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# Routing Protocol for MANET Based on QoS-Aware Service Composition with Dynamic Secured Broker Selection

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**Abstract:** MANET is a mobile ad hoc network with many mobile nodes communicating without a centralized module. Infrastructure-less networks make it desirable for many researchers to publish and bind multimedia services. Each node in this infrastructure-less network acts as self-organizing and re-configurable. It allows services to deploy and attain from another node over the ad hoc network. The service composition aims to provide a user's requirement by combining different atomic services based on non-functional QoS parameters such as reliability, availability, scalability, etc. To provide service composition in MANET is challenging because of the node mobility, link failure, and topology changes, so a traditional protocol will be sufficient to obtain real-time services from mobile nodes. In this paper, the ad hoc on-demand distance vector protocol (AODV) is used and analyzed based on MANET's QoS (Quality of Service) metrics. The QoS metrics for MANET depends on delay, bandwidth, memory capacity, network load, and packet drop. The requester node and provider node broker acts as a composer for this MANET network. The authors propose a QoS-based Dynamic Secured Broker Selection architecture (QoSDSBS) for service composition in MANET, which uses a dynamic broker and provides a secure path selection based on QoS metrics. The proposed algorithm is simulated using Network Simulator (NS2) with 53 intermediate nodes and 35 mobile nodes of area 1000 m $\times$ 1000 m. The comparative results show that the proposed architecture outperforms, with standards, the AODV protocol and affords higher scalability and a reduced network load.

**Keywords:** MANET; QoS metrics; routing protocol; cluster formation; link failure

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## 1. Introduction

MANET consists of autonomous mobile nodes, which are capable of self-organizing and frequently reconfiguring due to the mobility in their nature. Therefore, the nodes are incapable of sharing services to other nodes available in the surrounding area [1,2]. Generally, web-service composition enables application-to-application interactions over networks by comprising functional and non-functional characteristics. Functional requirements are related to the conformance of web-service composition to the conditions of its functionality.

In contrast, nonfunctional requirements are associated with the QoS, e.g., response time, availability, and cost [3]. It provides interoperability because a single service cannot satisfy user requirements. The system requires composite services to achieve interoperability, consisting of many existing atomic services. These services may be hardware, software, raw data, etc. For example, you can consider that a laptop, which has software to be exchanged, can act as a service. Service composition is the integration of any existing e-services communicated over the Internet through wired media [4]. Recently, the research [5–11] on service composition over infrastructure-less networks has evolved enormously. Most of the works in the literature deliberate that the services available on the wired network are easily accessible; whereas, the services offered by the wireless network can be accessed by matching service composition protocols with infrastructure-less protocols.

In addition, these services need brokers to exchange services among the requester and provider nodes in MANET. So, the research follows on providing service composition based on non-functional QOS parameters such as throughput, end-to-end delay, and packet-delivery ratio in MANET. A dynamic service composer is assigned based on QoS metrics among nodes, to compose various services for a wireless network based on user requirements. The various challenges in developing a dynamic service broker are due to node mobility, link failure, and topology changes in MANET, as discussed in [12]. The mobile nodes are grouped to form clusters, and each cluster is capable of assisting the scalability of the mobile nodes. A mobile node is selected to act as a cluster head based on the Multiple Cluster Head Gateway (MCHG) [13]. QoS is the term used to measure the objectives of both service provider and service requester; the QoS composition process will select the task based on metrics and aggregate the services that have obtained the maximum value by satisfying the user's requirement. Selection of the protocol for routing based on the QoS metrics in MANET is required.

The research problem of embedding service composition in pervasive environments is divided into two approaches. The first approach is based on developing a language and workflow approaches such as BPEL4WS, DARPA, and Web Services Flow Language discussed in [14]. The second approach is based on constructing architecture for discovering and integrating composite services in an infrastructure-less environment. This paper deals with the second approach, since it is indeed important to consider QoS parameters for the pervasive environment.

The main contributions of this paper are presented below:

1. Initially, an efficient cluster formation mechanism, namely the MCHG algorithm, is introduced to balance the load in the network.
2. A dynamic broker selection based on the QoS metrics is formulated to select an active broker and routing path.
3. A secured communication link within the intra-cluster is designed based on symmetric encryption and key-exchange protocol to prevent intrusion in the network.

The rest of the paper are organized as follows. Section 2 discusses the various literature works. Section 3 illustrates the problem definition, and Section 4 deals with the overview of the QoSDSBS model. Further, a detailed discussion of the QoSDSBS model is presented in Section 5. Experimentation and result analysis are carried out in Section 6. Finally, Section 7 concludes the work with its outcomes.

## 2. Related Work

Service composition is an active research topic in a wired network environment; most research is on wired composition in a centralized architecture. First, a wired environment-based background work is discussed. At first, Zeng et al. proposed a service class that consists of many distinct services and used service class to differentiate from other services, which have the same functionality but differ in terms of their QoS metrics [14]. The process consists of selecting multiple QoS metrics for wired networks such as cost, time, security, reliability, and availability. The local selection is based on QoS metrics for various composite services and uses global selection to select the best provider. Many researchers have proposed frameworks for service composition based on ontology and QoS metrics. Aggarwal et al. proposed a framework called METEOR-S, that selects the services based on semantic values and groups those values into functional, non-functional, and execution data [15]. With this framework, they choose the best and unique service to fulfil the user requirements based on their SLA (Service Level Agreement). Many research works are done toward considering multiple QoSs for the composition to find the outstanding service. Xingzhi Feng et al. [16] have proposed an architecture for considering multiple QoS constraints for service composition and used both QoS-based functional and non-functional parameters. Their composition is highly critical because they need to select the best service from many specific services and provide QoS metrics, to satisfy the user's requirements with maximum utility function, as constraints.

L. Zeng et al. [17] developed a standard QoS middleware that provides interoperability for service composition by integrating with integer programming search. The authors obtained better QoS performance with less complexity and combined global planning with local optimization [18]. Multiple QOS constraints are proposed into MANET to assist the network in its energy-saving method and effective data transfer process [19]. Peng Cheng Xiong et al. [20] developed a Petri net framework based on graph structure and algebraic property for considering multiple QoS attributes. This workflow will support functional requirements and also QoS parameters. It deals with a business process for sequencing and runtime execution. Message-forwarding applications such as traffic block notice have been addressed in an effective QOS-based metric analysis system. It also deals with the intelligent traffic-management system to determine the features and service area of coverage to maintain the data-transmission rate [21]. The multi-objective evolutionary algorithm, namely MOEQA, has been addressed to solve the multicast-routing problem in MANET. It also includes the greedy and family competition approach to maintain the convergence and diversity among the density coverage area [22]. However, this mechanism requires lot of information to process an efficient selection.

The second research work is based on wireless network composition. The research work by [23] developed a hierarchical task graph-based workflow for service composition in the infrastructure-less environment. The authors represented a graph with each composite service in a task graph with leaf nodes containing atomic services. The subtrees for the task graph can be computed in distributed networks. The services are combined based on demand or are dynamic. This architecture provides better resource utilization. The authors in [24] have considered both the requester node and composer node in a single module; however, this approach will decrease the system efficiency by increasing network load.

Therefore, an efficient cluster-head-selection mechanism can handle the network load as well as boost network efficiency. The research work in [6] proposed a Linked Cluster Algorithm that assigns an id to each cluster and selects the cluster head with highest id value. A node with higher mobility does not get a chance to act as the head. The authors in [25] proposed a mechanism for cluster formation based on QoS metrics for a wireless network. However, this approach is inefficient and stagnates in local issues, while there is an increase in scalability of the network. The authors in [26,27] proposed an extended ZRP (Zone Routing Protocol) for the clustering-based network that selects a single cluster head with overlapping zones. Various security issues in web services including DDOS [28] are solved. A detailed survey regarding various QoS metrics in web services is discussed in [29,30]. These algorithms selected a single header, resulting in a centralized cluster that might lead to single point of failure.

From the existing research, we observed that an efficient cluster-head election should possess the following eminences in MANET:

- Maximum utilization of a resource such as battery power;
- Header should be capable of withstanding any packet traffic;
- Load balancing;
- Lesser node mobility.

Therefore, our proposed work considers the above-mentioned eminences along with QoS metrics for dynamic secured broker selection mechanism. In addition, a secured communication path is established between the broker and CHs to eradicate the intrusion.

## 3. Problem Definition

Services provided in MANET are afforded by the broker available in the middle. Based on the cluster head algorithm, a single broker can be selected to transfer the benefits to the service requester and provider in a centralized system. As a result, it is more prone to a single point of failure. However, a multiple broker-selection mechanism converts the centralized system into a decentralized system that might eradicate the single point of failure. The service traffic will increase with respect to the link failure between the requester or provider and the broker. By using ZRP [27], a region can be formed and transfer services to different zones in a network. The zones in the architecture become overlapped, while the clusters will not become overlapped in the network. The ZRP requires more control messages to be transmitted for updating the routing table. So, we need cluster-based architecture and a dynamic broker based on QoS metrics to avoid and overcome link failure as well as balance the network load.

The cluster-based dynamic broker architecture is required to recover from link failure and provide reliability to the network. More than one dynamic broker is selected, which provides the decentralized model. When the link fails between brokers, it automatically redirects to another broker. The dynamic broker in our proposed architecture is selected based on the QoS metrics. We need a protocol based on the QoS metrics to choose the broker in a cluster architecture. The dynamic broker is determined based on the QoS metric's value calculated by each mobile node, providing a secure transfer of services from one cluster to another cluster by the AODV protocol. The proposed system architecture using QoSDSBS consists of four modules:

1. Cluster formation of mobile nodes;
2. Routing protocol;
3. Dynamic broker selection;
4. Secure broker selection.

The working process of the proposed methodology with four modules is discussed in detail in Section 5.

## 4. QoSDSBS System Model

Our system model, QoSDSBS, consists of an environment where mobile nodes use services to publish and bind with another node. Each mobile node provides services and acts as a service provider, and the service requester communicates using MANET protocols. Each node will have specific services, power, and battery life. Service composition is a process to integrating all the services, according to the user requirement from multiple mobile nodes. In our proposed system architecture, the QoSDSBS broker acts as a service, which can incorporate these composite services from numerous mobile nodes, as depicted in Figure 1.

Each N mobile node from N1 to N7 will have specific or the same services, with different QoS metrics for each service. Consider the nodes N2 and N6 in Figure 1, which provide the same service S2 as the other QoS metrics. In Figure 1, seven nodes offer six different and standard services. In Figure 2, the broker will group the mobile nodes based on their services. The services offered by each node are depicted, and the broker that acts as a composer will combine and integrate these services based on the user's requirements.

Different nodes offer the same services. In this process, the broker utilizes QoS metrics such as such as delay, bandwidth, throughput, etc., to select the best service from the distinct nodes. The service registration takes place at the broker, whenever the mobile nodes within the cluster initiate a service. So, a broker's responsibility is to find adequate services by applying the QoS metrics. The broker will match the service and lists the node offering atomic services inside the cluster. According to Figures 1 and 2, we list the nodes services as follows.

N1 = [Service 1, Service 2]
N2 = [Service 2, Service 3]
N3 = [Service 1, Service 4]
N4 = [Service 4, Service 5]
N5 = [Service 2, Service 3]
N6 = [Service 2, Service 4, Service 6]
N7 = [Service 5, Service 6]

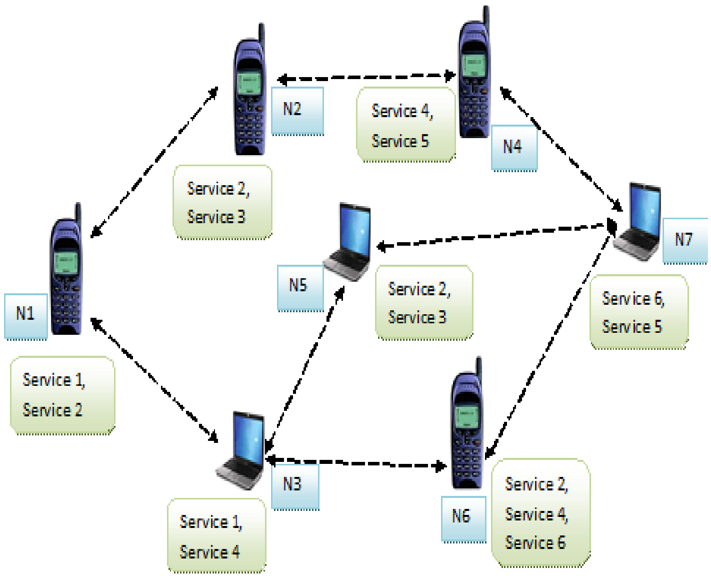


**Figure 1.** Composite services of mobile nodes.

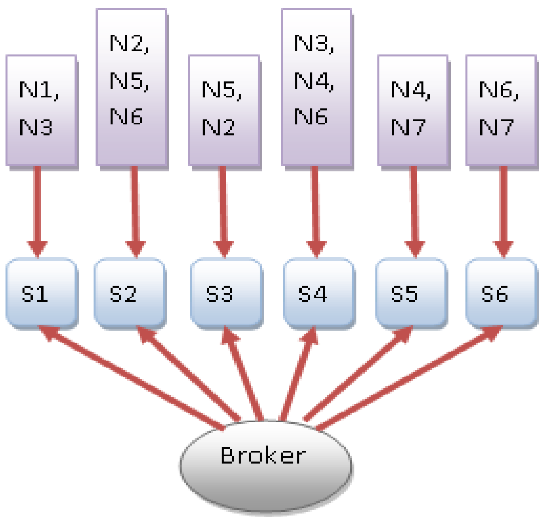


**Figure 2.** Selection of broker based on its services.

Figure 3 describes the overall architecture of QoSDSBS for service composition in MANET, with nodes functions in different layers of service. The service-composition layer can cope with other protocols; the communication layer provides wireless connectivity with nodes in their region. The connectivity for such a network includes ad hoc 802.11 standards, Bluetooth, etc. The communication with other networks is done with the help of IEEE 802.11. In the network layer, it provides general routing between the mobile nodes. For MANET, many traditional routing protocols are available such as the AODV [30], DSDV

(Destination-Sequenced Distance Vector) [31], etc. For the proposed QoSDSBS architecture, the AODV acts as a routing protocol because it outperforms with the QoS metrics for mobile nodes. The service-discovery layer provides the protocol to discover the services available in the mobile nodes.

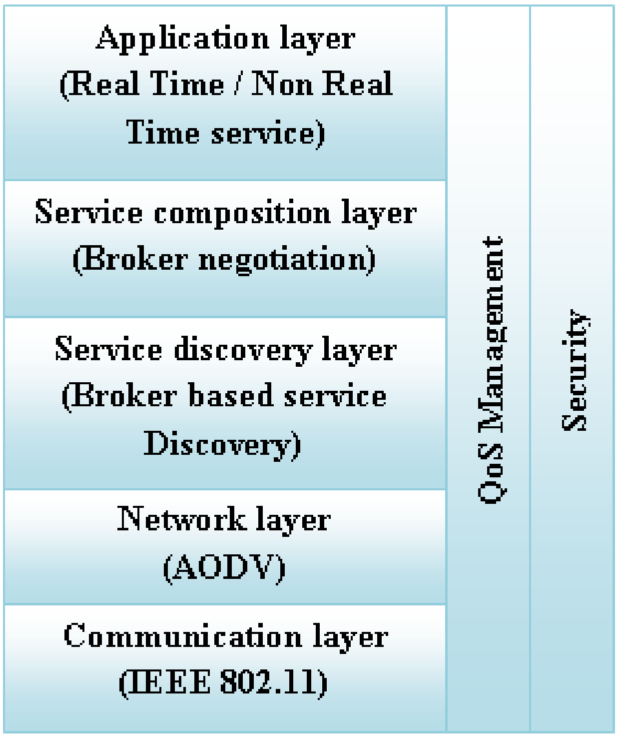


**Figure 3.** Layered architecture of QoSDSBS.

The protocol used for service discovery is GSD (Group-based Service Discovery) and any cluster-based broker selection for service discovery [32,33]. In the service composition layer, broker-based integration of services based on the QoS metrics from the QoS management is used. This protocol is used to discover the service with different QoS metrics and integrate those services that provide a composite service to the requester node, with the help of a broker node. In the application layer, it gives a different platform for service composition. The services offered include either real-time service or non-real-time service.

## 5. Proposed System

Our proposed QoSDSBS architecture model consists of MANET service composition, which uses a broker to integrate services. The broker will use the QoS as a metric to acquire distinct services from different nodes. For the routing services in the proposed architecture, the authors have considered a dynamic broker selection based on the QoS metrics. The QoS metrics include bandwidth, delay, throughput, load balancing, and node mobility. The entire node architecture is grouped into clusters based on its coverage area. Each cluster consists of one or two brokers that are dynamically selected. In the literature, the authors have considered one broker to avoid link failure. However, the centralized broker might be prone to aa single point of failure. In this work, we introduced the multiple broker concept using a dynamic broker-selection approach, which might eradicate the above-mentioned issue. This dynamic approach selects a broker based on the QoS metrics that provides reliability and scalability even if there is an increase in the number of nodes in the future. As depicted in Figure 4, the architecture consists of many mobile nodes and the cluster with a broker encircled is formed based on the coverage area.

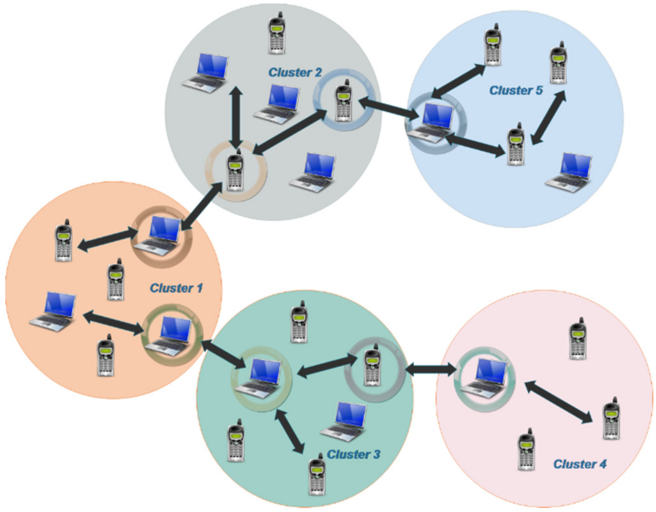


**Figure 4.** Cluster-based dynamic broker-selection process.

The communication between the inter-cluster and intra-cluster takes place with the help of traditional routing protocol, namely the AODV. If a requester node in Cluster 1 requires a service from Cluster 4, then it broadcasts a request to the rest of the other nodes present in cluster1 to act as a broker. Then, the requester node will select the nearest broker and further process the reply message to the responding node as the broker. Next, the dynamic broker will provide the details of the available service providers in Cluster 4. Each broker will have the address of the service provider through which a requester node can get the service. The brokers are responsible to find the shortest path between cluster1 and Cluster 4 through the intermediate Cluster 3, using the AODV protocol. The dynamic broker is automatically selected in each cluster based on the QoS metrics.

Our proposed architecture consists of four different modules. We will discuss each module precisely.

### 5.1. Cluster Formation of Mobile Nodes

Clusters are formed based on the node's range and bandwidth. It provides a hierarchical formation that divides mobile nodes into groups to avoid transfer rates and provide scalability. Clusters can be formed by the MCHG algorithm; here, each cluster will have more than one cluster head to act as a broker for our architecture. Multiple brokers based on their neighbor cluster are inherited to avoid a single point of failure. In Figure 4, there are five clusters and the brokers are encircled; in cluster1, two brokers are selected and used for interconnection between Cluster 2 and Cluster 3. In Cluster 4, a single broker helps to serve the services. According to number of services, selection of brokers will increase and that will withstand for more scalability and ease of data transfer. If cluster1 wants to transfer its services to Cluster 5 and Cluster 3, it can use the nearest brokers to process the request; thus, our proposed architecture provides load balancing and an increased data delivery rate.

### 5.2. Routing Protocol

All the required QoS metrics are exchanged among the nodes using hello messages. Each node should maintain a table that consists of node identification, service provider name, services available, and the QoS metrics for each service. Table 1 shows the structure of the fields required to acquire the service description. The traditional protocol AODV is used to find the shortest path between the service provider and the dynamic broker; the broker will find the best service by acquiring hello messages from different nodes and computing the QoS metrics based on Table 1. Table 1 contains the list of service providers available for a particular service, with their specifications. Service provider SP1 will provide services (S1, S4, and S6). They will calculate the QoS metrics for their services and exchange the table with other mobile nodes using the routing protocol AODV.

**Table 1.** Service description in hello packet.

| P. Name | Node ID | Services | | | | | | QoS Metrics | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | **S1** | **S2** | **S3** | **S4** | **S5** | **S6** | **Cost** | **A** | **T(s)** |
| SP1 | 10.10.1.1 | √ | | | √ | | √ | 245 | 0.90 | 0.5 |
| SP2 | 10.10.12.2 | | | | √ | √ | | 754 | 0.87 | 0.9 |
| SP3 | 10.10.32.5 | √ | √ | | | √ | √ | 438 | 0.70 | 1.4 |
| SP4 | 10.10.3.28 | | √ | √ | √ | | √ | 783 | 0.96 | 0.67 |

P. Name represents the provider name; A means availability of the node; and T(s) represents response time in seconds.

### *5.3. Dynamic Broker Selection*

The QoS requirement for selecting the dynamic broker is based on the QoS metrics. Here, we will discuss what needs to be considered when selecting a dynamic broker and routing path. Algorithm 1 will describe the selection of the broker based on the QoS metrics. Some of the QoS metrics are described as follows.

**Algorithm 1** Broker Formation

1. Input: Consider $n$ nodes,
Calculate the QoS metrics and compute $W_t$
2. **For** every node $n$ in N
3. **If** $W_t > W_i$ where $i \epsilon \eta(n)$ // $\eta(n)$ is the neighbor set of nodes n
4. **Then**
5. Broker = $n$
6. **For** every weight factor $W \epsilon N_j$ //$N_j$ is the set of uncovered nodes
7. **If** distance (Broker, z) <= Broker $_{\text{transmission-range}}$
8. **Then**
9. Broker $_Z$ = Broker
10. **End for**
11. **End for**

- *Availability*

Availability is the occurrence of services to a node; it is the absence of service downtime and is associated with time to repair, which is the time it takes to repair the failed services. It is the probability of assessing the services for a particular node. The availability of services can be represented as

$$Availability\ (A) = \frac{No.\ of\ services\ responded}{Total\ no.\ of\ services} \tag{1}$$

- *Data Packet Delivery Rate*

The data packet delivery rate is calculated by dividing the total number of services received by the service provider by the total number of benefits that originated in the network. The data packet delivery rate can be expressed as

$$Data\ Delivery\ (DD) = \frac{No.of\ services\ received}{Total\ no.of\ services\ originated} \tag{2}$$

- *Data Packet Loss Rate*

The data packet loss rate is calculated by dividing the total number of services transmitted by the service requester by the total number of services received by the service provider in a network. The data packet loss ratio can be calculated as

$$Data\ Loss\ (DL) = \frac{services\ transmitted\ by\ requester}{services\ received\ by\ provider} \tag{3}$$

- *Comparative Mobility*

Comparative mobility can be calculated by the node that exists in the network for a longer time and remains static with its own neighbor node. The node with lesser node mobility is considered to act as a broker. The mobility of the particular node $n$ at time $t$ is given by

$$M_n^t = \frac{N_t}{N_{t-1}} \tag{4}$$

where $N$ is the neighbor set of nodes for '$n$', $N_t$ is the neighbor set of node $n$ at time $t-1$, and $N_{t-1}$ is the neighbor set of node $n$ at time $t$ but not in time $t-1$. The comparative mobility for '$s$' time is given as

$$C_n^t = \frac{1}{s} \sum_{k=t-n}^{t} M_n^t \tag{5}$$

- *Energy*

Energy can be calculated by the physical battery life of a node to hold the services.

- *Network Load Balancing*

The network load balancing can be calculated by dividing the total number of service messages transmitted for routing by the total number of services received by the node. Network load balancing is expressed as

$$Load\ Balancing\ (LB) = \frac{total\ number\ of\ service\ messages\ transmitted}{total\ number\ of\ service\ messages\ received} \tag{6}$$

- *Delay*

Delay is when the service travels from the service-requester node to the service-provider node across the prescribed channel. Delay can be calculated by

$$delay(d) = \left(d_{propagation} + d_{transmission} + d_{processing}\right). \tag{7}$$

- *Throughput*

Troughput is defined as the number of service requests served successfully for a given amount of time period over the prescribed channel. Throughput can be calculated by

$$Throughput\ (T) = \frac{No.of\ service\ request}{Communication\ Channel} \tag{8}$$

- *Node Memory Capacity*

Node memory capacity indicates the amount of data storage available for a node to store service descriptions.

The overall total weight of a node can be calculated by

$$\begin{aligned} Wt = (&W1 * A + W2 * DD + W3 * DL + W4 * M + W5 * LB + W6 * d \\ &+W7 * T + W8 * Energy + W9 * Power + W10 * Memory) \end{aligned} \tag{9}$$

where $W_{1,2\ldots10}$ is the weight factor for each node, with their metrics.

### 5.4. Secure Broker Selection

Our cluster broker architecture uses a secured link between the broker and the nodes in a cluster. Inside a cluster, the broker acts as a Certification Authority (CA), which provides a secured communication link within the intra-cluster by using symmetric encryption and a key-exchange protocol to prevent intrusion, based on Algorithm 2. The stenography method offers a secure connection from one cluster to another (intra-cluster) for communication. Each broker sends its address and security methods over a hidden channel, by maintaining a neighbor node and routing table based on Algorithm 3. The security methods travel through a hello message to another cluster; the broker will provide secure communication for the cluster-to-cluster architecture.

**Algorithm 2** Intra-Cluster Security

Input: Select Prime Number "p", an element g which is the prime root of "p", and consider two nodes A and B
**For** any "n" node in the cluster
"A" select random integer $X._A. < p$
**Compute**
$Y_A = g^{X_A} \pmod{p}$
**Set**
Private $Key_A = X_A$
"B" select random integer $X._B. < p$
**Compute**
$Y_B = g^{X_B} \pmod{p}$
**Set**
Private $Key_B = X_B$
**Broadcast** "Y"
"A" compute
$K = (Y_B)^{X_A} \pmod{p}$
"B" compute
$K = (Y_A)^{X_B} \pmod{p}$
**End for**

**Algorithm 3** Inter-Cluster Security

**For** any "n" node
**If** (broker-node + $W_n$) exceeds **then**
//$W_n$ is the Net Weight of a particular node
Listen (Address, Channel)
**If** (Listen + $W_n$) exceeds **then**
Update (Routing Table)
**End if**
**End if**
**If** (Listen) then
Stegnomsg (Listen)
//Compute steganography for listen hello message
**Find** (Channel, Address)
**End if**
**If** (Update)
Update Routing table
**End if**
**End for**

## 6. Simulation and Results Discussion

### 6.1. Simulation Setup

To simulate our routing protocol for MANET with secured dynamic broker selection, to provide composite services for a particular user according to their requirement, we used

NS2 [34]. The required simulation parameters and their values are provided in Table 2. The proposed system is implemented in Network Simulator version 2.35 (NS2) under the Ubuntu 11.10 Linux operating system with 4 GB of RAM. We simulated 53 intermediate nodes and 35 mobile nodes moving into an area of 1000 m × 1000 m according to the random-mobility model [35]. We have considered 12 brokers at the data rate of 1 Mbps with a transmission range of 250 m and bandwidth of 1000 kHz, and nodes are scattered in the simulation area randomly throughout 450 s at each simulation. The traffic follows the Constant Bit Rate (CBR) model, and the authors have used 25,600 bits for the buffer size. Our model with dynamic broker and cluster formation is described in Figure 5.

**Table 2.** Simulation parameters.

| S. No. | Parameter | Value |
|---|---|---|
| 1. | Number of nodes | 53 |
| 2. | Number of mobile nodes | 35 |
| 3. | Number of brokers | 12 |
| 4. | Number of packets | 8 |
| 5. | Area size | 1000 × 1000 (m$^2$) |
| 6. | Mobility | 0–15 m/s |
| 7. | Data rate | 1 Mbps |
| 8. | Transmission range | 250 m |
| 9. | Routing protocol | AODV |
| 10. | Speed | 10 m/s |
| 11. | Buffer size | 25,600 Bits |
| 12. | Bandwidth | 1000 KHz |
| 13. | Simulation time | 450 s |

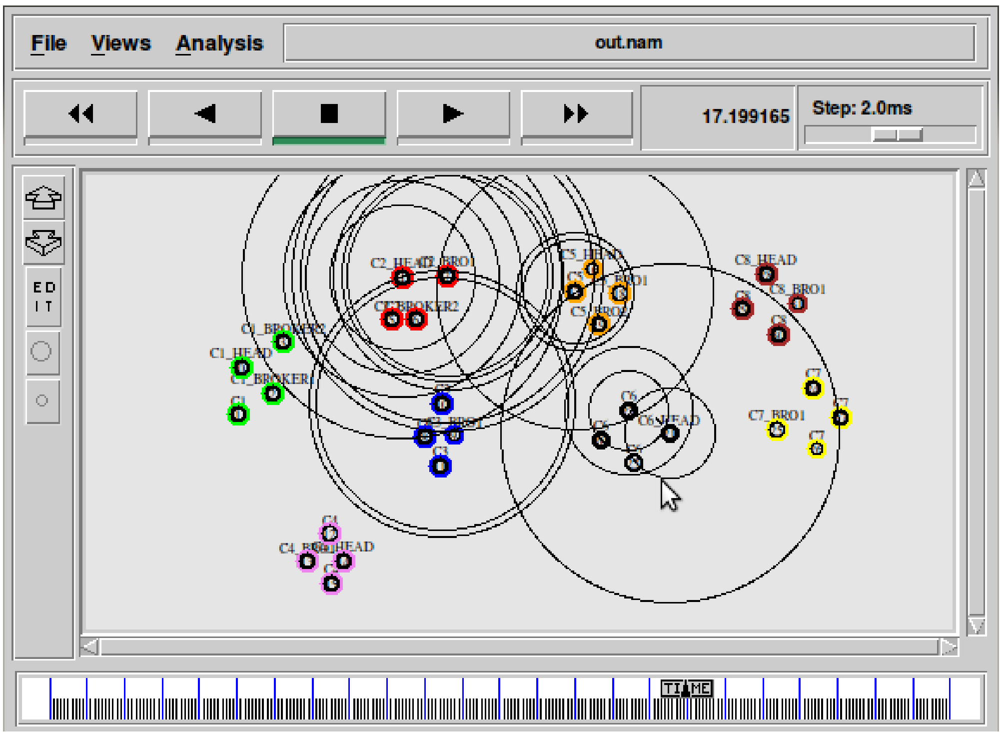


**Figure 5.** Dynamic broker and cluster formation.

The performance evaluation metrics such as throughput, end-to-end delay, delivery ratio, average path lifetime, and routing control overhead are used to measure the performance of the algorithms. The results of the proposed QoSDSBS algorithm are compared with existing algorithms such as the energy efficient routing based on the hierarchical routing algorithm (EE-OHRA) [36], energy efficient demand routing protocol (EE-DRP) [37], and novel energy efficient trust aware routing (NETAR) [38].

### *6.2. Results and Discussion*

#### 6.2.1. Bandwidth vs. End-to-End Delay

It refers to the data bandwidth and end-to-end delay; it measures the amount of data transferred in the link by the service provider, which is not yet received by the service requester. Our model QoSDSBS shows that the overall delay is reduced to 25 Mbps/s. Figure 6 shows the bandwidth and end-to-end delay for both the securities-enabled QoSDSBS and other existing algorithms. In this case, our proposed work reduces the number of data lost to the desired level, as depicted in Table 3. The outcome of the proposed algorithm deliberates better performance in providing minimal end-to-end delay compared to other existing algorithms.

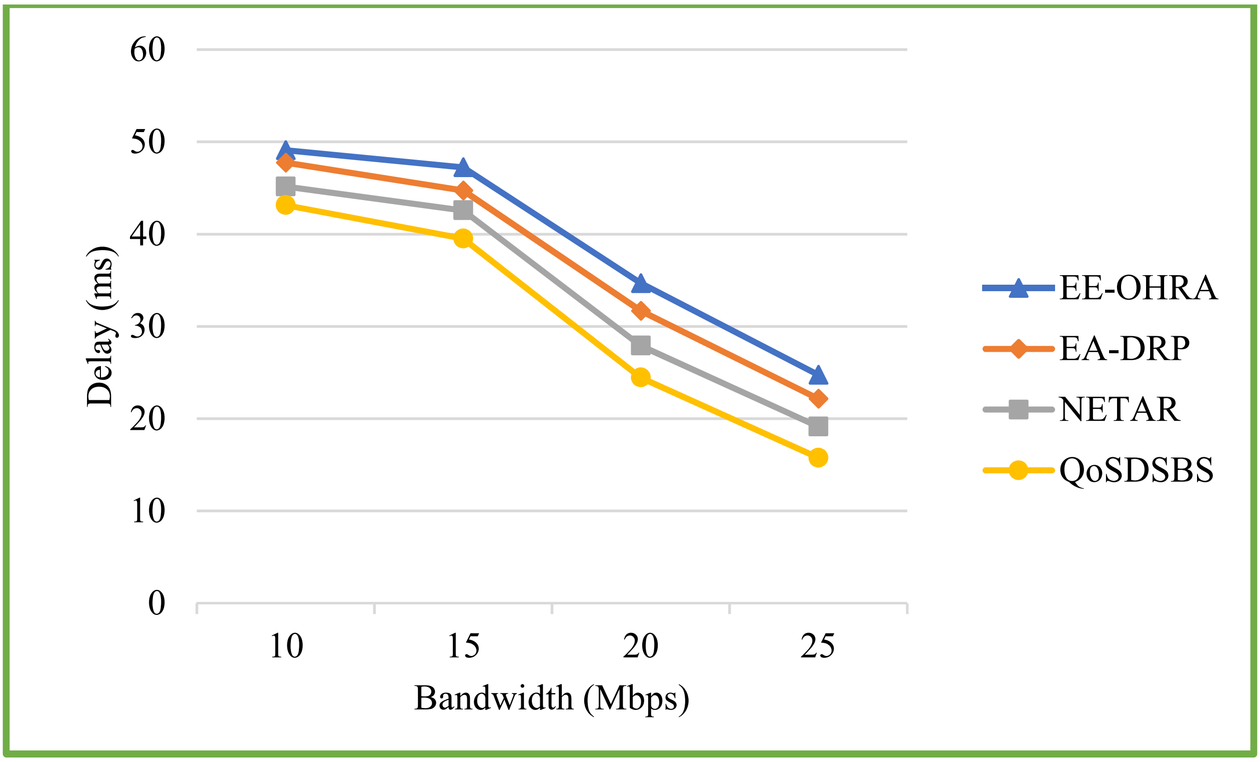


**Figure 6.** Bandwidth vs. end-to-end delay.

**Table 3.** Results of bandwidth vs. end-to-end delay.

| Bandwidth (Mbps) | End-to-End Delay | | | |
|---|---|---|---|---|
| | **EE-OHRA** | **EA-DRP** | **NETAR** | **QoSDSBS** |
| 10 | 49.1023 | 47.75 | 45.15 | 43.141 |
| 15 | 47.2451 | 44.73 | 42.57 | 39.5123 |
| 20 | 34.691 | 31.69 | 27.91 | 24.4581 |
| 25 | 24.742 | 22.16 | 19.13 | 15.762 |

#### 6.2.2. Throughput vs. Delivery Ratio

It measures the average rate of successful data delivery over the communication channel. The throughput value rises gradually with the number of nodes, and the packet-delivery ratio rises along with the throughput. Figure 7 depicts the throughput and delivery ratio for both the securities-enabled dynamic secure broker (DSB) system and other existing algorithms. Our model, QoSDSBS, outperforms with an increase in the delivery ratio for increased throughput with DSB, as shown in Table 4. The proposed algorithm attains better results than the compared algorithms, EE-OHRA, EA-DRP, and NETAR. However, the NETAR algorithm competes with the proposed algorithm, but it fails to attain the maximal delivery ratio.

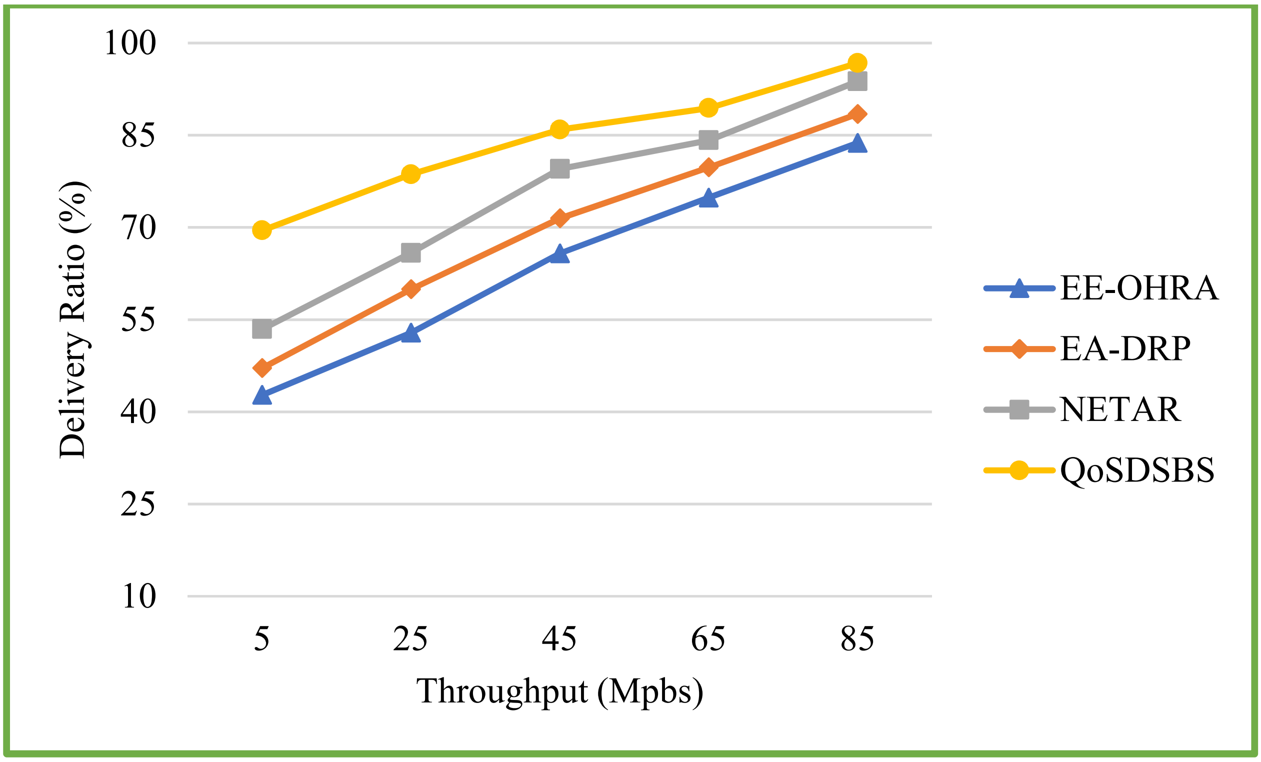


**Figure 7.** Throughput vs. delivery ratio.

**Table 4.** Results of throughput vs. delivery ratio.

| Throughput (Mbps) | Delivery Ratio (%) | | | |
|---|---|---|---|---|
| | **EE-OHRA** | **EA-DRP** | **NETAR** | **QoSDSBS** |
| 5 | 42.75 | 47.13 | 53.45 | 69.51 |
| 25 | 52.87 | 59.94 | 65.84 | 78.63 |
| 45 | 65.78 | 71.48 | 79.51 | 85.91 |
| 65 | 74.84 | 79.76 | 84.17 | 89.42 |
| 85 | 83.75 | 88.45 | 93.75 | 96.74 |

6.2.3. Lifetime with Routing Control Overhead

The average path lifetime is the minimum time in which the maximum number of mobile nodes is desired to shut down. The routing control overhead is the number of control packets required to send each data packet in a network. We have used the channel-access AODV protocol. Figure 8 shows the lifetime and routing control overhead with the secured DSB and other existing algorithms. Our proposed model, QoSDSBS, with the desired channel-access AODV protocol is depicted in Table 5. Table 5 deliberates that the proposed QoSDSBS algorithm attains minimal routing overhead compared to the other existing algorithms. However, the proposed algorithm stagnates in a lifetime of 4 ms. Although, in a later case, it improves nearly 20% in a lifetime of 12 ms, due to the efficient broker-selection process.

**Table 5.** Results of average path lifetime vs. routing control overload.

| Lifetime (ms) | Routing Overhead ($10^4$ Packets) | | | |
|---|---|---|---|---|
| | EE-OHRA | EA-DRP | NETAR | QoSDSBS |
| 2 | 3.9178 | 3.5879 | 2.8451 | 2.4456 |
| 3 | 3.1128 | 2.8421 | 2.507 | 2.207 |
| 4 | 2.7423 | 2.6124 | 2.387 | 2.014 |
| 5 | 2.4712 | 2.3156 | 2.145 | 1.8098 |
| 6 | 1.9023 | 1.8612 | 1.7451 | 1.5256 |
| 8 | 1.437 | 1.372 | 1.278 | 1.0162 |
| 12 | 1.254 | 1.197 | 1.1345 | 0.9489 |

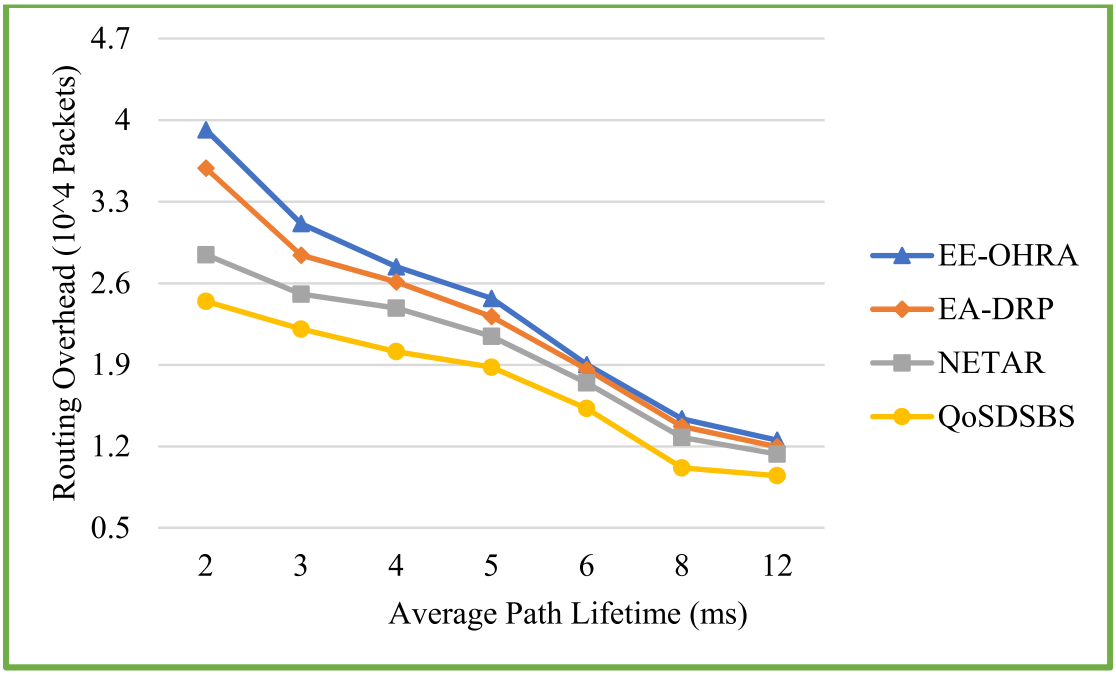


**Figure 8.** Average path lifetime vs. routing control overload.

### 6.2.4. Throughput vs. Delay

It measures the success rate of packet delivery during the communication with less data loss due to the reduced delay. The throughput will increase with the number of mobile nodes at the range of bits per second, and the delay is measured in milliseconds. Our proposed model, QoSDSBS, provides a decline in packet loss, a reduced delay, and an increase in throughput, as shown in Table 6. Figure 9 shows the throughput and delay with the securities-enabled DSB and other existing techniques. The above experimental results show that the proposed QoSDSBS model provides the desired level with increased QoS parameters compared to EE-OHRA, EA-DRP, and NETAR.

**Table 6.** Results of throughput vs. delay.

| Throughput (Mbps) | Delay (ms) | | | |
|---|---|---|---|---|
| | EE-OHRA | EA-DRP | NETAR | QoSDSBS |
| 5 | 17.0178 | 15.789 | 12.842 | 8.518 |
| 25 | 19.8112 | 17.459 | 13.741 | 11.314 |
| 45 | 26.4712 | 23.541 | 20.845 | 15.8256 |
| 65 | 29.4712 | 27.8423 | 25.842 | 23.0362 |
| 85 | 38.0023 | 35.7121 | 31.8745 | 29.9489 |

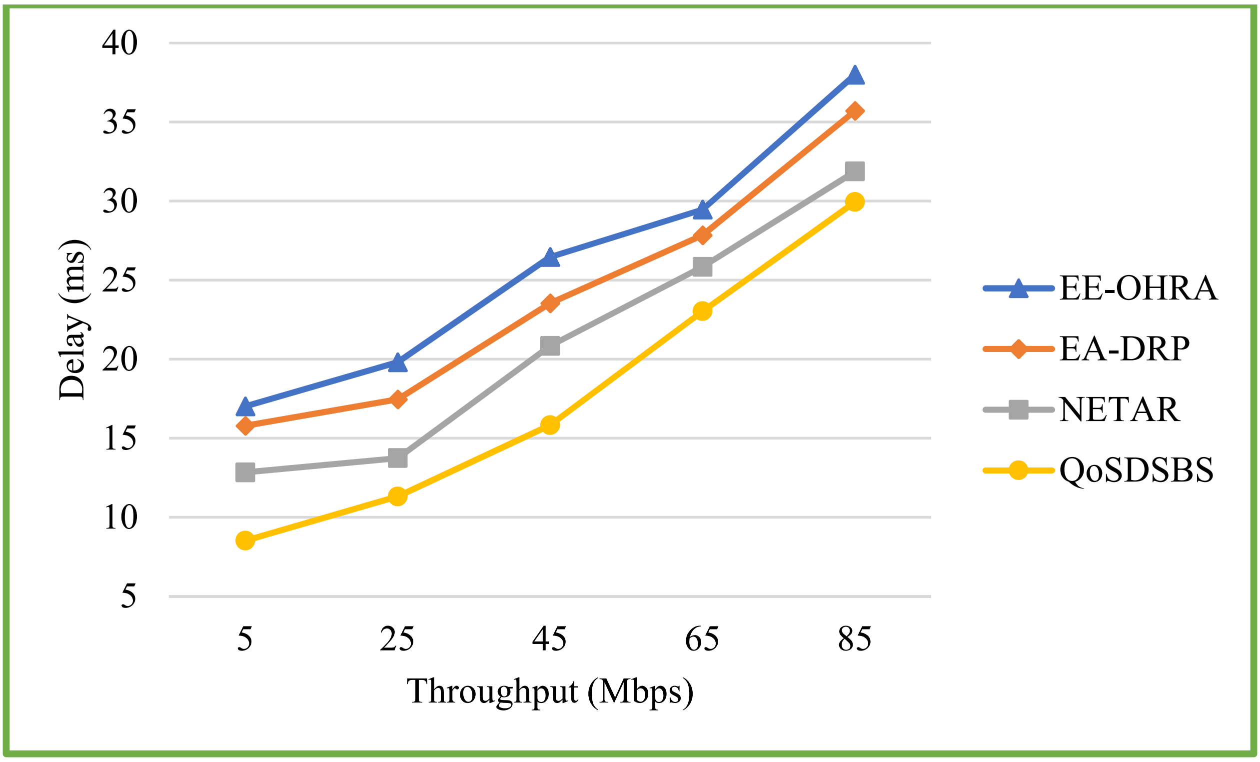


**Figure 9.** Throughput vs. delay.

## 7. Conclusions

This paper presents the cluster formation and dynamic broker selection, which provides security. The services are transferred among nodes in a secure environment, with the aid of a broker that is selected based on the QoS metrics among the mobile nodes. We have analyzed the performance of the AODV routing protocol in MANET with secured and unsecured conditions, with the effects of the QoS metrics. Our proposed model provides a better QoS and scalability with the help of the cluster formation and a number of brokers to avoid congestion. By the results shown, it is proven that bandwidth, end-to-end delay, throughput, delivery ratio, routing-control overhead, and network lifetime outperform better with our proposed model. Finally, our simulation results show better performance with the AODV routing protocol in the dynamic secured environment. The delay and packet-drop ratio scales down in the proposed secured model. Thus, the proposed architecture reduces the network load for the single mobile node and achieves more scalability. In the future, the optimization algorithm can be incorporated into our current proposed architecture to select the optimal broker node to improve the efficacy in a large mobile area network. In addition, the same can be evaluated with different QoS metrics for a large mobile area network.

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