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A Survey on mitigating network congestion in wireless sensor networks using opportunistic routing

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Abstract

The network congestion is one of the challenging problem as the network grows into bigger size. The congestion makes network inefficient due to loss of packets and delay in the transmission of messages. Routing packets in multi-hop networks having multiple sources for generating the traffic on wireless links increases the delay in packet transmission. The major challenge in the design of routing policies to reduce the transmission delay is balancing the trade-off between traffic distribution in the network using backpressure technique and shortest path routing of the packets to the destination. The opportunistic routing concept in Wireless Sensor Network (WSN) is emerging to overcome deficiencies of the conventional routing techniques. The variants of opportunistic routing is proposed, it works by combining certain important advantages of shortest path routing and back pressure routing with congestion diversity is called as distributed opportunistic routing. The opportunistic routing techniques will ensure a bounded expected delay for any kind of network and under any admissible traffic.

1. Introduction

The networks made by spatially distributed sensors are called wireless sensor networks (WSN's) [1] which is used to collect information from external world. Environmental conditions can also be monitored including moisture levels in the soil, amount of pressure applied on physical objects, amount of temperature in different geographical areas etc. It's proven advantages also found in many different domains like military applications, traffic monitoring and controlling, weather forecasting, detecting landslide, detecting forest fires etc. WSN's are the backbones of modern techniques like IoT and embedded systems or Cyber Physical Systems (CPS). The ability to sense the information from various real-world physical entities makes WSN's a popular topic for the research.

Ad Hoc networks [2] are developed using either two or more personal computers or Wi-Fi enabled wireless devices such as smart phones or tablets, these devices are connected with the help of wireless connections. Ad hoc networks are used over traditional networks because of their disadvantages. A typical wireless network is based on a wireless router or access point that connects to a wired network and/or internet. An access point or wireless router is used in wireless network to wired network and to internet. Ad hoc network will not uses the router instead of that computers are directly connected to each other with the help of wireless network adopters. As the network grow bigger the problems arise, one of the problem is congestion, because of which the packets may get dropped or the delay time may get increased. The increased delay time makes the network inefficient.

The routing is one of the difficult task in wireless sensor network. Routing protocols are used to develop routing tables, designing such protocol for WSN is much more difficult than designing a routing protocol for traditional networks. Opportunistic routing is trajectory based protocol uses both the vehicle movement and the geographical information provided by Global Positioning System (GPS). In Opportunistic routing nodes stores the data until it receives a suitable node. For choosing the suitable next hop each node computes the closest point in their trajectory in direction of the destination [2]. The wireless communication networks are deployed in many places with variety of environmental conditions including volcanoes, underground mining and regions affected by hurricane are to mention a few but not limited. In these environments we suffer from lack of network infrastructure, routing using traditional techniques is inefficient and impossible. Moreover, the wireless connected devices have been increased tremendously creating the necessity of new routing strategies to exploit the potentials of the heterogeneity in wireless devices. Hence, in order to overcome the limitations of traditional

routing techniques, and to improve the radius of wireless networks having dynamic heterogeneous in nature, the opportunistic routing strategy is evolved.

In WSN, there is a requirement to save energy to increase network lifetime is becoming an very interesting issue in this research domain. Therefore, the resource management in the design of routing protocols is becoming important. Routing is again divided into two sub categories one is route selection and another one is data forwarding. Multi hop routing is a traditional routing strategy which suppresses the wireless network ability to broadcast by using Automatic Repeat Request [ARQ] and Forward Error Control [FEC] data link techniques [3].
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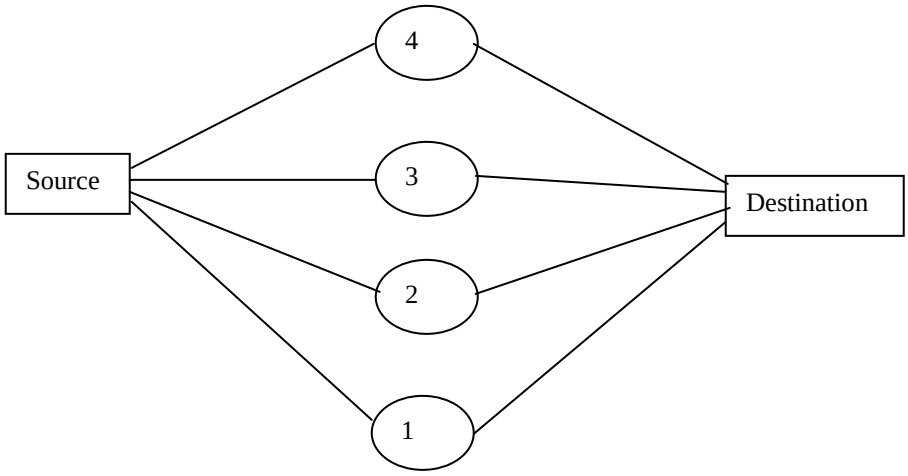

Fig. 1: Illustration of data transmission through intermediate nodes from source node to destination node.

The main idea in OR is using broadcasting feature of sensor networks such that data transmission from source node to destination node can be eavesdropped by many nodes. Unlike selecting next node to forward the packet ahead of time, the opportunistic routing selects the next immediate node quickly at the time of transmission. If 15% is the probability of packet delivery from source node than all intermediate nodes can have 85% packet delivery probability to the destination. Choosing any one intermediate node for forwarding the data in traditional routing leads to decrease in the packet delivery probability. Thus in OR we consider every intermediate node for forwarding the data which results in packet will reaches the destination through closest node. It is proven that OR technique will gives good performance compared to traditional approach in routing. The main task of the opportunistic routing is to choose the set of node as the forwarding set and assign priority to every node. Consider the example in the above figure, Here the node S is considered as source node having 4 intermediate nodes instead of one intermediate node makes it more reliable and efficient in routing techniques. In next section of the paper the work related to opportunistic routing in different kinds of network and its comparison is made available [4][5][6].

2. Literature Survey

VANET uses verity of routing protocols. Broadcast based routing, Cluster based routing, Geocast routing, Position based routing, Topology based routing and hybrid routing. Each and every routing methodology is having some challenges during the implementation. In this survey position based routing is considered and one important issue is acknowledged, disruption or delay is considered as an important issue and handling this situation is a big challenge for researchers. Opportunistic routing algorithm provides the solution for this issue by implementing this algorithm in Delay/Disruption Tolerant Network [2].

A. GeographicAdhoc network multihop performance using geograhic random forwarding (GeRaF) [7]

The geographic random forwarding scheme is proposed which relay on nodes geographic position information. Initially relay node of the wireless network is unknown by the sender but the decision is postponed after the transmission. Geographic routing is based on the telecasting nature of the existing wireless network. Network topologies are changing random over time, due to this which of the neighbor node acts as a relay node is unknown to the sender. Hence, contention problem occurs at the receiver end, the above scheme is proposed to overcome this problem. The simple idea that author proposed in the paper is as follows: the broadcasted packets contain location information of the destination and source unlike network information in other routing techniques. All neighbor nodes will receive the packets automatically find out the right relay node which is nearer to the destination based on distance they automatically prioritize the node. The relay packet from relay node is forwarded to the broadcasted address which is also having source and destination location thus creating a geographic route without having routing table.

Geoloaction based packet forwarding approach is explained in the paper and here relay node will be selected randomly at the receiver side through contention. The multihop performance analysis is done based on the number of nodes will reach from source to destination as a destination function and as well as total number of neighbor nodes to the source node.

B. *Multihop Opportunistic Routing for wireless sensor Network (ExOr) [8].*

The first basic protocol to implement practically the opportunistic routing techniques in wireless networks. ExOR makes batches to forward packets. The packet intended for the same destination are grouped together by the source node which collects and groups the packets. Batch is allocated for each batch. Batch ID and the prioritization in forward list is made by the source node based on the matrices in ETX table, priority is high if distance of node from target node is shorter. Forwarder list contains only nodes with higher priority. Local batch map is associated for each node in the forwarder list. Packet will be sent to packet batch for the associated batch. Local batch map entry is compared with each holes map entry in the packet, if entry with higher priority detected, entry in the local batch is replaced. Already scheduled packet transmissions are implemented by ExOR to make sure packets are forwarded by only one node at a particular time. ExOR working is illustrated in the below example. Consider an network consists of 4 nodes, node A sends the packet to D, So node A, in the list of forwarding node will be (C,D,B) , ExOR always tries to forward the packets to the node having least remaining distance from the destination. So, if C, B, D will receives the packets then ACK will be sent by each of them to node A along with sender ID. If node D is the first node to send the ACK along with it's ID as higher (forwarding list first candidate). So, the node C will not receive this ACK it will send own ACK having own ID as the higher ID. Node B has receives the ACK made by node D, Sends it's own Acknowledgement with node D as higher ACK. Thus node C does not sends the packets because it founds through node B's Acknowledgement that the higher known Acknowledgement.

ExOR produces more throughput than the conventional routing techniques it is having certain drawbacks. 1. ExOR will not responds to the measurements without update. It considers only the info available at the transmission time. So, incorrect measurements can degrades it's performance and it can cause packet redundancy. 2. It seeks always the proper coordination between all nodes which contributes for the overhead in large networks. It doesn't use the information repeatedly.

C. *Forward List selection in Opportunistic Routing strategy [9].*

The Minimum Transmission Scheme (MTS) algorithm proposed in the paper carefully selects forwarder list t reduce expected transmission delay under ideal coditionas in the network. It is assumed that high priority nodes only broadcast the packets to the low priority nodes to avoid transmission of duplicate packets. Under this assumed situations author proposed Minimum Transmission Schme (MTS) algorithm to reduce number of transmissions in the network by optimally selecting forwarder list. Using MTS in ExOR instead of ETX in ExOR gives better throughput due to fewer transmissions. I some exceptional cases ETX will perform well compared to MTS when ideal ACK is not obtained.

D. Opportunistic routing in multi-hop wireless networks carrying heavy payloads [10].

Short haul multi-hop wireless networks are examined to develop efficient opportunistic routing scheme. In proposed technique an opportunistic routing algorithm is modified to send ACK after receiving the packets. The destination node receives the packets opportunistically according to the algorithm by overhearing the packet transmissions at different nodes in the network. ACK will be sent to all other nodes in the path by destination node after receiving the packets from the source node. Packets can be retransmitted by the node in case destination node or nearest node in the path fail to send the packets. Hence duplicate packets can be easily discarded by this technique. Thus , the main contributions of the proposed algorithm is reducing the packet duplication rate, increasing the throughput more than the opportunistic routing. Proposed algorithm is very simple can be incorporated with other routing algorithms.

E. Cognitive Radio using Spectrum aware routing [11]

The Spectrum Aware Opportunistic Routing (SOAR) for Cognitive Radio Networks (CRN) is proposed by Shih-Chun Lin and Kwang-Cheng Chen. Optimal Link Transmission (OLT) technique is used in the proposed system as cost evaluation metric to assign different priorities to the nodes in the forwarder list. OLT metric is also considered for evaluating delay. Two other such evaluation metrics called optimal path and optimal node elaborates information about total nodes from source to destination path and delay obtained in each path to the respective destination. Due to the new evaluation metric proposed SOAR guarantees the more throughput and decreased end to end delay compared to traditional routing in cognitive network.

F. Opportunistic Routing for Energy Efficient Wireless Sensor Network [12].

Here cost metric is used for choosing forwarding list to minimize energy usage when broadcasting the packets in wireless sensor networks. Energy Efficient Opportunistic Routing (EEOR) evaluates the cost in occurs for forwarding the data packets to the particular node than that node will be selected for forwarding list. The new forwarding list will be selected by the rule that expected cost of nodes must be less than expected cost of nodes in the prefix forwarding list, Hence expected cost of nodes is minimized. The expected cost of each node is calculated by using Bellman Ford algorithm. The transmission speed and data receiving rate is more in EEOR compared to ExoR. EEOR consumes less energy compare to ExoR due to considering expected cost metric in selecting the forwarder list.

G. A Framework for opportunistic routing in ad hoc network [13].

In this paper an author proposed theoretical model for opportunistic routing. The proposed strategy considers packet delivery ratio and prioritizing the nodes for selecting the next best hop for packet transmission. This framework helps to analyze the different performance metrics including packet drop rate, data transmission rate, transmission delay etc.

H. The guaranteed opportunistic routing algorithm for Vanet [14].

The paper deals with security deficiency and uses trust mechanism to overcome the deficiency in opportunistic routing algorithm. There should be balance between expected cost metric and security in the system. In the proposed system trust percentage is calculated regularly and trust degree is updated. Direct trust degree is calculated by observing neighboring nodes and indirect trust is calculated by the recommendations. Based on direct and indirect trust the author implemented the opportunistic forwarding mechanism with trust and efficient forwarding list as well as prioritization mechanism. The proposed algorithm performs well in throughput, transmission delay and security in communication. The proposed system avoids the suspicious node in the network to participate in communication by detecting the malicious node using trust metric. Hence it reduces the packet transmission delay and provides better security.

I. A New Opportunistic Routing Algorithm in Mobile Networks [15].

Two new cost metrics are introduced in the paper used for MANETS. One is social relationships and another one is profiles of the nodes, both use the existing expected cost. The proposed system uses distributed protocol called as Social Relationship Opportunistic Routing (SROR) to calculate the forwarding node list for routing. The system considers

relationship in the society, relationship mobility and public profile for Ad hoc networks. In SROR the three parameters are used for selecting the forward node in routing process, Matching profiles, connectivity matching in social relationships and interaction. Hence, probability of forwarding the data to the similar intended candidates is more due to algorithm. SROR achieves more throughput using higher data delivery rate and gives efficient routing when compared to other traditional protocols for MANET.

J. Relay Node Selection in Opportunistic Routing Algorithm for Wireless Sensor Networks [16].

Improving the network lifetime by saving energy in the WSN's is the main concept in this paper. The paper describes how the proposed algorithm minimizes the consumption of energy in the network. Energy Efficient node (EEN) concept is introduced in proposed energy saving opportunistic routing (ENS-OR). EEN is a logical relay node formulated by relay function on some of the real nodes. The process of selecting the forwarding list and assigning priority to the nodes in that list is carried out by the ENS-OR algorithm. Which calculates the optimal hop distance for deciding the next hop node to forward the data. The nodes in the forwarding list prioritize themselves by their residual energy and their distance from EEN. ENS-OR obtains better network energy usage. Also it increases the network lifetime by achieving higher residual energy of the nodes in the network. The packet delivery rate of ENS-OR is greater than that of GeRaF.

Table. 1 Forward list selection and protocol design comparison of OR protocols.

Protocol	**Forward List selection**	**Protocol designed for which network.**
GaRaF	Hop by Hop	Ad-hoc Sensor Network.
ExOR	End to End	Wireless Sensor Network
MTS	End to End	Wireless Sensor Network
OR for short haul path	Hop by Hop	Short haul Multi hop WSN
SAOR	Hop by Hop	Cognitive Radio Network
EEOR	End to End	Wireless Sensor Network
Theoretical model for OR	End to End	Ad-hoc Sensor Network.
TMCOR	End to End	VANET
SROR	End to End	MANET
ENSOR	End to End	Wireless Sensor Network

3. Conclusions

Wireless sensor networks opportunistic routing technique has gained attention from many researchers now a days. The broadcast approach of the wireless sensor networks is utilized in OR to improve it's efficiency than the traditional routing strategies for W.S.N. The challenging issues of WSN's are network infrastructures can't be predetermined, Sensor nodes having limited battery power, environmental conditions may be disastrous so that many sensor nodes are vulnerable etc. In sensor networks due to limited battery power resource allocation has become the major challenging issue. OR chokes many of the critical challenging issues concerned to WSN's. The OR protocols currently exist deals with issues like securing energy, minimizing data redundancy, increasing the network utilization etc. ExOR2 protocol is first protocol to implement this opportunistic routing technique in WSN's. The efficiency of routing has improved many folds using OR, but one drawback associated with OR is packet duplication problem which in further minimized by MHS4. Designing of VANET's, CRN and MANET's also utilize OR to provide QoS guarantee and throughput improvement. Energy saving technique in has to be improved in future. The energy saving in sensor network is a prime issue. Integrating OR with duty cycles can provide efficiency in terms of survey energy. Nodes in the network need not be active all time, those nodes which are not involved in receiving and transmission activities are pushed to sleep mode. The network lifetime can be improved with this mechanism.

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