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Implementation of Energy Efficient Adaptive Load Balancing Algorithm by Rainbow Mechanism in Wireless Sensor Networks

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ABSTRACT: This project presents an EALBA-R (Enhanced adaptive load balancing algorithm), protocol in wireless sensor networks. EALBA-R is designed based on the concept of ALBA and Rainbow mechanism. An ALBA features the geographic routing with contention-based MAC relay selection and load balancing. Rainbow mechanism is used to detect and route around dead nodes. This protocol gives the better performance in localization and distribution of the packets by varying traffic. ALBA and Rainbow (ALBA-R) solve the problem of routing around dead nodes without any techniques such as face routing and graph planarization. An EALBA-R protocol is designed such a way that to reduce the time when transmitting packet from source to the destination, when increase in the load intensity. According to ns2 based simulation, our result achieves the better performance in terms of packet delivery ratio, energy consumption, and end-to-end latency. When compared to ALBA-R the Enhanced ALBA-R achieves good performance in end to end latency.

KEYWORDS: Wireless sensor network; convergecasting; geographic routing; graph planarization; face routing.

I. INTRODUCTION

Wireless sensor network (WSN) is spatially distributed autonomous devices using sensors to monitor the various physical and environmental conditions. These sensor nodes perform the data collection duties and the corresponding packets are then transmitted to the destination through multihop wireless routes (convergecating or WSN routing). Many researches happening on protocol design for WSNs has focused on MAC relay selection and routing solutions. An important class of protocols is represents geographic or location based routing schemes, where a relay is greedily chosen based on the advancement it provides towards the destination. Many geographic routing schemes fails fully address important design challenges, including 1) efficient relay selection, 2) routing around connectivity holes, and 3) resilience to localization errors. Connectivity holes are inherently related to the greedy forwarding mechanism even these are fully connected topology these are fully connected topology these may exist nodes (called as dead ends)these that they have no neighbors that provides packet advancement towards the destination (the sink). The busy node and dead ends are unable to forward the packet to the sink and the packets get discarded. Many of the protocols have been proposed to alleviate the impact of connectivity holes, but these are fails in the energy efficiency, packet delivery ratio (PDR) and end-to-end latency. In this paper we present a new approach to route the packet routing around dead ends [1] that works in any connected topology without overhead occurs based on topology planarization. The proposed protocol is named as ALBA (Adaptive load balancing algorithm) whose main approach is based on geographic routing [2], contention based relay selection and load balancing are blended with to route packet out and around connectivity holes, the Rainbow protocol. The combination of ALBA and Rainbow called as ALBA-R these results the convergecasting in WSNs. This paper contributes the WSN research this includes the following:

1. The geographic forwarding happens by consideration of congestion nodes to making routing decisions. This protocol achieve the performance in packet delivery ratio (PDR), latency, and energy efficiency.
2. Energy efficient load balancing algorithm uses the rainbow mechanism in WSN [5] to route the packets around dead ends and guarantees the packet delivery efficiently.

3. The metrics of packet delivery ratio and latency are investigated through experiment by using 40 sensor nodes. This is done by using ns-2 based simulations. ALBA-R shows that it is the superiority with respect to previous geographic and topology based convergecasting, such as GeRaf[3] and IRIS[4] protocols.

4. Using NS2 based simulation the work further enhanced to reduce the energy consumption when increase in the load intensity, the data packets is transmitted successfully form source to sink node within a short period of time. The simulated result shows that modified ALBA-R protocol is an energy efficient protocol.

The paper is organized as follows: section II gives the literature survey of the project. Section III describes the detail of proposed algorithm ALBA-R and EALBA-R. Section IV explains performance evaluation. Section V explains conclusion and future scope.

II. RELATED WORK

The GeRaF and IRIS protocol are designed for convergecasting in wireless sensor network. But these protocols are fails to achieve the performance in packet delivery ratio, end to end latency and energy efficiency. The ALBA-R protocol is designed to avoid the packet dropping around dead end or busy node. This proposed protocol achieves the better performance in packet delivery ratio and energy consumption when compared to IRIS and GeRaF protocol. But this protocol requires more time to transmit packet from source to destination without packet dropping. An adhoc network consisting of mobile nodes these are established whenever needed but without requiring any existing network architecture. The communication takes place between any two nodes is performed as multi-hop routing by using intermediate nodes to forward the packet. Position based routing ids performed by using greedy mode and forward mode algorithm. This provides the excellent delivery rate and short hop count. These protocols may fall because of routing either some connection are not considered and results in disconnecting the network, or use of some connections causes lovelocks. Several papers explain about how to perform routing in adhoc network based on positions of mobile nodes [6].Position based algorithm include Greedy and Recovery mode. This type of algorithm contains information about shortest path, hop count to perform the routing. It provides low delivery rates and high communication overhead in sparse [7] network. It can perform up to 200 nodes geographic routing. Robust has the ability to deliver a message. Position based routing fails the packet transmission due to the natural, man- made obstrucles or due to the weather conditions. This provides the high communication overhead and low delivery rate in the network. The geographic routing protocols require only neighbour node location information and it does not require destination information to route packets. Wireless sensor networks use the geographic routing[8] protocols to perform the packet transmission efficiently in the network. Geographic routing protocols use greedy forwarding for packet transmission. Greedy forwarding performs based on next forwarding hop and it is chosen to minimize the distance of the sink node. Geographic routing fails in connectivity holes. Face routing has been introduced in order to correct routing in the presence of connectivity holes. The combination of greedy forwarding and face routing is used in the GPSR protocol. Geographic face routing is more advantages in conserve energy and low overhead. This type of routing fails in hiding data. GPSR (Greedy perimeter stateless routing) is a geographic routing protocol for WSNs that combines greedy forwarding and face routing. The main applications are data storage and distributed indexing. individual node’s battery energy; if node is having low energy level then optimization function will not use that node.

III. PROPOSED ALGORITHM.

A. Adaptive Load Balancing Algorithm(ALBA):

In this paper we proposed ALBA protocol, it is a cross layer solution for convergecasting in WSNs that integrates awake/asleep schedules, routing and traffic load balancing takes place in the case of back to back packet transmission. Data packet transmission happens when the sender broadcast the request to send (RTS) packet to its neighbor nodes, the available neighbor nodes respond the clear to send (CTS) packet to the sender this is used for best relay selection. This relay selection is good for efficient transmission of data packet. This relay selection depends on the two parameters: Geographic priority index (GPI) and queue priority index (QPI). The GPI is the distance between the nodes it is calculated by using the formula is

$$GPI= \sqrt{\left((x2-x1)2+(y2-y1)^{2}\right)} \qquad (1)$$

Where, X2= node 2 distance in x direction, X1= node 1 distance in x direction, Y2= node 2 distance in y direction, Y1= node 1 distance in y direction.
The QPI value is calculated by using the formula is

$$QPI= \{(Q+Nb)/M\} \qquad (2)$$

Where, Nb= Requested number of packets to be transmitted back to back, Q=Total number of packets in the queue of an eligible relay, M= The average number of packets it was able to transmit back to back without errors.

The figure 1 shows the computation of QPI and GPI value. The white circles represent the awake and asleep mode. The black color represents the source node and arcs represent the GPI region centered at sink. The gray color represents the forwarding area. The source node is denoted as S it wants to send a 2 packets that is NB=2. Among awake node A has empty queue with bad forwarders records M=1 hence QPI becomes 2. Nodes B and C has same M=4, B contains smaller queue hence QPI is 1 and C becomes 2. The sender has sense the channel with low QPI value.

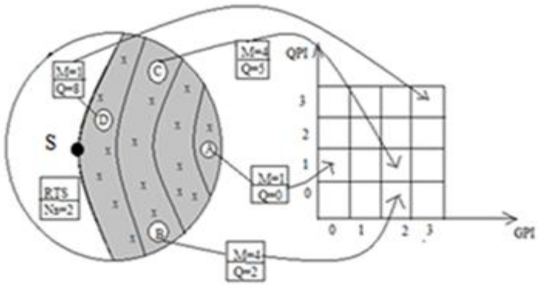

Fig 1.Computation of QPI and GPI values.

In ALBA protocol source node broadcast the RTS for eligible forwarders to calculate their QPI and GPI values and it inviting answer from the node whose QPI is 1. The RTS having complete information required for relay to calculate their QPI and GPI values, that is location of the source and sink node, and requested number of data packet transmitted in a burst NB. The source node broadcast first RTS with QPI1 only nodes which has QPI is 1 they are allowed to answer with CTS packet to the source node. If anyone node answer with CTS packet immediately the data packet sent to the destination, and source node gets the ACK from the sink. If no node answering for first RTS packet with QPI 1 and source node broadcast other RTS packet with higher QPI. If in the case two are more node respond with same requested QPI then it's broken via GPI. According to GPI value the best node is selected by broadcasting new RTS packet calling the answer from node whose GPI is 0 and it provide the high advancement. If no node find awake with GPI value 0, the source node broadcasting the RTS packet with higher GPI value. If in the case the multiple nodes are replying with same (QPI, GPI) values they are broken according to the binary splitting tree collision mechanism. Figure 2 shows that source node broadcast the RTS packet with QPI 1, only node C is in awake mode with QPI value 1 and all other neighbor nodes are in asleep state. Node C replies to source node S with the CTS packet and it select the relay. The node S sends the data packet to the node C, after receiving the data packet at node C it sends the ACK to the source node. The node C is in asleep mode all other nodes are in awake mode. The node S broadcast the RTS packet with QPI 1, no node answer for the first RTS because no node with QPI 1. The node S broadcast second RTS packet with QPI 2, the node A and B both answered with CTS packet for the second RTS. In this case the GPI computation takes place to choose the best relay. The node S again broadcast the RTS packet with QPI 2 and GPI 1, the node A responds with CTS packet for GPI 1.After choose the best relay node S sends the burst of data packets to the destination node A and it is acknowledged individually. If the ACK for any one of the packet is missing, the node S stops the data packet transmission of the burst, rescheduling the unacknowledged packet in the burst. In this ALBA handshake we observed that one or more forwarders answer for the same RTS, the GPI value used for the best relay selection. The relay selection fails only in the case of no node with any QPI found and the nodes which as the same QPI and GPI values this is not resolved with a maximum number of attempts. In both the situation causes the sender to back off. The packet get discarded when the sender back off more than NBoff times.

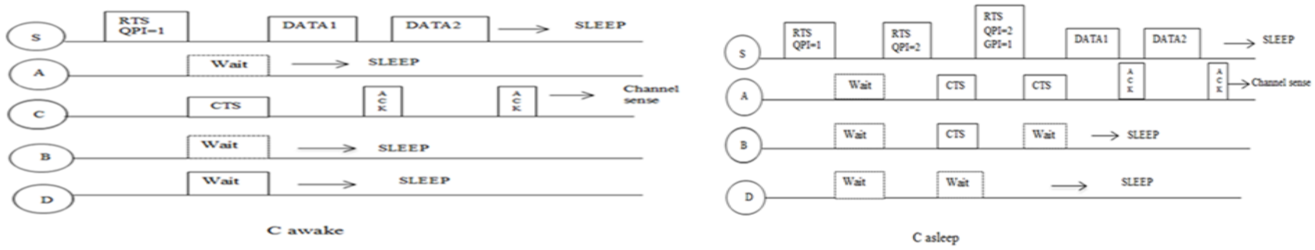

Fig 2.ALBA handshake.

B. **Rainbow mechanism with ALBA:**

Rainbow mechanism used by ALBA to handles the connectivity holes. To avoid the dead ends the nodes are forward the packet away from the destination but when the relay is chosen towards the sink this cannot find in the ALBA mechanism. The Rainbow mechanism is used to search the relay in the direction of the sink or in the opposite direction. In this mechanism every node is labelled by a color and this color is chosen by an order in the list. To find the relay among the nodes is searched based on its own color or the color is immediately before in the list. Hence color of each node is able to route towards the sink is shown in figure 3.

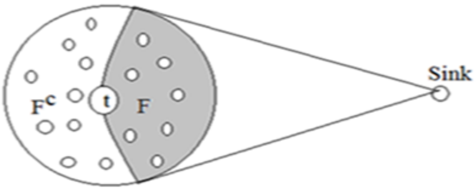

Fig 3.The F and F^C region.

Let't' be a busy node in packet forwarding, the transmission area of 't' is divided into F and F^C regions. The F and F^C region as the neighbors to offer the positive and negative advancement towards the sink. The t node wants to transmit the packet, it seeks a relay in positive or negative advancement based on colorsC_n, and it is selected from the set of colors $\{C_0, C_1, C_2, C_3, C_4.......\}$. The nodes with even colors C_0, C_2….. Search for neighbors in F region and the nodes with odd colors C_1, C_3…… search for neighbors in F^C region. Nodes with the colorC_n, $n \geq 0$ it chose the relay only for nodes with colorC_n or C_{n+1}, if the node with colorC_n, $n>0$ it can only takes the color C_{n-1} or C_n. In this mechanism initially all the nodes are colored as C_0 to perform the greedy forwarding. The nodes at the boundary holes it cannot find the relay to offer the positive advancement after the fixed number of N_{hsk} consecutive failed attempts. Hence the node may be a dead end, it correspondingly increase their color to C_1. According to the Rainbow concept the C_1 node sends the packet away from the destination by searching for C_0 or C_1 nodes in F^C region. If the node C_1 cannot find the C_0 or C_1 in F^C region it changes the color to C_2 after the N_{hsk} failed attempts. Therefore node C_2 searching C_2 or C_1 the relay in F region. Similarly node C_2 cannot find C_2 or C_1 relay in F it turns to C_3 and it start searching for C_3 or C_2 node in F^C. This process continues until it reaches to their final color. At this point the any node has color C_0 it can find the greedy to route to the destination. The nodes which finally reach to the C_0 node the routing performed based on the ALBA greedy forwarding.

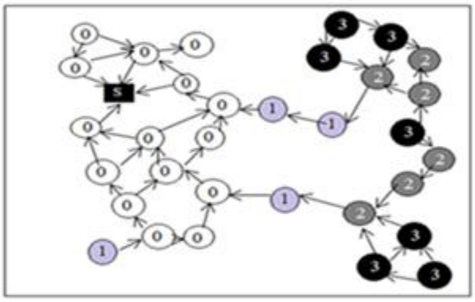

Fig 4.Rainbow mechanism.

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The figure 4 shows that the numbers in the node indicates the color is assumed. Higher colors are shown by darker shade. This mechanism is performed in finite time and it is loop freedom of route determining at the dead end.

C. EALBA-R Protocol.

The EALBA-R protocol is a cross-layer solution for convergecasting in wireless sensor network. In this protocol packet forwarding takes place between awake/asleep schedules with a fixed duty cycle d. In the case of packet transmission if busy node occurs, it uses the Rainbow coloring mechanism to perform the routing. This EALBA-R is designed by using the concept of ALBA-R. The source node sends the RTS (Request to send) packet to the destination, the transmission takes place via user defined intermediate node address and it calculates how much energy consumed by each intermediate nodes that is called “sending energy”. After receiving RTS message sink node replies with CTS (clear to send) through the user defined intermediate nodes to the sender and it calculates how much energy consumed by each intermediate nodes, it is called as “receiving energy”. The sender finally calculates the total energy of user defined intermediate nodes. i.e. (sending energy + receiving energy). The energy calculation of each node is calculated by using the formula After calculating total energy consumed by user defined intermediate node, which node consumes less energy among user defined intermediate nodes, that path is established. Finally source node transmits data packet to the sink node using best path and it is acknowledged.

The energy calculation of each node is calculated by using this formula.

$$E_{TX}(r) = E_{TX_e} + E_{TX_a}(r) \qquad (3)$$

Where, E_{TXe} = The energy needed by the transmitter.

$$E_{TX_a}(r) = \varepsilon a.r^2$$

$E_{TXa}(r)$ = The energy required to cover the transmission range r.

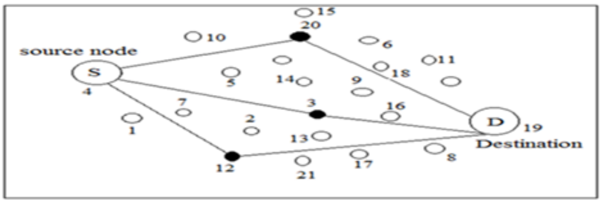

Fig 5.The source node sending RTS and CTS packet through three intermediate nodes.

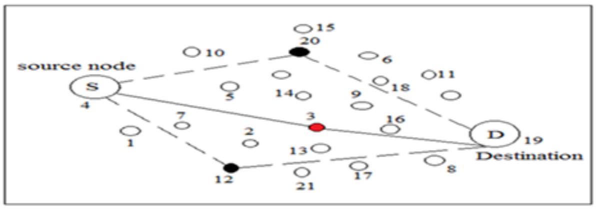

Fig 6.Transmission of data packet source to destination using EALBA-R.

Figure 5 explains performance of EALBAR protocol. Here node 4 is assumed as source node and node 19 is assumed as destination. The node 20, 3 and 12th are user defined nodes, first source node sending the RTS packet to the destination and source node receives the CTS packet from destination through the 20, 3 and 12th node. After receiving CTS message the energy calculation has done. The 3rd node is chosen as intermediate node for transmission of data from source to the destination because, the 3rd node consumes less energy based on energy calculation is explained by figure 6 In the figure straight line indicates transmission of data is on progress and dotted line indicates that there is no transmission in the network. An EALBA-R protocol is designed by using NS2.33 simulator. The simulated results shows that when compared to ALBA-R, EALBA-R protocol is requires less time to transmission of packet from source to sink node. The performance metrics achieves better performance in packet delivery ratio, energy consumption and end to end latency. An EALBA-R achieves better performance when compared to IRIS and GeRaF protocol.

IV. SIMULATION RESULTS

A. ALBA-R versus GeRaf and IRIS.

The GeRaf protocol is the first cross layer protocols for geographic greedy forwarding. The other protocol is IRIS these perform as same as ALBA based on hop count metric and local cost function. But this GeRaf and IRIS protocol fails to achieve the performance in PDR, per packet energy consumption and end to end latency. The ALBA-R protocol achieves the best performance in the per packet energy consumption and end to end latency. The ALBA-R protocol achieves the best performance in per packet energy consumption, latency and packet delivery ratio. It gives the best performance in the increasing traffic and it is much better than other two protocols, because it uses the QPI based selection scheme for balancing the traffic among relays.

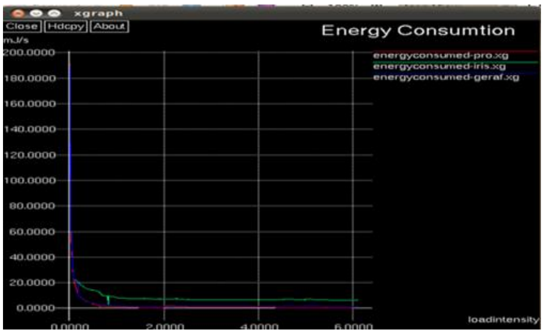

Fig 8a.energy consumption for ALBA-R versus GeRaF and IRIS.

Figure 8a explains packet per energy consumption for ALBA-R versus GeRaf and IRIS metrics. The IRIS protocol consumes more energy when increasing the packet per second. These simulated result shows that GeRaF and IRIS fails to achieve the per packet energy consumption when increase in load intensity per second.

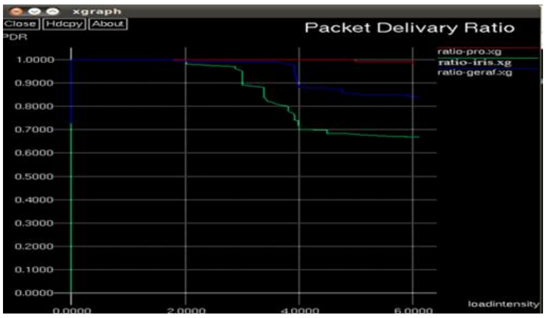

Fig 8b.Packet delivery ratio for ALBA-R versus GeRaF and IRIS.

Figure 8b explains ALBAR achieves better performance in packet delivery ratio, when compared to the GeRaf and IRIS protocols. The packet delivery ratio for ALBAR when λ=4 packets per second it gives 98% of the packet transmitted successfully when compared to IRIS and GeRaF. But IRIS and GeRaF fails to achieve packet delivery ratio when increase in the load intensity. When increase in the load intensity GeRaF results worst performance when compared to the IRIS and ALBAR. GeRaF does not transmit packets from source to sink node successfully.

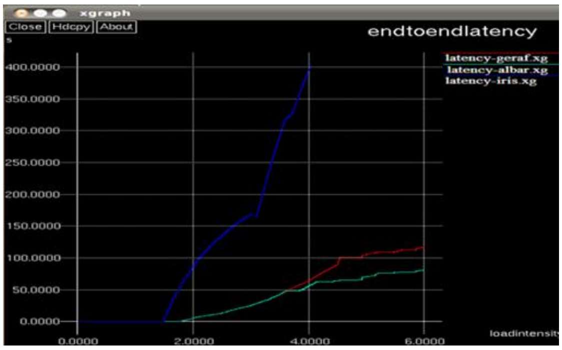

Fig 8c. End to end latency for ALBA-R versus GeRaF and IRIS.

An ALBAR and GeRaF protocol result requires less time to transmit packet from source to sink node, when increase in the load intensity. The IRIS protocol requires more time to transfer packet from source to sink node, it is explained by figure 8c.

B. **EALBA-R versus ALBA-R.**

The simulated graphs for EALBA-R versus ALBA-R. Both the protocol achieves good performance in energy consumption. These two protocols require less energy to transfer the packet from source to the destination. The comparison between enhanced ALBA-R with ALBA-R protocol. The enhanced ALBA-R achieves better performance in packet delivery ratio when compared to the ALBAR when increase in the load intensity (λ). The end to end latency explains that the EALBAR requires less to time to transfer the data packet from source to sink node when increase in the load intensity per second. But when compared to EALBAR the ALBAR protocol requires more time to transmission of packet from source to sink node.

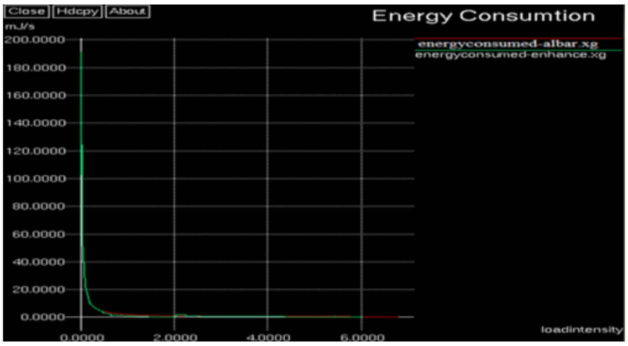

Fig 9a.Energy consumption for EALBA-R versus ALBA-R.

Figure 6.9a explains the energy consumption of Enhanced ALBA-R versus ALBAR protocol. Both enhanced ALBA-R and ALBA-R protocol requires less energy to transmit data from source to destination.

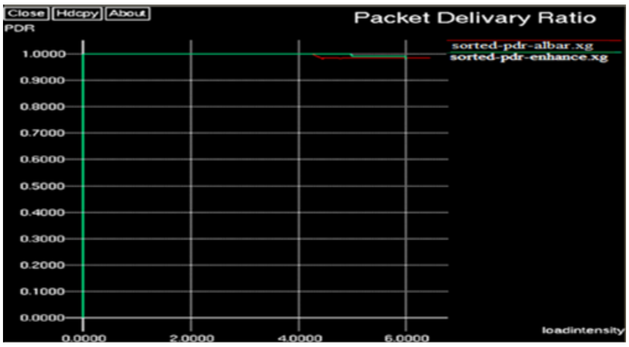

Fig 9b.Packet delivery ratio for EALBA-R versus ALBA-R.

The above figure 6.9b shows that the comparison between ALBA-R with ALBA-R protocol. The enhanced ALBA-R and ALBA-R protocol both achieves better performance in packet delivery ratio when increase in the load intensity (λ).

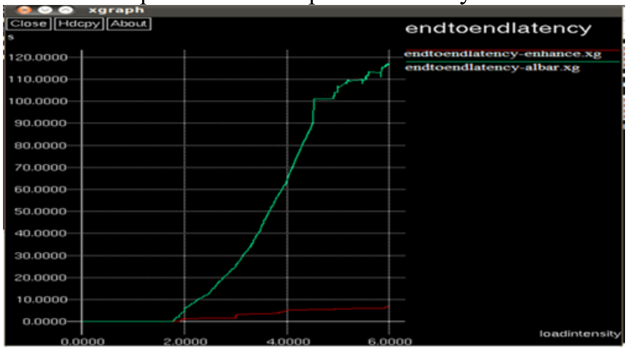

Fig 9c. End to end latency for EALBA-R versus ALBA-R.

Figure 9c shows that end-to-end latency comparison graphs for EALBA-R and ALBA-R. This graph explains that the EALBA-R requires less to time to transfer the data packet from source to sink node when increase in the load intensity per second when compared to ALBA-R protocol.

V. CONCLUSION AND FUTURE WORK.

Our simulation result gives ALBA-R protocol achieves the end to end latency and packet delivery ratio when compared to the IRIS and GeRaf protocol and it gives the better performance when increase in the load intensity. An Enhanced ALBA-R (EALBA-R) protocol is requires less time to transfer packet from source to destination when compared to ALBA-R protocol. Hence Enhanced ALBA-R is better than ALBA-R protocol. Further, the Enhanced ALBA-R protocol is needed to be designed for real-time applications and test in the presence of localization errors. Enhanced ALBA-R can be extended for mobile nodes and investigation must require based on packet delivery ratio, energy consumption and end to end latency.

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