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# An Opportunistic Routing Protocol to Maximize Network Lifetime in Wireless Visual Sensor Networks

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***Abstract: Wireless Visual Sensor Networks (WVSNs) is an emerging trend in which network lifetime is very critical. We enhance Geographic Opportunistic Routing to maximize network lifetime by choosing the best nodes. Many nodes can have the same capability to forward and it is very difficult to select the best nodes with less constraints. As the number of constraints increase, the Best Node Selection is done efficiently which leads to an efficient routing path with increased network lifetime. We use multihop routing which reduces the overhead. Evaluation in NS-2 proves the efficiency of the proposed protocol.***

***Keywords: Geographic Opportunistic Routing, Best Node Selection, Maximizing Network Lifetime.***

## I. INTRODUCTION

Wireless Visual sensor networks (WVSNs) use camera nodes to capture either image or video. These camera nodes use smart cameras that support many different kinds of applications. Unlike ordinary cameras used only for monitoring, smart cameras have internal processing power for compression, image identification, detection and alerting the personnel. WVSNs are different from Wireless Sensor Networks and they require separate attention. Unlike WSNs, WVSNs obtain only 2-dimensional & 3-dimentional data. They are independent and do not need cluster head.

WVSNs require routing mechanisms which provide high reliability, low delay, energy conservation, low bandwidth, high performance and low cost. Choosing the best nodes for packet transmission is much needed for a good routing in WVSNs. The protocols used in WSNs cannot be directly applied to WSVNs, since visual data can either be two dimensional or three dimensional, which require more convenient mechanisms. The main quality constraints that can be obtained through the network layer are reliability, timeliness, robustness, availability, security and energy efficiency. The fundamental Qos parameters such as delay, jitter, and packet loss rate can be used to measure the degree of satisfaction of these services [1].

Maximizing network lifetime is very important because there will be some way to transmit the packets. Increasing network lifetime reduces the overall cost of the WVSNs. Considering just one or two constraints and not considering other constraints will not lead to best node selection. Rather taking multiple constraints into account and choosing the nodes is a better idea. The proposed system could also increase the reliability and speed of the routing. In wireless networks, either multipath routing or multihop routing is used to provide quality constraints. The basic idea from Pareto Principle leads us to move towards the proposed protocol.

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## II. Related Work and Background

In wireless networks, either multipath routing or multihop routing is used to provide quality constraints. Multipath routing can be used to provide reliability and shorter end to end delay. But multipath routing is not energy efficient.

Multipath routing uses the most nodes in the network and the destination node may receive the same packet multiple times and hence, it is not energy efficient. Hence multihop routing is better than multipath routing. In the proposed algorithm, we consider the constraints at each hop. The authors in [4] also convey the same.

Geographic Opportunistic Routing (GOR) can be exploited to provide the above quality constraints without the drawbacks of multipath routing. Geographic routing [5] has low overhead, good scalability and high capacity and it is a good choice for many wireless sensor applications, where data progress is based on location information of the nodes. Having this information, the data can be directed to a particular region and progress towards the sink at each hop.

To transmit the packets with the required constraints, two important issues are considered: (1) candidate selection and (2) relay priority [6]. Candidate Selection refers to the choosing of nodes and relay priority is the flow of packet through the nodes in the network. These two constraints form the core of the proposed system.

In [7], the authors propose an Efficient Qos-aware GOR (EQGOR) for WSNs which considers the above mentioned issues. They exploit GOR to provide end to end reliability and delay constraints. But they do not focus on how to increase network lifetime. The next disadvantage of the EQGOR is that, they use broadcasting which consume more energy, since all the nodes receive the data.

In [8] the authors consider energy efficient data processing and visual data transmission schemes. They propose a distributed algorithm to maximize network lifetime. The authors in [9] consider cross- layer design and residual energy. But most works [10], [11], [12], [13] and [14] consider only reliability, speed or energy efficiency.

The Geographic Opportunistic Routing is considered effective for a multi-hop wireless networks. Each node in the network knows the location information of their one-hop neighbors in the network. Since Visual Wireless Sensor Networks are considered here, the nodes are sparsely deployed. Here we use MAC layer protocol to provide the link quality services. We consider two important link estimation services [7]. First one is Packet Reception Ratio (PRR) [6] which is obtained by the ratio of successful messages received to the total number of messages sent to that node. The second one is Single hop Packet Progress (SPP) [6] which is the distance between the sender node and the receiver node or the intermediate node, where the receiver node must be within the coverage area of the sender and also towards the destination. The receiver node capable of receiving the visual data may not be necessarily the destination or the sink node. The Euclidean distances are calculated between the source and destination and between the intermediate nodes and destination. Only the positive values of the difference between the former and later are considered.

## III. System Model

We make three filtrations in choosing the best nodes. The first filtration is based on the coverage. The second filtration is done based on the link quality estimation services. The third filtration is done based on delay, reliability, energy, remaining number of hops to destination and channel capacity which is compared with the expected reliability, delay. Even though there can be many forwarders, the best three forwarders can give a good start. The first filtrated nodes are sorted in descending order based on the PRR and SPP. The sorted nodes must be tailored such it must be less than or equal to 25% of the total nodes present. But a condition is that there must be at least one node to forward the packet. The efficient first three nodes from the second filtered nodes are chosen for forwarding which increases the network life time.

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Best Node Selection uses the Pareto Principle also known as the 80 – 20 rule which states that 80 percent of the events are due to 20 percent of the causes. Best Node Selection triggers the 20 percent causes for the 80 percent more network lifetime, reliability and less delay.

The nodes within the coverage area (S*cov*) are selected and the distances between the intermediate nodes and the sender are calculated. There will be less number of hops if the distance between the sender and the intermediate node is more. It is best illustrated in figure 1.

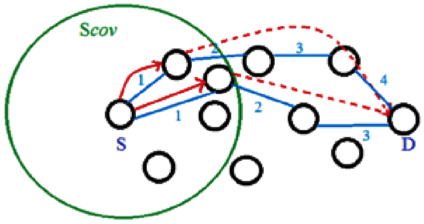


Fig 1 Illustration for Remaining Number of hops

Thus, SPP will assure that will make minimum number of hops. Based on node density the hop counts can increase. For each node, the next-hop neighbors must be calculated. The one hop neighbors within the coverage. They are refined based on the positive high SPP and high PRR values. The distances between the nodes are compared with the range and the nodes within the range are processed for the next filtration. Since GOR provide the location information of their one-hop neighbor, PRR and SPP can be accessed by the neighbor node. The next-hop neighbor list is sorted based on their PRR and positive SPP values.

One cannot expect the nodes to be uniform in a wireless network and that too after a single transmission the nodes have various differing capabilities to transmit the packet. The more the number of nodes utilized for packet transmission, the more will be the energy consumption. According to us, reliability can be provided by choosing efficient nodes and these nodes need not necessarily be more. Reliability cannot be assured only on the basis of the number of hops towards the destination. Reliability is the assurance that the packet must be delivered without any loss which depends not only on the number of hops but also the other constraints such as the node's PRR, energy and its position within the coverage. Few numbers of hops to the destination increase the network's lifetime and energy conservation of the other nodes. Hence reliability Re,

$$Re = PRR, within\ Scov \qquad \text{--------(1)}$$

Delay De is calculated by the time taken to transmit the packet which includes the overall delay for transmission between two nodes.

$$De = Ri - Ss \qquad \text{-------(2)}$$

Where, Ri is the receiving time of the packet by the intermediate node and Ss is the sending time of the packet by the sender. Energy of the node is difference between initial energy and drained energy. The energy may be drained from the node due to packet reception and transmission.

While choosing the nodes, energy of the particular node has to be considered. Consider a node having high reliability and very low energy in the network. The question is how the node can be able to transmit the visual data to the other nodes or sink.

$$EN = ENi - ENd \qquad \text{--------(3)}$$

Where, EN is the available energy obtained by subtracting the drained energy. ENd from the initial energy ENi. The node which involves in high transmission and reception will soon drain out of energy which decreases network lifetime. The node having high energy is highly reliable. So we take into account the node having not only the high reliability and low delay but also it must have high energy. Assumption of end to end delay and reliability values and then comparing with the values for each hop may only be an additional calculation but does not improve the notion any further. The top nodes in the next-hop list

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(NNL) are checked for high reliability, high energy and low delay and within the coverage of selected. These selected nodes are reduced to three nodes such that the first node is assigned the highest priority, the second node, less priority than first one and the third node is the least priority.

All the constraints are checked with average values to provide consistency. Consider node i to be the current node and j represent all the neighbors of the current node. The estimated number of hops, the expected reliability and the expected delay are calculated and checked with the actual delay, actual reliability. The actual delay of the nodes must be less than the expected delay and the actual reliability must be greater than the expected reliability and then the nodes are prioritized. Here EstNH is the estimated number of hops, ExpRe(i) is the expected reliability of node i and ExpDe(i) is the expected delay of node i. The Re must be greater than ExpRe and De must be less than ExpDe.

$$EstNH = \frac{Distance(i,destination)}{Avg\{minDistance(i,j),maxDistance(i,j)\}} \quad \text{----- (5)}$$

$$ExpRe\{i\} = Avg\{SPTR(i,j)\} \quad \text{------ (6)}$$

$$ExpDe\{i\} = \text{Max}\{\frac{maxDe\{i,j\}}{Dist(i,dest)} * EstNH\{i\}, Avg\{minDe(i,j), maxDe(i,j)\} \quad \text{-----(7)}$$

As the number of constraints increase, the level of efficiency in choosing the nodes will increase dramatically. This in turn will increase the efficiency of the routing path and also the network lifetime. There will be at most three forwarders because three priorities are more than enough when most constraints are considered.

After Best Node Selection for each node is done, relaying the packets must take place. The sender transmits the data through multicasting to the best nodes. They in turn again transmit the data to their best forwarders and so on. Broadcasting with priorities in packet header can cause additional overhead to the routing. Instead of broadcasting, we choose multicasting to relay forward the packets. Multicasting considerably reduces the energy consumption, since the nodes that don't involve in forwarding can turn off their radios. Broadcasting may introduce overhearing, while multicasting limits it.

The proposed protocol openly considers three constraints such as reliability, delay and energy while choosing the nodes to increase network lifetime. Minimum number of energy efficient forwarding candidates can lead to achieve the required constraints, since the other nodes can save the energy for their turn. To ensure high reliability to transmit visual data, the number of forwarding candidates should be less but efficient.

## IV. EVALUATION

The proposed protocol for WVSNs is evaluated using ns-2 simulator. For our convenience, we have implemented the EQGOR protocol in WVSNs and then we have compared it with the proposed protocol for efficiency in WVSNs. In our implementation in ns-2, the visual sensor nodes are placed in a 600m x 600m square area. The nodes are deployed varyingly from 20 to 30 nodes. Two nodes are selected randomly such that one behaves as the source or the sender and the other as the sink or receiver, since any node can perceive the data. The image is sensed by the source node and it is forwarded through multiple hops to the sink. The transmission range of the node is set to 50m. We have shown that the proposed protocol for WVSNs is the efficient protocol when compared to the EQGOR protocol.

Figure 2 illustrates the Network lifetime of our proposed protocol and EQGOR. It tells the proficiency of the routing protocol in network lifetime.

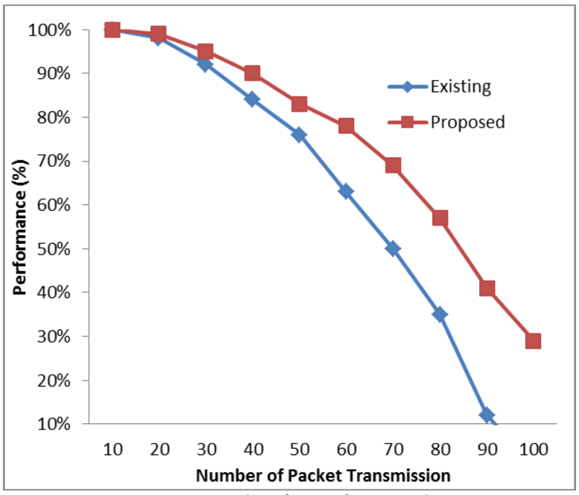


Fig. 2 Network Lifetime for 20 nodes

## V. CONCLUSION

The comparison of the proposed protocol with existing protocols prove that the more the constraints, the more efficient will be the forwarder selection. The network lifetime is greatly increased due to the consideration of node energy and multicasting the packets. We are further adding more constraints such as bandwidth and remaining number of hops to choose the nodes. In future, we try to avoid repeated transmission to the same nodes to increase the network lifetime further.

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