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Efficient Multipath Routing and Congestion Control Scheme for Wireless Sensor Networks

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***Abstract* – In Wireless Sensor Networks, Sensor nodes are controlled by either base station or without bases station. Once the sensor node sent a packet to the destination node, the residual energy is calculated through the multipath routing approach. There is a need of Energy based Routing in the wireless sensor network Energy based Routing in the wireless sensor network is a demanding assignment. This assignment may lead to a number of routing protocols which effectively use the limited resources available at the sensor nodes. Due to congestion, the packet loss is occurred in the particular link. To avoid congestion, cross layer based congestion control scheme is proposed for reducing the packet losses in the network. The cross layer design is proposed to ensure that the information sharing can be done between the different layers in protocol stack. The congestion control is achieved using cross layer approach. By simulation, the proposed scheme achieves better throughput, congestion ratio, packet delivery ratio and low end to end delay than the existing schemes. In recent years, Wireless Sensor Networks are the most popular networks among the other networks.**

***Keywords* – Energy Consumption, Data delivery ratio, mobility, time, Congestion, multipath routing and WSNs**

I. INTRODUCTION

A. Wireless Sensor Networks

Wireless sensor network generally composed of a large number of distributed sensor nodes that organize themselves into a multi-hop wireless network. Each network is equipped with more than one sensors, processing units, controlling units, transmitting units etc. Wireless sensor networks (WSN) are now used in many applications including military, environmental, healthcare applications, home automation and traffic control. It consists of a large number of sensor nodes, densely deployed over an area The position of sensor nodes need not be pre-determined. This allows random deployment in inaccessible terrains or disaster relief operations. On the other hand, this also means that sensor network protocols and algorithms must possess self-organizing capabilities. Another unique feature of sensor networks is the cooperative effort of sensor nodes. Sensor nodes are fitted with an on-board processor. Instead of sending the raw data to the nodes responsible for the fusion, sensor nodes use their processing abilities to locally carry out simple computations and transmit only the required and partially processed data. to terms with immense potential of Wireless Sensor Network, which consists of tiny sensor nodes scattered in a region communicating with each other over well defined protocols and transferring information of temperature, humidity etc between each other. Compared to ad hoc networks, sensor networks have some unique feature and application requirements.

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B. Design goals of Wireless Sensor Networks WSNs)

Based on the application, different architecture, goals and constraints have been considered for WSNs. As discussed in [18], the following design goals are given.

C. Energy Considerations

During the creation of an infrastructure, the process of setting up the routes is greatly influenced by energy considerations. Since the transmission power of a wireless radio is proportional to distance squared or even higher order in the presence of obstacles, multihop routing will consume less energy than direct communication. However, multi-hop routing introduces significant overhead for topology management and medium access control. Direct routing would perform well enough if all the nodes were very close to the sink. Most of the time sensors are scattered randomly over an area of interest and multi-hop routing becomes unavoidable.

D. Denial of service (DoS)

A compromised node may stop aggregating and forwarding data. Doing so, it prevents the data sink from getting information from several nodes in the network. If the node still exchanges routing messages despite its unfair behavior, that problem may be difficult to solve. Smarter attacks also involve dropping messages randomly. It is also difficult to detect when an attacker sends garbage messages.

E.Energy consumption without losing accuracy

Sensor nodes can use up their limited supply of energy performing computations and transmitting information in a wireless environment. As such, energy conserving forms of communication and computation are essential. Sensor node lifetime shows a strong dependence on the battery lifetime. In a multihop WSN, each node plays a dual role as data sender and data router. The malfunctioning of some sensor nodes due to power failure can cause significant topological changes and might require rerouting of packets and reorganization of the network.

F. Congestion Control in MANETs

The main issue in MANET is congestion control. It is totally associated to control the incoming traffic into a telecommunication network. The solution is to send a reduced packet sending rate to overcome the effect of congestion effectively. In general, the Transmission Control Protocol mainly combines the congestion control and dependability mechanism without explicit feedback about the congestion position. The congestion control principles include packet conservation, Additive Increase and Multiplicative Decrease (AIMD) in sending rate, stable network. The other techniques for congestion control are end system flow control, network congestion control, network based congestion avoidance, and resource allotment The packet loss can be condensed by involving congestion control over a mobility and failure adaptive routing protocol at the network layer. The congestion causes following difficulties: More delay: Several congestion control mechanism takes much time for detecting congestion. It leads to heavy delay. Sometimes the usage of new routes in some critical situations is advisable. The main problem is the delay moving for route searching in on-demand routing protocol. High Overhead: Congestion control mechanism takes effort for processing and communication in new routes for discovering it. It also takes effort in multipath routing for maintaining the multi-paths, though there is another protocol. More packet losses: If the congestion is detected, the packets may be lost. Congestion control solution is applied either by decreasing the sending rate at the sender, or dropping packets at the intermediate nodes or by both methods to decrease the traffic load. If the high packet loss rate occurs, small throughput may be occurred in the network.

1.3. Cross Layer design Cross layer design is said to be the violation of layered communication architecture in the protocol design with respect to the original architecture. This design emphasizes on the network performance by enabling the different layers of the communication stack to share state information or to coordinate their actions in order to jointly optimize network performance. Distributed algorithms can exploit a cross-layer design to enable each node to perform fine-grained optimizations locally whenever it detects changes in network state. Mobility causes changes for the physical layer (for e.g. interference levels), the data link layer (for e.g. link schedules), the routing layer (for e.g. new neighbouring nodes), and the transport layer (for e.g. connection timeouts). As such, a cross-layer based design enhances the capability of the node to manage its resources in the mobile environments Antenna arrays can also enable the reception of multiple packets simultaneously on the wireless channel and the data packets corresponding to several connections could also arrive simultaneously at a node. The cooperation of various layers such as routing, data link, and physical layer can ensure the forwarding of data for all the connections within time. 1

II. Related Work

Shafiullah Khan et.al [1] discussed the importance of cross layer security mechanisms and routing protocols for multi-hop wireless networks by critical comparison. The selection of optimal path for routing and the detection of multilayer security attacks cannot be achieved with the traditional approaches. They suggest that cross layer design is the only solution to cope with these kinds of challenges in multi-hop wireless networks.

In [2], the performance of four queuing disciplines like first in first out, Random early detection, priority queuing and weighted fair queuing are evaluated which is implemented in the AEERG protocol. Rajeswari et.al presented simulationbased performance evaluation and comparison of three queuing techniques for different number of nodes, packet size and pause time for the impact of using random-early drop as compared to drop-tail policy and weighted fair scheduling.

Shitalkumar Jain et.al [3] reviewed that signal strength based measurements used to improve such packet losses and no need to retransmit packets. So, the node based and link based signal strength can be measured. If a link failed due to mobility, then signal strength measurement provides temporary higher transmission power to keep link alive. When a route is likely to fail due to weak signal strength of a node, it will find alternate path. consequently avoids congestion.

G.S.Sreedhar & Dr.A.Damodaram [4] proposed Medium Access Level Multicast Routing for Congestion Avoidance in Multicast Mobile Ad Hoc Routing Protocol to avoid the congestion in networks. This protocol derives an algorithm that transmits the data in multicast manner at group level unlike other multicast protocols, concentrating of data transmission in a sequence to every targeted node. Being independent, the proposed work was with group of either tree or mesh

Tian et.al [5] proposed a node-scheduling scheme, which can reduce system overall energy consumption, therefore increasing system lifetime, by turning off some redundant nodes. The coverage-based off duty eligibility rule and backoff-based node-scheduling scheme guarantees that the original sensing coverage is maintained after turning off redundant nodes. In the scheduling scheme, the operation was divided into rounds. Each round begins with a self-scheduling phase, followed by a sensing phase. In the self-scheduling phase, nodes investigate the off-duty eligibility rule. Eligible nodes turn off their communication unit and sensing unit to save energy. Non-eligible nodes perform sensing tasks during the sensing phase. To minimize the energy consumed in the self scheduling phase, the sensing phase should be long compared to the self- scheduling phase.

Jing deng et.al [6] proposed the Balanced-energy Scheduling (BS) scheme in the context of cluster-based sensor networks. The BS scheme aims to evenly distribute the energy load of the sensing and communication tasks among all the nodes in the cluster, thereby extending the time until the cluster can no longer provide adequate sensing coverage. Two related sleep scheduling schemes, the Distance-based Scheduling (DS) scheme and the Randomized Scheduling (RS) scheme were also studied in terms of the coefficient of variation of their energy consumption. A sufficient number of sensor nodes were deployed over a sensing field such that some sensor nodes can go into the sleeping mode without degrading the sensing coverage of the network. Static circular cluster associations were assumed in the sensor network. Each sensor node belongs to the same cluster throughout its lifetime.

Ram Kumar Singh and Akanksha Balyan [7] mainly focussed on the energy efficient communication with the help of Adjacency Matrix in the Wireless Sensor Networks. The energy efficient scheduling can be done by putting the idle node in to sleep node so energy at the idle node can be saved. The proposed model in this work first forms the adjacency matrix and broadcasts the information about the total number of existing nodes with depths to the other nodes in the same cluster from controller node. When every node receives the node information about the other nodes for same cluster they communicate based on the shortest depths and schedules the idle node in to sleep mode for a specific time threshold so energy at the idle nodes can be saved.

Mohamed Lehsaini et.al [8] proposed a cluster-based efficient-energy coverage scheme Virtual Sensor (CSA_VS) to ensure the full coverage of a monitored area while saving energy. CSA_VS uses a novel sensor-scheduling scheme based on the k-density and the remaining energy of each sensor to determine the state of all the deployed sensors to be either active or sleep as well as the state durations. In this work, it is addressed that the k-coverage problem because in some applications, it is possible that some locations called sensitive regions in the monitored area are more important than others and need to be covered by more sensors to achieve fault tolerance and to deal with erroneous measurements collected by the sensors. The solution proposed can test whether a point within the monitored area is k-covered or not. To check k-coverage of this point, it the algorithm CSA_VS is applied and verified if each virtual sensor has at least k active sensors in its neighbourhood.

Babar Nazir et.al [9] presented a sleep/wake schedule protocol for minimizing end-to-end delay for event driven multi-hop wireless sensor networks. In contrast to generic sleep/wake scheduling schemes, the proposed algorithm performs scheduling that is dependent on traffic loads. Nodes adapt their sleep/wake schedule based on traffic loads in response to three important factors like the distance of the node from the sink node, the importance of the node's location from connectivity's perspective and if the node is in the proximity where an event occurs. Using these heuristics, the proposed scheme reduces end-to-end delay and maximizes the throughput by minimizing the congestion at nodes having heavy traffic load. The variable active durations are assigned to the nodes based on node distance from the sink node, node topological importance, and occurrence of event in its vicinity. It will enable the nodes to gracefully handle the traffic, as nodes are dynamically assigned active durations according to their expected traffic load. It minimizes delay at the nodes near to the sink node, node having critical topological position, and nodes in vicinity of event occurrence. This ensures rapid dissemination of data to the sink node and hence reduces the end-to-end delay.

Dimitrios J. Vergados et.al [10] proposed a Scheduling Scheme for Energy Efficiency in Wireless Sensor networks. The basic concept of this scheme is to try to maximize the time each sensor node remains in sleep mode, and to minimize the time spent in idle mode, taking into account not only the consumed power, but also the end-to-end transmission delay. This is accomplished through the synchronization of the wake up times of all the nodes in the sensor network. More specifically, the gateway gathers the available connectivity information between all the nodes in the network, and uses existing energy-efficient routing algorithms to calculate the paths from each node to the gateway. Then, the gateway constructs a TDMA frame which ensures the collision avoidance. This schedule is broadcasted back to the sensor nodes, allowing every sensor to know when it can transmit and when it should expect to receive a packet.

Rakhi Khedikar et.al [11] explored the lifetime of wireless sensor network. The research of the network lifetime for wireless sensor network is analyzed to introduce some scheduling the methods of the researchers' uses. The proposed work is focussed on increasing the lifetime by scheduling. Depletion of these finite energy batteries can result in a change in network topology or in the end of network life itself. Hence, prolonging the life of wireless sensor networks is important.

In my previous work [12], a New Multipath Routing Approach is developed which attains energy model, maintenance of optimal energy path, multipath construction phase to make a correct balance between network life time, energy consumption and throughput to the sensor nodes. In the first phase of the scheme, construction of multipath is implemented. In second phase, the optimal energy path is maintained. In third phase, residual energy consumption is increased using energy model. It uses following factors called distance , residual energy, mobility factor, mobility factor and data correlation to favour packet forwarding by maintaining high residual energy consumption for each node.

III. IMPLEMENTATION OF PROPOSED ALGORITHM

A.Multipath Routing

The concept of proposed multipath feature is towards broadcasting the traffic load among two or more routes. Load delivery is to avoid the congestion problems in the network and to increase data throughput rate. The proposed multipath system in figure1 uses multi-path routing in order to select the route with the best maximum data throughput rate.

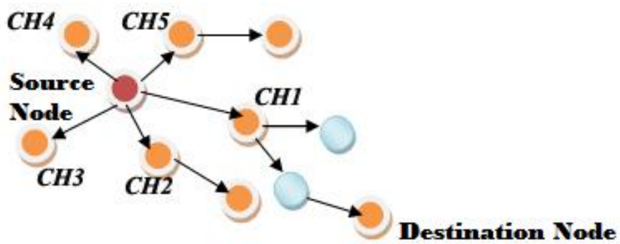

Figure 1. Multipath Routing Approach

In the proposed multipath routing scheme, the network is organized as a collection of Cluster node. Each cluster has its own cluster head. The cluster head is chosen based on the higher priority depends on communication status among the nodes, bandwidth, frequency, energy level. If two cluster participant nodes wants to communicate between different regions, they need to get permission from CH_1, CH_2. In the proposed scheme, certain constraints are to be followed.

- The node in Cluster (C), only if the hop count is below the node's hop value.
- Each node should have minimum four multiple paths to reach the particular destination D.
- The energy level of the clusters is determined based on the energy level of cluster nodes. The threshold energy level is calculated by cluster head (CH).
- The RREQ message is transmitted when the source node is reached and to create a new entry in the local routing neighbor table.

B.Congestion Detection using cross layer approach

Step 1: Source node sends the data packet to destination node via intermediate nodes to establish the route discovery process.
Step 2: Set the interval between the two adjacent packets in MAC layer.
Step 3: Calculate the packet loss rate
Step 4: Calculate the congestion scale factor
Step 5:. If the number of data packets in buffer queue exceeds the threshold value, indicating that the data packets will overflow the buffer queue in short time and congestion will happen in the local mobile node.

Congestion Control Procedure

Let the signal to interference to noise ratio (S) of the link l is given by

$$S = \frac{P_k G_d}{\sum_{d \neq k} P_o G_{ko} + n_k}, \qquad (1)$$

where P_k is the transmission power on the link k, G_d is the path gain of the link k, G_{ko} is the path gain of the node on link k to another node on the link o. n_k is the thermal noise on the link k. The maximum capacity attainable in the link k is determined using Shannon capacity theorem.

$$C_l = \frac{1}{T} \log(1 + M.S)\ pkts/\sec \qquad (2)$$

Where T is the symbol period and M is the constant based on modulation scheme used.

Step 1: Set the initial transmission rate $x_i = x_{initial}$.

Step 2: Set power of the link k is $P_k = P_{k,min}$ Step 3: Broadcast the S to the entire link.

Step 4: Update path gain of the link (G_d, G_{ko}) after receiving the broadcasting signals.
Step 5: Calculate the maximum capacity of the link C_l. Step 6: Determine the loss probability

$$\gamma_m(t) = \begin{cases} \dfrac{\max(0,(x_l(t) - c_l(t)))}{x_l(t)} & x_l > 0 \\ 0 & x_l = 0 \end{cases} \qquad (3)$$

Step 7: Calculate the data sent to the link k,

$$m_k(t) = \frac{\gamma_m(t) * S}{P_k G_{kk}} \qquad (4)$$

Step 8: Set the threshold value of path gain G, Congestion Scale Factor and Buffer tenancy fraction.

Step 9: If the any parameter below its threshold value, the route is considered to be a congestionless route.
Otherwise
Route is considered as congestion based route.

Step 10: Choose the alternative path while congested route found.

IV.Performance Analysis

Network Simulator (NS 2.34) is used to simulate the proposed algorithm. In this simulation tool, the C++ language is back end language and tool command language (tcl) is front end language. The basic advantage of this tool is more updation. In our simulation, 1500 mobile nodes move in a 1500 meter x 1500 meter square region for 120 seconds simulation time. All nodes have the same transmission range of 400 meters. The simulated traffic is Constant Bit Rate(CBR). The simulation settings and parameters are summarized in table 1.

Table1. Simulation settings and parameters

No. of Nodes	1200
Area Size	1200 X 1200
Mac	802.11

Radio Range	400m
Simulation Time	120 sec
Traffic Source	CBR
Packet Size	512 bytes
Mobility Model	Random Way Point
Protocol	DSR
Pause time	3msec

V. Performance Metrics

We evaluate mainly the performance according to the following metrics.

End-to-end delay: The end-to-end-delay is averaged over all surviving data packets from the sources to the destinations.

Packet Delivery Ratio: It is defined as the ratio of packet received with respect to the packet sent.

Throughput: It is defined as the number of packets received at a particular point of time.

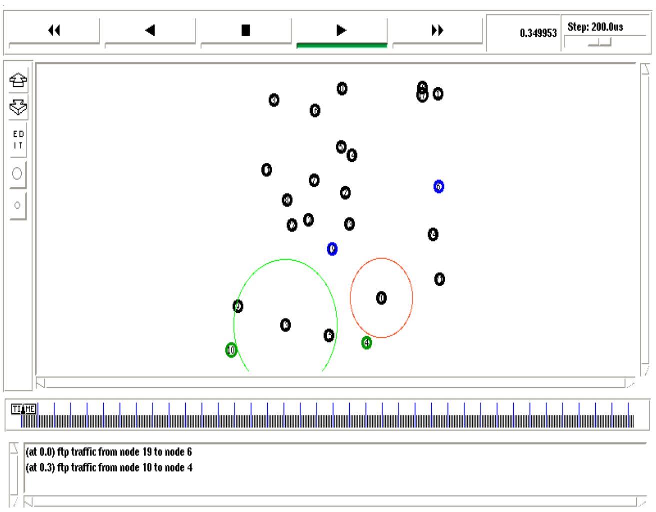

Figure 1 Topology of the proposed scheme

Figure 1 shows that the proposed scheme topology for ensuring the multipath routing. Source node sends the packet to destination node via intermediate nodes. In case if the node failure occurs, the node choose the alternative path to reach correct delivery of packets.

V. CONCLUSION

In WSNs, the nodes are totally distributed in a random manner. The control may be issued by base station or without any base station. A Multipath Routing Approach is proposed which attains energy model, maintenance of optimal energy path, multipath construction phase to make a correct balance between network life time, energy consumption and throughput to the sensor nodes A Cross Layer based congestion control scheme is developed which attains congestion detection and congestion control among nodes. In the first phase of the scheme, cross layer design is proposed. Here, information is shared between the different layers of the protocol stack. In congestion control phase, the route is found without congestion

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