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ENHANCING QUALITY OF SERVICE IN MANET ENVIRONMENTS WITH CRYPTOGRAPHIC SECURE MECHANISMS TO SECURE SUSTAINABLE SMART CITIES

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A B S T R A C T

The utilization of wireless sensor networks to gather, process, and act upon data may be a powerful tool in the development of a city-wide communication network that can accommodate many applications, ultimately leading to smart city solutions. Several challenges might be encountered by a smart city network. These include the need to adapt the network's coverage area to suit various applications, uneven distribution of nodes, a rise in message volume, the use of several communication technologies, and heterogeneity in both nodes and messages. There are many different facets of smart cities that are being studied, and certain applications are being created in each of them. Several options for smart city sensor networks are outlined in this article, which uses a survey format. Applications like ridesharing, emergency medical services, and others that depend on real-time traffic data supplied by the smart traffic domain are used to examine message transmission problems in this study. The versatility and speed with which Mobile Ad Hoc Networks (MANETs) may set up networks have led to their widespread use. Because mobile nodes function best in tandem and have faith in one another, we take a look at MANET routing algorithms and how they handle message transmission for this service.

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1. INTRODUCTION

A fully digital society will emerge with the launch of 5G networks. The capacity to connect an enormous number of devices, together with ultra-low latency, very high bandwidth, and end-to-end mobile connection rates of up to 1 Gbps, opens the door to a plethora of new services and applications. Also, mobile data traffic will account for around one-quarter of all network data traffic by 2023, up seven times from where it is today, according to Cisco's projection. Furthermore, mobile devices come with machine-to-machine (M2M) modules that allow devices to talk to one other directly, without the need for pre-existing infrastructure (the idea behind mobile ad hoc networks, or MANETs) (Gaur et al., 2015). Actually, MANETs came into being in the 1980s as a system of mobile radio devices that could more easily connect inside the network thanks to their self-establishing and self-configuring characteristics (Pandey et al., 2016). Recent human-centered applications of MANETs include smart retail, intelligent transportation systems, smart agriculture, green energy, and IoT ecosystems (Villanueva et al., 2006; Souil & Bouabdallah, 2011; Bellavista et al., 2012; Rosati et al., 2015; Jacob & Sivraj, 2016; Nicholas & Hoffman, 2016; Castellanos et al., 2016; Ojetunde et al., 2017; Bujari et al., 2017; Chen et al., 2017; Palazzi & Ronzani, 2018; Mumtaz et al., 2018; Quy et al., 2019; Xie & Murase 2020 for a list of examples). The eight nodes that make up a MANET are shown in Figure 1.

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Topology, mobility, and deployment environment all have a role in how well MANETs function. The performance of MANETs is relatively poor due to their restricted capacity. Routing protocols play a crucial role in improving performance in MANETs, which need mobile network devices to connect with one another (Toh et al., 2009; Khalifa et al., 2019; Mohamed et al., 2020; Hassan et al., 2021). Dynamic source routing (DSR) based on the hop-count measure and ad hoc on-demand distance vector (AODV) are ineffective, according to (Jimi Persis & Paul Robert 2017; Khamayseh et al., 2019; Abdelhaq et al., 2020.). Academics place a premium on and devote time and energy to studying and proposing high-performance routing systems that are both dependable and resilient. The years (Gankhuyag et al., 2017; Fazio et al., 2015; Ejmaa et al., 2016; Quy et al., 2018; Abuashour & Kadoch, 2017) saw the introduction of several routing protocols. But there was a structure or situation for which each answer worked perfectly. That is why we feel compelled to investigate this matter further.

There have been several fruitful outcomes in the performance improvement research area for MANETs based on various methodologies throughout the years. Consequently, the RARP protocol for UAV networks was suggested by the authors in (Villanueva et al., 2006) as part of the location-based strategy. In order to increase the distance between aerials, this effort primarily seeks to forecast the position and path of nearby nodes. In addition, this study suggested schema-updating system architecture to cut down on route reestablishment and latency. The empirical results indicate that the suggested protocol significantly improves the performance of Unmanned Aerial Vehicles (UAVs) inside the network. A novel routing algorithm named MTOP, which operates based on geographic location, was recently disclosed by Xie and Murase 2020 with this objective in mind. The primary goal of this study is to establish the domain of the search space by deriving lower and upper limits from possible location assemblies. In addition, a conflict set of locations graph (CSLG) is defined to demonstrate this claim. In various mobility and density MANET settings, experimental findings demonstrate that the MTOP algorithm outperformed the previous technique in terms of system performance. A location-based approach called PAB3D was suggested by Bujari et al. 2018 for UAV networks that can handle three-dimensional situations. In contrast to the current routing protocol, the suggested method improved the network in different density and mobility situations, according to the experimental findings.

Consequently, Fazio et al. (2015) introduced a signal-based routing algorithm that utilizes a medium access control (MAC) mechanism for multi-channel mobile ad hoc networks (MANETs). Radio signals provide the basis in this context. The primary aim of this undertaking is to optimize system performance while concurrently reducing co-channel noise. The experimental results indicate that the routing protocol exhibits superior network performance compared to conventional methodologies.

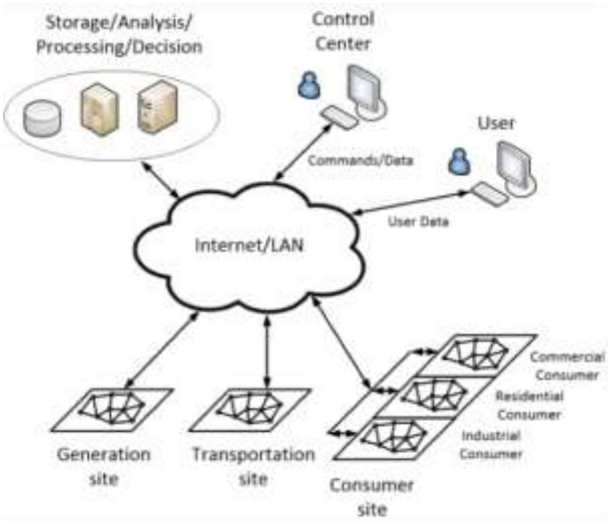

Figure 1. Architecture of a smart grid system used in smart city

The topology-based approach was introduced which incorporates the use of the topology-based protocol known as DFCP. Here, we put forth the neighbourhood rate-based routing statistic as our main emphasis. When compared to more conventional methods, the experimental findings reveal that DCFP significantly improves system performance and energy efficiency. Consequently, Quy et al. (2018) suggested a novel protocol based on integrated metrics for the traffic-based approach. Improving system performance is the main goal of this effort, which aims to provide a new statistic that combines three existing ones: hops number, connection status, and queue. In addition, studies conducted recently demonstrate that research into improving MANETs' performance, namely via a traffic network-based strategy, is very intriguing and garners considerable attention from academia and business.

2. RELATED WORK

The figure1 shows the basic structure of various domains in smart city network. The domains are connected using various communication technologies. A smart city provides an intelligent method to manage several components, including the environment, transportation, health, residences, and structures, according to Gaur et al. (2015). To effectively handle data and provide information for intelligent and dynamic resource management and use, new approaches and techniques are required. Using semantic web technologies and the Dempster-Shafer uncertainty theory, the authors suggest a multi-level smart city design.

The authors propose deploying the architecture on a service platform (SaaS). Sensor applications are connected and used by various web applications through this platform for intelligent operating condition. The following aims are targeted by integrating wireless communication technology and wireless sensor networks. Context aware high level real time customized service, environment for better living, improving the utilization of available resources. Steps for the implementation of architecture can be outlined as follows. First the raw data collected are processed so that it is web consumable. The Web Ontology Language concepts based on knowledge of domain expects are used to enrich the data after converting into a common format. Dempster Shafer rules are used to process the collected data to deal with uncertainty aspect of semantic model. The aim is to learn new rules and recognize activity governing an activity. The new rules studied at the level are utilized in defining the semantic model knowledge. The communication services used in smart city infrastructure: LTE, WiFi, Wi-max, 3G, ZigBee, CATV and satellite communication plays an important role so that the smart city concept is achieved. In this architecture the heterogeneous information is taken from the sensor nodes and converted so that the web applications access these data for customized services. Experiments that include discovery of real time heterogeneous information, proposal of common semantic knowledge model, combining the sensor data using Dempster Shafer and defining data interoperability can be done in the future.

The self-healing wireless structure and mobile power aware stable nodes for smart city networks were suggested by Pandey et al. (2016). Even in the face of a catastrophic event, the smart city network will continue to operate thanks to the introduction of self-healing technology. Mobile nodes will be able to keep their routes to destinations with more consistent route selection thanks to the MANET-healing routing system. Some examples of self-healing technologies include TORA, DSR, and AODV.

The AODV has been enhanced by its authors to become a self-healing network protocol. Virtual nodes, a novel idea, are used. During the rebuilding phase, virtual nodes aid in route selection by being only one hop away from their neighbor. When choosing virtual nodes, power status availability is taken into account. Power status and virtual node elements are tied to individual route tables. The power condition is checked and a new route is constructed if the requirement arises. Upon detecting a connection failure, the node will broadcast data to its next neighbor in a one-hop fashion. The data header indicates that the connection has been terminated and that an alternative route is necessary. The route maintenance phase begins when the packet reaches its previous one-hop neighbor, and an alternative path is built via virtual nodes once the status and stability of power are checked. NS 2.34 is used as simulation environment. Scheme has been structured for both the TCP and UDP with same number of connections. The results of simulation are compared with other self-healing techniques. Proposed scheme is proved to be better than the others but the end to end delay were bit more and overhead was higher than the others. Here the AODV routing protocol is modified to make itself healing routing protocol. How to make the modified protocol robust for traffic load is not presented.

Among smart city-related topics, Jacob and Sivtaj (2016) concentrate emphasis on message transmission between domains. Ad hoc on demand distance vector (AODV), Destination sequenced distance vector (DSDV), and dynamic source routing (DSR) are some of the routing protocols utilized in mobile sensor networks. The efficiency of the protocol in smart cities is evaluated by metrics such as the time it takes to establish a connection and the delay in message transit. Smart city possibilities include smart healthcare, smart transportation, smart emergency services, and smart administration. As a communication technology, Wi-Fi is chosen because of its wireless nature, end-to-end latency, high throughput, and capacity. The viability of the sensor network protocol is tested via the simulation of a smart city transit scenario.

The findings for message passing of traffic block information show that AODV has a longer connection establishment time than DSR, but better packet delivery ratio and end-to-end latency. Whereas DSR only discovers the route once at start-up, AODV creates it with each message pass. When it comes to adjusting changes in topology, AODV is up to the task. The findings for the message of route clearance indicate that AODV takes less time to establish a connection than DSR. The application calls for a routing protocol that can transfer messages quickly, and DSR satisfies that need. Because the DSDV network is inherently unstable, updates must wait until the system has settled in before they can be made. Because DSDV requires users to be mobile, the system becomes unstable and communication breaks down. Because the same network carries several messages in a smart city, the criteria and metrics used to evaluate them may change. Hybrid routing protocol that satisfies the requirements of smart city application is proposed. But it is not shown that individual protocol characteristics may conflict when used together.

Villanueva et al. (2006) suggested that MANETS could be used in large in-home environments like hospitals, buildings, office etc. The authors presented an adaptive QoS architecture oriented framework to provide context aware QoS to the traffic which is generated in smart building network. A flexible technology is needed to integrate and expand the existing infrastructure. The architecture proposed in this paper is based on the work called SENDA that is used to easily integrate network, device for home applications and protocols. The traffic generated in large home applications can be divided into four classes. Control traffic, multimedia traffic, user traffic, and best effort traffic. These traffics have a different requirement which needs different resources at the network level. Middleware defines QoS agent to provide and controls the network resources. All of the nodes include this integrated software component. In terms of architecture, SENDA is crucial. By building upon the SENDA architecture, the MANET method was included. Two ad hoc wireless gateways are created for applicable home technology. First, the TINI device has an X10 to 802.11 gateway. A Java implementation of the AODV algorithm has been created to carry out routing operations. 2. Double-Origin Box at the Gateway. The TV remote, a cheap interface for length and Lon working technologies, and other similar devices make it easy to use. All of the auxiliary nodes, which include laptops and spinal nodes like computers, were implemented. Nodes here are PDAs and PIC processors from wireless devices. Wireless devices allow users to operate basic household appliances that are linked to the SENDA prototype. Gateway nodes fulfils the QOS requirement of active profile, QOS parameters of various technology on every side of gateway is matched. They also mark the traffic from one network to another. QoS provisioning require coordinated efforts from every layers. This approach decreases the number of lost packets showing more reliable paths. MANETS offer good solutions for user requirements that include using heterogeneous device. Here the QoS is provided to traffic generated in various applications and the resources are managed and given to the traffic based on their availability. Work is focused on expanding the service based on SENDA architecture and MANET.

Souil and Bouabdallah (2011) conveyed that pervasive healthcare applications of smart city are enabled by combining wireless body sensors with wireless sensor networks. Location tracking, continuous medical monitoring, emergency alerts are the features of remote medical monitoring applications. QoS support and wireless awareness are two key concepts of this paper. Context awareness is required for QoS management and data interpretation in WSN for healthcare. For the network to meet the needs of its users, it must be accurate, reliable, timely, and operable, have a long lifespan, and be aware of its context. Difficulties and unresolved matters exist. In order to implement strong WSN for healthcare, a global framework is necessary. The model should be kept basic due to the restricted resources in order to make the implementation viable. The issue of reliability is discussed, but no trustworthy method for transmitting data from beginning to finish is provided. Encryption is necessary to protect sensitive information and authentication is necessary to monitor patients. The node's mobility has to be managed.

3. PROPOSED METHOD

Using the same on-demand basis as the AODV protocol, the new protocol offers many improvements. Figure 2 shows how a network node uses the route discovery technique to find the best way to transmit data to another node. During the route discovery method, the packets requesting a route are broadcast. The packets go down the red line to the final target node via intermediate nodes. In response, the blue line represents the MS node, and the MD node will send a router reply packet to it. The suggested protocol includes both a route discovery technique and a route update mechanism that makes use of route error messages, like the yellow line. The last step is for the source node to get a collection of potential routes

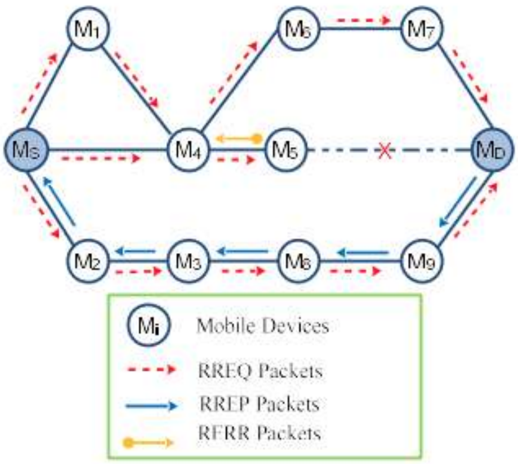

Figure 2. The PRPD protocol has three possible operating states

Function for making a choice Our technique specifies two things that must be in place when the route discovery operation is finished and the candidate route set is received by the source network node: Any potential candidate paths' hop counts (Hopcount) need to fall inside the interval [Hopmin, Hopmax]. We will reject paths whose hops are outside of this range.

Hopcount = [Hopmin, Hopmax] (1)

Where, Hopmin is the shortest path that packets must take to reach the MD node from the MS node. Our approach defines Hopmax as Hopmin + 2 with the aim of reducing the number of possibilities. Choosing the most suitable routes with the least amount of time is essential. The average route delay (Lati) is defined and used by our approach. This is how you find out the average delay of a route: add up the delays of all the connections in that path:

Lati = Total (Lati1, Lati2 ,………….. Latin) (2)

The variable "Latik" represents the sum of all individual Latin values, denoted as Lati1, Lati2, and so on, up to the final Latin value. I would like to kindly request that you rewrite the text provided by the user in a more (2) The variable "Latik" represents the delay of the kth route in route i. Let "Z" be the route number acquired from (1), and "Lat_Set" represent the delay of the candidate route set determined by (2), as described in (3):

$$Lat\_Set = \int_{Latz}^{\substack{Lat1 \\ Lat2 \\ \vdots}} . \qquad (3)$$

the candidate route with the lowest delay can be determined as

optimalroute = Min (Lat_Set) (4)

Hence, (4) helps us choose the best course of action. As seen in algorithm 1, the routing technique is detailed in depth using pseudo code.

The PRPD algorithm 1
What They Mean:
//$Mmteex$: The source node's list of possible routes
The smallest number of options in $Xouteeb$
Routes that meet the condition in Eq. (1)
Lat(i): The function is given the path's delay value i
//$Selectedroute$: The chosen route
$routeset$=$shortest\_route$(S,D)
$minhop$=min($shortest\_route$(S,D))
$maxhop$=$minhop$+2 // $Equation$ (1)
$fori$=1 $tomaxsize$($routeset$)
if do
$ifminhop$<$numh$($routeex$(i)) < maxhop then
consvalid route(i)
end if
end for
// equation (2-4);
delaymin = √ $fori$=1 $tosixmnf$
If do
$ifdelayin$ = Lat (consvalid (i)), then
$delayin$ = Lat (consvalid (i)).
If end
if end
for Return (selectedroute, latmin),
that line ends.

4. RESULTS AND DISCUSSION

In order to assess the efficacy of the suggested technique, this study used a simulation using NS2. The simulation system has a total of 250 mobile network nodes distributed across a circular area with a radius of 1000×1000 meters. Table 1 displays the remaining parameters. In this research, we investigate the efficacy of our PRPD protocol in simulated scenarios, wherein the mobility of network nodes is varied within the range of 2 to 20 m/s. In this study, we conduct a performance comparison between our protocol and two well recognized routing protocols, namely AODV and DSR.
The parameters have been assigned specific values. The dimensions of the topology are 1000 m x 1000 m, and it consists of 250 nodes. The duration of the simulation was 200 seconds.
The MAC layer in the 802.11 standard is responsible for managing the medium access control protocol for wireless communication. The traffic type in this context is constant bit rate (CBR), which refers to a kind of data transmission where the data is sent at a fixed rate. The bandwidth for this particular communication is 2 megabits per second (Mbit/s), and the Transport Layer protocol known as User Datagram Protocol (UDP). The range of mobile speed is between 2 and 20 meters per second. The packet size is 512 bytes. The transmission range is limited to a distance of 250 meters. The mobility model used in the simulation is the Two-Ray Ground model. The simulation protocol utilized includes PRPD, AODV, and DSR.

4.1 Performance parameters

The average packet delivery ratio, often referred to as PDR, is a metric that quantifies the ratio of received packets to the total number of packets issued during a simulation (5):

$$PDR = \frac{P_s}{P_r} \times 100\% ------------- (5)$$

The average delay, or end-to-end delay, is the total amount of time it takes for all packets received by the destination nodes in a simulation to complete the transmission, as in (6):

$$\text{Delay}_{\text{avg}} = \frac{\sum_{i=1}^{n} (t_r - t_s)}{P_r} ----------(6)$$

Throughput: A packet's throughput is defined as the number of packets received multiplied by its size, destination node, and the number of seconds passed. The average throughput idea is used in this study, denoted is throughput$_{avg}$ as (7):

$$\text{Throughput}_{\text{avg}} = \frac{P_r \times KT}{T \times \text{Delay}_{\text{avg}}} ------(7)$$

The total number of packets received by the destination nodes is denoted as Pr. A source node's total packet number is denoted by Ps. At the destination device, the time the packet was received is denoted as tr. When the source device is ready to transmit the packet, it takes time (ts). The total time required to run the simulation is denoted by T. The package size is KT.

4.2 Results

The present study included the execution of a simulation to assess the PRPD protocol's performance in comparison to two conventional in particular, the MANET routing protocols known as AODV and DSR. The evaluation of the effectiveness of the PRPD protocol was the major emphasis of this project. In the course of the research, a complete collection of fifty source-destination pairings was included into all of the simulated situations. The process of evaluating the velocity of mobile devices is carried out within the range of [0, Vmax], where the maximum velocity is set as [2 − 20] meters per second. The major purpose of adjusting the velocities of mobile devices in urban mobile ad hoc networks (MANETs) is to examine the adaptive features of the PRPD protocol. This is the primary aim. According to the results of the experiments, the PRPD protocol performed better than the AODV and DSR protocols in a variety of mobility scenarios. This was shown by the PRPD protocol's superior performance in terms of average latency, average throughput, and delivery ratio. As the velocity of node mobility increases, the Performance-Related Performance Degradation (PRPD) protocol demonstrates superior performance metrics compared to traditional protocols. The simulation results shown in Figure 3 are derived from the throughput parameter. The PRPD outperformed the AODV and DSR procedures in terms of throughput, according to the findings of the observation. Findings proved PRPD protocol's viability in multimedia-MANET applications requiring quality of service.

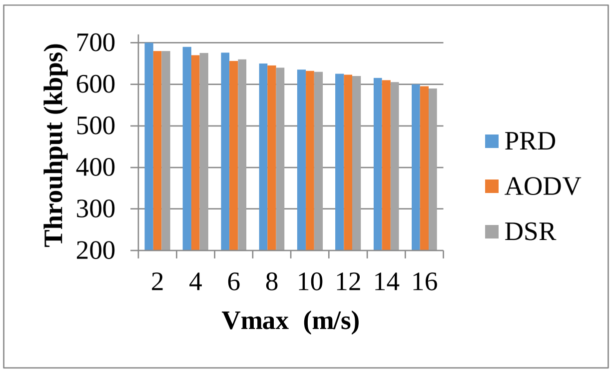

Figure 3: The mean throughput in relation to velocity.

Using the delay time option, Figure 4 displays the simulation results. Latency time is a metric in protocols that tends to grow when node movement speeds up.

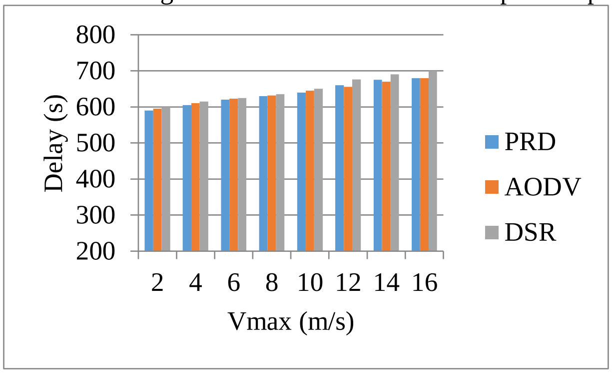

Figure 4: The average delay experienced using Velocity

All protocols exhibit very large average delays at velocity Vmax = 20 m/s, which is equal to 72 km/h; the AODV and DSR protocols attain an average delay of around 0.9 s, while the PRPD protocol achieves an average delay of approximately 0.8 s. While protocols do enhance network performance, trial and error revealed otherwise. On the other hand, more research into better performance routing systems is necessary for various mobility urban-MANET situations.

The results of the simulation using the average PDR are shown in Figure 4. Once V_{max} is less than or equal to 6 (m/s), the simulation results reveal that the average PDR of procedures reaches around 95%. The average RDP of protocols, however, drops sharply as node velocities rise. For each mobility multimedia-MANET scenario, the simulation results demonstrated that the suggested protocol outperformed the conventional protocols. Using the same mobility situations, the findings also demonstrated that the PRPD protocol outperformed established protocols like AODV and DSR in terms of performance metrics. Various changes in network traffic should be taken into account to further illustrate the adaptive nature of the PRPD protocol. Our future investigations will provide the details of this subject.

5. CONCLUSIONS

This study presents PRPD, a delay-based routing system that aims to improve performance in multimedia MANET settings. A route selection mechanism based on many metrics was the main focus of this effort. One requirement is that the candidate route has to be within the allowed hop count. The second criterion pertains to the selection of the candidate who exhibits the lowest average route latency. With the goal of further demonstrating the PRPD protocol's adaptability, this study incorporates simulated scenarios that account for variations in mobility. The PRPD protocol outperformed the more conventional AODV and DSR routing protocols in terms of average throughput, average latency, and average packet loss rate (PDR). Future research will concentrate on assessing the PRPD protocol's efficacy in response to varying velocities and mistake rates.

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