FREEGOR: A FAST AND RELIABLE AND ENERGY EFFICIENT GEOGRAPHIC OPPORTUNISTIC ROUTING PROTOCOL IN WIRELESS VISUAL SENSOR NETWORKS

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ABSTRACT

Network lifetime, reliability and timely communication in Wireless Visual Sensor Networks (WVSNs) are major problems since visual data are not one dimensional. Reliable communication may need multiple transmissions resulting in delay and waste of energy and may need retransmissions. Our challenge is to provide these contradictory quality constraints in one protocol.Attaining one particular quality service proficiently and not considering the other quality services is not a smart choice nowadays. In this paper, we have made an attempt to provide multiple quality constraints such as reliability, timeliness, energy efficiency, network lifetime, bandwidth consumption and less overhead cost for routing in WVSNs. We propose FREEGOR protocol which exploits geographic opportunistic routing to transmit visual data by choosing the nodes having high reliability, maximum energy and least delay. The FREEGOR protocol provides the best routing with maximum network life time, less overhead and negligible retransmissions. Evaluation results show that the FREEGOR represents its name.

Keywords: Wireless Visual Sensor Networks, Geographic Opportunistic Routing.

I. INTRODUCTION

Recent advancements in sensor technology make it easier to use them in a variety of applications. Visual sensor networks are camera based sensors, which capture either image or video. They may be both wired and wireless, where wireless visual sensor networks (WVSNs) require more attention due to unreliable links. WVSNs are applied in many important applications such as traffic surveillance, military, monitoring in both indoor and outdoor environments, etc. Since WVSNs deal with video or image, energy efficiency, network lifetime, bandwidth, reliability and speed are required.

WVSNs are now given more importance than Wireless Sensor Networks because people from various parts of the world can understand images or video better than one particular language.Images or Video explain more than words and numbers. Processing image/video is more difficult than processing words or numbers. The vitality of WVSNshas encouraged us to implement good routing protocol for it. 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 ismuch 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 ofthese services [1].

Providing just one or two quality services proficiently and not considering other qualities is not a smart choice nowadays. Rather taking multiple constraints into account and providing a particular level of service is much better. But there are some challenges [2] (1) Providing reliability may need multipath transmission or retransmissions which may result in delay and waste of energy (2) Conserving energy by limiting the usage of nodes makes reliability difficult to achieve (3) Both the above statements require time to choose paths and nodes. Hence we come to a conclusion that reliability, delay and energy are contradictory quality constraints [3] and attaining them is our challenge.

Section 2 describes some of the related work and their drawbacks. Section 3 describes the system model and the problem formulation. Section 4 describes the FREEGOR Design with the description of the FREEGOR algorithm and the Relay forwarding. Section 5 provides the evaluation of the FREEGOR algorithm.

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. The authors in [4] reveal that there are some disadvantages in multipath routing (1) Sending a packet over multiple paths increases energy cost (2) Multipath introduce channel contentions and interference which may cause delivery delay and transmission failures. Hence multihop routing is better than multipath routing. In the proposed algorithm, we consider the constraints at each hop.

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 authorspropose 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. They try to prove that less delay can lead to energy efficiency. But they have not considered energy as a separate energy constraint. 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. The next disadvantage of the EQGOR is that, they use broadcasting which consume more energy, since all the nodes receive the data. Figure 1 explains that the more there is energy consumption the less will be the network lifetime.

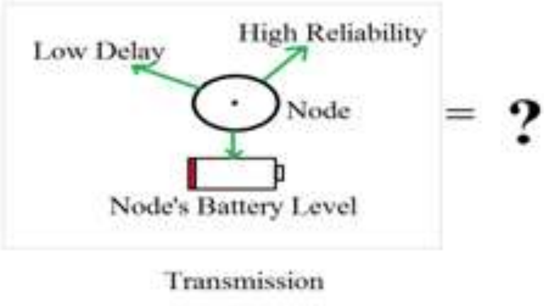

Fig1 Transmission impossible without Node energy

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 one or two quality constraints, but not many. This induced us to develop the protocol FREEGOR, which openly considers three constraints such as reliability, delay and energy while choosing the nodes, which in turn improves two other quality constraints such as performance and 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 beless but efficient.

III. SYSTEM MODEL AND PROBLEM FORMULATION

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. First one is Successful Packet Transmission Ratio (SPTR) which is obtained by the ratio of successful messages transmitted to the total number of messages transmitted by the node.The successful messages are those that are reached at the destination by the proof of the acknowledgement. The second one is Per hop Max Distance Progress (PMDP) which isthe maximum 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. In figures 2and 3, 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.

Thus, PMDP will assure that will make minimum number of hops. Based on node density the hop counts can increase. For each node, the next-hop neighbor list (NNL) must be calculated. The one hop neighbors within the coverage are listed in NNL. They are refined based on the positive high PMDP and high SPTR values.The distance between the nodes are compared with the range and the nodes within the range are put in the next hop neighbor list of the node. Since GOR provide the location information of their one-hop neighbor, SPTR and PMDP can be accessed by the neighbor node. The next-hop neighbor list is sorted based on their SPTR and positive PMDP values.

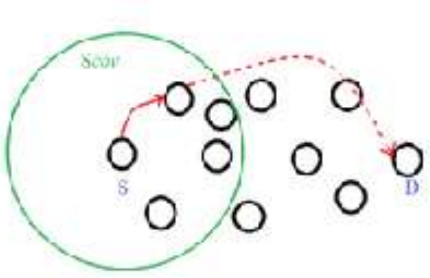

Fig. 2 Chances of more hops

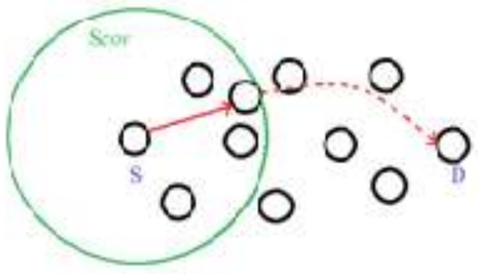

Fig.3 chances for fewer hops

We considered three constraints such as delay, reliability and energy of the node to select the best node from NNL. The node which has high reliability, high energy and low delay is given high priority. The sender multicasts the data to the forwarders based on their priorities.

Reliability is an important constraint and it is a foolproof that the transmission is reliable when the packet is transmitted to more number of nodes. Transmitting to more number of nodes is just an option to increase reliability when all nodes are considered uniform. 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 bychoosing 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 SPTR, energy and its position within the coverage.Few number of hops to the destination increase the network's lifetime and energy conservation of the other nodes.Hence reliability,

Re = SPTR, EN, PMDP <Scov --------(1)

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

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

where,Ri is the receiving time of the packet by the intermediate nodeand 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.

$$EN = ENi - ENd\text{--(3)} \quad \text{--------(2)}$$

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 (NNL) are checked for high reliability, high energyand 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.

When the network becomes dense, there can be more nodes with the same capability to forward. To refine the best more constraints such as channel capacity, remaining number of hops to the destination from the current node can be considered. 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.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 sender multicasts the data to the best forwarders. They in turn again transmit the data to their best forwarders and so on.

IV. FREEGOR DESIGN

4.1 Freegor Description

The FREEGOR algorithm (a) describes the best forwarders selection and the algorithm (b) describes the relay forwarding. Even though there can be many forwarders, the best three forwarders can give a good start. FREEGOR will only prioritize the best forwarders. The NNL is sorted in descending order based on the SPTR and PMDP. The sorted NNL must be tailored such it must be less than or equal to 25% of the total nodes present and assigned to BNL (Best Neighbor List) in the same order. At the same time it must be greater than 1. The BNL contains only the minimum nodes with high link quality services. These nodes are then compared respectively with each other based on their energy, delay and reliability values. The efficient first three nodes are placed in the BFL and are assigned priorities based on their values.Initially we included first node of BNLi into BFLi and remove it from BNLi.

Then, we check whether the sink node is present in the BNLi, because sometimes the destination may be near. If sink node is present in BNLi, then checking for quality is waste of time and calculation and so we can directly transmit the packet to the sink. The nodes are selected by the delay, reliability and energy. Then we will include first node of BNLi into BFLi and adjust all nodes in BFLi by theirquality criteria. Otherwise, we eliminate the node inBNLifrom adding to the BFLi. If the node is the only available node in NNLi or BNLi then simply add the node into BFLi and find theNNLi for that node and routine starts again.

4.2 Freegor Algorithm

4.2.1 Best Forwarders Selection

Input: Available Next-Hop Neighbor List NNLi(NNLi>= 1), Quality Requirements : Delay (De), Reliability (Re) and Energy (EN), Maximum Number of forwarders **$0<\alpha \leq 3$**

Output: Best Forwarders List BFLi

Algorithm:

1. **if** <NNLi = 1>
2. **then**
3. BNL ← { NNLi };
4. **else**
5. Sort NNLi w.r.t SPTR and PMDP
6. BNL ←<sorted NNLi>, sorted NNLi<= 25% of total nodes
7. **if**<SINK in BNL>
8. then assign only SINK in BFL
9. **else**
10. BFLi← {BNL1}

11. BNLi $\leftarrow$ BNLi - {BNL1 }
12. **WhileB**NLi $\neq 0$
13. **do**
14. **if** Min delay of BNLi and Max reliability of BNLi and Max Energy of BNLi**then**
15. **for** i=0 to α**then**
16. Add BNL1 in BFLi and
17. Arrange the nodes in BFLi w.r.t Delay, Reliability and energy
18. insert BNLi to BFLi
19. BNLi $\leftarrow$ BNLi - {BNL1 }
20. **end**
21. **else**
22. BNLi $\leftarrow$ BNLi - {BNL1 }
23. **end**
24. **end**

4.2.2 Relay Forwarding Through Multicasting

Input: Source(Si), Destination(Di), Best Forwarders List BFLi

Output: Packet Received at Di

Algorithm:

1. Si<--- SourceNode
2. **While** |BFLi of Si| <> 0 then
3. **if**<Destination Exist in {BFLi} of Si>
4. **then**
5. Sent packet to Destination Di
6. Return
7. **else**
8. Multicast message to all BFLi of Si till destination reached
9. end

In relay forwarding, we multicast the visual data to the BFLi of the source node and the nodes in the BFLi transmit the packet to their own BFLi respectively. This is done continuously until the packet is reached at the destination. As soon as the destination reaches the packet, all the other nodes stop transmitting the data.

V. EVALUATION

The FREEGOR 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.

5.1 Simulation Settings

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 35 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 250m. In the following figures we have shown that the FREEGOR protocol for WVSNs is the efficient protocol when compared to the EQGOR protocol.

Figure 4 represents that FREEGOR limits the number of forwarding nodes. In figure 5, the delay in the proposed protocol does not make much difference than the existing one. Figures 6 prove that FREEGOR is good in performance. Figure 7 tells the proficiency of FREEGOR in network lifetime.

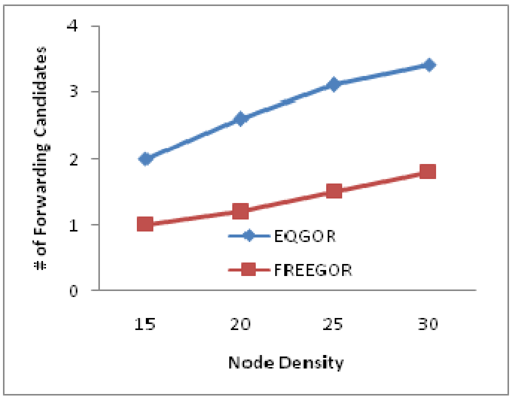

Fig4 Number of Forwarding Candidates

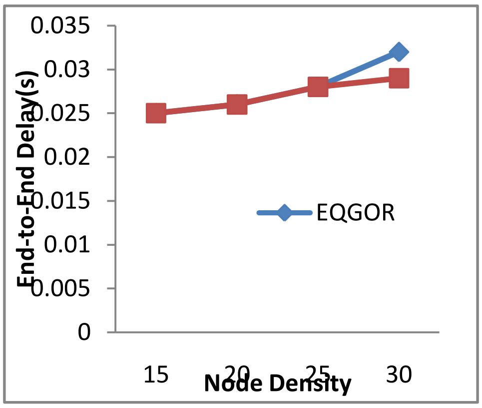

Fig 5 End to End Delay

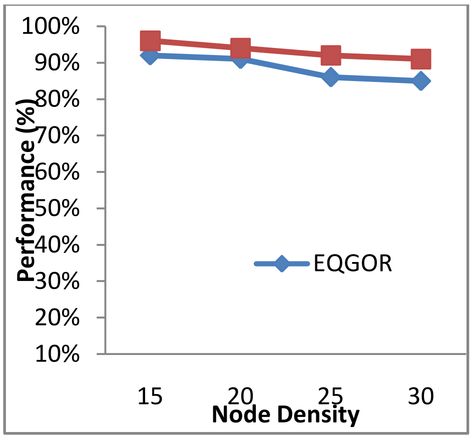

Fig6 Performance

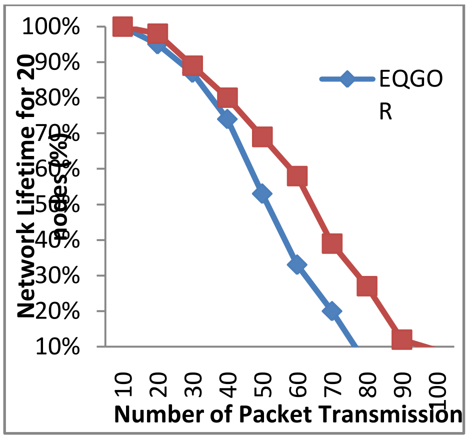

Fig7 Network Lifetime for 20 Nodes

VI. CONCLUSION

The comparison of FREEGOR 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 as per the statement. FREEGOR proves its proficiency in speed, reliability, network lifetime and performance.

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