ISSN No: 2348-4845
International Journal & Magazine of Engineering, Technology, Management and Research
A Peer Reviewed Open Access International Journal

Distributed Traffic-Balancing and Energy Aware Routing Algorithm to Alleviate Congestion using Multi-Sinks in WSN's

Ms. Preethi Gandreti
M.Tech Sudent,
Dept of Computer Science and Engineering,
Avanthi Institute of Engineering & Technology,
Narsipatnam, Visakhapatnam, Andhra Pradesh

Mr. P.Raja Sekhar
Associate Professor,
Dept of Computer Science and Engineering,
Avanthi Institute of Engineering & Technology,
Narsipatnam, Visakhapatnam, Andhra Pradesh

Abstract:

A distributed traffic-balancing and energy aware routing algorithm is proposed for multi-sink wireless sensor networks that effectively distributes traffic from sources to sinks. Each node has a gradient field that is used to decide on a neighbor node to reach a sink. The node's gradient index contains (1) the distance cost from a source to a respective sink (2) traffic information from neighboring nodes and (3) The residual energy of the node. The proposed algorithm considers the residual energy and traffic being faced by surrounding neighbors before forwarding packets to any sink and uses gradient search for routing and providing a balance between optimal paths, possible congestion on routes toward those sinks and also possible death of intermediary nodes due to being used as a relay node even though they are running with low residual energy. The key objective of this work is to achieve traffic-balancing by detecting congested areas along the route and distributing packets along paths that have idle and under loaded nodes. And also to increase the life time of a node that was running with low energy by preventing the node to act as a relay node but only used for sensing event. Extensive simulations conducted to evaluate the performance of the proposed scheme indicate that it effectively reduces the overall packet delay, energy consumption and improves the packet delivery ratio under heavy traffic and also increases the network life time.

Index Terms:

Distributed Traffic Aware, Gradient based Routing Protocol, Multi Sinks, Energy Consumption, End - to - end Delay, Packet Delivery Ratio, Traffic Congestion, Wireless Sensor Networks, Network Life-time

I. INTRODUCTION:

In general the Wireless sensor network consist of huge number of sensor nodes which are spatially dispersed and dedicated for gather the information about the sensed data in the network area. The gathered information is forwarded to the base station either by single hop or by multi hop communication to process and analyze according to the requirement[1]. Inlarge-scale applications of wireless sensor networks (WSNs), such as environment monitoring or agricultural scenarios, several hundreds of sensor nodes are deployed over a large covered-area[2] deployment of huge number of sensor nodes may require more energy and lead to traffic congestion too.

In Wireless Sensor Networks Congestion has a negative impact on the performance of the network, which will decreases the throughput, packet delivery ratio and increases the packet retransmission, packet delay and consumes more energy. In this scenario congestion control in

WSN is important. Under this circumstance, node energy, communications bandwidth, network computing capacity and other resources is generally limited [3].

The centralized approach, The data traffic from sensors nodes to the sink is not efficient in terms of energy consumption or packet delays, and that approach is impossible due to limited network capacity. Therefore, a new approach of multiple sinks is proposed as it is more feasible scheme for such networks [4].The multi sink approach balances the traffic load and increases the network efficiency. Data traffic from sensing node (Source) to the sink (final Destination) needs an optimal routing protocol that utilizes the limited power , memory, and processing resources of nodes effectively. Now various solutions are present in WSNs[5,6,7], gradient based energy aware routing protocol is standardized by Internet Engineering Task Force (IETF) working group as an feasible protocol for low power and network (LLNs)for which existing routing protocols such as OSPF, AODV, and OLSR cannot meet the requirements.

In Event driven networks, those used for detection and monitoring applications nodes normally operate under low or idle load states, When events occur, these nodes are activated ,by this sudden activation congestion in the network may occurs in some areas. Lot of research was undergone of using gradient search for solving the routing problems in wireless sensor networks. As the observation of results of the gradient scheme, we propose a traffic balancing routing algorithm for multi sinks in WSNs to route packets around the congested areas made by other paths toward the sinks. Our proposal exploits two-hop information and enhances the congestion detection ability and monitoring the buffer size at a node place. Our proposed algorithm was constructed based on three factors, they are number of hops, number of packets at one-hop neighbors and the number of packets at two-hop neighbors. The number of hops is calculated conventionally as in other gradient-based routing protocols that find the shortest paths for packets.

The second and third factor specifies the queue length at neighboring nodes which may become the next forwarder. Once the queue length, network traffic exceeds a threshold, it means that there is congestion at a particular node in the path toward a specific sink. The node sends a requests to its surrounding nodes to increase or decrease their gradient field so that packets can flow along other paths. by this method we can establish a tradeoff between shortest paths and packet delays caused by congestion at overloaded nodes. The remaining part of the paper is organized as follows. In Sect. 2, we summarize the studies related to gradient-based routing, Congestion control. In Sect. 3, we build a system model with the total gradient field and specify the local cost and global cost models and those are combined in our proposed scheme. In Sect. 4, the implementation of our idea i.e. proposed algorithm and is described briefly. Our implementation is simulation based and the performance is evaluated in Sec 5. Finally Sec. 6 concludes this paper and infers some limitations and future work.

II. RELATED WORKS:

In gradient search, a node's gradient field is constructed in response to neighbor nodes in the direction of a specific sink. Data traffic then forwarded to the neighbor node with the least gradient value in order to reach the sink.

The gradient field can be designed in terms of hop count from sink to node, energy consumption, physical distance, or cumulative delay, depending on the objectives of routing such as energy consumption, packet delay, or packet delivery ratio [10].Direct diffusion technique is the first routing protocol that uses gradient routing in WSNs. It was successful to save energy by storing and processing data. The direct diffusion technique uses data rate and duration information field from a node to its neighbors towards the sink for construction of its gradient. A lot of researchers have devoted their area of research to solve energy-aware routing for wireless sensor networks. One of the researchers proposes GLOBAL to improve energy utilization in large-scale multi-sink wireless sensor networks. It constructs its gradient field by using a weighted factor of cumulative path load and traffic load of overloaded nodes over the path. And the source nodes select the least loaded path by selecting the neighbor node which has the least gradient value and so the next relay node does the same thing and finally the sink node gets the event information. But, this approach uses global in-formation and we cannot guarantee the correctness of this information over the long path because of the network dynamics in high traffic scenarios.

Another gradient based routing protocol SGF was able to save a significant amount of energy savings by building the gradient fields for nodes without using routing tables. These gradient values are updated on demand by data transmission with little overhead. Another researcher Suhonen et al. used energy, traffic load, delay, and link reliability to build a nodes gradient value and gave rise to a new cost-aware multi-hop routing protocol. This algorithm was also focused on efficient usage of energy and it is very significant in saving lot of energy consumption. Finally, the authors in [4] formed clusters of nodes which have the same value of hop count away from the sink. Each node in the cluster takes its turn to become the cluster head too balance energy consumption and lifetime of sensor nodes in a cluster. Apart from energy-aware, traffic control is also a significant issue in wireless sensor networks. The main objective of the traffic-aware routing protocols is to achieve network balancing and congestion avoidance in WSNs.

Another Gradient based routing protocol, GRATA [3] builds a nodes gradient value by using a cumulative cost model that uses packet delay at one-hop neighbor and the number of hops to make routing decisions. But, this protocol uses only the one-hop traffic information and lacks traffic information at two-hops and some hops away, which might lead the packet to a new congested area. TARP [8] focuses on improving the data transmission efficiency and energy consumption for WSNs by using a lightweight genetic algorithm that helps to distribute the data traffic away from congested areas. And it is only used for single-sink WSNs, and focuses on packet loss due to queue overflow, power efficiency. A distributed traffic-balancing routing algorithm designed for multi-sink wireless sensor networks, and it effectively distributes traffic from sources to sinks. In this every node maintains a gradient field for all its neighbor nodes through which it decides which node to be selected as a next forwarder.

The gradient field of the neighbor contains the hop count from the source to a respective sink, number of packets present in the neighboring nodes and minimum number of packets present in

ISSN No: 2348-4845
International Journal & Magazine of Engineering, Technology, Management and Research
A Peer Reviewed Open Access International Journal

its two-hop neighbor's queue. But in this method if there are two neighbors with the same gradient value it forwards the data randomly in a stochastic scheme. In this paper, we follow gradient-search model to solve the traffic-aware and energy-aware routing problems. Compared to the previous studies, it focuses on multi-sink WSNs application ns with heavy traffic scenarios where the large amount of traffic may cause black spot on the paths to the sink. It uses the hop count from a node to sink and present traffic information of the nodes which are two hops ahead of the current node to construct gradient field at each node. If the two nodes have the same gradient un-like the other gradient based protocols it uses the residual energy field and forwards the data packet to the node with the highest residual energy. thus it improves network performance such as end-to-end delay, packet delivery ratio, and energy consumption through comparison to some gradient-based routing schemes.

III. SYSTEM MODEL:

In this section, we discuss about our new proposed gradient based routing protocol solves traffic-aware and energy-aware routing in multi-sink WSNs. firstly, a distance cost model is discussed which is similar to the shortest cost model. Next, we insert additionally two metrics into the nodes gradient field that reflects the traffic information and the residual energy of the neighboring nodes. The traffic information can be know by monitoring the number of packets in queue and the residual energy of a neighbor node can be know by some means discussed below.

A. Distance Cost Model:

Each node defines a scalar field, called the node's height by advertising packets. A packet is forwarded on the link with the steepest gradient to the next nodes. Each node x maintains a distance cost with respect to each sink i (in a multi-sink scenario).

$$V_i^d(x) = hop_{count}. \qquad (1)$$

The height of each node also implies the minimum hop count from the node to reach the corresponding sink. A node then forwards packets to the neighbor with the lowest gradient value. In a special case, if there are two or more next neighbors with the same lowest gradient values, the node with the highest residual energy is chosen as next forwarder.

B. Queue Length Field:

This study considers areas of collision by means of buffer monitoring. A node s sends a packet to another node x (neighbor of s) only when x has enough buffer size to store the packet from node s.The proposed concept avoids packets to be dropped at the receiver due to buffer overflow. The value of the buffer size field of a node is the average queue lengths obtained by sampling over a small time interval Δt_qto ensure the stability of the routing metric. Advertising packet (ADV) containing information about node's height and buffer size is generated after an update time to inform neighbor nodes about congestion. A node can detect congested areas in two-hop away by this routing technique using two-hop information. Moreover, it can also know about the congestion before the neighbor's buffer begins to overflow. This technique solves problems related to local information [5].The function Q(x) denotes the normalized buffer size at node x as defined by Eq. 2:

$$Q(x) = \frac{Number\ of\ Packets\ int\ he\ Buffer}{Buffer\ Size} \qquad (2)$$

The value of Q(x) is in the range [0, 1], which

ISSN No: 2348-4845
International Journal & Magazine of Engineering, Technology, Management and Research
A Peer Reviewed Open Access International Journal

denotes nodes' traffic information. The buffer-based method indicates possible congestion at the destination node [9].When the number of packets in the buffer exceeds a threshold, the node also sends out ADV packets to inform its neighbors about this event. To ensure stability, the node should not react quickly to events. Therefore, the al-gorithm defines a time period, called the lower threshold (tLT), the buffer size has to exceed the predefined thresh-old for a specific time before generating an ADV packet.

C. Traffic-balancing Routing Cost Model:

The gradient field combines two types of information: geographic distance and traffic loading. Our main objective is to avoid possible congestion by not forwarding to the congested areas which leads to reduced end-to-end delays in the network. Our algorithm a node chooses one of its neighbor nodes to become the next forwarder by considering the buffer size at one-hop neighbor (x) and the next one-hop neighbor of x with minimum buffer size (x*). His means that a node takes into account both the one-hop neighbor and the two-hop neighbor that can possibly become the next forwarder after x.

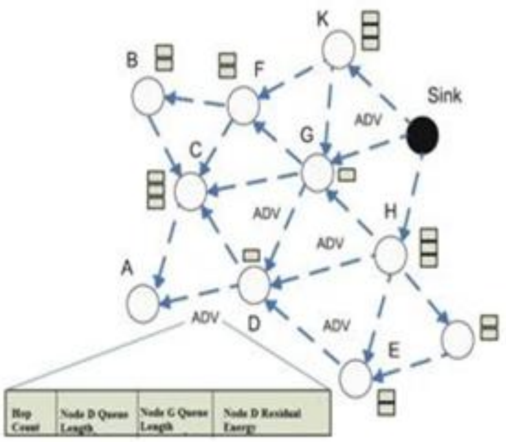

Fig. 1. Traffic Information Being distributed.

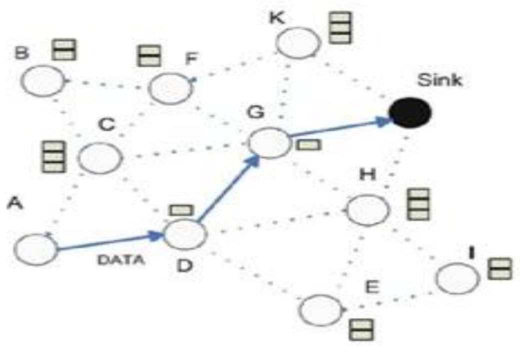

Fig. 2. Data being forwarded to sink

Once a node(s) has packet toward a sink, calculate and compare the gradient field of its neighbor x(x € nbr(s)) in response to each sink i following Equation

$$\nabla_i(s,x) = (1-\alpha)\,\nabla_i^d(x) + \alpha\nabla_i^c(x) + \beta\nabla_i^c(x^*) \qquad (3)$$

where α and βare the weighted factors of traffic cost ∇_i^d (x) is the gradient field with the number of hops. $\nabla_i^c(x)$, $\nabla_i^c(x^*)$ denote the traffic cost at one-hop and two-hop neighbors, respectively. As showed in Fig. 1, each node broadcasts ADV packets so that neighbors can update the routing table. Whenever a node has data, it will use the routing table to choose the next forwarder.

IV.THE PROPOSED SCHEME IMPLEME NTATION:

In our proposed scheme we divide the protocol in to two phases, initialization phase also called as setup phase and data forwarding phase. And this setup phase is run periodically also called as time to update. In the first setup phase sensor nodes come to know about their neighbor information such as hop count from a neighbor node to a specific sink, traffic information i.e., the number of packets that are already existing in the neighbor nodes queue also called as queue length and that neighbor's one hop neighbor which has the

ISSN No: 2348-4845
International Journal & Magazine of Engineering, Technology, Management and Research
A Peer Reviewed Open Access International Journal

minimum queue length and the neighbor's residual energy. In each round we use this neighbor information to detect the congested nodes, the nodes that are running with low residual energy, and the nodes which are dead. Depending upon this information a sensor node decides its next forwarder and thus providing a balance between a shortest path and an optimal path. In this section we discuss about how setup phase has to be run, and discuss about the packet format used in setup phase. And how routing is done from a particular source to sink when a event occurs.

A. Distributing Traffic Information:

The sensor nodes interchange the traffic informa tion by sending the advertisement (ADV) packets. The various fields present in ADV packet are as follows: neighbor ID, sink ID, hop count, one-hop neighbor queue length, two-hop neighbor queue length and residual energy of the neighbor. Every node maintains a gradient table and it is built using these ADV packets that were periodically broadcasted by all the nodes to their neighbors including sinks participate in this process.

The sink node runs this setup phase every time. The setup phase is run various numbers of times. And this update time must be set in trade-off between the effects of updating information and the use of network utilization. The node processes the incoming ADV packet as follows, it checks whether the sink and source ID are in table G. Initially there will be neither connection status nor the network information relating to sinks and neighbors. So, after receiving the first ADV packet the node add these IDs in to Gradient Table G and update the field type of neighbor value to parent following that sink ID.

B. Route Discovery and Data Forwarding:

Algorithm 2 describes how the event information is forwarded to the sink. And after executing Algorithm 1 to process ADV packets, every node knows its neighbor information, such as hop count to specific sink and neighbors queue length. The proposed algorithm forwards the packets from a node to the predetermined sink through forwarding packets through intermediate nodes. The node, calculates the gradient value for the entries in the gradient table G except for the children nodes and the node that forwarded the event information using Eq:3. Here comes the elimination of the nodes which has high traffic by eliminating the nodes whose queue length is greater than or equal to Q_{thres}. And a sibling node becomes a next forwarder only when the difference in queue length between patient and sibling is greater than or equal to ΔQ_{thres} . And if the nodes RE(x) is less than or equal to E_{thres} then, that node is not considered for route calculation. and finally, a neighbor node which has the least gradient value will be selected as a next forwarder of the data message

Algorithm 1 Updating gradient table G with each of its sinks:

1. Hop-Count = $\nabla_i^d(x)$
2. One-Hop Traffic-Info = $\nabla_i^c(x)$
3. Two-Hop Traffic-Info = $\nabla_i^c(x^*)$
4. Residual Energy = RE(x)
5. If(G=Ø) then
6. Add new neighbor as Parent to table G including Hop-Count, One-Hop, Two-Hop Traffic Info and Residual energy.
7. Else
8. If Hop-Count < HC[i] then
9. Set Node Height is the Hop Count and the neighbor to be a parent.
10. ElseifHop-Count = HC[i] then

ISSN No: 2348-4845
International Journal & Magazine of Engineering, Technology, Management and Research
A Peer Reviewed Open Access International Journal

11. Keep the Node Height and the neighbor to be a sibling.
12. Else
13. keep the current node height and neighbor to be a child.
14. Update table G with new $\nabla_i^c(x)$ and $\nabla_i^c(x^*)$ and RE(x).
15. Update new Minimum Hop-count and Traffic -Info and Residual Energy for sending ADV packets.

Algorithm 2Gradient index Calculation and Data Forwarding:

1. If Traffic -info from neighbor x $\geq Q_{thres}$or $\Delta Q < \Delta Q_{thres}$ or RE(x) $\leq E_{thres}$ **then**
2. Remove x from route calculation.
3. **Else**
4. Calculate Gradient indexes $\nabla_i(s,x)$ from neighbors;
5. Choose the node with $\nabla_i(s,x)$ minimum value;
6. If there are many nodes with the same gradient index then choose the node with higherRE(x).
7. If the RE(x) values are also identical then Choose by random trail.

Time to Update Information:

The routing information is updated when after some period of time in next round, when the neighbor node queue size is greater than or equal to Q_{thres} also when the node x's RE(x)value less than or equal to E_{thres}. In all these cases our protocol update the routing information in order to avoid congestion and possible death of a node.

V. SIMULATION AND EVALUATION:

This protocol performance is evaluated by using NS2 2.35 simulator in comparison with SPF (Shortest Path Routing), in terms of end-to-end delay, packet delivery ratio, and energy consumption.

A. Simulation setup:

We deploy the sensor nodes in random topology 850 m x 350 m area with 96 homogeneous sensor nodes and four sinks placed in grid.

The Table 1 below depicts the simulation setup and values of various constants.

TABLE I. SIMULATION SETUP

Parameter	Value
Deployment Type	Random
Number of Nodes	100 (96 + 4)
Number of sinks	4
Radio range	15m
Packet Length	30B
Transmission rate	250kbps
Buffer Size	20 packets
α , β	0.7,0.2
Time to update	0.5 - 5 s
Q_{thres}	0.7
Simulation Time	200s

Numerical Results: The proposed protocol performance is evaluated by two different traffics: constant bit rate and exponential distribution. The simulation results are compared with the first routing protocol SPF.

Average end-to-end packet delay: We evaluate the Average end-to-end packet delay for the both the proposed and SPF.

The Fig 3 depicts a clear picture that our new routing protocol out performs the SPF routing algorithm. In x-axis represents Packet Inter-arrival Time and y-axis end-to-end delay.

ISSN No: 2348-4845
International Journal & Magazine of Engineering, Technology, Management and Research
A Peer Reviewed Open Access International Journal

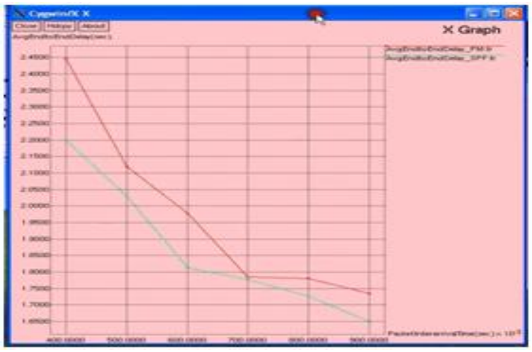

Fig 3 : Average End - to - end Delay

2) Energy Consumption: We evaluate the energy consumption for the both the pro-posed and SPF. The Fig 4 depicts a clear picture that our new routing protocol out performs the SPF routing algorithm. In x-axis represents Simulation time and y-axis energy consumption.

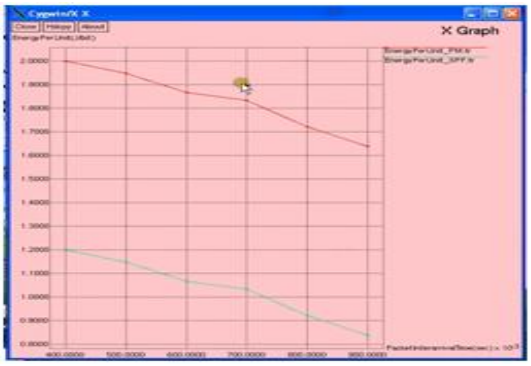

Fig 4: Energy Consumption (Energy Per Unit)

3) Effect of weighted factors on network performance:

The weighted factors α and β values are determined by many experimental trails. These weighted factors are also responsible for a high packet delivery ratio apart from the queue length thresholds. The Fig 5 depicts the how the packet delivery ratio varies for different α values under the traffic sending rate λ=0.4 and λ=0.6 and x-axis rep-resents packet delivery ratio and the different Alpha values.

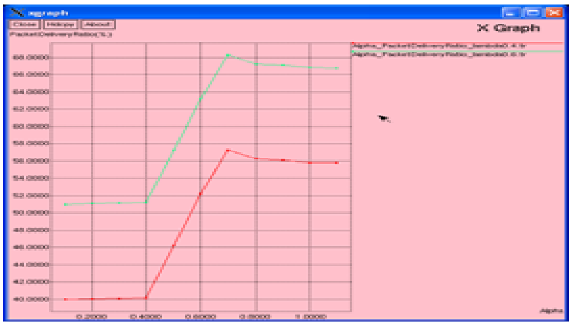

Fig 5 :packet delivery ratio for different α values

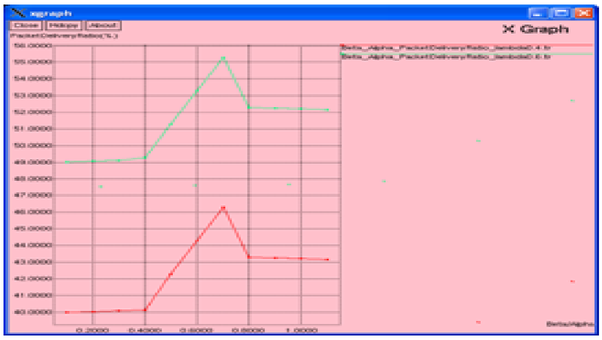

Fig 6 : packet delivery ratio and the different β/α values.

The Fig 5 depicts the how the packet delivery ratio varies for different α values under the traffic sending rate λ=0.4 and λ=0.6 and x-axis represents packet delivery ratio and the different β/α values.

VI. CONCLUSION:

As many other gradients based routing protocols our protocol suffers from the problem of storing the extra information. But it was able to solve the problem that the other existing protocols could not solve and fail to address till now.

VII. REFERENCES:

[1]Akkaya, K., & Younis, M. (2005) A survey on rout-ing protocols for wireless sensor networks. Ad Hoc Net-works, 3, 325–349.

ISSN No: 2348-4845
International Journal & Magazine of Engineering, Technology, Management and Research
A Peer Reviewed Open Access International Journal

[2]Basu, A., Lin, A., & Ramanathan, S. (2003) Routing using potentials: A dynamic traffic-aware routing algorithm.In Proceedings of the 2003 conference on applications, technologies, architect ures, and protocols for computer communications, SIGCOMM, pp. 37–48.

[3] Dinh, N. Q., Hoa, T. D., & Kim, D. S. (2011).Distributed traffic aware routing with multiple sinks in wireless sensor networks. In 9th IEEE international conference on industrial informatics (INDIN), pp. 404 –409.

[4] Gao, D., Zheng, T., Zhang, S., & Yang, O. W. W. (2010). Improved gradient-based micro sensor routing protocol with node sleep scheduling in wireless sensor networks.In IEEE 72nd vehicular technology conference fall (VTC 2010-Fall), pp. 1–5.

[5]IETF ROLL WG. (2010). RPL: Routing protocol for low power and lossy networks. In IETF internet-draft. IETF ROLL WG, March 8. Wireless Netw (2014) 20:1239–1250 1249

[6]Intanagonwiwat, C., Govindan, R., Estrin D., Heide-mann, J., & Silva, F., (2003).Directed diffusion for wire-less sensor networking. IEEE/ACM Transactions on Net-working, 11(1), 2–16.

[7] Kanavalli, A., Jayashree, M., Shenoy, P., Venugopal, K., & Patnaik, L. (2008). Hop by hop congestion control system for adhoc networks. In IEEE region 10 conference TENCON, pp. 1–4.

[8] Park, C., & Jung, I. (2010). Traffic-aware routing protocol for wireless sensor networks.In International conference on information science and applications (ICISA), pp. 1 –8.

[9] yih Wan C., &Eisenman S. B. (2003). CODA congestion detection and avoidance in sensor networks (pp. 266–279). Newyork: ACM Press.

[10] Yoo, H., Shim, M., Kim, D., & Kim, K. H. (2010). GLOBAL: A gradient-based routing protocol for load-balancing in large-scale wireless sensor networks with multiple sinks. In IEEE symposium on computers and communications (ISCC), pp. 556–562.

BIOGRAPHIES

Preethi.Gandreti completed her B.Tech degree from Avanthi Institute of Engineering &Techno logy,Visakhapatnam, Andhra Pradesh. Currently pursuing M.Tech in Avanthi Institute of Enginee ring &Technology, Visakhapatnam, Her research interests are Wireless Sensor Networks, Soft Com puting, Big Data Analytics.

RajaSekhar.P is working as an Associate Profess or in Avanthi Institute of Engg & Technology, Visakhapatnam, Andhra Pradesh. He has received his Masters degree (M.Tech) from Gandhi Institute of Technology and Management University (GITAM University), Visakhapatnam. Andhra Pradesh. His research areas include Data Mining, Distributed Systems, Big Data Analytics.