6. End-to-end delay analysis

PSR maintains fresh list of destination nodes and its routes periodically. The time is required for restructuring of the network in case of failure of the network. DSR also takes more amount of time in construction of route. Therefore the Cross Layer Protocol increases the Throughput and reduces the End-to-end delay.

Fig.6 shows the performance analysis between three protocols with respect to End-to-end delay. The other two parameters used as design metrics in this work are Packet delivery ratio and Packet Loss Ratio. Fig.7 gives performance analysis between three protocols using Packet Delivery Ratio.

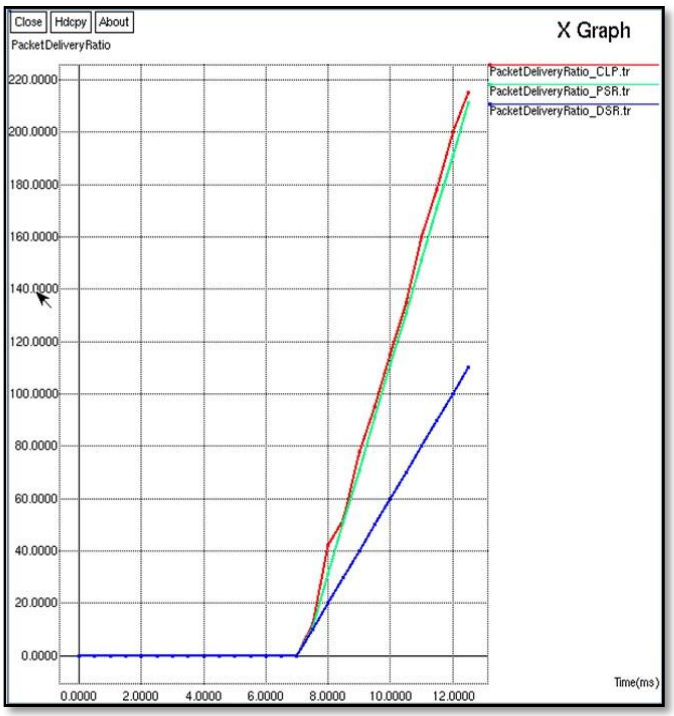

Fig. 7. Packet delivery ratio analysis

V. CONCLUSION AND FUTURE ENHANCEMENT

The Wireless Sensor Networks (WSN) follow proactive and reactive routing techniques that consumes more energy. The proactive routing technique (PSR) uses routing table for routing the packets so that it requires more maintenance of the table, and needs more data exchange during failure and reconstruction. The reactive or Dynamic Routing technique follows flooding to find the route so that it increases the latency time and it may lead network blocking due to more flooding. The cross layer approach provides solution for these problems. The cross layer provides the new interfaces to improve the energy efficiency. This paper presents cross layer approach using adaptive retransmission technique and also presents the performance analysis between PSR, DSR and Cross Layer Protocol.

The performance analysis is carried out by considering the parameters like Energy Efficiency, Throughput, Packet delivery ratio, Packet loss ratio and End-to-end delay. The Energy Efficiency is higher than the PSR and DSR techniques. The other parameters considered also provides support in improving the energy efficiency. The parameters Throughput and Packet delivery ratios are higher in CLP. The packet loss ratio and End-to-end delay are less in CLP. All these parameters presenting the cross layer approach gives a better result than PSR and DSR to improve energy efficiency.

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