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Implementing Two Phase Geographic Greedy Forwarding protocol for Multiple Source Wireless Multimedia Sensor Networks

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Abstract

The problem of exploring node-disjoint paths for multiple source nodes in Wireless Multimedia sensor networks (WMSNs) is essential for several multimedia applications. This requires each of these nodes to discover, at least, one node-disjoint path to the sink node in order to deliver its data in an efficient and reliable manner. To the best of our knowledge, none of the research projects has addressed the problem of allowing multiple source nodes to concurrently discover node-disjoint paths for transmitting multimedia traffic. In this paper, Two- Phase Geographic Greedy Forwarding routing mechanism (TPGF) for WMSNs is implemented. This mechanism allows multiple source nodes to simultaneously discover and utilize as many node-disjoint paths to the sink node as possible. The performance of the implemented protocol is evaluated via NS2 simulation and compares with the state-of-the-art. The result demonstrates that TPGF allows the multiple source nodes to get connected to the sink node as expected, and improve the overall network capacity and throughput. The average end-to-end delay is slightly degrades, due to an increased average path length, this drawback is overcome by discovering more concurrent paths and achieving higher packet delivery ratio.

Keywords: NS2, TPGF, WMSNs

I. Introduction

A new type of wireless sensor networks (WSNs) that has emerged recently is the wireless multimedia sensor networks (WMSN), which is concerned with collecting data such as audio and video that is needed in many important applications such as forest

monitoring, wildlife monitoring, and security of premises. Since the data sensed in WMSN is dense by nature, any routing protocol to be designed for these types of networks should take into consideration the specific requirements that should be satisfied in order to work properly in terms of successful timely data delivery and the order of delivery [1]. Some of these requirement are:

1) Node-disjoint path transmission: Since the multimedia stream required a considerable amount of network resources. Therefore, each multimedia stream needs to have a distinct path from other multimedia streams.
2) Multiple path transmission: The set of nodes that form a specific path and are responsible to forward the dense data from a specific source node to Base Station (BS) will be exhausted rapidly. Thus, multiple paths should be explored to balance the heavy traffic over them.
3) Shortest path transmission: Since multimedia streaming has strict delay constraints, the selected path must reduce the end-to-end delay that is often provided by the path with minimum number of hopes.

Many routing protocol were proposed to achieve these requirement for multimedia transmission in WMSN. However, these protocols addressed the problem for the single source node scenario. Therefore, finding node-disjoint path for multiple source nodes is still an open research problem and, hence, optimal or near optimal solution for that problem should be investigated [2].

II. Wireless Multimedia sensor networks (WMSNs)

During the last decade, WSNs received a large attention from both the academia and the industrial all over the world. Wireless sensor nodes are low-cost, low-power, and multifunctional tiny devices that have the ability to sense, communicate together over a short distance through a wireless medium, and perform computational operation [3]-[4]. Despite the limited capabilities of these sensor nodes. A large number of them can together perform any complex task such as environment monitoring, military surveillance, and industrial process control [5].WSNs consist of densely wireless sensor nodes that are usually distributed in a random fashion. This random distribution, besides the power, computation, memory and higher unreliability of sensor nodes imposes a big challenge on how the will support different type of complex application requirements. From here, a strategy that controls and manages various types of WSNs functions, such as synchronization, node localization, network routing, and network security, is highly recommended. Many researches from all over the world were carried to investigate WSNs constraints and thus finding the optimal solutions for the design and application issues of WSNs.

II.1. Location-based Routing in WSNs

There are a lot of various routing protocols that were proposed in the area of WSNs, each of them try to find the optimal solution for specific application requirement, taking into account the available resources capabilities [6]. the most important protocols are

Location-based protocols, These types of protocols find the optimal path from source node to BS based on the location information of the sensor nodes. Thus, the next hope node toward the BS is selected based on the distance information. There are a lot of forwarding strategies that take into consideration the distance information to find the next hope node such as The Greedy Forwarding Scheme (GFS) [7]. The Most Forward within Radius (MFR) scheme [8]. The Nearest Forward Progress scheme (NFP) [9]. The Compass routing (CR) [10]. The Randomized Compass Routing (RCR) [10]. And the Random Progress Forward scheme (RFP) [11]. are single path WSN geographic routing protocols that only differ in the way, in which the next hope node is selected. GFS selects the closest neighbor to the sink, MFR selects the farthest node to the current relay node, NFP selects the closest neighbor to the current relay node, CR selects the neighbor node that has the smallest angle at the source; formed by drawing s line from the neighbor node to source node and from source node to the sink, RCR selects the neighbor that has the smallest angle with the source node among a randomly selected set of neighboring nodes, and RPF selects the next hope randomly among the neighboring nodes. Also, distance information can be combined with other metrics such as link reliability and resident energy to solve various routing issues [12]-[13]-[14].

II.2. Location-based routing in WMSNs

Most of the geographical routing protocols designed for WMSNs focused mainly on finding multiple disjoint paths for a single source node, some of these protocols are discussed below.

Geography based Ad hoc On-demand Disjoint Multipath scheme GAODM [15]. Uses the push-relable algorithm to convert the ad hoc network into a flow network, and then find multi node-disjoint paths based on the flow assignment. The main target of the push-relabel algorithm is to find the maximum number of flows in a flow network. The forwarding strategy used here is the greedy forwarding. Although GAODM is a multi-disjoint path routing protocol, it does not guarantee the shortest path exploration.

Node-Disjoint Parallel Multipath Routing protocol DPMR [16]. Uses GFS to select the next hop node. Although DPMR is a multi-disjoint path protocol, it uses the planarization the face routing algorithms and hence it does not guarantee the shortest path exploration.

Adaptive Greedy-compass Energy-aware Multipath AGEM [17]. Uses real-time geographic forwarding decisions at each hop to achieve load balancing and reduce the overall consumed energy. The main idea here is to make the multimedia stream passing through multiple paths from source to BS in order to balance the traffic over more relay nodes and so decreasing the overall consumed energy and increasing the network life-time.

The Director Geographical Routing algorithm DGR [18]. Is a direction-based multi-disjoint path protocol. It consists of two phases: the expanding phase and the converging phase. DGR starts by sending a set of control messages, which are used to construct the disjoint paths, each with a specific distinct deviation angle between -90° and 90°. In the expanding phase, the deviation angle of a certain path starts with its

highest value and then the angle is decreased as the path converges to the sink. When the deviation angle is equal to zero, the routing algorithm starts the converging phase, in which the explored path moves in a straight towards the sink.

The Enhanced Directed Geographic Routing algorithm E-DGR [19]. Is an enhanced version of DGR. The functionality of E-DGR is the same as the DGR except that it adds a new phase, called the parallel phase, between the two phases of the DGR. In this phase, the explored path moves in parallel to the straight line between source and the sink. By doing this, the contention between the explored paths is reduced and hence more node-disjoint paths are explored than that of DGR, but on the other hand, DGR finds shorter paths than E-DGR. However, both DGR and E-DGR guarantee finding more node-disjoint paths than earlier algorithm such as GSPR, but do not guarantee finding the shortest paths.

A non-interfering multipath geographic routing for WMSNs is proposed in [20]. It shows the importance of finding non-interfering disjoint paths rather than finding more paths. Doing that, the collision possibility decreased between the sent data over different paths, and so the overall network performance, such as throughput, PDR, and end to end delay, are enhanced.

A radio-disjoint geographic multipath routing for reliable data transfer in lossy WSNs is proposed in [21]. It also handle the problem of interfering, but here three paths between the source and the sink nodes are established, the path found should go through three pipelines that are far from each other by distance equal to the transmission range (R) and have a width equal to (R). Thus, the distance between any two nodes on different paths will be at least equal to (2R). hence, any distance with value smaller than (2R) will not guarantee the non-interfering case. Also, the paths found here are restricted to three.

an interfering-free multi disjoint paths algorithm is proposed in [22]. The main idea is to reduce the interfering between the sent packets over different disjoint paths as much as possible. To do this, the region between the source and the sink nodes is divided into several district with width equal to the communication radius (R), and then the district are grouped into three groups with distance between two district in the same group equal to (2R) except the nodes in the proximity of source and sink nodes. When sending data, it will be sent through different group each time, through different distinct in the same group, simultaneously, that far from each other by distance equal to (2R). the path in each district is found using the greedy forwarding scheme.

Ad hoc On-demand Distance Vector Routing AODV is an on demand routing protocol. It is a standard routing protocol with RFC (Request for Comments) 3561. It has three control packets. These packets are Route Request (RREQ), Route Reply (RREP), and Route Error (REER)

The RREQ is broadcasted to find the sink node. However this broadcast packet is generated when a source needs to send the data packets. RREQ is broadcasted till the sink is discovered. The RREQ packet contains the source identifier and the broadcast identifier. Both are used to maintain the reverse route entries. When the RREQ reaches at the sink node, it replies back to the source by sending the RREP message. This RREP message is a unicast message sent by the destination and while sending the

RREP message each node maintains a forward route entry. When the RREP reaches at the source node the route is discovered. This discovered route is based on the hop count and is considered as an active route for data forwarding. If the packet loss or link layer notification is received by the node while sending the data packets, AODV generates a RRER message to rediscover a new route. The new route use the same process as described above.

All algorithms that are proposed in [20]-[21]-[22]. Find non-interfering disjoint-paths for the single source node scenario, they did not take care of the real scenarios in which there are multiple source nodes need to forward their important data to BS, if such cases taking into account, the complexity of the problem, "finding non-interfering disjoint-paths", will be increased since new parameter will be added, which must be taken onto account while finding disjoint paths for multiple source nodes, such as interference between paths from different source nodes.

II.3. Tow-phase Geographic Greedy Forwarding Protocol (TPGF)

TPGF [1]. Used a new strategy for greedy forwarding routing by selecting the closest neighbor to the sink as the next hop node without taking into consideration the distance of the current relay node to the sink. Thus, in this algorithm, the local minimum problem never occurs. However, this may cause routing loop during path setup which are called path circles. TPGF solve this problem by adding a path optimization phase, which eliminates any loop while the acknowledgment (ACK) message is sent back to the source node in order to reserve the selected relay node along the path. Furthermore, the TPGF can provide multi-disjoint paths for the same source node by rerunning the algorithm again. However, due to the greedy nature of the TPGF, any additional path, if exists, will be longer than the previous ones, which makes the explored paths imbalanced. Thus, the simple strategy used by the TPGF offers the capability to find shortest path without any extra overhead compared to its predecessor algorithms such as GPSR, GAODM, and DPMR.

TPGF is implemented for WMSNs. This algorithm initially finds the shortest path to the base station and forwards the packets along the selected shortest path. However, if the situation comes where one flow of traffic is blocked due to another flow, the packet loss occurs that degrades the network performance. At this point, TPGF is able to find the node disjoint path based on the notification sent by the node. Fig. 1 shows the flow chart of TPGF and its operation.

Phase one (1): The greedy forwarding strategy will choose the closest neighboring node to the BS on each hop. The only difference in TPGF protocol over other routing techniques such as GPSR is that there is no exists to local minimum problem, since TPGF will not involve the current relay node in the preference decision that will determine the next hop node, the preference decision will just be made among the neighboring nodes. So, local minimum situation will not happen [23]. While exploring the path toward the BS using greedy forwarding strategy, a case in which the current relay node has no forwarder neighbors may happen, this case is called block situation as shown in Fig. 2. To exit from this situation, TPGF uses a step back & mark strategy

that will step back to previous node and mark the current relay node, which called a block node, as unavailable.

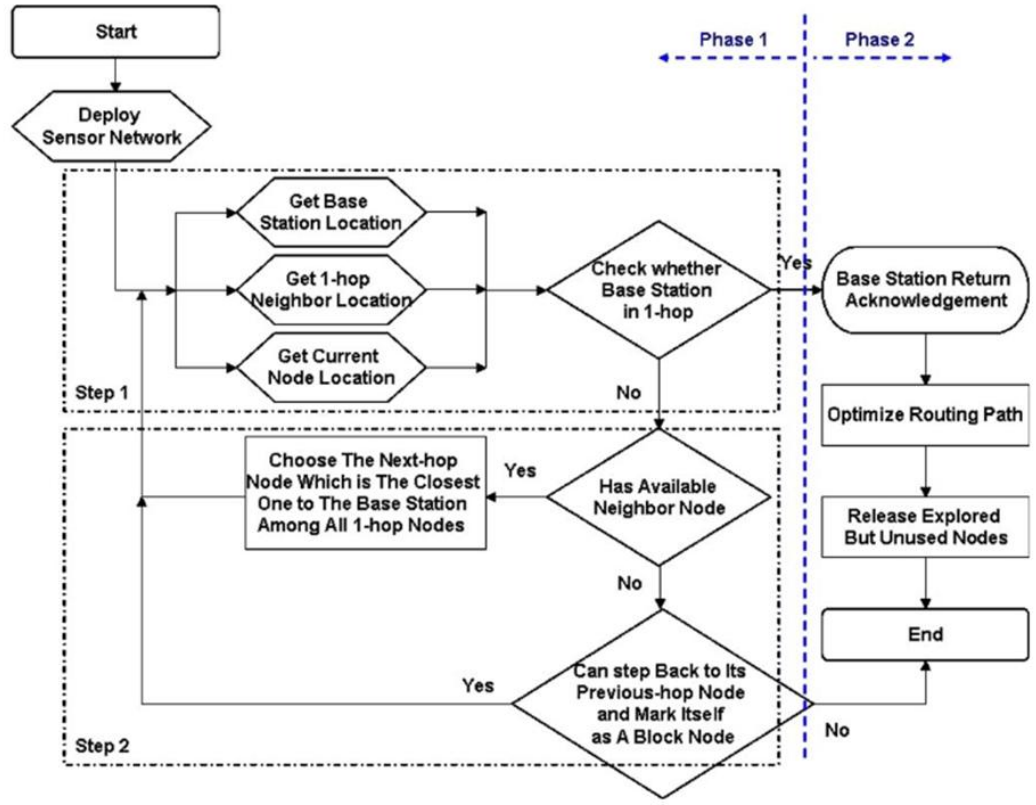

Fig. 1. TPGF flow chart

Phase two (2): path optimization or acknowledgement, Since TPGF is a new forwarding strategy that will prevent local minimum problem from happening. This strategy will lead to another problem to appear called path circles. A case in which there are a three or more relay nodes along the explored path in the range of each other as shown in figure 2. In this phase, TPGF will eliminate these path circles by using a smart strategy that will detect the path circles and eliminate them. To eliminate path circle TPGF will first give each selected relay node in the path exploration phase a Position Sequence Number (PSN) that determine the position of each relay node along the explored path, then at the ACK phase from BS to source node, each relay node along the found path will first explored the neighboring node that belong to the same path, and explored the PSN of these neighbors, and then send ACK to the neighbor that has the least PSN and release the others as shown in Fig. 3. Thus, the path found will be shorter and the nodes that released will be available to be used by other sources path.

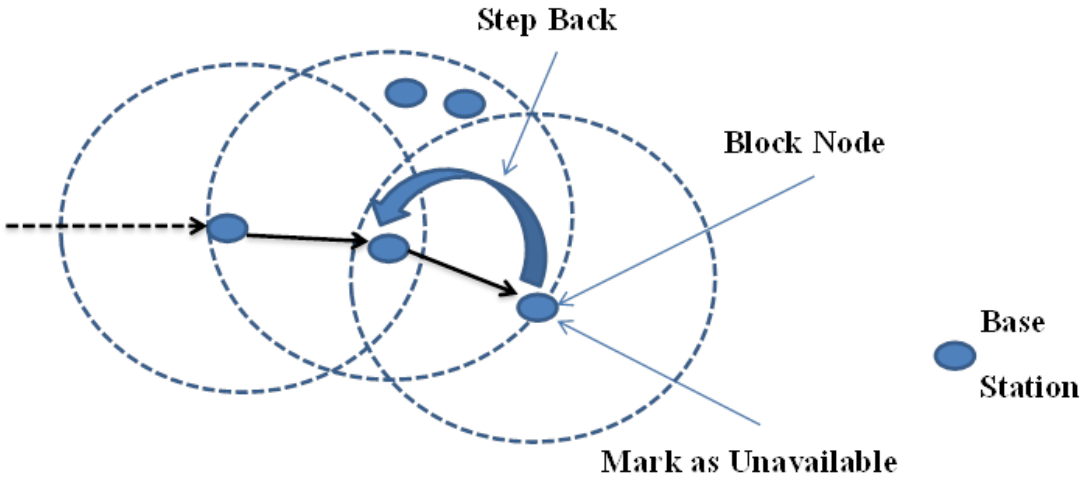

Fig. 2. Block Situation and Step Back & Mark strategy.

During the path exploration phase. Fig.3 shows the optimization criteria obtained by TPGF protocol, it shows that the path circle elimination operation done during the ACK phase from BS to source node as follows:

1) Node D will broadcast a control message to all its neighboring nodes to discover how is in its range and involved in the same path.
2) A replay message will be sent by each neighboring node to D (in this case: C, B, and A) with the needed information.
3) Node D discovers that nodes (A, B, and C) lie in its range and involved in the same path.
4) Node D send ACK to the node that has the least PSN (in this case: A) and send release to other nodes (B, and C).

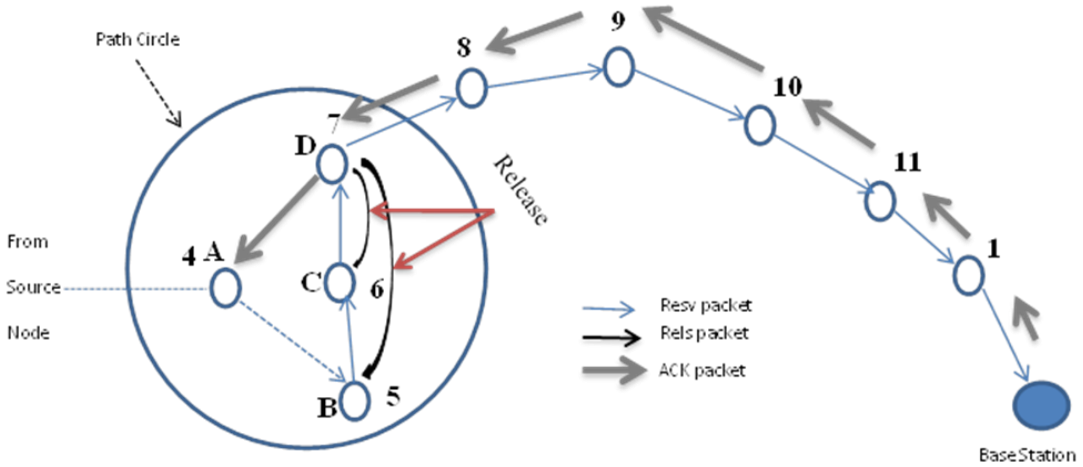

Fig. 3. Path optimization phase.

When the TPGF is applied with multiple source nodes, the source node that reserve a certain relay node first gets the best chance for the shortest path. While other source nodes may get relatively longer paths or even no paths at all [2]. This degrades the overall network capacity and imbalance the utilization of its resources, which may shorten the network lifetime.

III. Design details

For single path: Initially, each node in the network computes its own location and sends it to its 1-Hop neighbor using the 1-Hop broadcast messages. When all the nodes are able to know about the location of the nodes in their vicinity then a source node that wants to send the data is triggered. The source node first checks its routing table to send the data to the destination. If the entry to the base station is available in the routing table then it simply starts forwarding the data packets over the discovered route. However, if the source node could not find the route to the base station in its routing table then it sends a request that integrates the location of the node, source id and the broadcast id. This request will disseminate in the network until the base station is found and then when the base station receives the first request it acknowledge to the source for the shortest End to End route. It is to be noted that the subsequent requests reached at the base station after the first request will be dropped at the base station. When this acknowledgement reached at the source node it forwards the data packets to the discovered route.

For multiple node-disjoint paths: In this mechanism, the procedure to discover the route is the same however, destination will reply to the source node against multiple requests. For example, when the first request reached at the base station, it acknowledges it and the requests came from other route will also be replied back to the source. At the end source, will going to have multiple node-disjoint paths. This node-disjointness will be achieved based on the source id and broadcast id. Each node can only re-broadcast the first route request it receives and the subsequent requests received at the intermediate nodes will be dropped. So, at the end there will be no common node among different paths and due to which the node-disjointness will be achieved.

IV. Simulation and Result

In our experiments, we used Full-Circle (FC) network topology. Fig. 4 shows the full-circle topology, in which 25 nodes are placed on the perimeter of a circle that is centered at the BS location. FC topologies represent the real network scenarios such as boarded surveillance, in which cameras are distributed around the perimeter of the target area and capture any security breach. The source nodes are placed sufficiently off of the network border lines such that the whole coverage area of each lies within the network area.

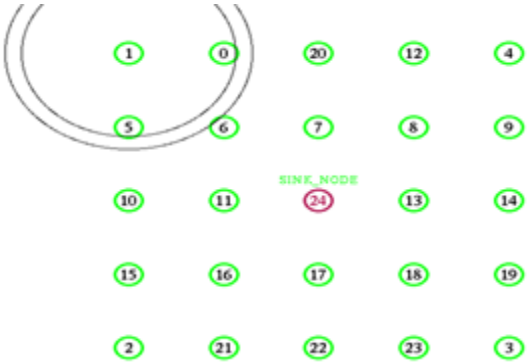

Fig. 4. full-circle network topology.

The main goal of this experiment is to study the effect of varying the node density and source count in FC topology on the performance metrics experienced by both TPGF and AODV routing protocol. By varying nodes density many network parameter are varied such as source nodes and BS neighbors that effect the number of available paths in the network and their corresponding length. While varying the number of source node in the network affects the competition between the paths explored by different source node, which in turn, affects the number of connected source nodes and the amount of delay. Also the number of paths found per source node is affected, which affects some performance metrics such as PDR and throughput. In this experiment, FC topology with source nodes varied from 1 to 5 and nodes varied from 25 to 125 nodes were simulated.

In our evaluation process, different simulation experiment with different network parameter are used in order to study the effect of each parameter on the performance metrics experienced by TPGF and AODV routing protocol. The simulation parameters that have been used in this simulation are shown in Table I.

TABLE I COMMON NETWORK PARAMETE

Simulation Parameters	**Value**
Packet Size	100 Bytes
Routing Protocol	TPGF and AODV
Queue Size	50 Packets
Channel type	Wireless Channel
Radio communication range	100m
Simulation Time	100 s
Network dimensions	600 x 600m

Fig. 5 presents the behavior of packet delivery ratio. The packet delivery ratio is computed by taking the ratio of the number of received packets to the number of sent

packets. Here, initially both the protocol achieve high packet delivery ratio however, it can be seen that packet delivery ratio in the case of AODV is less as compared to TPGF. The reason to this is that as due to the convergence of traffic over a single node the packet loss occurs. This packet loss will results in link layer notification sent by the lower layer. Based on this notification, AODV re-route the traffic however, TPGF will suddenly diverts the traffic based on this notification to another node-disjoint path. This ultimately increases the performance of the TPGF as compared to AODV.

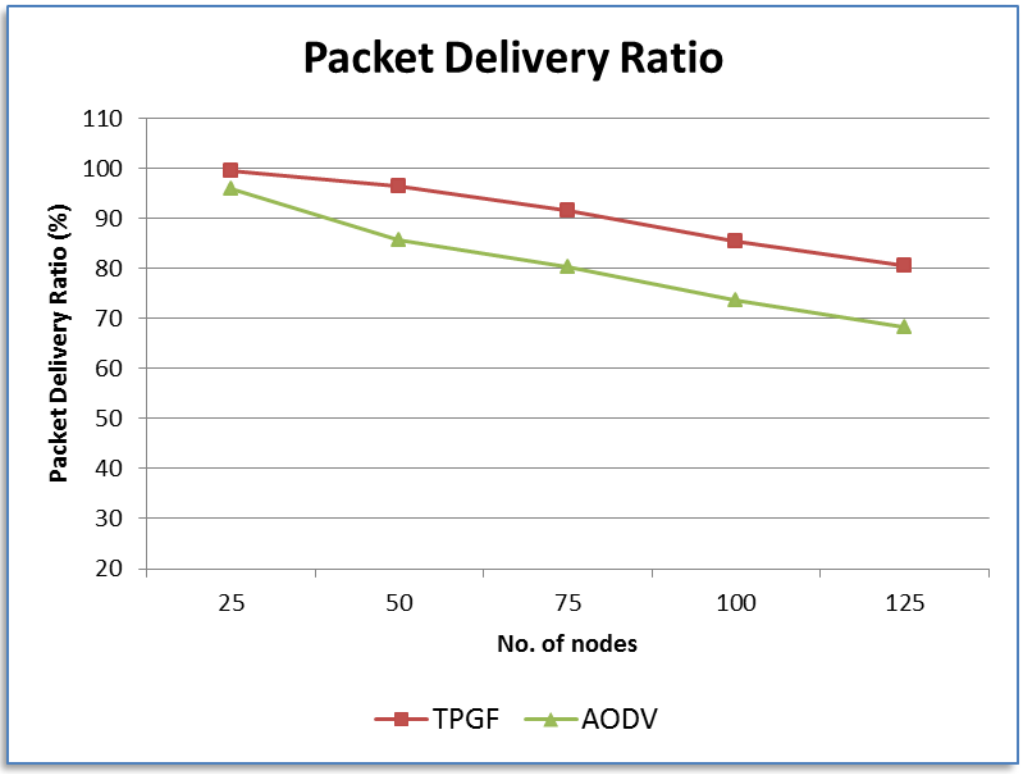

Fig. 5. Packet Delivery Ratio with respect to the number of nodes

Fig. 6 depicts the number of packet dropped in both the protocols. It can be seen that the packet dropped of both the protocols increases by increasing the number of sources. However, It is very clear that the number of packet dropped are very high in the case of AODV as compared to the TPGF. This is because, AODV tries to send the packet on a single path however, if the node drops the packets in AODV, it rebroadcast the route request again for the new path. On the other hand, TPGF while facing the packet drops suddenly deviate the traffic to an alternate path. This makes TPGF perform better as compared to AODV.

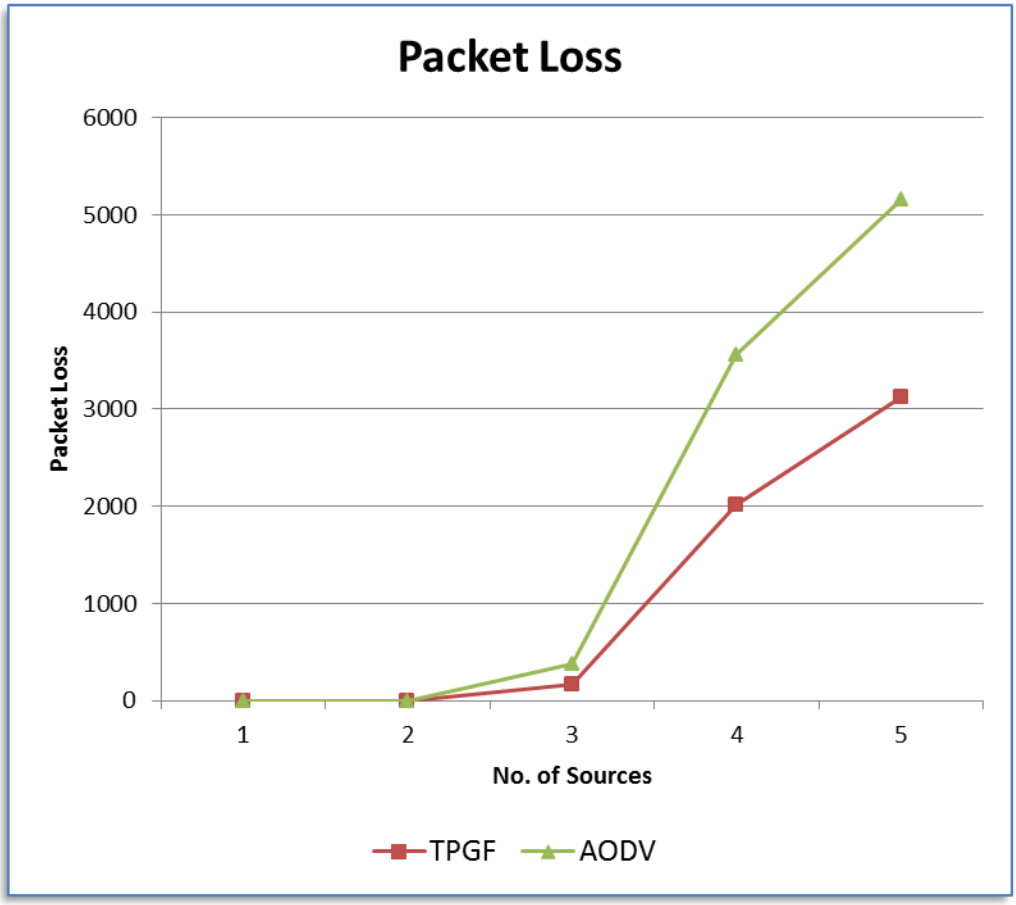

Fig. 6. Number of packet drop with respect to the number of sources

Fig. 7 shows the end to end delay with respect to the number of sources. It can be seen that till number of sources equal to three, the difference between delays of both the protocols are almost equal however, as the number of sources increased the respective delay also increased. This delay is high in case of AODV and low in case of TPGF. This is due to the fact that the data packet are forwarded on the active routes. So if the active route is not available in AODV it finds the route which delays the packet however, in the case of TPGF, it does not need to find the new route because the alternate route is available in the routing table. This ultimately decreases the delay in the case of TPGF as compared to AODV.

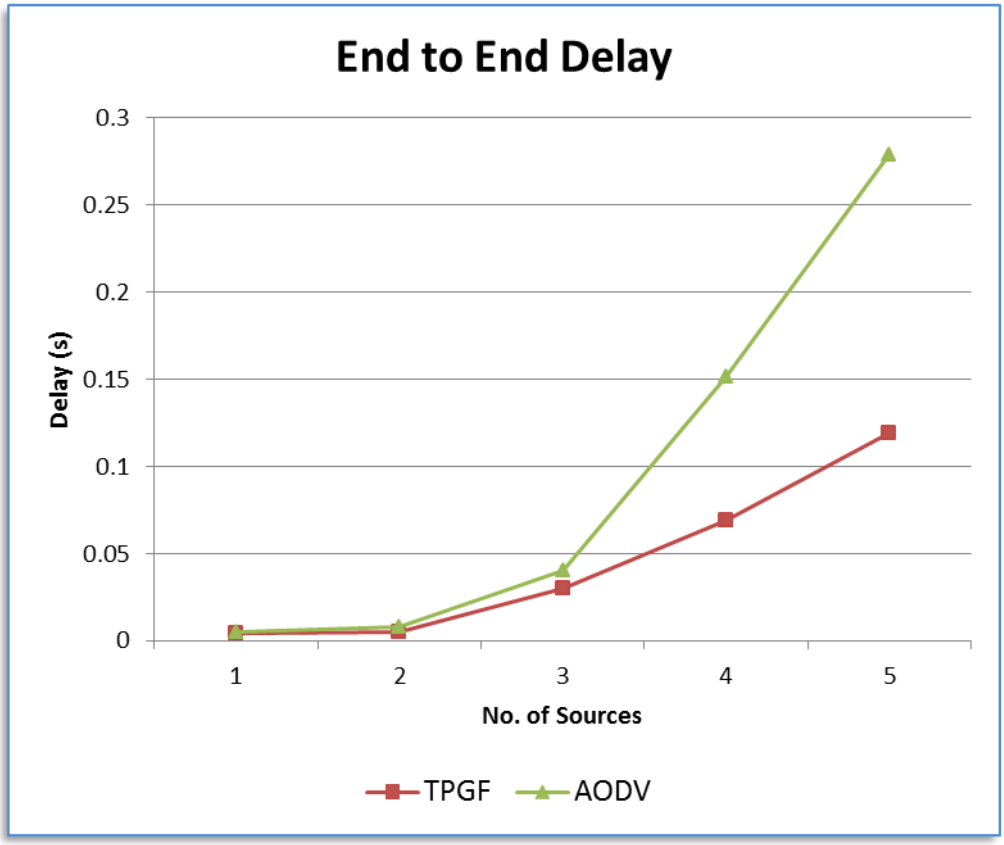

Fig. 7. End to End delay with respect to the number of sources

Fig. 8 shows the jitter with respect to the number of sources. Jitter is basically computed based on the delay experienced by the packet in both the protocols. Like in the case of TPGF, the delay is increased so the jitter also increased and same is the case with AODV. However, it is to be noted the jitter will not behaves the same as delay. It might happen that the delay is increased in a particular case and the respective jitter might decrease. However, because the topology is static so there are no movements, due to which the behavior of jitter is highly dependent on the delay experienced by both the protocols.

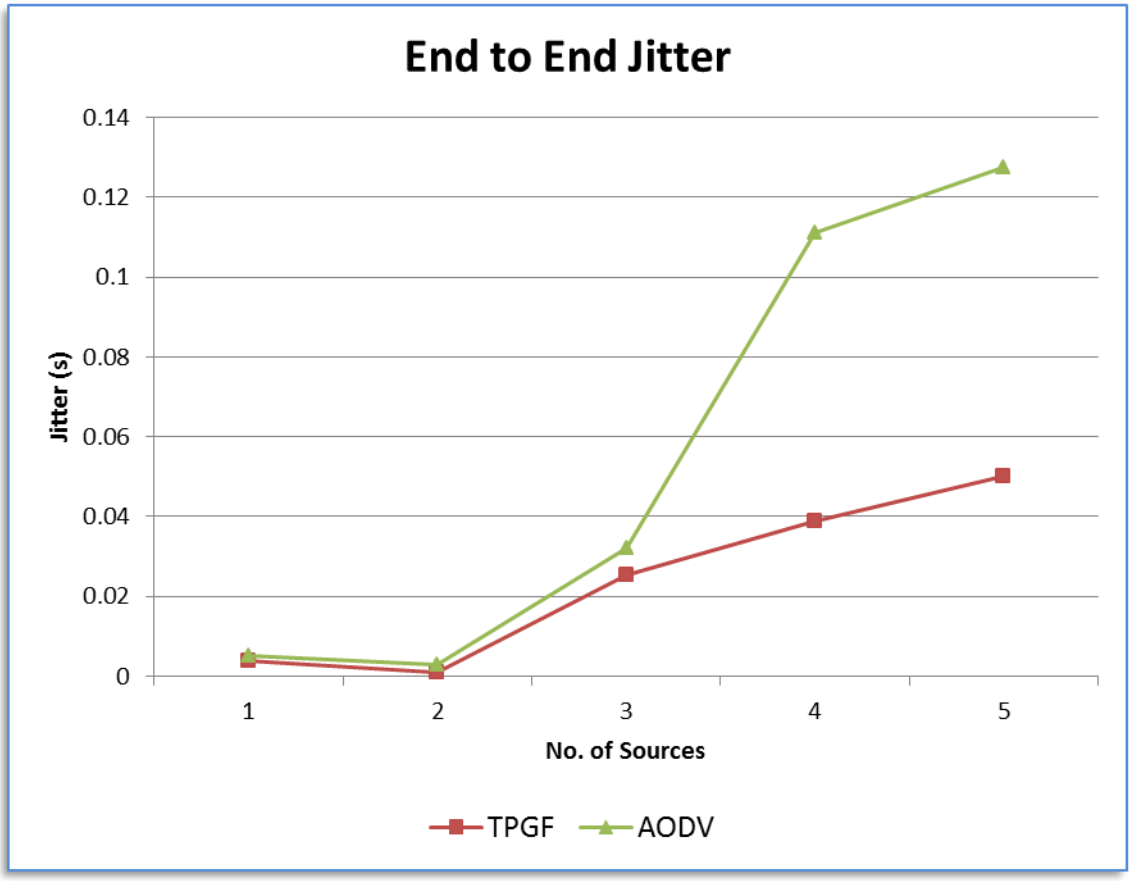

Fig. 8. End to End Jitter with respect to the number of sources

Average throughput is computed in both the protocols. It can be seen from the Fig. 9 that the trend of throughput is increased in both the cases till number of sources equals to 3. However, as the number of sources increased beyond 3, the behavior or the tendency to increase is very less. This is because of the congestion due to high traffic in the network. Therefore, more the number of sources in the network, the more traffic will flow and hence there will be a high chance of congestion that might increase the packet loss. Due to this packet loss the throughput decreases in both the cases.

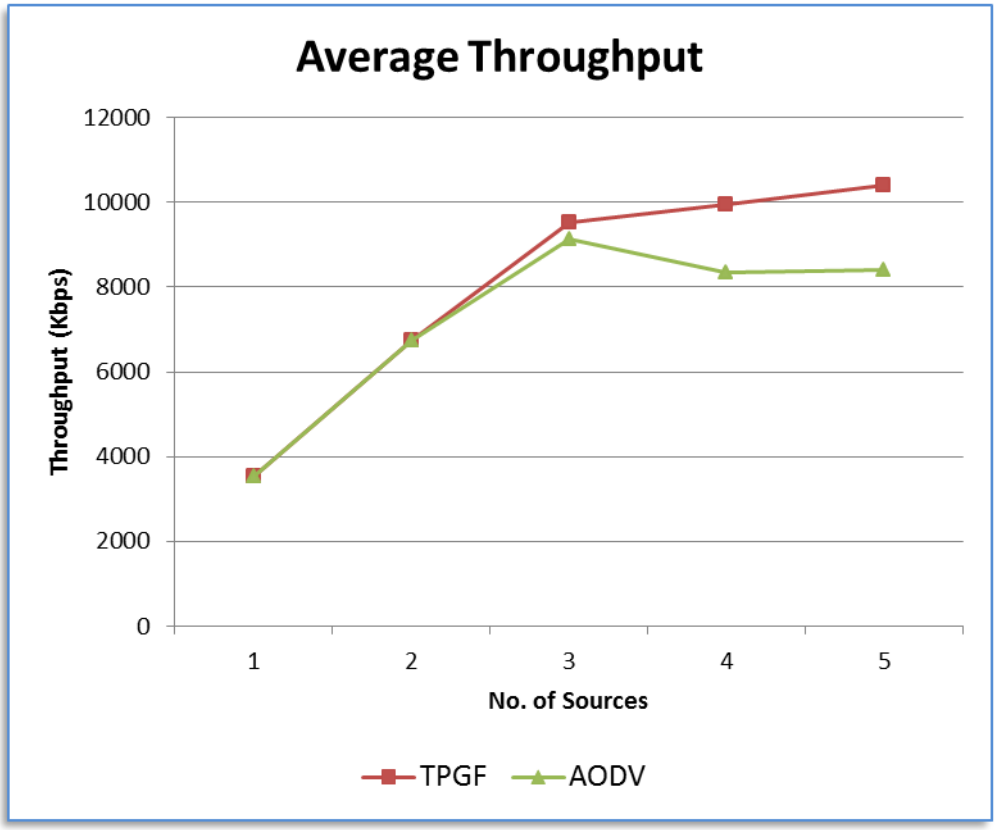

Fig. 9. Average Throughput respect to the number of source

V. Conclusion

The implemented algorithm has proven that competition among the source nodes to reserve relay nodes that reside on their shortest paths toward the BS and the increasing packet loss as traffic gets closer to the BS are solved. This would improve the network capacity and aggregate throughput. The main drawbacks of the implemented algorithm are that the TPGF algorithm is designed originally for single source but according to the operation of the TPGF can used in multiple source, this can cause some problem in choosing the source nodes paths and overall increase the overhead, and end-to-end delay. Therefore, the suggested future work is implement a new algorithm for multiple source tack into consideration the fairly paths distributing between the source node. The new algorithm should has path discovery phase such that the competition is resolved among the different source nodes with less control overhead. Designing a congestion control mechanism that enhance the data delivery and reduce the end-to-end delay.

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