Enhancement of QoS performance in Mobile Ad-Hoc Networks

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Abstract

A Mobile Ad Hoc Network (MANET) is an autonomous system of mobile nodes connected by wireless links. Applications supported by MANETs have stringent Quality of Service (QoS) requirements and to support these QoS parameters MANETs should have efficient routing protocols. Most of the reactive routing protocols like AODV provide a single route and backup route for packet delivery. However, when the single route fails, it results in a decline in a performance of various QoS parameters and it does not also solve the problem completely as this backup route may also fail. Hence, it is essential to provide multiple backup routes in each node. For this an efficient routing protocol is required which provides solution to this problem. This paper presents AODV routing protocol with n number of backup routes (AODV nBR) that provides source node with more than one back up routes in case of a link failure. The proposed scheme results in better throughput, minimum hop count, lesser end to end delay and improved network lifetime ratio.
Keywords—AODV, DSR, AODV BR, AODV nBR, QoS, throughput, network lifetime ratio, hop count, end to end delay.

1. INTRODUCTION

A Mobile Ad Hoc Network (MANET) is a collection of mobile nodes with no pre-established fixed infrastructure. The devices communicate with each other through a radio link. With the rapid development in computing devices, interest in ad hoc networks has increased manifold [1, 2]. Most of these networks are multihop in nature because of their limited radio propagation [3]. In MANETs, network nodes act as routers by relaying each other's packets and all the nodes form their own cooperative infrastructure [4]. Due to the limited range of these devices, they have to communicate through multihop paths [5]. Since each node has to perform the task of transmitting, receiving as well as routing, the routing protocols in these networks should be efficient and provide various Quality of Service (QOS) parameters. Routing is extremely challenging in MANETs as due to frequent change in position of nodes even the efficient nodes may become unusable or inefficient. Several routing protocols have been specifically designed for ad hoc networks and they can be mainly classified as proactive and reactive.

In the proactive routing protocols the routes are established in advance [6, 7]. This results in considerable overhead especially when the topology changes frequently. This is highly inefficient when updating routes that hardly carry any traffic. The routing table must be updated regularly. Although this kind of an approach leads to less packet transfer delay between nodes but at the same time it leads to a large control overhead especially in MANETs where nodes are changing their position constantly.

The most suitable and popular routing protocols for ad hoc networks are reactive or on demand protocols. Here, the routes between communicating nodes are established only when the

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need arises [8]. The control overhead is considerably reduced as the route record of all nodes need not be maintained. In a resource constrained environment this proves very beneficial. Some of the prominent reactive routing protocols are Dynamic Source Routing (DSR), Ad Hoc On Demand Distance Vector (AODV).

1) Dynamic Source Routing Protocol (DSR)

Dynamic Source Routing(DSR) is a reactive routing protocol. It is one of the simplest routing protocol consisting of two mechanisms: route discovery and route maintenance [13]. It contains a route cache maintained by each node [14]. During route discovery phase, if a source node wants to send data packets to a destination node then route cache is first checked to find route to the destination. When the route is not available in the route cache, source node initiates route discovery mechanism. For route maintenance, any broken or malfunctioning node is reported to all the nodes that transmit data packets over it. Also, information about broken links is also sent to the nodes. In DSR protocol, a record of all the nodes passed through it is maintained and based on this data, the optimal path is selected.

2) Ad Hoc On Demand Distance Vector (AODV)

Another reactive or on demand routing protocol is AODV (on demand distance vector). In AODV routes are discovered as and when necessary [10, 11]. This results in better utilization of resources and routing table is maintained by each node. The routing table contains the Internet Protocol (IP) addresses of source and destination, the address of the next hop along with the route expiry time. A new route is searched only if the route address is not available with the node and the node wants to transmit data packets to a destination. When a node has to transmit data packets, it looks up in the routing table and starts searching for a new route only if it is not available in the table. In reactive routing protocols like AODV, routes are only discovered when required [10]. Although AODV was found to be better than proactive routing protocols, still it resulted in considerable protocol overhead due to the system-wide broadcasts of Route Request (RREQ).

3) Ad Hoc On Demand Distance Vector Backup Routing (AODV BR)

The traditional AODV BR relies on creating a mesh like structure to provide an alternate route [13]. The neighbouring nodes overhear the packets that are being transmitted and in this way establish alternate path. During the route reply phase, node hears many RREP packets for the same destination, it chooses the best among them and that route is accommodated in the routing table. Although AODV BR shows better performance in terms of total number of processed messages [12] but it results in many drawbacks also. It creates a routing problem in a Multi-hop environment. After detecting a failure when sending data, a repairing procedure occurs near the failed node of the primary path. Here again, the issue of backup route failure is not addressed. When a node failure occurs in AODV BR routing scheme, then there will exist several nodes that can transmit several copies of the data packet to the destination node. In a bandwidth constrained environment this results in resource wastage. Moreover, overhearing of the RREP packets by neighbouring nodes and keeping multiple copies of the data packets comprises security and also requires more processing power and storage. To avoid this problem, this paper presents AODV with n number of Backup Route (AODV nBR) technique that provides backup routes in AODV environment. Here, when the original route fails, the first backup route comes

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into picture and when the first back up route also fails then the next backup route comes into focus for packet delivery. The selection of nodes for routing is done efficiently on the basis of distance and energy available with the nodes. There is no multiplicity in data packets that are transmitted to the destination as data packets are not simultaneously transmitted on multiple routes.

II. PROPOSED WORK

In the proposed system, an energy dissipation model has been considered for proper selection of nodes for routing. Whenever node failure occurs it may happen because of an attack or energy of the node finishes as it is depleted of resources. When such a situation arises it becomes imminent to look for an alternate or back up route for data transmission and avoid packet loss.

A. Network Model

Fig.1 shows the MANET setup for simulation purpose. A rectangular field area of 100m × 100m has been considered for simulation purpose. A large sized MANET with 100 nodes has been considered for the purpose of simulation and these nodes move in the field at a speed of 20m/sec. All the nodes are randomly placed in the field area and initial energy of a node is 6000mJ and total packets to be transmitted are 4000 with each packet of size 1 bit.

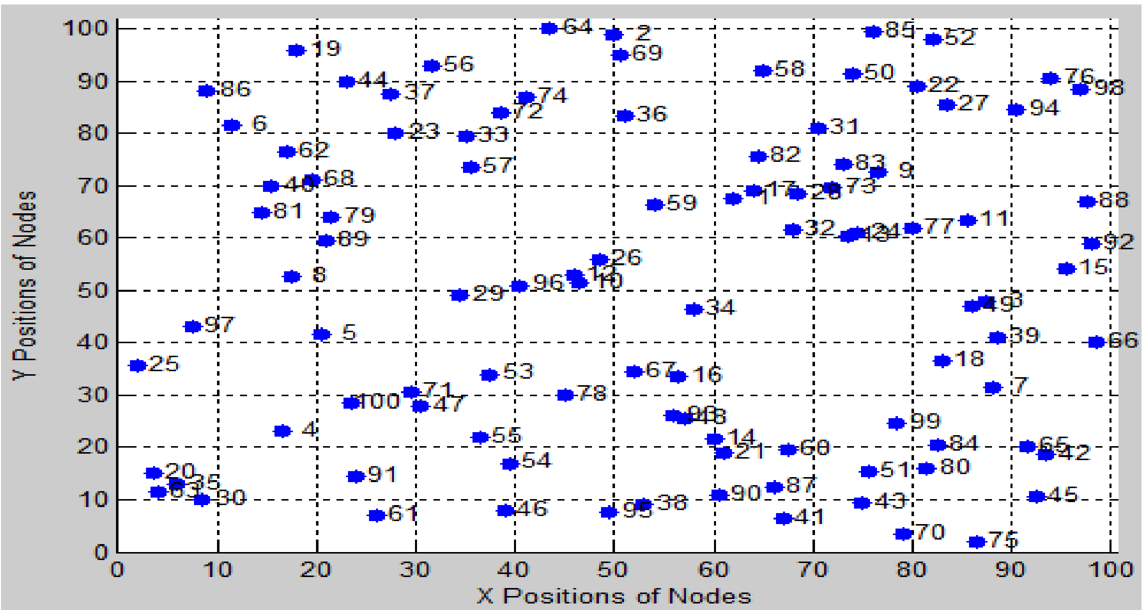

Fig.1: A MANET Setup

B. Implementation of the Proposed protocol

In the proposed protocol, the distances between all the nodes are calculated using distance vector calculation [10, 11]. Average distance between the transmitting device and destination is

D_{bs} = (one dimension of field)/$\sqrt{2\pi k}$ (where k=1) --------------- (1)

D_{bs} = (0.765×one dimension of field)/2 --------------- (2)

With the help of distance vector calculation the node which is nearest to the failed node is found out. This node is checked for its energy efficiency. If its remaining energy is within the threshold value required for packet transmission then node is selected for backup route.

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Threshold distance, E(c) = $\sqrt{\frac{E_{fs}}{E_{mp}}}$ ------------------ (3)

Where

E_{fs} = Amplifier energy consumptions for a short distance transmission.

E_{mp} = Transmit Amplifier Energy

To improve the QoS parameters of the system it is required to have a efficient routing protocol that searches for alternate routes. The next nearest node is selected with the help of distance vector calculation. If the node's energy level is above the threshold level then this node is selected for transmission otherwise the node is considered dead or failed and the procedure is repeated again for next route selection. This process of finding the first back up route, second back up route third back up route and so on till the nth available node is called AODV with n number of Back up Routing (AODV nBR). The proposed scheme multiple alternate routes are formed based on the average energy level of intermediate nodes between source to destination. The path having maximum energy level is selected for routing for packet transmission. This scheme has been proposed to maximize the network lifetime and minimizes the energy consumption during for route establishment. The total energy dissipated in the network during a round is calculated by [11, 12].

E_t = bits data × (2 × n × E_{tx} + n × E_{da} + K_{opt} × E_{mp} × D_{bs}^4 + 4 × n × E_{fs} × D_{ch}^2) ----- (4)

Here

E_t = Electronics Amplifier energy

n = No. of nodes in field

E_{mp} = Transmit Amplifier Energy

E_{tx} = Received Amplifier Energy

E_{da} = Data Aggregation Energy

K_{opt} = Optimum number of node groups

D_{ch} = Average distance between transmitting node and the destination

E_{fs} = Amplifier energy consumptions for a short distance transmission.

The AODV with n number of Backup routes (AODV nBR) protocol results in multihop transmission which also avoids duplicity of packets as the packets are not transmitted simultaneously on all available nodes. Selection of efficient nodes for routing results in improved throughput and lesser end to end delay and minimum hop count used. Hence, AODV nBR improves the Quality of Service parameters of MANETs with the help of efficient routing. MATLAB, an open source package, has been chosen to achieve the desired results.

IV. SIMULATION RESULTS

The proposed AODV nBR protocol is simulated for the throughput, end to end delay, minimum hop count and network lifetime ratio parameters. The performance of the proposed protocol is compared with the results obtained with existing protocols like AODV, DSR and AODV BR.

A. Throughput

It is defined as the total number of data packets received by the destination over the total simulation time. Throughput has been calculated for 100 nodes moving nodes over a 100m × 100m area. As seen from Fig. 2, throughput is least when calculated for DSR and AODV

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protocols. Number of transmitted bits per total number of rounds increase in case of AODV BR but the numbers of transmitted bits per the number of rounds are maximum in case of AODV nBR.

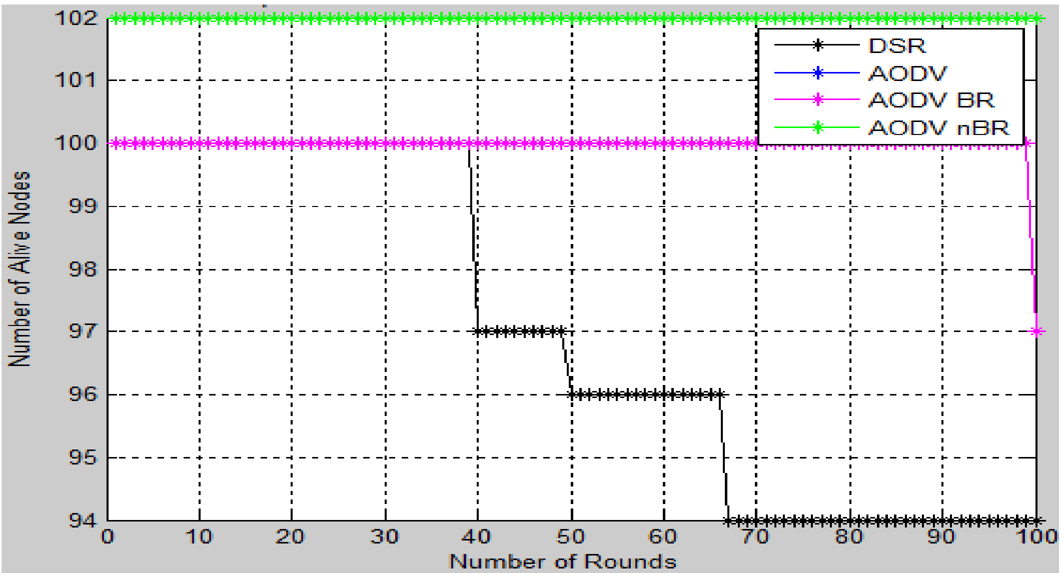

Fig.2: Alive nodes v/s Number of rounds

B. End to end delay

Here, end to end delay is a measure of how many rounds it takes for the data packets to reach the destination. This value should be least in an efficient AODV nBR protocol.

$$\text{End to End delay} = \frac{data\ received\ \ by\ destination}{Current\ \ round\ \ w.r.t.\ time}$$

As seen from the results obtained (Fig. 3), end to end delay is maximum in case of DSR protocol. The least end to end delay is obtained when data is transmitted through AODV nBR Protocol.

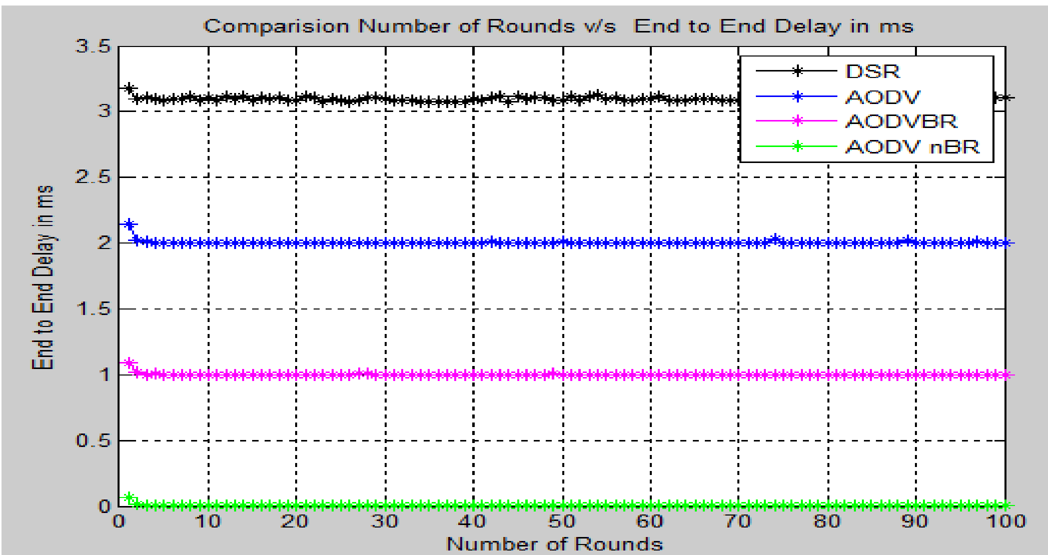

Fig. 3: End to End delay v/s number of rounds

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C. Lifetime of Devices

Lifetime of devices means how many nodes are alive or capable of data transmission per number of rounds. Fig. 4 shows that as the number of rounds increase the maximum number of alive nodes (devices that are capable of transmission) decreases. For the same number of rounds, DSR has the least number of nodes that are capable of transmission. AODV and AODV BR have more number of nodes capable of transmission than DSR for the same number of rounds. However, the results obtained with AODV nBR are found to be the best.

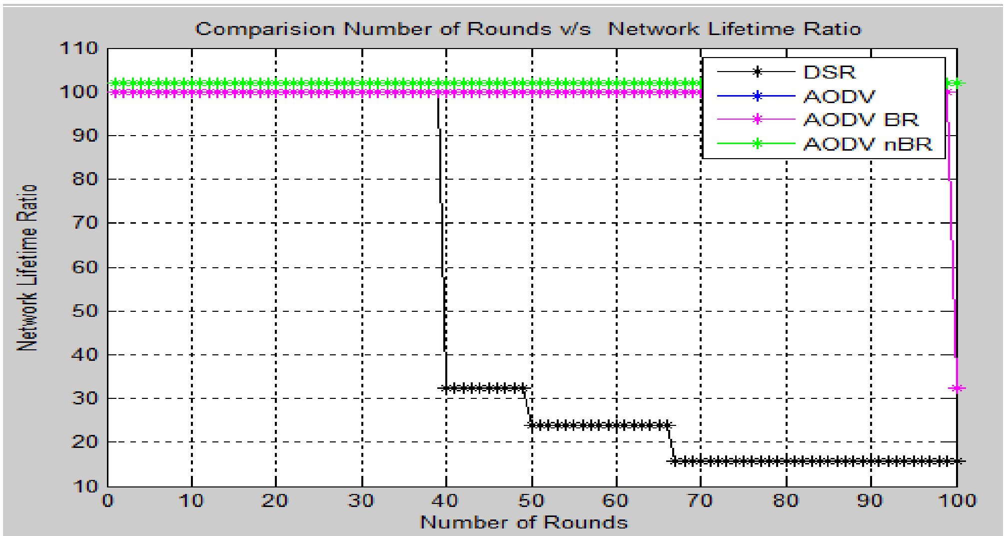

Fig.4: Network lifetime ratio v/s number of rounds

D. Number of dead nodes

Fig. 4 shows that as the number of rounds increase the maximum number of dead nodes (devices that are not capable of transmission) increases in case of DSR protocol. For the same number of rounds AODV and AODV BR have less number of dead nodes that are not capable for transmission. However, the results obtained with AODV nBR are found to be the best because it contains very least dead nodes.

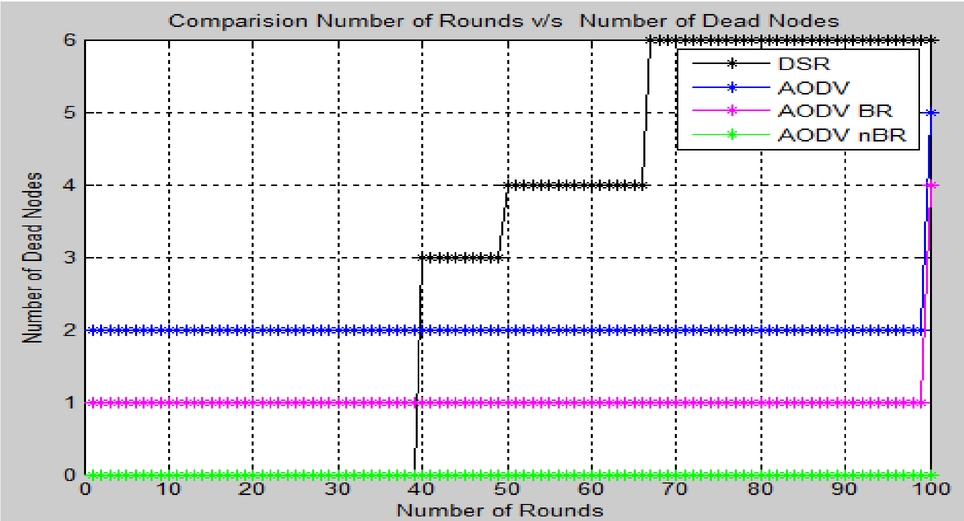

Fig.5: dead nodes v/s number of rounds

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E. Hop count

Hop count refers to the number of intermediate devices (like routers) through which data must pass between source to destination. The fig.6 shows number hop counts for the same number of rounds is more in case of DSR protocol where as in AODV it has comparatively less hop counts. AODV BR also has minimum number of hops for routing and data transmission when compared DSR and AODV. But AODV nBR consists of very least number of hops for routing hence, it performs best.

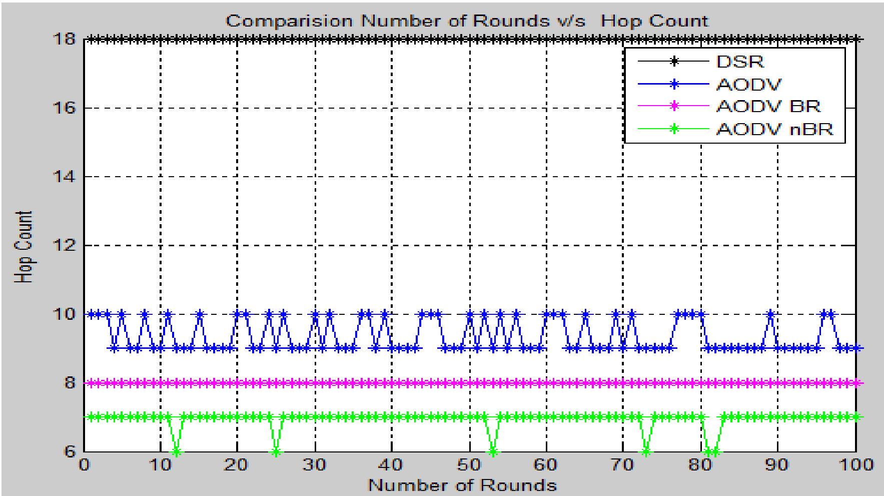

Fig.6: Hop count v/s number of rounds

F. Energy consumption

Fig.7 shows the energy consumption for data transmission per rounds. DSR protocol uses more energy for routing and packet transmission. AODV and AODV BR utilizes less energy for packet transmission when compared to DSR. But AODV nBR performs best by considering least energy for routing and data transmission.

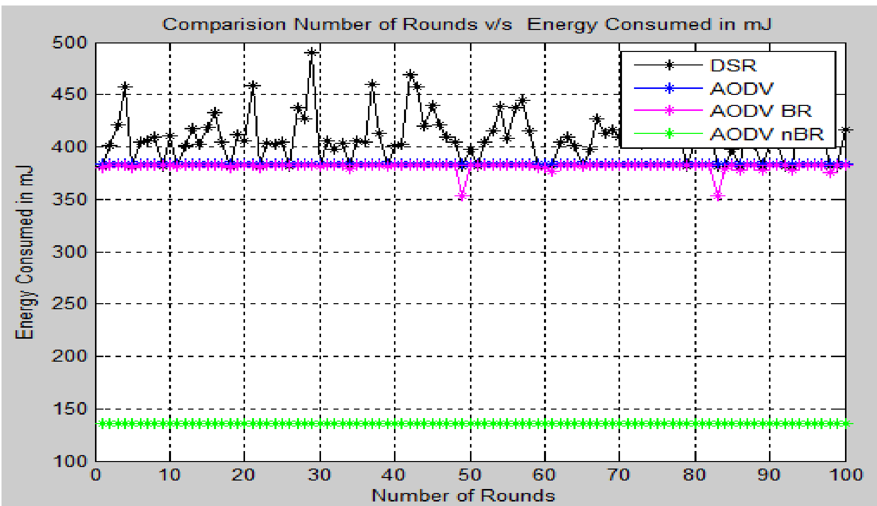

Fig.7: Energy consumed v/s number of rounds

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VI. CONCLUSION

In this paper an AODV nBR protocol (an improved version of AODV protocol) is proposed. The presented scheme utilizes a mesh structure and alternate paths. The mesh configuration provides multiple alternate routes without yielding any extra overhead. The scheme has been simulated for the QoS parameters like throughput, end to end delay, network lifetime ratio and hop counts. The results obtained were compared with other reactive routing protocols like AODV, DSR and AODV BR. The results obtained with AODV nBR were found to be much better than other protocols for the same simulation set up. Hence, AODV nBR is found to perform efficient routing and gives better QoS parameters than other routing protocols. We believe that the advantage of providing backup routes will be significant in the mobility environments.

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