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He-SERIeS: An inventive communication model for data offloading in MANET

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ABSTRACT

Mobile Ad-hoc Network (MANET) is the dynamic infrastructure-less network that contains a heterogeneous wireless mobile devices. There are several issues that can occur in MANET such as limited bandwidth, dynamic topology, routing overhead, and battery constraints. In this paper, the heterogeneous MANET comprising of different MAC layer protocols are considered. The problems faced by the Heterogeneous Secure-dEed-Reflection-Inducement-eState (He-SERIeS) algorithm are scalability and offloading. In order to resolve these challenges of the existing SERIeS algorithm, a He-SERIeS algorithm is designed. The Cluster Head (CH) is elected using the on-demand clustering algorithm and the nodes with similar requirements are clustered into a distinct cluster using the similarity measure algorithm. The auxiliary key management schemes such as MD5 and SHA1 are used to predict the faulty nodes. The performance of the proposed He-SERIeS algorithm is analyzed with the existing algorithms such as Random Cache (RC), Centrality based Cache (CC), Set Cover Based Caching (SCBC) and SERIeS algorithm. The metrics used for comparison are throughput, Packet Delivery Ratio (PDR), end-to-end delay, replication overhead and offloading ratio. The proposed scheme achieved 92.8% PDR, a high throughput of 96.6% and a high offloading ratio of 0.532, less replication overhead, and end-to-end delay.

1. Introduction

Mobile Ad-hoc Network (MANET) contains a collection of independent nodes that are connected wireless [1]. In MANET the nodes tend to change their links in a frequent manner and their mobility is independent. The MANET has the following characteristics, autonomous terminal, distributed operation, multi-hop routing, inconsistent link capacity, and self-altering network topology. There is a limitation in the resources of MANET including processing power, on-board memory and battery power. The routing protocols in MANET are responsible for maintaining high degree of mobility that changes the topology of network. The nodes in MANET are heterogeneous with an enormous amount of resources. The mobile nodes with very high computational and communication power are more suitable for supporting the functions of ad hoc networks than other nodes. The heterogeneity and the routing information overhead are resolved by the cluster-based routing.

The main intention of clustering in MANET is to clutch the network nodes into several number of overlapping clusters. It is used for increasing the resource management and increasing the network performance in terms of routing delay, bandwidth, and throughput. Fig. 1 describes the clustering of nodes in MANET. A CH is selected as a representative for each cluster head during clustering.

The node that serves as an intermediate node is the gateway and the other members are the ordinary nodes. The non-ordinary nodes are considered as the dominant forwarding nodes. The CHs are responsible for holding the routing and the topology information. The three major types of clustering are active clustering, passive clustering, and on-demand clustering. During active clustering, the mobile nodes elect the CH by periodically exchanging the information. The passive clustering suspends the clustering procedure until the data traffic starts and it eliminates the major

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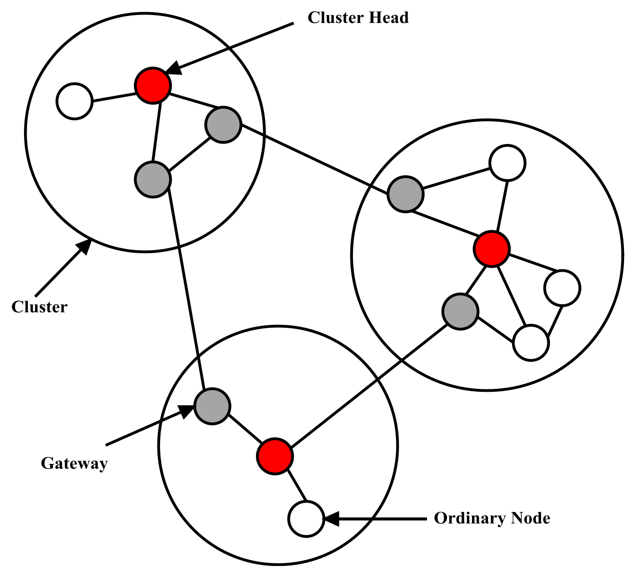

Fig. 1. Clustering in MANET [2].

control overhead of active clustering and it implies the larger setup latency. In the on-demand clustering, the cluster head is elected in an on-demand fashion. The dynamic election of the cluster head is used for minimizing the computation cost and the communication cost.

1.1. Problems in the traditional works

For minimizing the bandwidth and traffic in mobile nodes, the offloading concept plays a major role. The data offloading is used for allocating the load to several nodes. The mobile data offloading is often called as the Wi-Fi offload and is more similar to that of the 3G/4G offload. The mobile data offload through Wi-Fi (Wireless Fidelity) or the Wi-Fi offload is one of the implementations of using the small cell technologies like Wi-Fi. It offers services to the end users in an effective and economically best way. There are several reasons for using Wi-Fi offload and the following point justifies the reasons: it is useful for growing mobile data demand and the smart devices usage patterns having following characteristics such as short sessions, high throughput and low latency. It enhances the end-user experience by improving the service capacity and capability. It reduces the operating expenditure of the service providers. In the existing works, some of the techniques are developed for data offloading in MANET, but it has some major drawbacks, such as:

- Required more amount of time for data retrieval
- Consumed large amount of memory for storage
- The data cannot be reusable, once it is broke
- Also, it increases the problem at both user and server side

1.2. Motivation of the proposed work

For these reasons, this work focused to develop a new offloading model for heterogeneous MANET. Typically, the nodes present in the heterogeneous network have varying speed, so it requires different data rates for retrieval. Thus, this work proposed a novel technique, namely, He-SERIeS for increasing the security and link stability of the network with data offloading mechanism. Initially, the network is formed with some set of nodes, which are dynamic in nature. The nodes with same requirements are grouped into a single cluster. In the suggested research, the on-demand clustering is used for clustering the nodes. The clustering is performed whenever and wherever needed, based on the requirements of the nodes. The major contributions of this paper are listed as follows,

- The proposed He-SERIeS algorithm is used for obtaining the knowledge about the network paths.
- The node that has higher processing power, higher bandwidth capacity and memory capacity is elected as the CH.
- The nodes with similar requirements are grouped together into a single cluster using the on-demand clustering algorithm. The CH's are varied according to the requirements of the nodes. Therefore, CH is not fixed.
- The mobile nodes are responsible for storing the information regarding the neighbors in the link state database.
- The fault prediction and node authentication schemes are performed with the auxiliary key management scheme, then the data communication between the nodes is performed.

2. Related work

This section briefly explains the existing works related to Clustering and data offloading in MANET. Kaur et al. [3] suggested a Weightage based Secure Energy Efficient Clustering (WSEEC) algorithmic approach for clustering and securing the nodes. When compared to the traditional WCA, the proposed WSEEC provided optimal network lifetime, energy consumption, delay, throughput and packet delivery ratio. Bokhari et al. [4] surveyed various clustering algorithms that were applied in MANET. Among several algorithms, the Max-Min D-Cluster was the best clustering algorithm with a good controlled message complexity. Wang et al. [5] modelled the mobile traffic data offloading as a multi-objective optimization problem for the minimization traffic in mobile data and the QoS aware service provision. It also investigated several traffic offloading models for Wi-Fi in MANET. The offloading mobile data traffic through Wi-Fi was considered as the promising solution for solving the traffic overloading problem. Li et al. [6] established a mathematical framework to solve the issue of different types of mobile data offloading in real time scenarios. There were three optimal algorithms designed for handling the offloading scenarios such as Greedy, Approximation, and Homogeneous Algorithm. Conti et al. [7] explored the complementary mobile solution, where the mobile nodes relied on other nodes. The nodes in MANET were contacted through the direct communication based on Wi-Fi or Bluetooth for offloading the traffic from the cellular network. Lee et al. [8] reviewed the offloading performance in the 3G data via Wi-Fi networks. Both the distribution model-based simulator and a theoretical framework enabled the average performance of offloading. Han et al. [9] suggested opportunistic communication for facilitating data communication in the emerging Mobile Social Networks. The 3G networks were currently overloaded because of the increased popularity of various applications for smart phones. The promising solution to this problem was to offload the mobile data traffic through the opportunistic communication. Liu et al. [10] proposed the offload mechanism for mobile data in distributed environment like Software Defined Network (SDN). The Quality of Service (QoS) of the mobile was improved by avoiding the congestion using the data offloading concept.

Amani et al. [6] proposed an integrated Wi-Fi architecture with SDN. The offloading of Wi-Fi was considered as a vital approach for alleviating the mobile data traffic load. The main purpose of data offloading in MANET was to dynamically redirect the selected traffic towards the lower cost. Eom et al. [11] studied the possibility of applying the machine learning techniques for addressing the adaptive scheduling problem in mobile

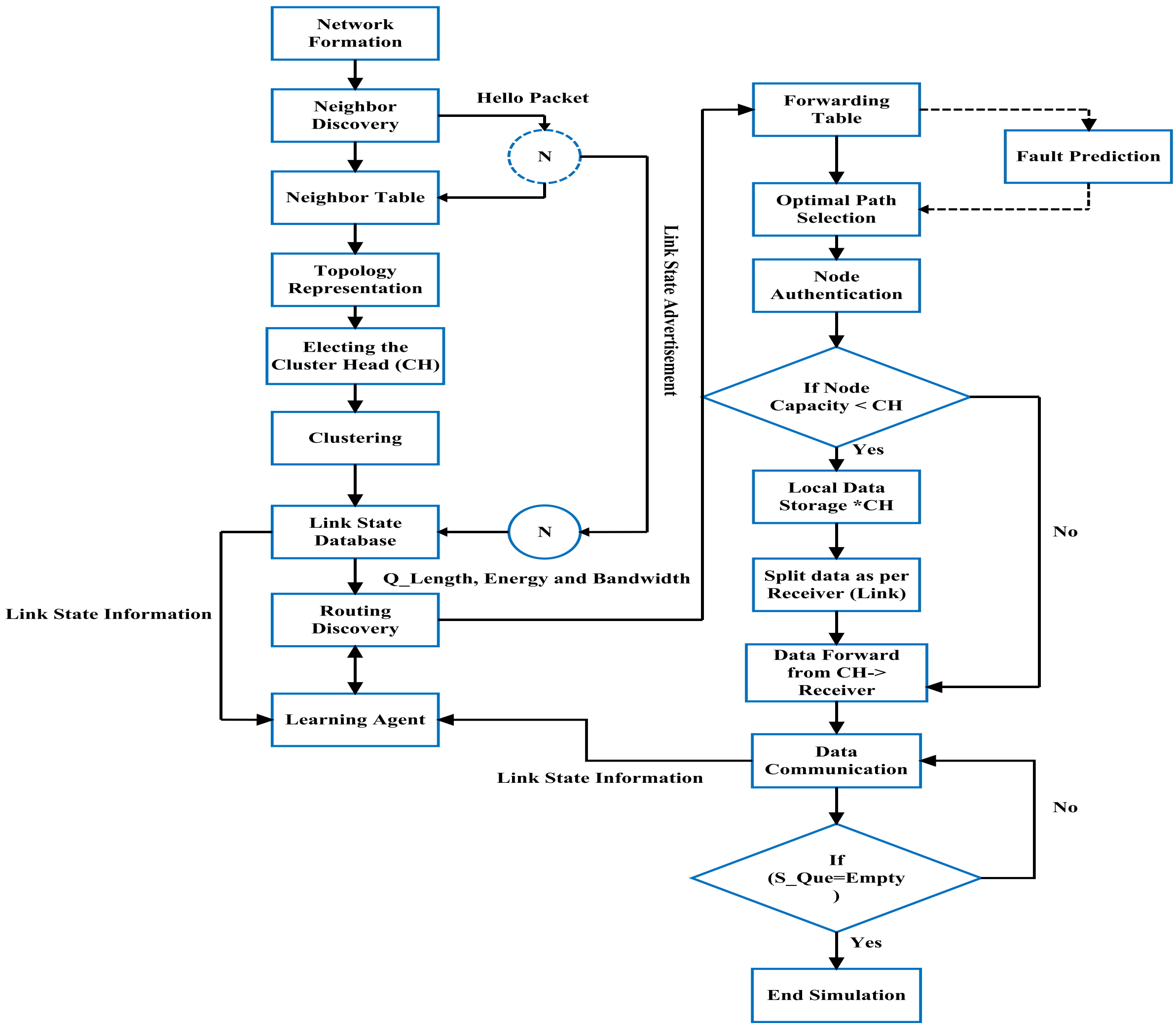

Fig. 2. Overall flow of the proposed He-SERIeS.

offloading framework. Budiyanto et al. [12] proposed a routing algorithm for MANET and the third generation Wireless Fidelity (Wi-Fi) offload networks. The Genetic Zone Routing (GZRP) and Vertical Handover (VHO) algorithms were combined in a 3G-Wi-Fi offload network. Xuyan et al. [13] proposed a centralized caching protocol for addressing the existing caching scheme issues. Experimental results proved that the suggested protocol enhanced the offloading revenues. It used the selective algorithm to cache the location based on set-cover. The proposed scheme outperformed the existing schemes in offloading scenario. Chenget et al. [14] presented a popularity-based relaying user selection algorithm for determining the amount of relaying users. The analytical model was also presented to estimate the number of reduced data traffic. Dias et al. [15] investigated the possibility of video streaming offloading through opportunistic connection sharing from a Long Term Evolution (LTE) network to a Wi-Fi ad hoc network. The AODV and OLSR protocols were combined and validated the streaming data performance. Novo et al. [16] explored three mechanisms such as, Wi-Fi offloading, Mobile Smart Loading (MSL) and smart cells. The service providers effectively managed the growing demands in mobile data traffic. Budiyanto et al. [17] suggested a Novel Genetic Zone Routing Protocol (N-GZRP) for optimizing 3G-Wi-Fi offload and load balancing among the nodes. It was based on the combination of Roulette Wheel Selections method and Rank Selection methods. It saved 60% of power consumption than the ZRP protocol. Esnault et al. [18] presented the communication model to offload the data in intermittently connected hybrid networks. It was implemented in a middleware platform, a Nephila to improve the quality of service. Bravo-Torres et al. [19] offloaded the mobile data from or to the VANET. The routing protocol in data offloading achieved better performance in routing. Chung et al. [20] proposed an adaptive offloading of mobile applications to identify the optimal offloading points. The offloading of mobile devices consumed minimum energy of the smart devices. Valipour [21] suggested an optimized neural networks to improve the accuracy of network by detecting the drought and wet year alarms. In this investigation, the Artificial Neural Network (ANN), Non-linear Auto Regressive Neural Network (NARNN), Non-linear Input Output (NIO) and NARNN with exogenous input (NARNNX) techniques and its structures were analyzed. Yannopoulos et al. [22] examined the water lifting devices with its apparent characteristics over the centuries. Here, the timeline of the historical development of water pumps for the last 5500 years throughout the world was presented. Valipour and Eslamian [23] recommended various temperature based models for analyzing the potential evapotranspiration. In this paper, the methods that include modified Hargreaves

Samani 1, Samani 2 and Samani 3 were utilized to analyze the evapotranspiration of Iran. Valipour [24] introduced a transfer based models for predicting the crop evapotranspiration under different weather conditions. The main intention of this paper was to select the best transfer based model to estimate the crop evapotranspiration in the areas of northern (near the Caspian Sea) and southern (near the Persian Gulf). Here, the measures such as mean, maximum and minimum temperature, wind speed and relative humidity were utilized to analyze the performance of the model.

The existing techniques used for offloading the data has certain drawbacks such as,

- It did not scale well with the Heterogeneous networks
- Similar requests were not grouped accurately.

For resolving these downsides of the existing data offloading mechanisms, a novel algorithm is proposed and explained in the next section.

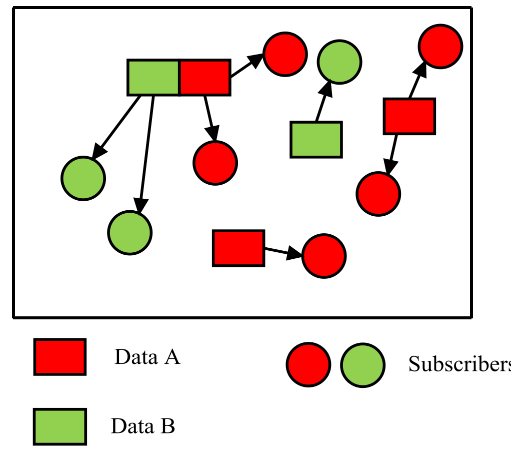

Fig. 3. Network formation.

3. Proposed method

This section presents the detailed description for the proposed He-SERIeS for Scalability and Heterogeneity in MANET. Fig 2 depicts the general flow of the proposed SERIeS.

It includes the following stages such as,

- Network formation
- Neighbor discovery
- Electing the cluster head
- Cluster member selection
- Updating the link state database
- Route discovery
- Optimal path selection
- Node authentication
- Data offloading and communication.

Initially, the network is formed with certain number of nodes. Then, the neighbors are discovered for communicating among the nodes and the hello packets are transmitted among the nodes. If the node is the neighboring node then, the individual node IDs are updated in the neighboring table. After the discovering the neighboring nodes, the nodes with highest energy is preferred as the CH. The nodes' requirements that are similar in nature are grouped together. In order to update the link state database, the link state advertisements are broadcasted among the nodes. The information available in the link state database is the queue length, energy, and bandwidth. Then, the learning agents are used for updating the link state database based on the link state information. After updating the link state database, the routes are discovered by using the forwarding table, then the optimal path is selected and the nodes are authenticated. If there is a necessity to offload the data then, the local data are stored in the CH and based upon the requirements, the data's are grouped. If the nodes have a less receiving capacity for eg., 256 bps but, the CH has an extraordinary transmission capacity for eg.,1024 bps, then the entire data is partitioned into many 256 bps and stored in CH. In accordance with the needs of the node, the data is transmitted. Finally, the CH will move the offloaded data with requested member node.

3.1. Network formation

Initially, the network is formed with some set of nodes and the links are established among the nodes that are represented in Fig. 3. The nodes are dynamic and mobile in nature. Normally, 100 nodes are used for forming the network.

3.2. Neighbor discovery

After creating the network, the nodes are responsible for communicating with one another. The neighboring nodes are discovered before the communication begins by transmitting the hello packets among the nodes. Once the hello packet is received by the node, it updates its neighbor table. The hello packet is the special packet and is responsible for simultaneously discovering the neighbors in the network. It is periodically broadcasted in order to approve the adjacency of the network relationships and also to discover the neighboring nodes. After the neighbors are discovered, the He-SERIeS algorithm is used for maintaining the topological information. This algorithm has many advantages,

- Robust in nature.
- It equally splits the link state information among several nodes.
- It provides highly secure and authenticated routing within the network.

3.3. Electing the cluster head

After the neighboring nodes are discovered, the CH is elected based on the specifications of the node. The node with highest energy, queue length and bandwidth is chosen as the CH and is responsible for downloading the data from data service provider. The requirements of the nodes that are similar are gathered together within a single cluster. The data from the cluster is transferred to other nodes, which has low energy and low memory. The clustering of similar requirements of the nodes is done with the on-demand clustering algorithms. The on demand clustering algorithm is briefly explained as follows, which initially starts by finding the neighbors of each node within its transmission range. Then, the distance between the individual nodes in the network are calculated. Based on the processing power, memory capacity and bandwidth capacity, the CH is selected. The proposed algorithm is repeated till all the nodes are assigned to a cluster. The values of R_v is varied to greater extend, in order to avoid the fluctuations these weighting factors are used. It is used for controlling the fluctuations. The total capacity of the node is calculated for electing the CH. The node with highest capacity is selected as the CH.

Algorithm 1: On-demand clustering algorithm

Step1: Find the neighbors of each nodes within its transmission range v.
Step 2: Compute the absolute value of intensity as follows [25],

$$N_v = |\text{Variance in mobility}| \quad (1)$$

Step 3: For every node, compute the sum of the distances, S_v, with all its neighbors.
Step 4: The average speed of each and every node is computed. This gives a measure of mobility that is denoted by P_v.
Step 5: Compute the time, T_v, of a node v during which it acts as a CH.
Step 6:For every node v, the total capacity is estimated using the following equation [25],

$$R_v = c_1N_v + c_2S_v + c_3P_v + c_4T_v \quad (2)$$

Step 7: Choose the node with maximum $R_v$as the CH. All the neighbors of the chosen CH can no longer participate in the election algorithm.
Step 8: Repeat Steps 2–7 until all the nodes are assigned as CHs at least once.

3.4. Cluster member selection

In this step, the cluster members are selected based on similarity in the request generation. Initially, the priority queue is assigned with the neighbor hop and the number of CH. Each and every node is checked, whether the node belongs to the cluster or not. The weight is computed for each request from the members. Based on the weight, the clusters are formed and the requests of each and every node are analyzed. Based on the requests, the nodes are grouped together under a single CH. For each and every cluster, the CH is elected and is responsible for the particular operation.

Algorithm 2: Cluster member selection based on similar request generation

Step 1: Initialize a priority queue (1-Hop-Neighbor, No. of CH,) pairs
Step 2:
For each Member m belongs to Cluster Cl Do
{
For every request R_k from the members, the weight is estimated using the following equation,

$$R_k = r_kT_k \; sum \; i \in N(\gamma_{s,i}, w_{i,k}), \quad \forall k \in C \quad (3)$$

Create and update the weights of all the requests for quantization using Eq. (4),

$$(r = |\log(\max(R_k)/c_1| \quad (4)$$

}
Step 3:
Initialize T as Empty, P_0 =0, Q_0 = {(T, P_0)}

(*continued*)

Algorithm 2: Cluster member selection based on similar request generation

for all k ∈ length. Cl Do
{
Extract highest Key node (R_k, CH) from the priority queue
}
Step 4:
For every element R_k of Cl
{
Load created by the user request is compared with the load limit of the CH.
If (load created by the user request < load limit of CH)
{
The additional load is added to the existing load of the CH
}
else
{
The requested member is shifted to an alternate cluster
}
Step 5: If the requested member is a low profile member, the data is stored in the CH
Step 6: Else Forward data packet as per link rate
Step 7: If (local Storage (Req. Data).Size!=0)
Step 8: Forward Data to Mreq as per link rate

3.5. Updating the link state database

After the CH's are elected and the nodes with similar requirements are clustered, the nodes are responsible for updating the link state database. The link state information are queue length, energy and bandwidth. The learning agents are responsible for storing the up-to-date, correct and authenticated link state information that is responsible for routing the information. Here, the learning agents are responsible for identifying the specific path from the source node to the destination node. It also obtains the path information such as prior successful and unsuccessful path information. These agents are used for identifying the fake nodes in the network. Hence, the routes are discovered by the knowledge obtained from the learning agents (see Table 1).

3.6. Route discovery

After the links are established to the neighboring nodes the routes are discovered to the destination node. The transmission of data from the source to destination via an optimal path is

Table 1
Notations.

N_v	Absolute value of intensity
R_v	Total capacity
c_1, c_2, c_3 and c_4	Weighing factors
P_v	Average speed of a node
T_v	Total amount of time the node acted as the cluster head
S_v	Sum of the neighboring distances
R_k	Request of the nodes
CH	Cluster Head
r_k	Length of the content
T_k	Lifetime of the content
N	Number of subscribers
$\gamma_{s,i}$	Contact rate between the helper and subscriber
$w_{i,k}$	Content interest of the subscriber
K	Data items
C	Data items in the system
R	Average of r_k

termed as routing. Initially, the Route Request (RREQ) packets are broadcasted among the nodes in the network and the neighboring node receives the packet and broadcasts the same packet by just adding its own address to the packet header. The neighboring node replies with the Route Reply (RREP) packet.

3.7. Optimal path selection

After discovering the routes, the optimal path is selected by predicting the faulty nodes. The optimal path is the best path from the source node to the destination node. In a network, there are several paths for forwarding the packets among the nodes. If the faulty nodes are predicted in the network then, the faulty nodes are removed from the network. If the optimal path is not selected then, it degrades the performance of the overall network. In order to detect the best optimal for data transmission, the end-to end delay across the network is computed. If the end-to-end delay is less then, a secure communication is established in the network. The behavior of the nodes is also considered to avoid the misbehaving communication.

3.8. Node authentication

The nodes available in the best optimal path are authenticated to avoid the packet drops and malicious attacks in the network. During this stage, the nodes in the network are authenticated as faulty or normal. The node authentication scheme is usually done with an auxiliary key management scheme. In this work, the nodes are authenticated using the MD5 and SHA1 algorithm. This algorithm is discussed in our previous work.

3.9. Data offloading and communication

After the nodes are authenticated, the specifications of the nodes are gathered. The specifications of the nodes include the energy, bandwidth, length of queue, etc. If the nodes are having low specifications such as memory or energy then, the data offloading mechanism is performed. The data is downloaded and stored by the CH and according to the specifications of the nodes, then the data is offloaded from the CH to the remaining nodes. The CH is responsible for splitting the data according to the requirements of the nodes and the data is forwarded from the CH to the requesting node. Finally, if the data is authenticated as normal node then, the communication of data is accomplished. The communication takes place until the queue is empty.

3.10. Advantages of the proposed work

The major advantages of the proposed method over the existing methods are as follows:

- It enables the data reusability and re-sharing
- Reduces the burden at both user and server side
- In this environment, the master node (i.e. CH) can store the data that are obtained from the server, then it forwards to the requested nodes in the cluster. So, it reduces the delay time and increases the speed of processing
- Moreover, it reduced the data cost and increased the data retrieval rate.

4. Performance analysis

This section presents the performance analysis of the proposed He-SERIeS algorithm using on-demand clustering and similarity searching. The experimental analysis is performed using the simulation parameters represented in Table 2.

The existing techniques used for comparison of the proposed He-SERIeS algorithms are Random Cache (RC), Centrality based Cache (CC), Set Cover Based Caching (SCBC) and SERIeS. The following parameters are used for evaluating the performance of the proposed He-SERIeS algorithm,

- Throughput
- Packet Delivery ratio (PDR)
- Packet delivery ratio vs. number of nodes
- End-to-end delay vs. number of nodes
- Offloading ratio
- Replication overhead
- End-to-end delay.

4.1. Throughput

The throughput is the total number of packets delivered within the total amount of time. Mathematically, it is given by the following Eq. (5).

$$Throughput = \frac{Total\ Number\ of\ packets}{Total\ amount\ of\ time} \tag{5}$$

Fig. 4 depicts the throughput for the proposed He-SERIeS algorithm. The existing algorithms used for comparison are RC, SCBC, SERIeS algorithms. The simulation-time (ms) is plotted in the X-axis, whereas the throughput (Kbps) is plotted against the y-axis. From Fig. 4, it is clear that the proposed enhanced SERIeS algorithm achieved higher throughput than the existing algorithms.

4.2. Packet Delivery Ratio (PDR)

PDR is the metric used for analyzing the performance of the proposed He-SERIeS algorithm. The PDR is defined as the percentage of number of data packets received to the number of data packets transmitted. The PDR is defined by the following Eq. (6).

$$PDR = \frac{Sum\ of\ data\ packets\ received\ by\ the\ destination\ node}{Sum\ of\ data\ packets\ generated\ by\ the\ source\ node} \tag{6}$$

Fig. 5 describes the PDR vs. Simulation time. The x-axis denotes the simulation time in ms and the y-axis describes the PDR in %. When compared to the existing algorithms, the proposed He-SERIeS algorithm provides a higher PDR.

4.3. Packet delivery ratio vs. number of nodes

The comparison of PDR with respect to the number of nodes for the existing RC, SCBC, SERIeS algorithms and the proposed

Table 2
Simulation parameters.

Simulator	NS 2.34
Simulation time	100 s
Simulation area	1000×1000 m^2
MAC	IEEE 802.11 b/g/n
Number of nodes	30, 50, 70, 90, 100
Speed of nodes	2–30 (m/s)
Mobility model	Random waypoint
Transmission range	250 m
Packet size	512 Kbps-2048 Kbps
Packet rate	4 packets/ sec
Traffic type	CBR
Routing protocol	AODV/SERIeS/He-SERIeS
Channel bit rate	10 MB/s
ACK	112 bits + PHY header
MAC header	272 bits
PHY header	128 bits
Propagation delay	1 µs

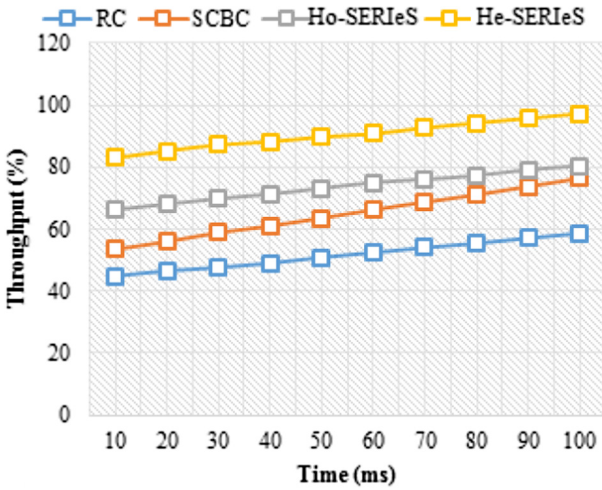

Fig. 4. Throughput vs. simulation time.

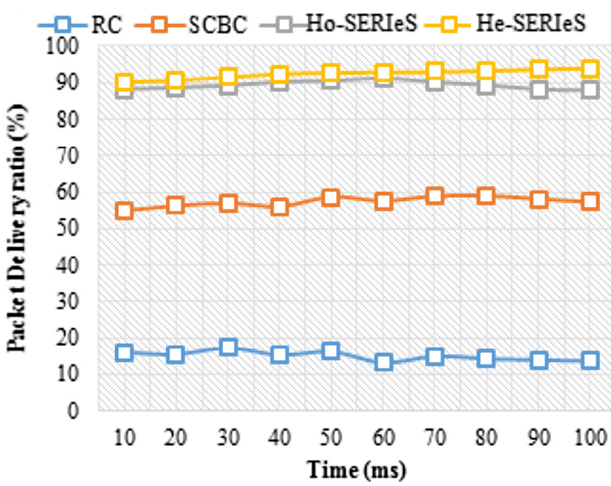

Fig. 5. PDR vs. simulation time.

He-SERIeS algorithm is represented in Fig. 6. From the results, it is analyzed that the suggested He-SERies algorithm provides higher PDR than the existing algorithms for varying number of nodes.

4.4. End-to-end delay vs. simulation time

The comparison of end-to-end delay with respect to the number of nodes for the existing RC, SCBC, SERIeS algorithms and the proposed He-SERIeS algorithm is represented in Fig.7. The comparison results show that the suggested algorithm provides minimal end-to-end delay than the existing algorithms.

4.5. Offloading ratio

The offloading ratio is defined as the ratio of offloading the data traffic to the overall traffic. It estimates the number of successful offloading performed by the CH. Fig. 8 explains the offloading ratio vs. the simulation time. The x-axis describes the simulation time in ms and the y-axis describes the offloading ratio. From graph it is clear that the proposed enhanced SERIeS algorithm is compared to that of the existing RC, CC and SCBC algorithms. The simulation time is varied from 10 to 100 ms. The offloading ratio is increased as the simulation time is increased. When compared to the existing algorithms, the proposed algorithms achieved high offloading ratio. Because, there is no self-downloading process in the network and it do not takes the time for downloading. Moreover, it represents how efficiently we provide the services based on the request. So, the offloading ratio can be increased in the proposed system.

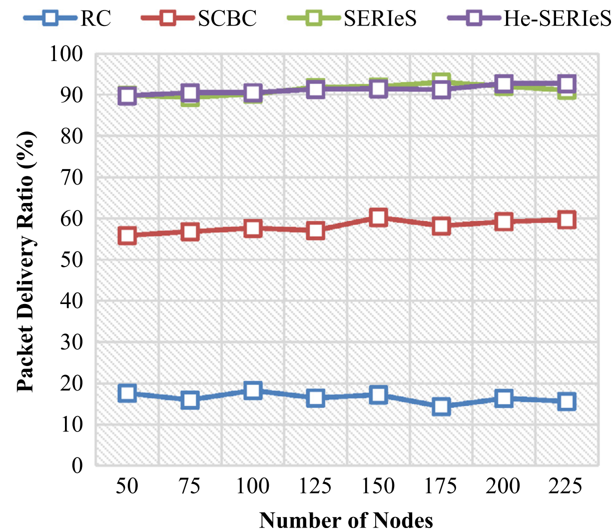

Fig. 6. PDR vs. number of nodes.

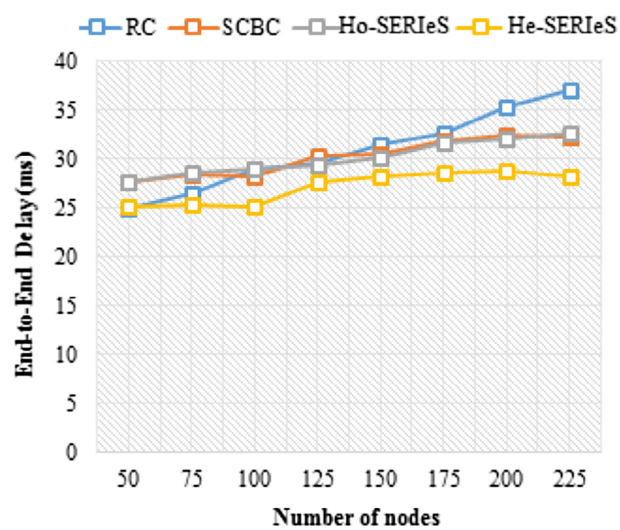

Fig. 7. End-to-end delay vs. number of nodes.

4.6. Replication overhead

The replication overhead is the metric used for analyzing the performance of the He-SERIeS algorithm with that of the existing algorithms. It is defined as the total number of data copies generated inside the network in which several paths are exploited to route the same data. Even if the data size increases, the replication overhead is unchanged. Fig. 9 depicts the replication overhead vs. the simulation time. The x-axis describes the simulation time, which is measured in milliseconds (ms) and the y-axis describes the replication overhead in %. From the figure, it is clear that the proposed He-SERIeS algorithm provides minimal replication overhead than the existing algorithms.

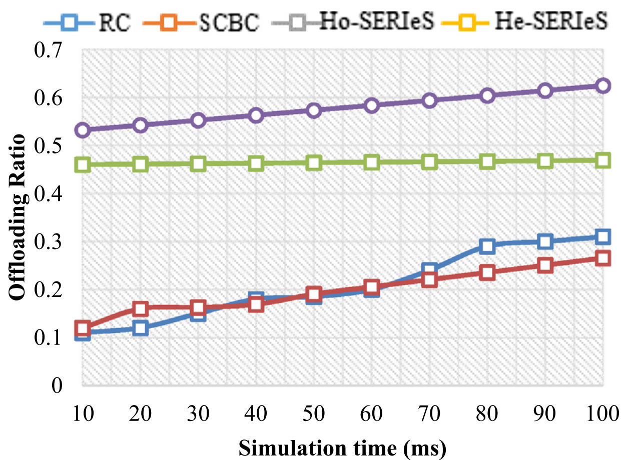

Fig. 8. Offloading ratio vs. simulation time.

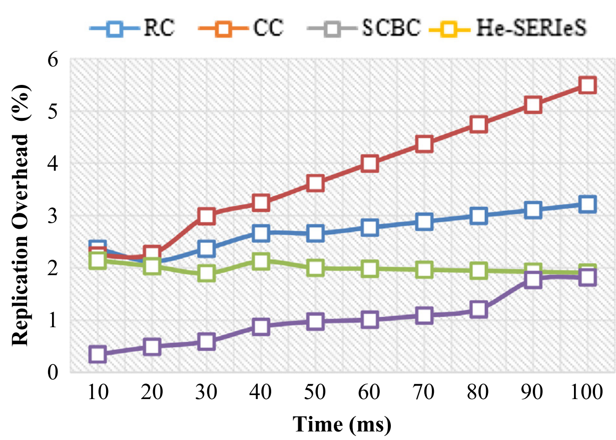

Fig. 9. Replication overhead vs. simulation time.

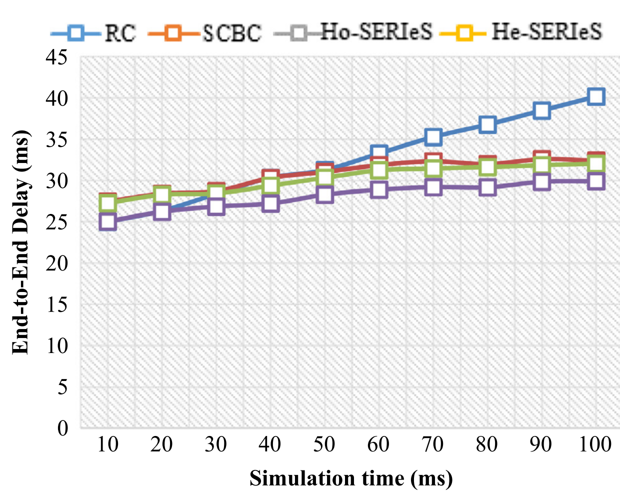

Fig. 10. End-to-end delay vs. simulation time.

4.7. End-to-end delay

The end-to-end delay is defined as the amount of time taken by the data packet to reach the destination. The delay time can be increased due to the reasons of route discovery, queuing and buffering. Also, it is defined as the ratio of the time spent on delivering a data packet to the total number of packets received at the destination. The estimation of the end-to-end delay is based on the following equation,

$$End-to-End\ Delay = \frac{S}{N} \tag{7}$$

where the S is the total time spent on delivering the data packets to the destination node and N is the total number of packets received by the destination nodes. Fig.10 represents the comparison of end-to-end delay for the existing RC, SCBC, SERIeS algorithms and the proposed He-SERIeS algorithm. The x-axis describes the simulation time in ms and y-axis describes the end-to-end delay in ms. The comparison results show that the suggested He-SERIeS algorithm provides minimal end-to-end delay than the existing algorithms. Because, the tradition techniques download the requested data with increased time, but the proposed He-SERIeS do not perform the routing process, so it efficiently reduces the delay time.

5. Conclusion and future work

This paper proposed a novel algorithm, namely, He-SERIeS algorithm for providing the scalability and Heterogeneity in MANET. The main aim of this work is to modify the existing SERIeS algorithm by using the learning agents, to cluster the similar requests from the nodes and to elect the CH that has the highest energy. There are two main algorithms developed for this purpose are Dynamic on-demand clustering and Cluster member selection based on the similar request generation. Our SERIeS protocol is extended in order to reduce the data management problems and to increase the throughput. The proposed system supports the service providers, who provides the services based on the factor of Quality of Service (QoS) and the service provides should support the data offloading mechanism. The performance of the proposed algorithm is compared with the existing RC, CC, SCBC and SERIeS algorithms. The metrics used for evaluating the performance of both existing and proposed techniques are throughput, delay, replication overhead, offloading ratio, and PDR. From the results, it is analyzed that the proposed enhanced SERIeS protocol achieved a high throughput of 96.6% and PDR of 92.8%, when compared to the existing algorithms. The advantage of the work is to balance the load among several nodes using the offloading mechanism.

As a part of our future work, multiple cellular networks are assumed with MANET communication and to examine the traffic offloading for multiple services in MANET cyber-physical systems.

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