# Design of Priority based Energy Productive Protocol for Controlling Congestion in Wireless Sensor Networks

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## Abstract

**Objectives:** Congestion is one of the major threats that we experience while transferring the data in WSN (Wireless Sensor Network). It occurs when the incoming rate of the packets to the sensor exceeds its outgoing rate which leads to queuing delay and packet loss. Since the energy consumed is proportional to the amount of data being transmitted, energy consumption can be reduced by minimizing the unnecessary transmission of data. **Methods:** During congestion it leads to exhaustion of energy and decreases the efficiency of the node. In the existing method DAlPaS algorithm is used to increase the network life time by reducing energy depletion at the sensors along a single path by finding alternative path when more than one flow is initiated through the same path. Alternate path selection could be done either by soft stage scheme or by hard stage scheme. In soft stage, the node that receives more than one flow and has the risk of buffer overflow or low power status, advises one of the sending nodes to change the path and it continues to forward the packets for that flow till the sending node finds alternate path and changes the path. But in hard stage, the availability status of this neighbor node is set as false in the sending node's neighbor table, so that the sending node is forced to find an alternate path before it sends the next packet. When more than one path exists, the sender will select the neighbor based on priority. The priority of a node is based on the distance from the sender and residual energy in the node. **Findings:** In the proposed method priority based dynamic alternative path selection algorithm is used to increase the network lifetime, to avoid network partition and packet loss due to energy depletion and to utilize the node's energy efficiently. **Applications:** Some of the major applications of Wireless Sensor Networks are security surveillance, environmental data compilation and tracking of sensor node. Sensor network applications are wide in range and they vary significantly in the mode of deployment, modality of sensing or the power supply.

**Keywords:** Congestion Control, Delay, Dynamic Alternate Path, Energy Efficiency, Packet Delivery Ratio, Wireless Sensor Networks

## 1. Introduction

Ad hoc networks in Wireless Sensor Networks are composed of nodes and they are low powered battery operated nodes. An example of infrastructure-less network is an ad hoc network where the nodes are connected with the other nodes that are in its transmission range and the nodes can communicate with other nodes either directly or indirectly through intermediate nodes. In ad hoc network all nodes should be capable of routing packets. If a packet received is not intended for itself, it forwards the packet to next node along the path to the destination. The sensors in Wireless Sensor Networks are usually deployed in areas where the power source cannot be renewed or replaced. Hence the design of any algorithm that has to be used in Wireless Sensor Networks should be aware of consumption of energy. Some applications may need to transfer huge amount of data from source to sink. In such cases while transferring large amounts of data there will be some possibility for the congestion to happen. In[1] con-

gestion leads to packet drops and retransmission of lost packets leads to higher energy consumption and higher latency. The congestion control is divided into two categories namely Traffic Control and Resource Control. In Traffic Control technique data rate is controlled, whereas in Resource Control it will make the nodes to be in the path from source to sink which will increase the network's capacity. Each method will have its own advantages and disadvantages. Traffic Control will work efficiently for transient demands and Resource Control will work efficiently for persistent demands. Resource Control method is effective when compared with the Traffic Control method. Even though the Traffic Control method is simpler and cheaper it will become improper when monitored event takes place. Implementing and designing a Resource Control method is somewhat a tedious process because many factors should be taken into account. If the nodes are randomly allowed to choose alternate path or next hop based on the occupancy level of the buffer it will become disastrous. In case of congestion when choosing an alternate path the parameters that need to be considered are:

- Residual energy of the nodes in the network.
- Congestion in requisites of interference and occupancy of the buffer.
- The time delay for transmission of data from source node to sink.
- Packet loss rate.

The routing algorithm based on the single path will suffer from the problem of power exhaustion when they tend to use the shortest path to forward the data. Congestion can be controlled in this algorithm by reducing the source node's rate of transmission which is not an acceptable condition in many applications. Hence this led to the development of lightweight, efficient and simple congestion control algorithm called as Dynamic Alternative Path Selection. The DAlPaS make use of the Resource Control method to mitigate the congestion where data load of network is not reduced which guarantees the performance. To choose the appropriate path it uses the flag decision algorithm. In the proposed method priority based congestion control is used along with dynamic alternate path. There are three modules namely discovery phase, congestion control module and priority decision module. In discovery phase, once the nodes are deployed in the transmitting area with one sink and multiple source

nodes, they initiate discovery procedure to learn about its neighborhood. In congestion control module, both soft stage and hard stage approaches are implemented to study the benefits of both. In soft stage approach, all flows through the node is monitored and when the incoming rate exceeds a threshold value, a message is sent to one of the sending nodes to change its path and till the sender finds alternate path, the packets form that node are forwarded to the destination. But, if the alternate path selection latency is higher there may be packet loss due to lack of buffer space at the congested node. In hard stage approach availability status of the congested node in the sender's table is set as false so that the sender is forced to find alternate path before sending the next packet. But this approach increases the latency in packet delivery. In both approaches, priority decision module is used to find alternate path and the priority is decided based on the distance and the energy of the nodes.

DAlPaS algorithm is an easy and efficient method which controls the congestion. It efficiently chooses an alternate path during congestion by considering certain parameters namely availability of buffer, low remaining power and the availability of the lower level nodes. Nodes are deployed in random manner. In[2] alternate path selection could be done either by soft stage or hard stage schemes. Soft stage advises to change the path in case of congestion. If congestion cannot be avoided using soft stage, hard stage is used which sets its flag value either to true or false. When a node is congested it sets its flag to false and sets to true when it is free. When compared to hierarchical tree alternate path selection and topology aware resource adaptation, dynamic alternate path selection is simpler and avoids the congestion immediately after the setup phase and also the signalling overhead will be minimum in the DAlPas. In[3] worked on congestion alleviation avoidance and detection approach; normally congestion not only causes information loss but also results in more consumption of energy. To reduce the amount of energy consumption, they have used three mechanisms: 1. To act as data sources certain nodes are selected, 2. Check for the utilization of the channel and the occupancy of the buffer, 3. By using Resource or Traffic Control, congestion is avoided. They have suggested this approach to reduce the energy consumption. In hierarchical tree alternative path[4] approach Resource Control algorithm is used by applying two methods, they are: 1. Load is reduced and 2. The resources are increased. In this paper, it is compared with other algorithms like TARA, no congestion control and

Traffic Control. Thus this approach is effective in reducing the congestion. In[5] topology aware resource adaption approach involves two types of nodes namely distributor and merger nodes. When the congestion happens, traffic is deviated from hotspot along detour path and finally reaches the merger. It will stop using the detour path when there is no congestion. Thus, in this method in order to make the adaption to happen in a quicker manner the distributor node will keep its memory within itself whereas on the original path the neighbour will be used. In[6] the distance vector routing is used in order to reduce the overhead. This ad hoc on demand approach is used to establish and maintain the path for the nodes that act as active destination. When this approach is compared with other approaches it has two important advantages: 1. Loop free paths are maintained and 2. In order to find the disjoint path it does not require source routing. Thus, they have used this approach to reduce or minimize the overhead. The upstream hop-by-hop congestion control protocol is composed of two components namely the detection of congestion component and the adjustment of rate component[7]. Upstream hop-by-hop congestion control calculates the congestion detection by making use of the difference between the unoccupied size of the buffer and the traffic rate which is used to calculate the congestion index. UHCC considers the priority of the traffic for the adjustment of the rate and the tendency is being observed before one interval of the congestion where very less packets have been dropped. In[8] Data rate and alternative path has been compared in order to avoid congestion. HTAP and SenTCP is used. When congestion happens it leads to packet drops and when no countermeasures are taken in that case there occurs dead paths. In the former algorithm to avoid congestion, alternate path is being used and in the latter the data rate of the source is reduced.

## 2. System Model

In the proposed methodology when congestion occurs, the packets will be forwarded to the other node in the same level based on the energy and distance. Initially the nodes are deployed and after discovering each other they can communicate with their neighbors bi-directionally. Figure 1 shows a random deployment of nodes and the nodes are connected to other the nodes that are within its range. The nodes which are going to transmit the data

will find the nodes in the lower level and it will forward the data. Each node present in the network will transmit the data through the shortest path. In the Figure 1, it is considered that node 18 forwards the packet to node 17. In 17th node is chosen based on the distance because it is located nearer to 18 than other neighbors. But when node 17 becomes congested, it cannot receive anymore packets from node 18 and hence sends a message to node 18 to choose alternate path. Node 18 chooses another node in the same level based on the priority, distance and residual energy to forward the packet. In this example node 18 chooses 11 instead of node 14 based on the remaining energy and distance. Then node 11 forwards the packet via 12, 3 to sink.
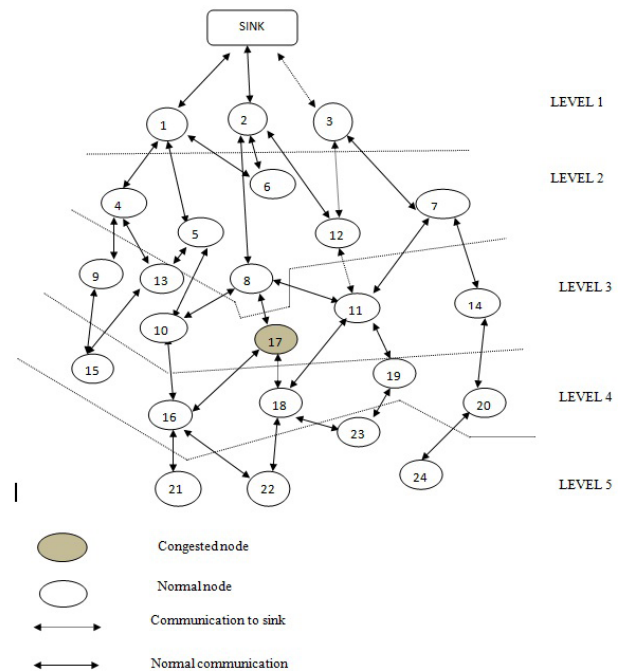


**Figure 1.** Network connectivity representing the congested node.

### 2.1 Discovery Phase

In the discovery phase the nodes discovers each other. After the deployment of the nodes randomly, during discovery phase the sink node which broadcasts hello message to all source nodes present. The nodes that receive the hello message transmit an acknowledgment message. Upon receiving those acknowledgment messages, the sink node in turn sends the connect message along the shortest path to each such source. The nodes that are closer to the sink, communicates directly with it.

## 2.2 Congestion Control Module

In a densely deployed network, topology control schemes are critical. The node which is going to transmit the data will find the node in the lower level and through that lower level node it will transmit the data. Hence tree is created and all the nodes present will transmit the data through shortest path. Traffic is being spread between all the nodes which lead to better load sharing and balanced energy consumption. When more than one node transmits the data at the same time to the transmitting node and if their cumulative rate of data is more than the available maximum rate it results in congestion. In this case, soft stage technique is applied which reduces the data rate and the remaining resources present remain unused. A node enters into the soft stage condition only when packets are received from more than one flow and informs it cannot receive any more data by sending the back pressure message. The flag field is used by the hard stage scheme which is used to indicate whether the node is ready to receive the packets or not. This flag is set to false when a node receives the packet with a high rate of data than the transmit rate, when the buffer occupancy reached its upper limit, when the power is low and when the lower levels nodes are unavailable. The flag is set to true if the buffer occupancy is below upper limit and if the lower nodes become available and also if the node is not running out of power.

## 2.3 Priority Decision Module

The priority is decided based on the energy of the nodes. In priority decision module it is mainly concentrated to increase the packet delivery ratio and to minimize the delay. Packet delivery ratio represents the number of packets received by the sink and the number of packets transmitted by the source. For transmitting a packet the node has to decide through which node it should transmit and the nodes are selected based on the distance. Nodes with smaller distance are selected. If two nodes have equal distance then the node with maximum energy[9] is selected. After selecting the node packet is forwarded to the next hop. After transmitting it checks whether the packet transmitted is received by the sink or not. The transmitting node is selected based on the distance and the energy of the node, which results in reduced packet loss, minimized delay, increased energy efficiency with better throughput and packet delivery ratio.

# 3. Experimental Results

The proposed priority decision phase for controlling the congestion was implemented in NS2. The main objective is to increase the packet delivery ratio and to minimize the delay. The performance of this protocol is calculated considering the metrics namely delay and packet delivery ratio. Delay refers to the time difference between the packets sending at the sender's side and receiving of the packets at the receiver's side whereas the packet delivery ratio is the amount of packets that has been delivered to the sink or destination. The nodes are deployed in a 500*500 m area. The performance of this scheme is carried out by considering some of the simulation parameters shown in Table 1. Figure 2 shows the packet delivery ratio graph where the time and packet delivery ratio are shown in x and y axis respectively. It represents the percentage of the successfully received packets. Figure 3 represents the delay graph where the packet id and delay are shown in x and y axis respectively. Initially the delay will be high as the time taken by the nodes to discover each other requires periodic exchanges of hello message.
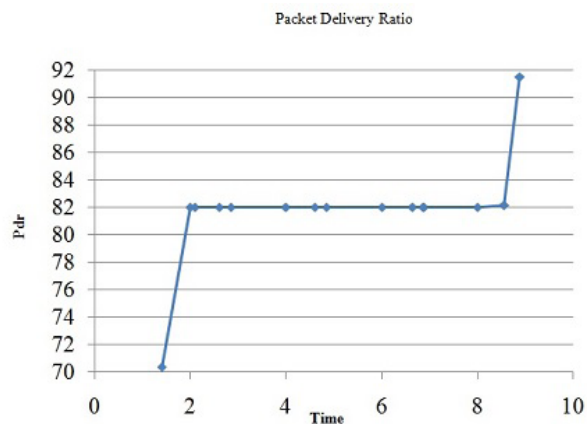


**Figure 2.** Packet delivery ratio.

**Table 1.** The simulation parameters

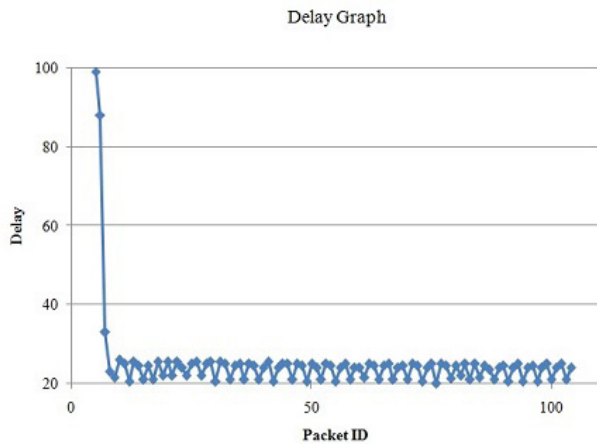| Parameters | Value |
|---|---|
| Simulator | NS2 |
| Area | 500*500 |
| Network size | 27 nodes |
| Simulation time | 10 minutes |
| MAC Type | Mac/802_11 |
| Initial Energy | 50 |
| Link Layer Type | LL |

Delay Graph



**Figure 3.** Delay graph.

## 4. Conclusion

In Wireless Sensor Networks, congestion either needs to be avoided or controlled. Dynamic alternative path selection avoids congestion by employing the soft stage scheme which will serve only one flow and advises to change the path in case of congestion. If congestion can be avoided with soft stage scheme then buffer based on the congestion can be reduced. In case if it is not able to achieve, then hard stage scheme is applied by the dynamic alternative path selection algorithm. By doing so, flows of data are strained to alter their path so that it will not congest. Path is changed by choosing an alternate path in DAlPaS. Instead of choosing an alternate path priority can be set based on the distance and energy. Priority for a node is given based on the distance from the transmitting node and the amount of energy present in the node. When more than one node exists at the same distance then the node with the higher energy is given the priority. Priority based congestion control protocol helps in improving the efficiency of the network, throughput, packet delivery ratio and minimizing the delay.

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