

An optimized PHASeR Routing protocol based upon AACO

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Abstract - This paper presents a optimized routing protocol named PHASeR(proactive highly ambulatory sensing routing) for mobile wireless sensor networks (MWSN). This protocol uses a simple hop count metric to enable the dynamic and robust routing of data towards sink. It is motivated by the application of radiation mapping. PHASeR maintains gradient metric in mobile network using a global TDMA MAC layer. It also uses the technique of blind forwarding to pass messages through the network in multipath manner. Fading problem occurs in PHASeR protocol due to long time transmission and due to any environmental change that affects the energy consumption of signal. AACO is the optimization technique used in this research paper to cop up with the signal fading in PHASeR.

Keywords - Mobile Wireless Sensor Networks, Routing Protocols, PHASeR , ACO, AACO

I. INTRODUCTION

A wireless sensor network [1] is a network formed by large no. of sensor nodes where each node is equipped with sensor to detect physical phenomenon such as light, heat, pressure the acquired data is transmitted to the gateway, which can operate independently of the host system where the data is processed and analyzed. Sensor nodes monitor the collected data to transmit along to other sensor nodes by hopping. During this process of transmission the monitored data may be handled by multiple nodes to get to gateway nodes after multihop routing and finally reach the management nodes through the internet or satellite.

However in some situations the sensor nodes maybe required to be dynamic, creating mobile wireless sensor network (MWSN). MWSNs have no fixed topology which makes routing difficult due to frequent link breaks, but the main advantage is increased coverage area. Mobile nodes maybe required for moveable objects in smart environments, people who require constant health monitoring [2], research on wildlife [3] or surveillance performed by drones [4]. Protocols designed for these types of emerging applications require high packet delivery reliability and low overhead to decrease latency even in highly mobile environments. Routing in mobile wireless sensor networks differs from conventional routing in fixed networks in various ways. Many routing algorithms were developed for wireless networks in general. The next sections will include the routing protocols used in MWSN. Section 2 will outline the description of PHASeR protocol that how the protocol works and its drawbacks. Section 3 then presents the optimization technique used to overcome that drawback and describes the performance metrics. Section 5 includes the simulation results and discussion before the paper is concluded in section 6.



Figure 1: Wireless Sensor Network

II. ROUTING PROTOCOLS IN WSN

Routing protocols for MWSN can be broadly classified as hierarchical and flat protocols. The hierarchical protocol assigns different roles to different nodes, whereas flat protocols assign same task to all the nodes. Hierarchical protocols in WSNs can reduce energy consumption and delay. However, mobile nodes will constantly needs to become associated with different clusters which may cause large overhead. There are no. of hierarchical protocols such as Low-energy Adaptive clustering hierarchy

(LEACH) which is highly energy efficient and provides less latency and high throughput. The main drawback of LEACH is that it assumes all nodes to be homogeneous which is practically not usual as heterogeneity in energy is the most common case. Improved algorithm of LEACH is provided in Power-Efficient Gathering in Sensor Information Systems (PEGASIS). Unlike LEACH it avoids cluster formation and selection of one node is done to transmit data to sink rather than doing it by multiple nodes. So a chain is formed and only one node performs the task of transmission to the sink. PEGASIS uses a greedy approach and in case if there is any node failure then it bypass that node. So in each round node selection is done randomly thus reducing the per round energy consumption compared to LEACH [5]. With this improved protocol lifetime of the network is increased and clustering overhead is avoided. Similarly TEEN[6] is the another hierarchical protocol which is suitable for critical applications by adjusting the value of hard and soft threshold. Drawbacks of TEEN is removed in APTEEN[7].

Another category of MWSN protocols is flat protocols which is further categorized as Reactive (on demand) protocol and the Proactive (table driven) protocols. Reactive protocol searches for the route in an on-demand manner and set the link in order to send out and accept the packet from a source node to destination node. Route discovery process is used in on demand routing by flooding the route request (RREQ) packets throughout the network [8]. Examples of reactive routing protocols are the dynamic source Routing (DSR), ad hoc on-demand distance vector routing (AODV). The proactive protocols are the protocols in which

each node in the network has routing table for the broadcast of the data packets and want to establish connection to other nodes in the network. These nodes keep the record for all the destinations, number of hops required to arrive at each destination in the routing table. The routing entry is tagged with a sequence number which is created by the destination node

As such, the objective of Proactive Highly Ambulatory Sensor Routing (PHASeR) is to provide robust and timely data routing in the challenging mobile environment of radiation mapping. It is assumed that all of the nodes will be generating data periodically with fixed time intervals, which can be taken advantage of by letting each node periodically transmit in predefined slots. Given that there are a relatively small number of nodes, each one may be assigned a unique identification number, which will indicate the time slot in which the node should transmit.

III.PHASER

In PHASeR, each transmission is received by all of the transmitting nodes neighbors, this allows nodes to gather local topology information; namely the hop-counts of the nodes neighbors. Using this information a node will determine its own hop-count as one more than the lowest hop-count of its neighbors. So, if a node had three neighbors, with the hop-counts two, four and five, the node would set its own hop-count to three.[1] Since a deterministic global TDMA scheme is in use, a node will hear a single transmission from each of its neighbors in every cycle. This means that the node can update its hop-count every cycle, which will enable the gradient metric to be maintained across the whole network without flooding. This greatly reduces the protocols overhead and is one of its main advantages.[1] PHASeR uses the hop-count gradient to implement blind forwarding; so a transmission from a node is heard by all of its neighbors and it is the receiving nodes who independently decide whether they should forward any of the received data. In other words, when a node overhears a transmission it compares the hop-count of the transmitting nodes with its own. If the received hop-count is lower than its own, then the transmitting node is closer to the sink and the packet can be ignored. If the received hop-count is higher than its own, then the transmitting node is further from the sink, so the data is extracted from the packet and stored. If the received hop-count is equal to its own, then the transmitting node is the same distance from the sink, so the data is extracted from the packet, evaluated and either stored or dropped. [1]

The main drawback of PHASeR protocol is fading. Fading may either be due to multipath propagation, referred to as multipath induced fading, or due to shadowing from obstacles affecting the wave propagation, sometimes referred to as shadow fading. Fading can cause poor performance in a communication system because it can result in a loss of signal power without reducing the power of the noise. This signal loss can be over some or all of the signal bandwidth.[1]

IV.FADING

In wireless communications, fading is deviation of the attenuation affecting a signal over certain propagation media. The fading may vary with time, geographical position or radio frequency, and is often modeled as a random process. A fading channel is a communication channel that experiences fading. In wireless systems, fading may either be due to multipath propagation, referred to as multipath induced fading, or due to shadowing from obstacles affecting the wave propagation, sometimes referred to as shadow fading.

The terms slow and fast fading refer to the rate at which the magnitude and phase change imposed by the channel on the signal changes. The coherence time is a measure of the minimum time required for the magnitude change or phase change of the channel to become uncorrelated from its previous value.

Slow fading arises when the coherence time of the channel is large relative to the delay requirement of the application.[1] In this regime, the amplitude and phase change imposed by the channel can be considered roughly constant over the period of use. Slow fading can be caused by events such as shadowing, where a large obstruction such as a hill or large building obscures the main signal path between the transmitter and the receiver. The received power change caused by shadowing is often modeled using a log-normal distribution with a standard deviation according to the log-distance path loss model.

Fast fading occurs when the coherence time of the channel is small relative to the delay requirement of the application. In this case, the amplitude and phase change imposed by the channel varies considerably over the period of use.

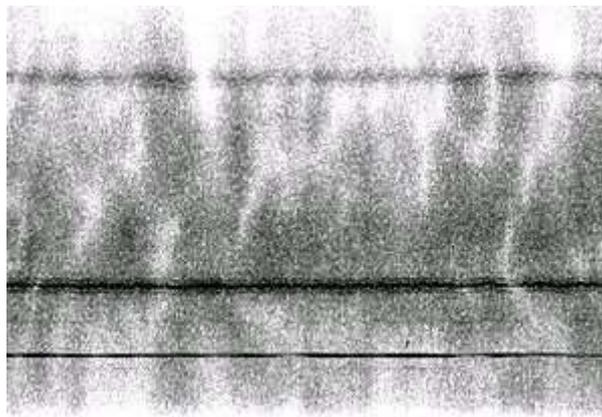


Figure 2: Fading

V. DEFINITION OF ENERGY EFFICIENCY

For a wireless networks, the devices operating on battery try to pursue the energy efficiency heuristically by reducing the energy they consumed, while maintaining acceptable performance of certain tasks. Using the power consumption is not only a single criterion for deciding energy efficiency. Actually, energy efficiency can be measured by the duration of the time over which the network can maintain a certain performance level, which is usually called as the network lifetime. Hence routing to maximize the lifetime of the network is different from minimum energy routing.

Minimum energy routes[1][6] sometimes attract more flows, and the nodes in these routes exhaust their energy very soon; hence the whole network cannot perform any task due to the failure on these nodes. In other words, the energy consumed is balanced consumed among nodes in the networks. Routing with maximum lifetime balances all the routes and nodes globally so that the network maintains certain performance level for a longer time. Hence, energy efficiency is not only measured by the power consumption but in more general it can be measured by the duration of time over which the network can maintain a certain performance level. There are lots of ways to categorize routing algorithms One is flooding and broadcast routing, which is often necessary during the operation of the wireless network, such as to discover node failure and broadcast some information. The second kind is multicast routing, which is very common in wireless networks, to communicate in a one-to-group fashion. The last is unicast, which is always in an end-to-end fashion and the most common kind of routing in networks. It goes without saying that node failure is very possible in the wireless network. Hence, saving energy when broadcasting in order to recover from the node failure or to re-routing around the failed nodes is essential. By the same token, multicast has the same challenge to achieve the energy efficiency [11][19]. For unicast, it is highly related to the node and link status, which require a wise way to do routing as well. Sometimes, shortest

path routing is possibly not the best choice from the energy efficiency point of view. Energy is a limiting factor in case of Ad-hoc networks[12]. Routing in ad-hoc networks has some unique characteristics. First-energy of nodes is crucial and depends upon battery which has limited power supply. Second-nodes can move in an uncontrolled manner so frequent route failures are possible. Third-wireless channels have lower and more variable bandwidth compare to wired network. Energy efficient routing protocols are the only solution to above situation. Most of the work of making protocols energy efficient has been done on “on demand routing protocols” because these protocols are more energy efficient rather than proactive protocols but still these have some drawbacks which have been discussed in the next section. Energy efficiency can also be achieved by sensible flooding at the route discovery process in reactive protocols. And energy efficiency can also be achieved by using efficient metric for route selection such as cost function, node energy, battery level etc. Here energy efficiency doesn’t mean only the less power consumption here energy efficiency means increasing the time duration in which any network maintains certain performance level.

VI. ANT COLONY OPTIMIZATION (ACO) AND ADAPTIVE ANT COLONY OPTIMIZATION (AACO)

Ant colony optimization is a part of the larger field of swarm intelligence in which scientists study the behaviour patterns of bees, termites, ants and other social insects in order to simulate processes.

The ability of insect swarms to thrive in nature and solve complex survival tasks appeals to scientists developing computer algorithms needed to solve similarly complex problems. Artificial intelligence algorithms such as ant colony optimization are applied to large combinatorial optimization problems and are used to create self-organizing methods for such problems. Ant colony optimization is a meta-heuristic technique that uses artificial ants to find solutions to combinatorial optimization problems. ACO is based on the behaviour of real ants and possesses enhanced abilities such as memory of past actions and knowledge about the distance to other locations. In nature, an individual ant is unable to communicate or effectively hunt for food, but as a group, ants possess the ability to solve complex problems and successfully find and collect food for their colony. Ants communicate using a chemical substance called pheromone. As an ant travels, it deposits a constant amount of pheromone that other ants can follow. Each ant moves in a somewhat random fashion, but when an ant encounters a pheromone trail, it must decide whether to follow it. If it follows the trail, the ant’s own pheromone reinforces the existing trail, and the increase in pheromone increases the probability of the next ant selecting the path. Therefore, the more ants that travel on a path, the more attractive the path becomes for subsequent ants. Additionally, an ant using a short route to a food source will return to the nest sooner and therefore, mark its path twice, before other ants return. This directly influences the selection probability for the next ant leaving the nest. Over time, as more ants are able to complete the shorter route, pheromone accumulates faster on shorter paths and longer paths are less reinforced. The evaporation of pheromone also makes less desirable routes more difficult to detect and further decreases their use.

However, the continued random selection of paths by individual ants helps the colony discover alternate routes and insures successful navigation around obstacles that interrupt a route. Trail selection by ants is a pseudo-random proportional process and is a key element of the simulation algorithm of ant colony optimization.

Adaptive ACO: In this proposed method, Ant colony optimization algorithm with uniform mutation operator using self-adaptive approach is used. Here mutation operator is used for enhancing the algorithm escape from local optima. In this method, an additional operator, mutation operator, is used and the new mutation rate is generated by the self-adaptive approach using equation (1). Here ACO algorithm generates the current solution (w). By using mutation operator, random position is changed by new mutation rate in current solution (w). After changing random position, new solution (w') is generated. Then the cost of this new solution (w') is compared by the current solution (w), if the cost of new solution is less than (or greater than) current solution, according to combinational problem, then new solution is replaced by current solution. This process is repeated until maximum iteration is not reached. The value of the current path and its reciprocal path is stored in table.

VII. PROBLEM FORMULATION

Existing technique presented an original routing protocol designed for MWSNs. It specifically targets the application of radiation mapping using UAVs. However, it should be noted that the protocol could be used in other similar scenarios and for different applications. PHASeR uses a novel, low overhead, method of maintaining a gradient metric, even in high speed scenarios, through the use of a global TDMA MAC layer. PHASeR is also particularly robust from its use of the blind forwarding technique, which allows data to simultaneously take multiple paths through the network. Extensive analysis and simulations, modelled on the radiation mapping application, have shown the protocol to be effective in a wide array of situations, over varying mobility, scalability and traffic levels. MACRO, AODV and OLSR results have also been given to illustrate the performance level of the routing protocols currently used in sensor network implementations.

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Fading can cause poor performance in a communication system because it can result in a loss of signal power without reducing the power of the noise. This signal loss can be over some or all of the signal bandwidth.

Fading can also be a problem as it changes over time: communication systems are often designed to adapt to such impairments, but the fading can change faster than the adaptations can be made. In such cases, the probability of experiencing a fade (and associated bit errors as the signal-to-noise ratio drops) on the channel becomes the limiting factor in the link's performance. The effects of fading can be combated by using diversity to transmit the signal over multiple channels that experience independent fading and coherently combining them at the receiver. The probability of experiencing a fade in this composite channel is then proportional to the probability that all the component channels simultaneously experience a fade, a much more unlikely event.

VIII. METHODOLOGY

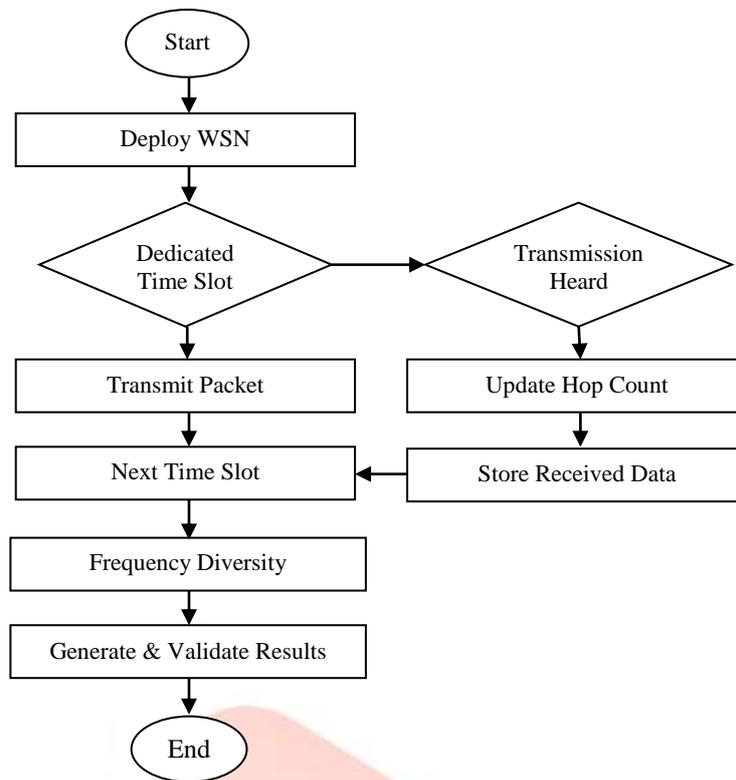


Figure 3: Flow Chart

Figure 3 shows the flow chart for a single node's operation at each timeslot. The node begins by determining if the current time slot is its own dedicated time slot, then it should compile a packet from the queued frames. Priority data is stored first and then any remaining room is filled with diversity data. The packet is then broadcast to any nodes within the transmission area.

IX. RESULTS AND DISCUSSION

In this research paper the effect on various QoS parameters such as Packet Delivery Ratio, Overheads, Average End-to-End Delay, Throughput, Average Energy Consumption have been seen by varying the no. of nodes i.e. 20,40,60,80 and 100 nodes at the constant speed of 100m/s.

Performance Metrics

1. Packet Delivery Ratio: The first metric is PDR, which is the number of packets successfully received P_{rx} , per number of packets transmitted P_{tx} .

$$\text{Given as } PDR = P_{rx}/P_{tx}$$

where P_{rx} is packets received and P_{tx} is packets transmitted

As the TDMA MAC scheme is contention free there will be no loss from collisions. However, nodes being disconnected from the network and path breaks may cause packet losses. PDR ratio should be as high as so the network could give best results.

2. Average End-to-end Delay: The second metric is average end-to-end delay, it is the average between a packet being created and being delivered to the sink. The average delay in a TDMA multihop based protocol depends greatly on the order of the allocated time slots of the forwarding nodes. The best case scenario is that the forwarding nodes are in sequence.

3. Overhead: Overhead is a major factor in designing routing protocols for mobile sensor networks since more no. of packets can cause congestion, which will limit the throughput of data. There are generally two types of overhead; packet overhead and control overhead. Packet overhead is the ratio of non-data bits to data bits in a data packet. Control overhead is the ratio of bits in control packets to bits in data packets. Control packets are often used to negotiate channel access, discover routes or share topology information.

4. Throughput: Throughput, is defined as the number of data bits successfully delivered to the sink, per second, over the entire simulation time.

5. Average Energy Consumption: Energy consumed in transmitting and receiving the message packets in a mobile wireless sensor network.

•Packet Delivery Ratio

Figure 4 shows the PDR in existing PHASeR, ACO and AACO. AACO-PHASeR shows the better results as compared to the ACO-PHASeR and PHASeR because if there is link breakage or there is a dead node in a network due to the more energy dissipation then we use the reciprocal path generated by AACO, as a result of which

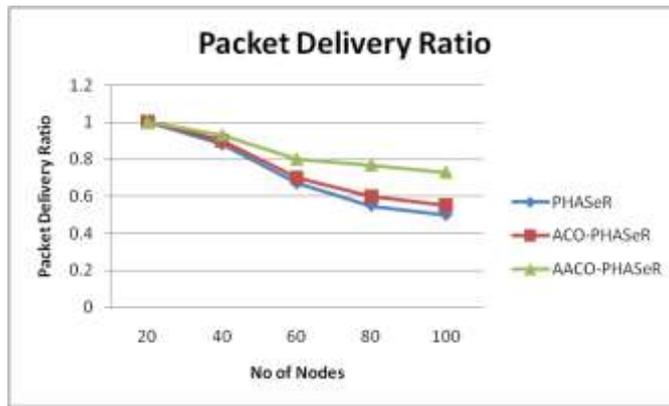


Figure 4: Comparison of PDR in PHASeR, ACO-PHASeR, AACO-PHASeR

losses are reduced thus the packet drop is reduced as the result of which the packet delivery ratio is improved in AACO-PHASeR.

- Average End-to-End Delay

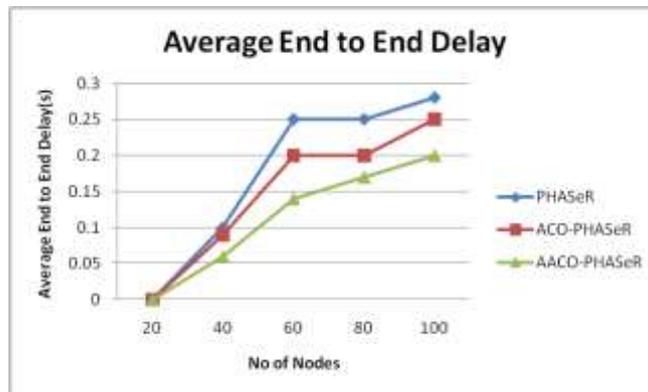


Figure5. Comparison of Average End-to-end delay in PHASeR, ACO-PHASeR, AACO-PHASeR

Figure 5 shows the better results of average end- to-end delay in AACO-PHASeR. As the path is deviated load is less so the packets will reach to destination in time without any delay as the result of which end to end delay in the AACO-PHASeR is less as compare to PHASeR and ACO-PHASeR.

- Overhead

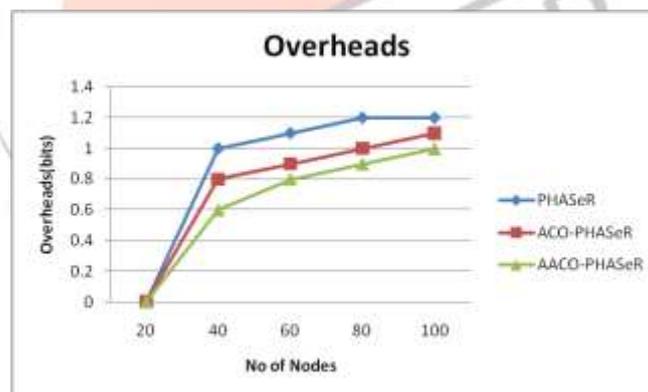


Figure 6: Comparison of Overhead in PHASeR, ACO-PHASeR, AACO-PHASeR

Figure 6 shows low overhead result shown by AACO-PHASeR as compare to PHASeR. As the packet drop is reduced the packet delivery ratio is improved so all the packets are delivered in time so overhead is reduced in AACO-PHASeR.

- Throughput

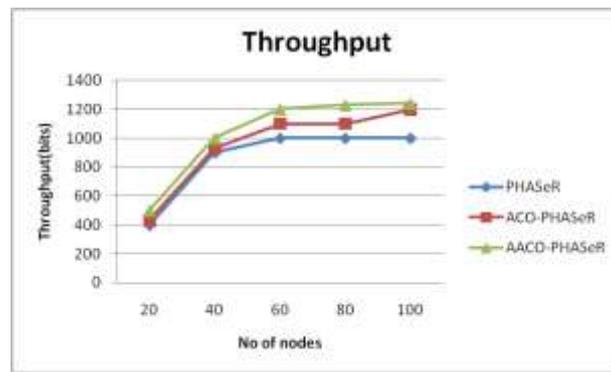


Figure 7 Throughput

Figure 7 shows that AACO-PHASeR shows better results as shown in graph. As the packets will take the reciprocal path more no. of packets will reach to the destination without any loss so as a result of which throughput of AACO-PHASeR is improved.

- Average energy consumption

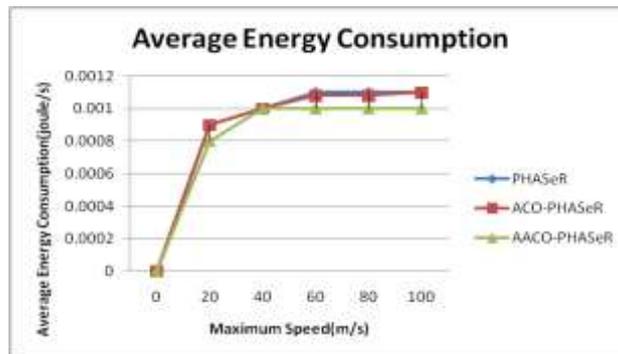


Figure 8. Average Energy Consumption in PHASeR, ACO-PHASeR, AACO-PHASeR

Figure 8 shows that there is less energy consumption in AACO-PHASeR than PHASeR. As the packet drop is less so the retransmission attempts for sending the message to receiver is decreased, so as the retransmission attempts is less so there is less energy dissipation due to which the average consumption of energy in optimized technique is less as compared to the existing protocol.

X. CONCLUSION

A wireless sensor network consists of three main components: nodes, gateways, and software. The spatially distributed measurement nodes interface with sensors to monitor assets or their environment. In the research proposal the optimized PHASeR protocol is implemented on the basis of AACO optimization scheme. AACO is used to provide a reciprocal path for every link in case of its failure. The proposed approach helps to reduce the load and drops in the network, so using the proposed methodology the QOS parameters are quite improved as shown in the result section.

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