

A Study on Energy Efficient Routing Techniques for Wireless Adhoc Network

Mrs. Lavanya C B¹, Prof. Asha K N², Prof. Asha Rani K P³

¹M.Tech, Dr. Ambedkar Institute of Technology, Bangalore-56, Karnataka, India

lavanya.basavaraj@gmail.com

²Assistant Professor, Dr. Ambedkar Institute of Technology, Bangalore-56, Karnataka, India

asha.kn@dr-ait.org

³Assistant Professor, Dr. Ambedkar Institute of Technology, Bangalore-56, Karnataka, India

asharani.kp@dr-ait.org

Abstract— Conserving the battery energy of the nodes in the wireless network is the most important task as these mobile devices are battery operated. Many methods have been presented to conserve and improve the energy level of these devices. In this paper we summarize energy efficient routing based on various metrics such as power awareness, residual energy etc.

Index Terms— Wireless Adhoc Networks, Energy efficient routing, Power Aware Routing, Drain rate, Online Energy Aware Routing, Metrics

INTRODUCTION

An ad hoc network does not depend on the preexisting infrastructure. A wireless ad hoc network is a decentralized type of the wireless network, where all the nodes or devices would have the equal status on a network. Each node participating in routing may use the classic routing techniques or could use the flooding for forwarding the data. The communication could be end-to-end or hop-by-hop which depends on the reliability requirement of many applications. Energy management plays a crucial role in wireless network due to limited energy availability in wireless devices since the communication between devices consumes significant amount of energy. An efficient energy routing techniques would help to prolong the network lifetime. This paper gives a brief about such energy efficient mechanism considering different metrics that can be reasoned in energy constrained environment. The defined solutions make use of different terminologies of wireless network such as number of nodes in a network, number of packets transmitted and received, minimum cost path, minimum energy path, the error rate, delay in transmission and receiving etc. In the next section we give a survey on the different methods based on the different metrics for energy efficient routing.

POWER-AWARE ROUTING

The main aim of using this technique is to conserve power and ensure increase in the node and network lifetime by carefully sharing the cost of routing packets^[4]. This can be achieved by considering different metrics such as minimizing energy consumed, maximizing time to network partition, minimizing variance in node power levels and minimizing cost or packets^[4].

Minimize energy consume/packets: it can be easily calculated that this metric will minimize the average energy consumed per packet. It can also be checked that the routes selected will be identical to that of routes selected by shortest hop routing while using this metrics for light loads. But this metric may tend to route packets around the congested areas when one or more nodes are heavily loaded in the shortest path. This may lead to drawback of this metric by having widely differing energy consumption profile^[4].

Maximize time to network partition: This may not be the optimized metric to use if it is to maintain low delay and high throughput simultaneously. This metric depends on the max-flow min-cut theorem, where the minimal set of nodes that would cause the network partition could be found. Therefore the routing technique should divide among these nodes to maximize the life of the network. We should make sure that these nodes drain their power at equal rates failing which causes the increases in delay as one of these nodes die. But in our case we cannot achieve global balance required for

maximizing network partition time while minimizing the average delay since nodes in different partition determine routes independently^[4].

Minimize variance in node power levels: this metric treats all nodes in the network equally and avoids penalizing one more than other. The goal of the metric can be achieved by using the policy called 'join the shortest queue' as this helps in solving the similar problem of load sharing in distributed systems. However if all the packets are of same length then equal power drain can be achieved by choosing next hop in round-robin fashion^[4].

Minimize cost/ packets: This metric helps to achieve the goal of maximizing the life of all nodes in the network^[4]. The care should be taken while using this metric that the paths selected and nodes in that path with depleted energy reserves should not depend on many paths. The advantage of using this metrics is we can increase the time of network partition and reduce variation in node cost, effects of network congestion can be incorporated and it is possible to use the battery characteristics directly into routing protocol.

POWER AWARE MULTI-ACCESS PROTOCOL WITH SIGNALING (PAMAS)

This protocol works as the intelligent system by saving up to 40-70% of battery power by turning off radios when they are of no use i.e., either transmitting or receiving packets. This method can be stated as the advanced method of the above said method^{[1][4]}. This makes use of the separate signaling channel. Thus the ready to send (RTS) and clear to send (CTS) messages are sent through this signaling channel separate from packet transmission channel.

Figure 1^[1] indicates the PAMAS protocol with six states Idle, AwaitCTS, BEB (Binary Exponential Back off), Await Packet, Receive Packet and Transmit Packet. Node would be in Idle state when it does not have any packets for transmitting or receiving, or does have packet to transmit but cannot transmit. When a node gets a packet to transmit it enters to AwaitCTS state by transmitting RTS. If the awaited CTS do not arrive, the node goes into BEB state. If CTS does arrive it enters to Transmit Packet state by initializing packet transmission. The intended receiver upon transmitting the CTS, enters the Await Packet state. It returns back to idle state if the packet does not arrive within one roundtrip time. If the packet does start arriving, it enters the Receive Packet state by transmitting busy tone over signaling channel.

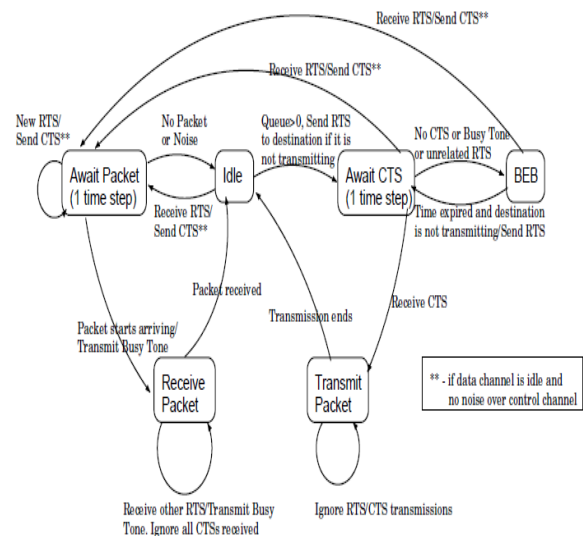


Figure 1: PAMAS protocol

The transmission by one node will be heard by all n-1 nodes. If we assume power consumed for transmitting a packet as 't' and to receive as 'r', then the total power consumed for one packet transmission system wide is t+(n-1)r. This results in drawback as total power consumption should be less than t+r. PAMAS protocol help to overcome those situation by shutting down n-2 nodes off during transmission^{[1][4]}. This can be achieved based on following conditions

- If a node has no packet to transmit and if its neighbor begins the transmission.
- If it's entire neighbor's neighbor are transmitting the packets.
- Similarly, if at least one of its neighbor nodes is transmitting and other is receiving.

The problems that arise with these conditions are

- For how long is a node is powered off?
- What happens if a node wish to send a packet to a node that is powered off?

These problems can be solved by estimating the length of the packet transmitted. In PAMAS the transmission of packet happens by exchange of RTS/CTS messages over separate signaling channel, thus not effecting the packet transmission. The RTS/CTS message sent consists of the packet length, using which the node can determine the length of the transmission and power of upon meeting the condition^[4].

ENERGY EFFICIENT ROUTINGS

A number of energy efficient routing protocols have been proposed to remedy the unreliability of wireless channels using energy efficient reliable routing structure.

To seek the balance of smaller transmission power and lower link error rate, the energy efficient routing and power assignment were integrated into one scheme by considering link error rate as a certain function of transmission power^[3].

We can notice that the expected link error rate could be derived when the power to support every link communication is given, thus finding the minimum expected power consumption could be found between any two given nodes. Change in the power transmission changes the shortest path found also^[3].

Energy efficient routing can also be done by considering the residual energy which makes use of the minimum energy cost information^[2]. Few algorithms that can be used for such technique are reliable minimum energy cost routing (RMECR) and reliable minimum energy routing (RMER)^[2]. The main aspects of these algorithm can be termed as energy-efficiency, reliability, prolong network lifetime, packet size, number of retransmission allowed for a packet and impact of the acknowledgment packets etc. These algorithms make use of either end-to-end or hop-by-hop transmission and retransmission for reliability^[2].

ENERGY DRAIN RATE

Here we make use of a metric called drain rate, which is found against the current traffic conditions, this would help in finding the remaining battery capacity of the nodes in the active path. A number of route selection mechanisms for ad hoc network have been proposed to find the routing protocol using drain rate metric such as Minimum Drain rate (MDR) and Conditional Minimum Drain Rate (CMDR). MDR gives prominence for extension of nodal battery life and the duration of the paths, whereas CMDR checks on minimizing total transmission power consumed per packet^[5]. Here the energy indulgence rate would be calculated for every node where it monitors the energy consumption caused during transmission, reception and other overhearing activities using which it calculates the drain rate for every sampling interval. The status of the selected path could be changed based on the variation in the power drain rate at nodes in the current active path. When these algorithms used in proactive routing protocols all the nodes are required to maintain the updated power information of all nodes regardless of their demand for routes^[5].

Minimum Drain Rate mechanism does not guarantee that the transmission power is minimized; it is here where the Conditional Minimum Drain Rate (CMDR) could be made use of. CMDR calculates and chooses the path with minimum total transmission power among all possible paths^[5].

ONLINE ENERGY AWARE ROUTING

Finding the energy efficient route to maximize the network lifetime without the knowledge of future message flows is difficult. The solution to this could be found by choosing the path that consume least total energy and also avoid energy depleted nodes, which conflicts each other. This conflict can be solved by depleting the system in two phases^[6]. The polynomial time combinatorial technique can be used to balance between minimum energy level of any node in the path and energy consumed along a path. This routing problem could be solved using the similar solution of the widest path approach. An addition advantage of using this method is that it allows us to address other quality of service metrics such as delay which is necessary for the resource constrained network^[10].

CONCLUSION

An energy efficient routing plays a vital role as the sensor networks are of restricted energy based. There are various techniques of energy aware routing in wireless ad hoc network as mentioned in the beginning sections of the work. This paper makes an effort of studying various metrics focusing mainly on the energy level of the nodes and the network. A number of energy efficient routing and power assignment protocols have been proposed in this literature giving the brief idea on the different metrics that could be considered during energy efficient routing.

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