# A POSITION BASEDOPPORTUNISTIC DATA FORWARDING IN HIGHLY DYNAMIC MANETS

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## ABSTRACT

*Due to the error prone wireless channel and the dynamic network topology, reliable data delivery in MANETs, especially in challenged environments with high mobility remains an issue. In order to provide an efficient and reliable data delivery for these MANETs, a position-based opportunistic routing (POR) protocol is proposed. It is based on geographic routing and opportunistic forwarding where there is no need to maintain end-to-end routes, leading to high efficiency and scalability. When a data packet is sent out, some of the neighbor nodes that have overheard the transmission will serve as forwarding candidates, and take turn to forward the packet if it is not relayed by the specific best forwarder. By utilizing such in-the-air backup, communication is maintained without being interrupted as well as additional latency incurred by local route recovery and the duplicate relaying caused by packet reroute is greatly reduced. A position-based opportunistic routing mechanism can be deployed without complex modification to MAC protocol and achieve multiple reception without losing the benefit of collision avoidance provided by 802.11. In case of communication hole, Virtual Destination-based Void Handling (VDVH) scheme is further proposed to work together with POR to provide an efficient and reliable data delivery. The features such as greedy forwarding and robustness through opportunistic routing can still be achieved when handling communication voids.*

***Keywords*: *Dynamic Network Topology, Forwarding Candidates, Position-based Opportunistic Routing, Mobile Ad Hoc Networks, Virtual Destination-based Void Handling.***

## I. INTRODUCTION

Mobile Ad hoc Networks (MANETs) are infrastructure less networks consisting of mobile nodes that communicate with each other in wireless mode. Some of the unique characteristics of these networks are, having no centralized control, ability to self-organize and restore transmission through multiple hops, frequent link breakages and dynamic change of network topology. All these features lead to a number of advantages which includes support for mobility, robustness, flexibility and rapid deployment.Over these years they have gained a great deal of attention because of its significant advantages brought about by multi-hop, infrastructure-less transmission. As MANET allow ubiquitous service access, anywhere, anytime without any fixed infrastructure they are widely used in battlefield communication, personal area networking using PDAs, laptops and hand phones, search-and-rescue, cellular network and so on. However, due to dynamic network topology the reliable data delivery in MANET is major issue. There are several ad hoc routing algorithms at present that utilize topology information to make routing decisions at each node in the network. Traditional topology-based

MANET routing protocols are quite susceptible to node mobility. One of the main reasons is due to the predetermination of an end-to-end route before data transmission. Because of the constantly and even fast changing network topology, it is very difficult to maintain a deterministic route. The discovery and recovery procedures are also time and energy consuming. Once the path breaks, data packets will get lost or be delayed for a long time until the reconstruction of the route, causing transmission interruption.

A routing protocol is needed whenever a packet needs to be transmitted to a destination via number of nodes in an efficient manner. Various features of many routing protocols have been an active area of research for many years. A number of issues and features of mobile ad hoc networks has to be considered before choosing a routing protocol for a particular ad hoc network. Many protocols have been suggested over these years for reliable delivery and high performance. All the different routing protocols proposed so far for mobile ad hoc networks aim at attaining four basic goals. They aim at maximizing throughput, minimizing packet loss, minimizing control overhead and minimizing energy usage. However, the relative priorities of these goals changes from each protocol to the other depending on the targeted application for which it was designed. The new structure which takes advantage of the broadcast nature of wireless medium is proposed here.By utilizing intermediate nodes as air-backup, communication is maintained without being interrupted. The aim of this work is to utilize position information to provide more reliable as well as efficient routing for certain applications.

A Position based opportunistic routing strategy was introduced in which several forwarding candidates' cache the packet that has been received using MAC interception. If the best forwarder does not forward the packet in certain time slots, suboptimal candidates will take turn to forward the packet according to a locally formed order. In this way, as long as one of the candidates succeeds in receiving and forwarding the packet, the data transmission will not be interrupted. Potential multipath is exploited on the fly on a per packet basis, leading to POR's excellent robustness. In the case of communication hole,that is if an intermediate node fails or moves out of the coverage area of the node, then a Virtual Destination-based Void Handling (VDVH) scheme is proposed in which the advantages of greedy forwarding (e.g., large progress per hop) and opportunistic routing can still be achieved while handling communication voids. The concept of in-the-air backup significantly enhances the robustness of the routing protocol and reduces the latency and duplicate forwarding caused by local route repair.

## II. RELATED WORK

### 2.1. Virtual Routing Protocol (VRP)

The VirtualRouting Protocol (VRP) [2] is a hybrid source routingprotocol. VRP defines a logical structure over the networkwhich is unrelated to the physical network topology. Routesbetween units are built by translating virtual paths intophysical routes. Although the protocol is found to achievehigh packet delivery ratio, VRP performs poorly under heavytraffic conditions since units are not able to maintain up-to-dateroute information about their logical neighbors.

### 2.2. Greedy Perimeter Stateless Routing (GPSR)

GreedyPerimeter Stateless Routing (GPSR) [3] protocol makesgreedy forwarding decisions using only information about arouter's immediate neighbors in the network topology. Whengreedy forwarding is impossible, the algorithm recovers byrouting around the perimeter of the region. This protocol has afew disadvantages too. Because GPSR's beacons are sentcontinuously, each beaconing interval results in a constantlevel of routing protocol traffic. The addition of locationregistration and lookup traffic for a location database is foundto increase the overhead of GPSR.

### 2.3. Most Forward Within Radius (MFR)

It is a progress-based algorithm, in which data is forwarded to the neighbor with the greatest progress. Its objective is to maximize obtainable expectable progress in a certain direction [4]. If no node is in the forward direction, within the range of the sender, the message is sent to the neighbor node with the least backward progress. This algorithm minimizes the number of hops, but doesn't minimize energy consumption.

### 2.4. Dynamic Route Maintenance (DRM) For Geographic Forwarding

The proposed routing strategy uses a dynamic beaconing scheme to obtain the information about the neighbors. In beacon based protocols, each mobile node transmits periodic beacons to its neighbors to update and maintain its routing table [5] [6]. The beacons are generally forwarded at fixed intervals of time. During low mobility, a longer interval would be the best as it would reduce control overhead while providing accurate location information. However, in cases of higher mobility, determining an appropriate beacon interval is rather difficult. In DRM, beacon interval and route information are carried out dynamically. Based on the node's mobility information, its beacon interval is computed while the route management function updates the routing table.

### 2.5. On-Demand Geographic Path Routing (OGPR)

This geographic routing protocol does not depend on a location service to find the position of the destination [7] [8]. OGPR is stateless and uses greedy forwarding; reactive route discovery and source based routing. It is a hybrid protocol incorporating the effective techniques of other well-known routing protocols for MANETs. OGPR constructs geographic paths to route packets between a source and a destination node.

### 2.6. Geographic Landmark Routing (GLR)

One of the new geographic routing protocols solves the blind detouring problem and the triangular routing problem in MANETs [9]. The blind detouring problem occurs when a packet arrives at a dead-end when the next node is blindly selected.

## III. PROPOSED WORK

### 3.1 Overview

In the proposed work, a reliable communication in the highly dynamic MANET is more concerned, where once a communication is established, should be carried out for a long period without any interruption. Here, reliable communication means the communication which does not involve too many route discoveries in a multipath system where more than one path is available between a pair of source and destination. Due to the dynamic change in topology, the dedicated path keeps changing with time and a special attention is required, so that the communication will get disturbed. Position based Opportunistic Routing (POR) protocol is designed to achieve maximum reliability in a mobile ad hoc network. It combines geographic and opportunistic routing to achieve high packet delivery ratio. The protocol chooses the best forwarder based on the receptive power. When the best forwarder fails, a candidate node takes over the forwarding function. Trigger nodes trigger a hole handling mechanism when routing holes are encountered.

### 3.2 Position-Based Opportunistic Routing

The design of POR is based on geographic routing and opportunistic forwarding. The nodes are assumed to be aware of their own location and the positions of their direct neighbors. Neighborhood location information can be exchanged using one-hop beacon or piggyback in the data packet's header. It could be realized using many kinds of location service.The location service is responsible for determining the position of the packet destination, before a packet can be sent from a source node. The position of the packet destination is then carried in the header of the packet so that intermediate hops can learn where the packet is destined for. In this scenario, some efficient and reliable way is also available. For example, the location of the destination could be transmitted by low bit rate but long range radios, which can be implemented as periodic beacon, as well as by replies when requested by the source.

When a source node wants to transmit a packet, it gets the location of the destination first and then attaches it to the packet header. Due to the destination node's movement, the multi-hop path may diverge from the true location of the final destination and a packet would be dropped even if it has already been delivered into the neighborhood of the destination. To deal with such issue, additional check for the destination node is introduced. At each hop, the node that forwards the packet will check its neighbor list to see whether the destination is within its transmission range. If yes, the packet will be directly forwarded to the destination, similar to the destination location prediction scheme. By performing such identification check before greedy forwarding based on location information, the effect of the path divergence can be very much alleviated.

In conventional opportunistic forwarding, to have a packet received by multiple candidates, either IP broadcast or an integration of routing and MAC protocol is adopted. The former is susceptible to MAC collision because of the lack of collision avoidance support for broadcast packet in current 802.11, while the latter requires complex coordination and is not easy to be implemented. In POR, the similar scheme is used as the MAC multicast mode. The packet is transmitted as unicast (the best forwarder which makes the largest positive progress toward the destination is set as the next hop) in IP layer and multiple receptions are achieved using MAC interception. The use of RTS/CTS/DATA/ACK significantly reduces the collision and all the nodes within the transmission range of the sender can eavesdrop on the packet successfully with higher probability due to medium reservation. In normal situation as shown in Fig 1 without link break, the packet is forwarded by the next hop node (e.g., nodes A, E) and the forwarding candidates (e.g., nodes B, C; nodes F, G) will be suppressed (i.e., the same packet in the Packet List will be dropped) by the next hop node's transmission. In case node A fails as shown in Fig 2 to deliver the packet (e.g., node A has moved out and cannot receive the packet), node B, the forwarding candidate with the highest priority, will relay the packet and suppress the lower priority candidate's forwarding (e.g., node C) as well as node S. By using the feedback from MAC layer, node S will remove node A from the neighbor list and select a new next hop node for the subsequent packets. The packets in the interface queue taking node A as the next hop will be given a second chance to reroute. For the packet pulled back from the MAC layer, it will not be rerouted as long as node S overhears node B's forwarding.

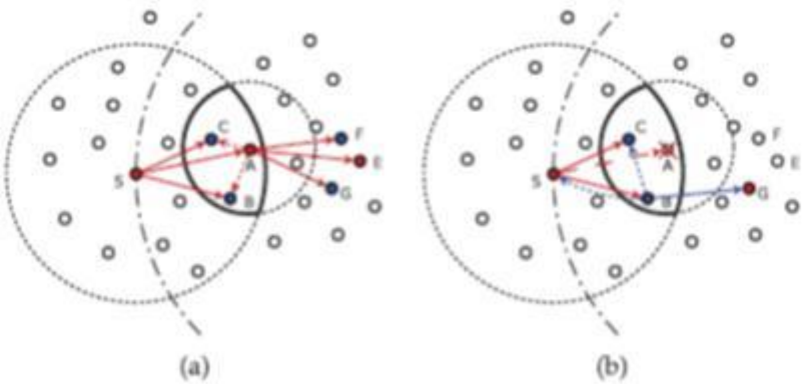

**Figure 1: (a) The operation of POR in normal situation. (b) The operation of POR when the next hop fails to receive the packet**

Every node maintains a forwarding table for the packets of each flow (identified as source-destination pair) that it has sent or forwarded. Before calculating a new forwarder list, it looks up the forwarding table. The forwarding table is constructed during data packet transmissions and its maintenance is much easier than a routing table. It can be seen as a trade-off between efficiency and scalability. As the establishment of the forwarding table only depends on local information, it takes much less time to be constructed. Therefore, expire time can be set on the items maintained to keep the table relatively small. In other words, the table records only the current active flows, while in conventional protocols, a decrease in the route expire time would require far more resources to rebuild.

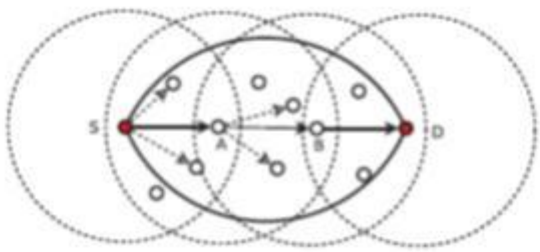

**Figure 2: Duplicate Relaying Is Limited In The Region Enclosed By The Bold Curve.**

### 3.3 Forwarding Node Selection

In Fig 3 node S is the source and D is the destination node, R is the radius of the transmission range of node S. Thetransmission range of S is denoted by the dotted circle.The nodes in the area enclosed within the dashed arc makepositive progress towards the destination. From these nodes,the one with maximum power for reception is chosen as thebest forwarder, namely node B.R/2 denotes the radius of half the transmission range ofnode B. The intersection area of the transmission range of Sand half of the transmission range of B is taken as theforwarding area. Nodes within the forwarding area, other thannode B, become candidate nodes, namely nodes H, A and F.

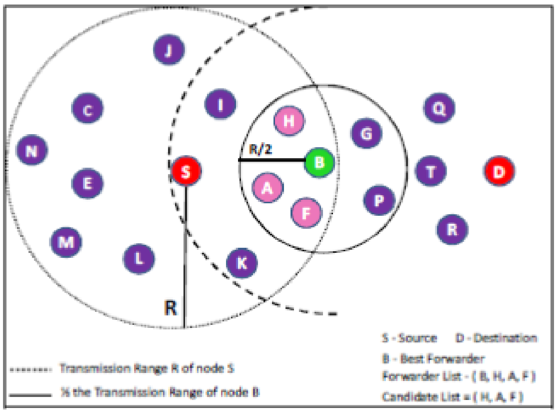


**Figure 3: Best Forwarder and Candidate Selection**

### 3.4 Function of the Candidate Node

The candidate nodes add a threshold time to the field ‘st’ and wait for that period. If no transmission is overheard during this period, the candidate node understands that the best forwarder has failed. The forwarding operation is then taken over by the candidate node. The candidate node now becomes the best forwarder and applies Candidate Selection algorithm to forward the packets.In Fig. 4 the best forwarder node B fails to transmit packets. So the candidate node having the next highest priority, node A takes over the forwarding function. Node A chooses node P as the best forwarder and nodes G and F as the candidate nodes. Even though node T is within the forwarding area, it is not chosen as a candidate, because its distance to destination is lesser that the distance of node P to the destination.

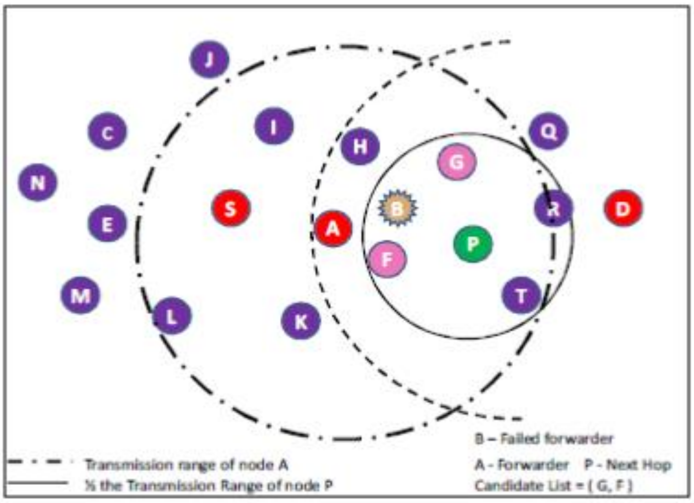


**Figure 4: Forwarding By Candidate Node**

### 3.5 Virtual Destination Based Void Handling (Vdvh)

In order to enhance the robustness of POR in the network where nodes are not uniformly distributed and large holes may exist, a complementary void handling mechanism based on virtual destination is proposed. To handle communication voids, almost all existing mechanisms try to find a route around. During the void handling process, the advantage of greedy forwarding cannot be achieved as the path that is used to go around the hole is usually not optimal (e.g., with more hops compared to the possible optimal path). More importantly, the robustness of multicast-style routing cannot be exploited. In order to enable opportunistic forwarding in void handling, which means even in dealing with voids, it can still transmit the packet in an opportunistic routing like fashion; virtual destination is introduced, as the temporary target that the packets are forwarded to. A fundamental issue in void handling is when and how to switch back to normal greedy forwarding. After a packet has been forwarded to route around the communication void for more than two hops (including two hops) the forwarder will check whether there is any potential candidate that is able to switch back. If yes, that node will be selected as the next hop, but the mode is still void handling. Only if the receiver finds that its own location is nearer to the real destination than the void node and it gets at least one neighbor that makes positive progress towards the real destination, it will change the forwarding mode back to normal greedy forwarding. In VDVH, if a trigger node finds that there are forwarding candidates in both directions, the data flow will be split into two where the two directions will be tried simultaneously for a possible route around the communication void. If a forwarding candidate receives a packet that is being delivered or has been delivered in void handling mode, it will record a reverse entry. Once the packet reaches the destination, a path acknowledgment will be sent along the reverse path to inform the trigger node. Then, the trigger node will give up trying the other direction. For the same flow, the path acknowledgment will be periodically sent (not on per-packet basis; otherwise, there will be too many control messages). If there is another trigger node upstream, the path acknowledgment will be further delivered to that node, and so on. On the other hand, if a packet that is forwarded in void handling mode cannot go any further or the number of hops traversed exceeds a certain threshold but it is still being delivered in void handling mode, a DISRUPT control packet will be sent back to the trigger node as reverse suppression. Once the trigger node receives the message, it will stop trying that direction.

## IV. RESULT ANALYSIS

### 4.1 Performance Evaluation

**TABLE 1: SIMULATION PARAMETERS**

| Parameter | Value |
|---|---|
| Number of nodes | 160 |
| Transmission range | 225 m |
| Speed | 10, 30, 50, 100 m/s |
| Network topology | 800 x 800 $m^2$ |
| Antenna model | Omni antenna |
| Transmitter antenna gain | 1 dBi |
| Receiver antenna gain | 1 dBi |
| System loss factor | 1.0 |
| Transmitter signal power | 0.28 watts |
| Propagation model | Two-ray ground |
| Simulation time | 200 sec |

The performance of POR is evaluated through a simulation study using NS-2.35. TABLE 1 summarizes the simulation parameters. For simulation the network is modeled with several mobile nodes placed randomly. Both the protocols, Position-based Opportunistic Routing (POR) and AODV are simulated independently and the performance metrics such as packet delivery ratio, average delay, packet drop ratio are evaluated.

## 4.2 Comparative Analysis

### 4.2.1 Packet Delivery Ratio

The ratio of the number of data packets received at the destination(s) to the number of data packets sent by the source(s). From Fig.5, it is clear that the Packet delivery ratio of the POR is better with respect to AODV. Also PDR decreases when the number of nodes increases.

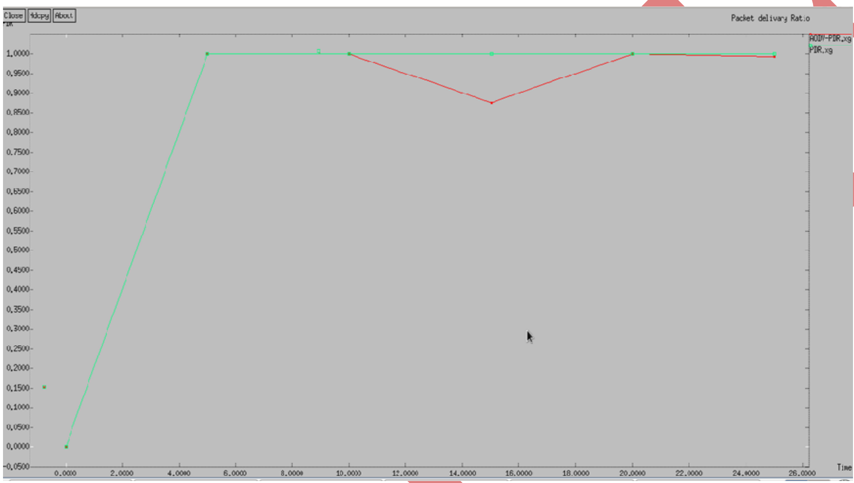


**Figure 5: Packet Delivery Ratio Comparison Graph**

### 4.2.2 Average Delay (End-To-End-Delay)

The average delay is the time taken for a packet to be transmitted from the source to the destination.End to End Delay will increase as amount of participating node increases. POR has lower delay compared with AODV as shown in Fig.6.

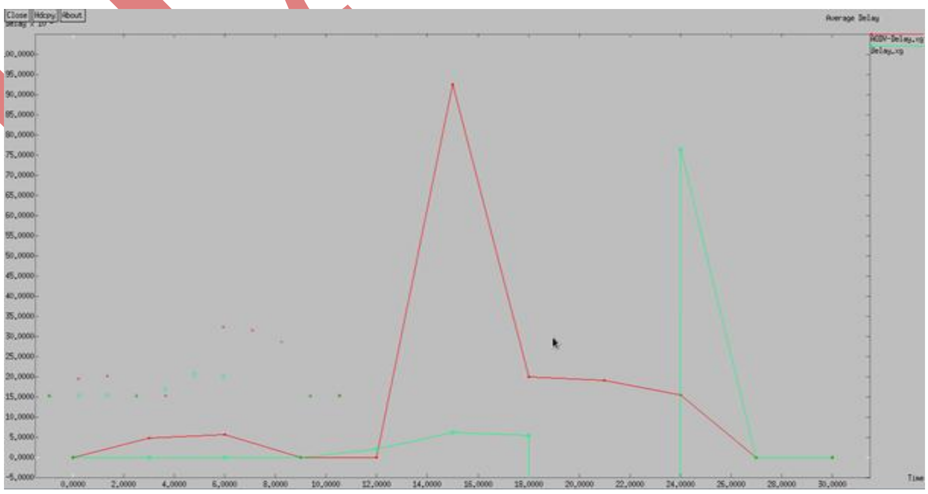


**Figure 6: End-To-End Delay Comparison Graph**

### 4.2.3 Throughput

Throughput is the average rate of successful message delivery over a communication channel. Fig 7 shows the increase in throughput when the number of participating node increases.When the POR is compared with the AODV, it performs well in case of a communication void and the process of rerouting.

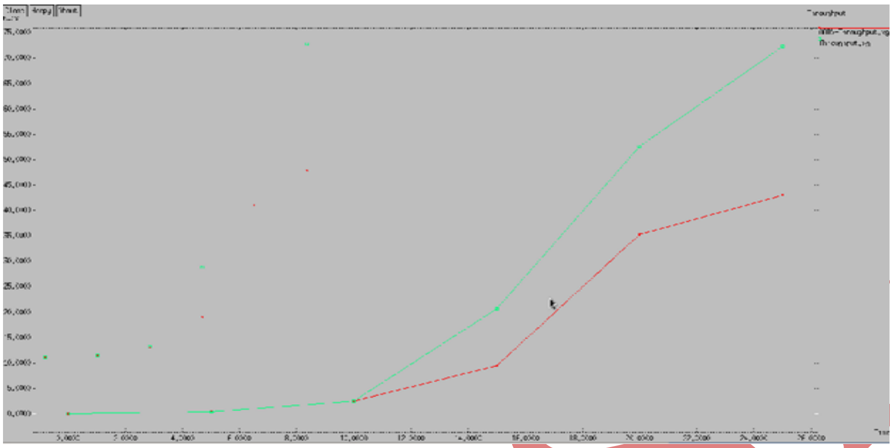

**Figure 7: Throughput Comparison Graph**

## V. CONCLUSION

In this paper,the problem of reliable data delivery in highly dynamic mobile ad hoc networks is addressed. In the face of frequent link break due to node mobility, substantial data packets would either get lost, or experience long latency before restoration of connectivity. Soa Position based opportunistic routing protocol and void handling mechanism based on virtual destination, to provide efficient and reliable data delivery in MANETs is proposed. POR takes advantage of the stateless property of geographic routing and broadcast nature of wireless medium and it guarantees reliability through best forwarder selection. To ensure best forwarding of the data packets, candidate nodes are selected for each forwarder. In case the best forwarder fails, these candidate nodes take over the forwarding function according to their priorities. These nodes are selected to be nodes that lie closer to the best forwarder for better data delivery. Routing holes are also efficiently handled through an additional mechanism. Leveraging on such natural backup in-the air, broken route can be recovered in a timely manner. The QoS metrics packet delivery ratio, delay, throughput, packets drop are taken for comparison with Ad-hoc On-demand Distance Vector (AODV) protocol. NS2 is used for simulation and the results proved that POR outperforms AODV in all aspects such as improved throughput, packet delivery ratio and decreased delay and duplication of the packets.

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