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Power Aware Routing Protocol (PARP) to Reduce Energy Consumption in Wireless Sensor Networks

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Abstract*: In Wireless Sensor Network (WSN), *energy consumption is a big challenge. The energy is mostly wasted by huge number of nodes even they are inactive. WSN is a collection of different technologies like embedded, processing, and communication technology. The use of WSN gets widened in the fields of health care, traffic management, monitoring of environment, and management during disaster. The main intention of research aims to analyze the WSN and propose a power aware routing protocol (PARP) to reduce consumption of energy by the wireless node in congestion. The proposed routing protocol works by constructing a multicast tree to send message to the destination with less effort and energy. In order to control multicast delivery system, this work selects the node nearest WSN node for the perfect position to the forwarding node for preserving the energy between two neighboring goals that is placed in multicast tree. This research work uses the Network Simulator version 2 (NS2) for evaluation purpose and the performance metrics as throughput, packet delivery ratio, energy consumption, and delay. The result indicate that PARP achieves its objectives in a efficient when compared with other approaches namely DACR (Distributed Adaptive Cooperative Routing) protocol and REER (Reliable Energy Efficient Routing) protocol.

Index Terms*: Energy, Load Balancing, Sensor, Routing, Wireless.

I. INTRODUCTION

Wireless sensor networks (WSNs) have several advantages than other type of communications that exist in real-time like security, environment monitoring and healthcare. The factors that affect the design and development are numerous which includes cost of implementation, management of power, scalability and fault tolerance. Additionally, the performances of WSN are affected by exhaustive energy consumption, weak links and node failures. There exist two types of nodes in WSN, which are master nodes and slave nodes. Slave nodes senses the environment, collects the data and send it to master node for the next level of processing. Environments with vast and more complexity leads a challenge to WSN communication in terms of reliability. The slave nodes that are out of range of master node cannot able to send the sensed data. This type of scenario leads to unreliable communication, where the intermediate nodes collect and send data to master node. Therefore, to attain reliability enabled wireless communication in WSN its necessary to have a better routing protocol.Most available routing protocols won't exploit the service-oriented architecture over WSNs. Link failures rates are getting increased in WSN, many routing protocols getting proposed in this thrust area but it is not taken any care, where the protocol just finds the alternate paths instead of finding the solution for avoiding the link failure. Energy consumption is getting high due to network congestion; Congestion is a situation where the performance of WSN gets down in all aspects.The main intention of this research work is to propose a protocol which reduces energy consumption and increase the lifetime of WSN by load balancing. This research work enhances particle swarm optimization and utilizes it to avoid the energy spent in looping path. Avoidance of looping path increases not only lifetime, but also the reliability.

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II. LITERATURE REVIEW

E. Zonouz et al.,2014 presented a link reliable model for WSN nodes. It has affected the various parameters like battery life-time of a battery, shadowing, network noise, and node location uncertainty. These things were affected during the validation process of a protocol. M. Zhao et al 2014 proposed a strategy to use the concept of mobility for the power replenishment in a joint manner and data gathering, where it employed a mobile entity which can perform multiple function, called SenCarin. It acts not only as a receiver of data and makes roaming greater than the field to receive more data via min-range message, where the result got affected due to increase in the jitter. D. Sharma and A. P. Bhondekar, 2018 studied different models of energy for WSN and proposed routing protocol for energy saving to increase the stability period, where it considers heterogeneous based routing to achieve optimal utilization of resource. Y. Sun et al., 2017 proposed a routing algorithm derived from the concept of ant colony optimization to find optimum path for data transmission in WSNs. Y. Wang et al., 2014 proposed a protocol named Bee-Sensor-C, it combined the concepts of clustering, routing, optimization to achieve the best performance. Y. Cheng et al., 2014 proposed a location free protocol for routing in WSN with topology changing concept, where this protocol initially describes the network embedded protocol to analyze and locate every node and link in WSN to more than one node.

Tunca et al., 2015 proposed ring routing protocol, it was based on the concept of distribution and sink routing protocol, and it was found to be suitable for time based applications, where the throughput count got decreased. N. Kumar and D. P. Vidyarthi, 2018 proposed a routing algorithm termed as "green"

with the aim of increasing the lifetime of WSN by using particle swarm optimization concept. Zhang and E. Dong, 2015 proposed an bypass based routing protocol. It makes a virtual coordination in WSN, which aimed to resolve the issues in geographic routing, but the control overhead and delay got increase. X. Lai and H. Wang, 2018 proposed a strategy using (i) broadcasting concept, and (ii) opportunistic routing by combining the distribution cooperative method and scheduling algorithm for priority. A. Ahmed et al., 2015 proposed a energy awareness routing protocol which uses distribution based trust model for the detecting and isolating the nodes which have misbehavior and faults, the results came inversely with low packet delivery ratio. H. Huang et al., 2018 proposed an routing protocol for geographical area by recovering the route from loop holes. It have fully utilized the information of location of nodes, but the load balancing become inverse and part of the network got congested heavily with poor performance M. Al-Jemeli and F. A. Hussin, 2015 proposed a procedure model. It was aimed to decrease the consumption of energy and increase the system throughput in WSN, but the network simulation shoed that there exist a heavy end-to-end delay. S. F. Al Rubeaai et al., 2016 proposed a 3D routing protocol for geographical WSN. It aimed to control the forwarding nodes in WSN by lowering the packets that are forwarded. It attempted to solve the void node problem. F. Mansourkiaie and M. H. Ahmed, 2016 presented an optimization concept to reduce the collision level by cooperative based routing in WSN. A mathematical model was developed to solve the issue as a linear programming model. D. T. Delaney et al.,2014 proposed a route stability framework to pass the information about routes to other neighbor nodes, but the energy consumption got increased a lot due to this. Md. Abdur Razzaque et al., 2014 proposed a protocol for routing in cooperative communication between delay and routing, which increases lexicographic optimization at each hop. M. Chen et al., 2008 proposed a trust based protocol for reducing the energy consumption to overcome the issues in scalability, energy consumption and error-resilient routing in WSN.

III. POWER AWARE ROUTING PROTOCOL (PARP)

This section presents the proposed PARP for efficient communication in WSN. Initially, analysis of PARP and building the multicast tree based on target is discussed. Lastly, delivery of messages uses the alternate route strategy when facing the congestion.

The principle concept of PARP is to save the energy utilization from resource node to target node by forming a multicast tree. In order to control multicast delivery system, it's necessary to select the node that is nearest to the perfect position to the forwarding node for preserving the energy between two neighboring goals that is placed in multicast tree. In this approach, the message that is to be multicast is sent to different destinations in an reduced energy consumption route. The multicast tree is framed by source node w, and goals x^1, x^2, x^3, x^4 and x^5 based on the idea of energy over development metric. With the end goal to minimize energy utilization, the delivery of message from x^1 to x^3 and x^4, and from x^2 to x^5 is relayed by nodes p^1, p^2 and p^3, individually. PARP is estimated to work in both (i) greedy mode, and (ii) alternate mode. PARP depends on checking its available neighbor nodes towards destination. PARP involves 3 steps which are, (i) development of multicast tree, (ii) delivery of data, and (iii) delivery of data in alternate route.

3.1 Development of Multicast Tree: Based on the position information of different destinations that is collected by the target node, all sender nodes necessarily have to take decision in forwarding the received multicasting message to all the receiver nodes. That is, it decides the send the message in a single shot or in different number of splits, at last it finds its best hop for sending the data. With the end goal to accomplish this objective, we utilize the metric of energy consumption to build a route that consumes low energy towards target node. It helps all the nodes to guide the delivery of multicast message. The development of multicast tree is done in procedural manner by following dual level tree for each partition as follows.

Considering z destinations $x^1, x^2, \cdots, x^p$, initial node w initially chooses y l-hop goals nearest to it, that is to frame a segment k. The nodes w is a fixed somewhere in the range of n^1 and n^2, where the condition leading the goal. The optimum energy required for forwarding the multicasting message in a specified distance is denoted as c^{opt}, and most extreme power needed is denoted as c^{max}. The estimation of constants n^1 and n^2 can be given by

$$\begin{cases} n^1 = \left\{ l \cup . c \dfrac{opt}{2} \right\} \\ n^2 = \left\{ l \cup . c \dfrac{max}{2} \right\} \end{cases}$$

Afterwards, node w separates partition area k into n subareas $N = [N^1, \cdots, N^n]$. Every subset N^h incorporates h destinations nearest to node w filling in as the hand-off nodes to other for delivery of data $N + h[N^h == k]$ destinations. Node w estimates every energy over development under all subsets $N^1, \cdots, N^n$, and holds the subset $N^{max(h,h')}$ among any two subset N^h and N^{hi} if $d^{h,k} = d^{h',k}$. At long last, it chooses a subset $N^r[1 == r == p]$ which completes the base energy over development $d^{r,k}$, disregarding the other subsets $N^1, \cdots, N^{r+1}, N^{r-1}, \cdots, N^n$. This implies the 2-level coming about multicast tree, signified by $Q^k[w, x^1, \cdots, x^t]$ has been assembled. In the blink of an eye subsequently, node w respects the nodes at the nearest to main nodes to enlarge the tree with the end goal that

it can cover m closest destinations to segregate another 2-level tree. This procedure revises until the point that the sum total of what destinations have been introduced into the building tree. Along these lines, node w develops a multicast tree, indicated by $Q[w, x^1, \cdot\cdot\cdot, x^p]$, which just comprises of itself and every one of the destinations $x^1, x^2, \cdot\cdot\cdot,$ and x^p. Then, node communicates via a message holding the data of the subsequent tree to every nodes destinations. While accepting this message, every destination separates its sub tree that just achieves the downstream destinations and stores it.

3.2 Delivery of Data: Destination is chosen random in x nodes that gets the message, it initially erases the packet that already holds and after that it includes the information related to position towards the destinations into the header of the packet and it includes it in the multicast tree as a subtree. Towards the source node w, it first includes its information of the position, following destinations of hops via the header of packet, then utilizes the subsequent tree $Q[w, x^1, \cdot\cdot\cdot, x^p]$ to choose a decision to continue forwarding the multicast message to every node recipients in a solitary network or to the entire network..

3.3 Delivery via Bypass: The node that is buffering the data packet may have not gotten any CTS message from the communicate region until the point when the clock is failed. In this case, it believes there exist no neighbor in communicate region, i.e., it experiences a directing gap and it is purported void node. Up until now, there has not been any multicast particular way to deal with bypass the navigation gaps, so in our plan, this case is dealt with by utilizing a unicast geographic directing separately for every destination. Not quite the same as the traditional bypass opening plans, there is no forceful reason to keep up the full system hidden subgraph developed from neighborhood data to withdraw from intersection edges, however just utilize RTS/CTS concept of handshaking component to frame the nearby node organize chart, to such an extent that the data can bypass the navigation gaps while without directing circles. Bypass delivery via point by point through node planarized approach is given as pursues.

To begin with, node w sets the data packet as bypass mode and it records the sensing area into header of the packet. From that point forward, it communicates via a RTS message hop information of the neighbors and sets its holding up clock to q^{max}, with the end goal that it can develop its nearby planar subgraph RNG^w from the neighbors location based information it locate a suitable successive forwarder. To accomplish this, a neighbor h that gets a message from WSN node w, sets its dispute time $\varphi^{h\infty w}$ as pursues

$$\varphi^{h\infty w} = \frac{\binom{\beta}{\rho}}{q^{max}}$$

For sending the CTS message to all nodes accordingly, where β can be believed as roaming in any direction, dependent upon the traversal heading (left-hand or right-hand), and is given by

$$\beta = arccos\left(\frac{c[w,h]^2 - c[w,x]^2 + c[h,x]^2}{2c[w,h]/c[w,x]}\right)$$

In the event that node h catches a CTS message communicated by another applicant k that lies in the nearness region $P[h,w]$, it communicates an "invalid CTS", which contains of the malicious node k, to node w when $\varphi^{h\infty w}$ expires. Else, it responds node w with a legal CTS message, based on the delay work. Once accepting more than one CTSs from nearby neighbors, node w first checks whether any node h fulfills the nearness condition in $P[k,w]$ for its any neighbor k, and after that rejects it from applicants if it continues. This implies the edge $[w,h]$ continues for any neighbor m of nodes w and h if $c[w,hi] == max \int c[w,m], c[m,hi]$ holds and additionally node h doesn't holds a place in the nearby region $P[k,w]$ of any neighbor k of node w. Along these lines, node w can get a neighborhood planarized sub tree sub graph in which no connection edges exist. It is worth noticing that eliminating the malicious nodes does not imply that the edges from node w to such nodes don't exist in the network, yet alludes to that node w has not thought about these nodes as competitors. Among the nodes in the left, node w chooses a successive forwarder by the appropriate hand rule when q^{max} terminates, and then sends a packet by unicast manner. This procedure revises in the mode of bypass till the point when the packet touches base at a node k with the end goal that $c[k,x] \propto c[w,x]$ then PARP comes back to the insatiable mode to forward it.

IV. PERFORMANCE EVALUATION

4.1 Simulation Setting: The performance evaluation is done to check how far the proposed protocol performs than the other protocols. This research work conducted the simulation using NS2. NS2 has the full stability to support multihop wireless networks with complete simulations on MAC, data link and physical layer.

The results are compared with DACR [Md. Abdur Razzaque et al., 2014], and REER [M. Chen et al., 2008] protocol. The simulation settings are listed in Table 1.

Table 1- Simulation Setting

Specification: Basic	
Size of Network area	2000 x 2000 mts
Type of Deployment	Random
Architecture of Network	Flat and Homogeneous
Nodes Count	2000
Location of Sink	(1000,1000)
Starting energy of node	10J
Size of buffer	50
Range of radio frequency	100 mts
Radius of Sensing	52 mts
Transmission rate of LL	512 Kbps
Power of Transmission	$7.214e^{-3}$ Watts
Threshold rate of Rcv. signal	$3.65209e^{-10}$ Watts
Rate of link failure	Varying from 0.05 to 0.5
MAC	lEEE 802.11 DCF
Number of Nodes	Varying from 50 to 250
Time of Simulation	200 sec
Specification: Sensed traffic	
Type of Application	Event-driven
One event sources	≈50 to 250Nodes
Size of Packet	64 Bytes
Type of traffic	CBR (3 pps)

4.2 Performance Metrics: This research work uses below-mentioned benchmark performance metrics for evaluating the proposed protocol PARP with DACR [Md. Abdur Razzaque et al., 2014], and REER [M. Chen et al., 2008] protocol.

- ✓Throughput – It is the sum of data packets that are transmitted successfully from the source node to sink node in a specified time period. The maximum value is taken or considered as the better performance.
- ✓Average end-to-end delay (E2E) – Time utilized by a packet to reach destination node from sink node. The time delay faced by each node is calculated against the sum of packets obtained by sink. The minimum value is taken or considered as the better performance.
- ✓Packet Delivery Ratio (PDR) – It is the percentage of packets obtained by the source node with a the specified time against the sum of packets generated by the nodes in the WSN. The maximum value is taken or considered as the better performance.
- ✓Energy Consumption – It is the percentage of the total amount of energy taken by the nodes from the source node to the sink node. The minimum value is taken or considered as the better performance.

4.3 Results and Discussion

4.3.1 Analysis of results based on Nodes

Figures 1–4 show the mentioned metrics, in which we simulated the performance of the proposed PARP with varying number of nodes from 50 to 250.

4.3.2 Analysis of results based on Link Failure Rates

Figures 5-8 shows the mentioned metrics, in which we simulated the performance of the proposed PARP with varying rate of link failures from 0.05 to 0.5.

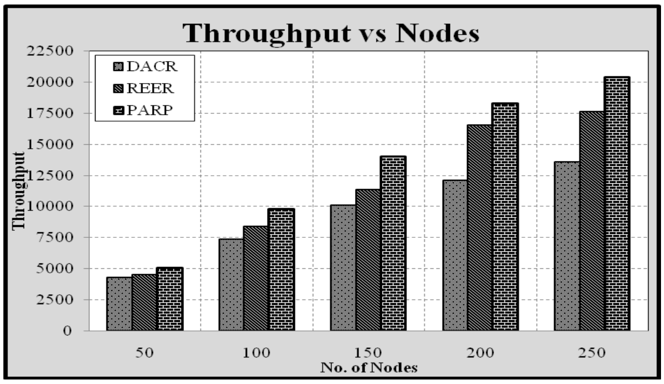

Fig.1. Throughput vs Nodes

Figure 1 shows the throughput of proposed protocol PARP, DACR and REER protocols. Comparing with DACR and REER, the proposed protocol PARP has higher throughput.

Figure 2 compares the average E2E delay of PARP, DACR and REER protocols. From the figure, it is clear that the average E2E delay is remarkably lower than DACR and REER. In this simulation, PARP has attained very low delay when compared with DACR and REER. It is because of the fact that PARP loads the node in a schedule manner on the paths which have more ratio on vacant for transmission of data.

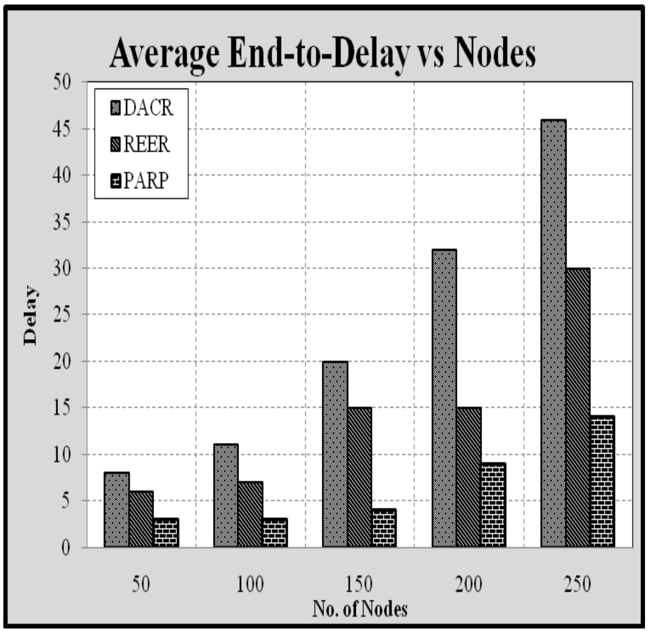

Fig.2. Average End-to-End delay vs Nodes

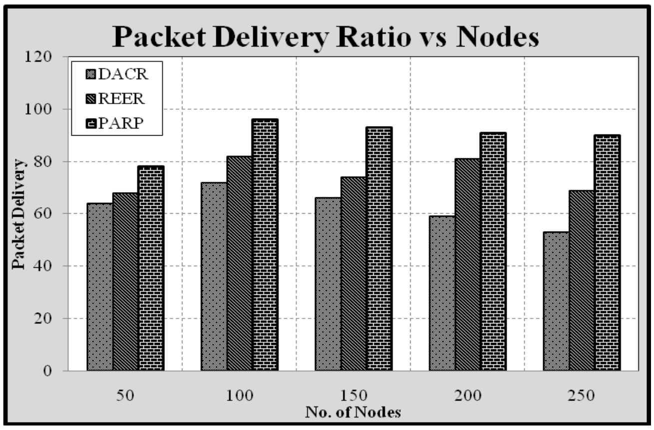

Fig.3. Packet Delivery Ratio vs Nodes

Figure 3 shows the PDR of PARP, DACR and REER protocols, where a fixed load of the work is used with constant bit rate (CBR). PARP have achieved the highest ratio when comparing with DACR and REER.

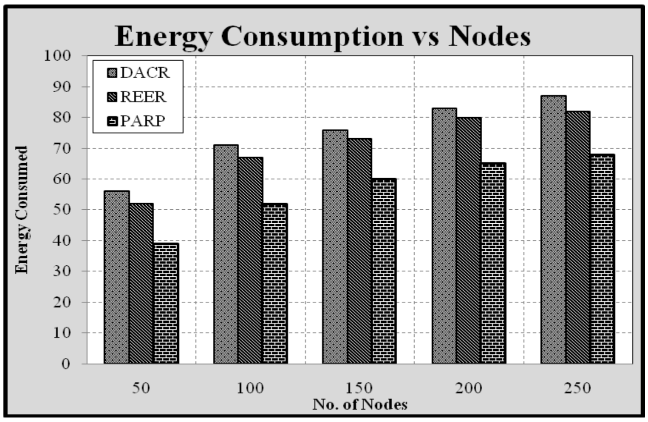

Fig.4. Energy Consumption vs Nodes

Figure 4 shows consumption of the energy by PARP against DACR and REER protocols, where a fixed energy of 10J is used. PARP consumed low energy when comparing with DACR and REER.

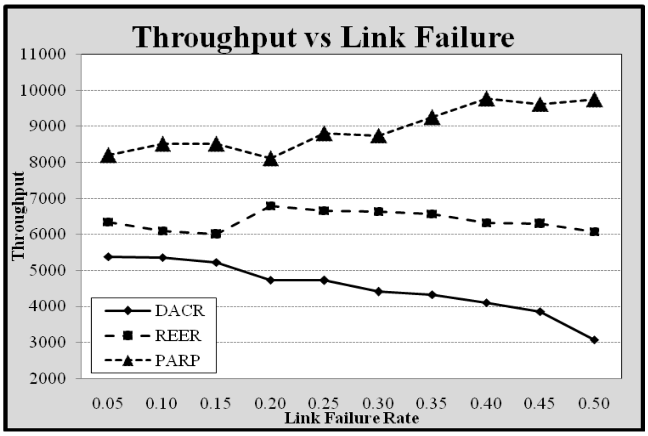

Fig.5. Throughput vs Link Failure

Figure 5 shows the throughput of proposed protocol PARP, DACR and REER protocols. Comparing with DACR and REER, the proposed protocol PARP has higher throughput in different rate of link failures.

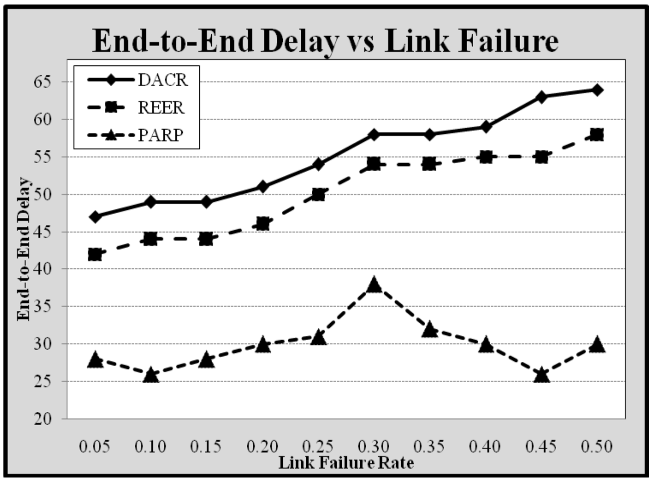

Fig.6. Average End-to-End delay vs Link Failure

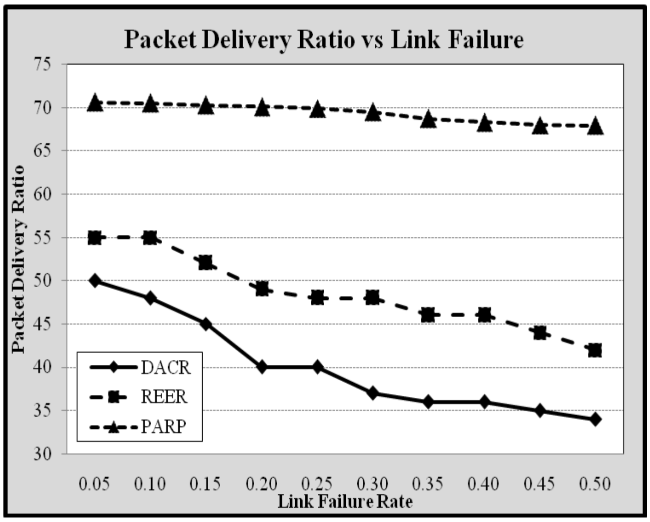

Fig.7. Packet Delivery Ratio vs Link Failure

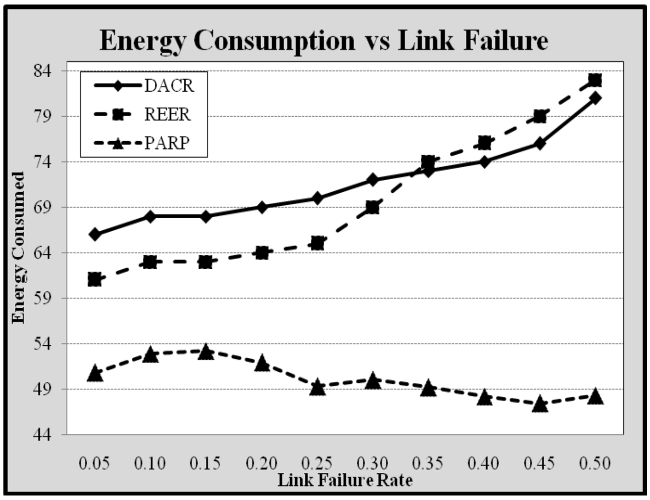

Fig.8. Energy Consumption vs Link Failure

Figure 6 have compared the average E2E delay of PARP, DACR and REER protocols. From Figure 6, it is clear that the average E2E delay is remarkably less than DACR and REER in different rate of link failures. In this simulation, PARP attains the less delay when compared with DACR and REER.

Figure 7 shows the PDR of PARP against DACR and REER protocols, where a fixed load of work is used with constant bit rate (CBR). PARP attains the highest ratio when comparing with DACR and REER in different rate of link failures.Figure 8 shows the energy consumption of proposed protocol PARP, DACR and REER protocols, where a fixed energy of 10J is used. PARP consumed low energy when comparing with DACR and REER in different rate of link failures.

V. CONCLUSION

This research work has proposed a routing protocol for WSN which aims in reducing the congestion and energy consumption by using the concept of muticasting. The proposed protocol PARP checks the disjoint links for the enhancing the quality of service. PARP involves detection of congestion, notifies the congestion to the neighbor nodes via multicast tree. This research work uses the benchmark performance metrics throughput, average end-to-end delay, packet delivery ratio, and energy consumption for the performance evaluation purpose. PARP is evaluated based on the number of nodes and link failure rate. In both the aspects the PARP attains better performance than DACR and REER protocol. The future dimension of this research work can be preceded by using the optimization concept.

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