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An Efficient Selfish Node Detection and Data Replication Technique for Distributed Database in MANET

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Abstract: Mobile Ad-hoc Network (MANET) is a network which allows mobile servers and clients to communicate in a dynamic Infrastructure. MANET is a fast and increasing region of study as it discovers and utilizes diversified applications, in which the information should be well structured for accessibility and data should be put together in the database. In such databases, the mobile peer stores and access the data functionality such as storage, manage and reports in the database. In this study, the challenges of data replicas in the mobile database are focused. Data replication mainly focuses on availability and reliability of data in the mobile nodes. Data replication concentrates on certain scenarios like frequency disconnection, node mobility, server network partition and power. In proposed method, a cluster based data replication technique for replicating data and to overcome the problems related to data management problems in MANET environment. The proposed approach has three phases; selfish node detection, formation of cluster and cluster head selection and finally, data distribution to the respective cluster head. By NS2 simulation, the performance of the proposed approach is observed to be efficient with improved data consistency with minimal overhead and delay.

Key words: MANET, replica allocation, clustering, watchdog, cluster head, mobility, selfish node, credit risk, artificial bee colony optimization

INTRODUCTION

In MANET, Mobile Host (MH) moves independently and causes network disconnections frequently which lead to network partitioning. The data of one host cannot be accessed by the other host due to migration of nodes. The technologies involved in the field of mobile computing have given way for the configuration of MANETs by Hara and Madria (2009) and Wu and Chang (2006).

Padmanabhan *et al*. (2008) real time applications like natural diasters, battle fields, etc., MANETs provide valid service since are established automatically. As a result in case of emergency circumstances, MANETs are extremely suitable for the purpose of addressing communication problems. For the purpose of addressing communication problems MANETs are employed effectively. For the purpose of file sharing and searching (Ding and Bhargava, 2004; Li and Singhal, 2004) peer to peer mobile overlay is one of the more remarkable properties in MANET. The accessibility of data in MANET is comparatively lower than the conventionally fixed networks. The network partitioning weakens the data accessibility in the network. Data replication has become one of the important research topics in MANET by Hara and Madria (2006), Hara (2001) and Yin and Cao (2004). The data replicas on the network are generally impossible because of the poor network resource. The replicated data has been likely to be projected in the MANET database.

Data replication can increase data accessibility if mobile nodes have adequate memory space to take in data items. Data accessibility and query delay has contrivance in the aspect of memory space limitation in the mobile nodes to replicate data. This trade-off may result in selfish behavior of mobile nodes in a network. A mobile node yearns for using the resource of the other node in which it cannot be supported by the available node (resource). Those nodes are expressed as selfish nodes which lead to ample problems in a MANET.

The host mobility causes unpredictable changes in network topology, thus finding and maintaining the routes is insignificant. Flooding scheme is most reliable in sending data packets in a mobile network. To boost the battery power and link channel in the network, an effective scheme must be introduced. The scheme gathers complete data regarding the locality of the mobile nodes. Storage is not a serious issue since memory

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gets less expensive recent years. Energy saving and communication bandwidth reports the node that requires the necessary information. All the nodes available in the network divide into clusters, to reduce the transmission overhead by updating the routing table. The overhead caused by maintenance and cluster formation cannot be ignored. In MANET, initially, clusters are established and a Cluster Head (CH) is selected from each cluster in a distributed fashion.

In this study, a swarm intelligence based cluster data replication technique is proposed for replicating data in MANET environment. The proposed approach has three phases; initially, selfish node detection based on data loss and credit risk is carried out and then, cluster and cluster head selection is formulated through PSO algorithm and finally, the distributions of data to the respective cluster head.

Literature review: To achieve higher data accessibility and better data sharing, replication of data is a best approach. To improve the distributed processing load provided by the server to avoid overload of routes for communication and improve the response time, replication suites the best. Hara initiated ad hoc data replication problem (ADRP), in which broaden by including the network connectivity issue. Data replication is divided into three categories in MANET: scalable data replication; energy aware data replication; partition aware data replication.

Zheng *et al*. (2004) proposed that network partitioning avails in the network between the clusters mainly with the cluster without overlap. Cluster Based Data Replication Algorithm (CDRA) mainly focuses on strengthening the data accessibility in the cluster. The data object is replicated in the network partitioning. The CDRA algorithm is described as follows: every CH holds the status of the entire remaining CHs in the networks. If more replicas of data exist in the cluster then the closest replica node serves the access request. The CH transmits the data request to the remaining nodes. During the process, call for the data object is preferred to copy the data object for a node in network. The primary concern for a quite lot of clusters is to be elected as replica nodes.

Huang *et al*. (2003) proposed that the behavior of each mobile node is exchanged with the neighbors in DRAM. A decentralized clustering algorithm is used to cluster the network nodes with similar motion behavior into mobility groups. Hence, the clusters are merged with one another to allocate the unit to save cumulative storage cost. Finally, based on the data replicas, allocation is made in the network. To reduce the network traffic, the minimal broadcast of information within the network is maintained by the DRAM mobility group. The two phases of DRAM are: in the first phase, every node exchanges its mobility information with other nodes located within a determined hop count known as allocation unit construction phase. Then, nodes with similar motion behavior are grouped into clusters using clustering algorithm. in the second phase, the in accordance with depending on the access frequency of data items and the derived allocation units data replication are allocated for data objects knows as replica allocation phase. Stable K-hop Direct Acyclic Graphs (SKDAG) has been presented by Derhab and Badache (2006) consisting of set of cluster which is generated by a localized scheme. K-hop DAG is a type of SKDAG in that each node has a strong path towards the direction of the sink node. Every cluster should have certain characteristic features which are listed below:

- The cluster is a direct acyclic graph fixed at the CH. Each node in the cluster is K hops apart from the CH
- The node and the CH have only one long lived links between the paths. The life time of the nodes and links are higher than the given threshold

Mukilan and Wahi (2012) recommended a data replication algorithm with energy consumption model based on energy efficiency and node mobility. To balance among the query delay, energy and data availability this approach mainly focused on the node mobility, energy consumption and data replication. It is observed from the results that the performance of this approach is significant with minimal delay, overhead and energy consumption.

Purpose of monitoring selfish behavior proposed by Liu and Yang (2003), Marti *et al*. (2000), Wang *et al*. (2004) is to inspect nodes by reputation schemes facilitate in MANET. In credit payment methods the nodes are rewarded when they behave sound at the time of participating in data access process like data forwarding. To increase the profits through MANET nodes the game based schemes are used in individual strategies presented by Hales (2004) and Srinivasan *et al*. (2003).

Packet forwarding is employed in all the schemes for the purpose of communication in MANETs. on the other hand, selfish replica allocation is basis for this study. On the other hand, the back bone of this paper is on selfish replica allocation. Several faith models were presented by Li and Singhal (2007). Besides dropping of packets the selfishness is considered as denial to forward the data and for replica allocation these schemes are not helpful which gets strip of selfish behavior. Query delay and inaccessibility were focused in problems by Yin and Cao (2004). To solve the problem of selfish nodes cooperative caching is used by Cao *et al*. (2004) which include the features like Cache data, Cache path and Hybrid. In

Choi *et al.* (2012) novel replica allocation method was proposed. Besides allocating replicas successfully it identify selfish nodes effectively.

MATERIALS AND METHODS

In this study, the proposed clustering based data replica allocation is discussed. The proposed approach three phases are explained.

System overview: The architecture of the proposed approach is depicted in Fig. 1. It shows the Data Replica Allocation system using MANET based on the Clustering Formation (DRA-CF). The nodes are grouped into clusters and the cluster head is elected based on the evaluation of node attributes in MANET. Initially, the selfish nodes are detected and reduced that selfishness and cooperate with other nodes to improve the resource availability. Then the mobility and energy attributes are used to select cluster head and form clusters using Particle Swarm Optimization (PSO) (Premalatha and Natarajan, 2008). Finally, the data replica allocation is performed in this clustering environment.

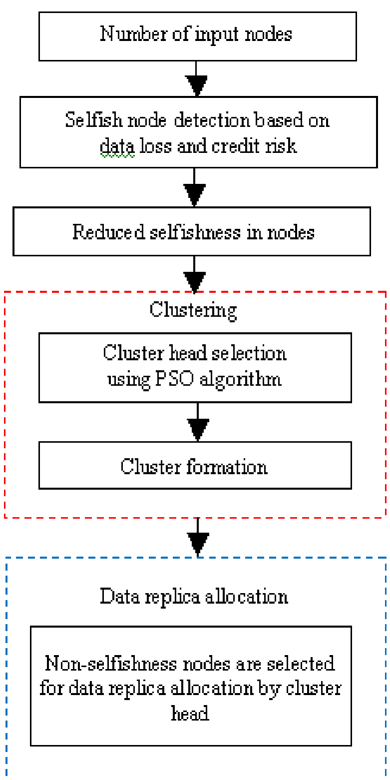

Fig. 1: Overall architecture diagram for proposed methodology

Selfish node detection: In this method, the BS sends pilot message to all the other nodes in the network in which except the selfish node all the remaining nodes respond to the Base station. Normal node combines to form a cluster, thereby cluster head decides the base station.

In selfish node detection Kanimozhi and Varadhaganapathy (2014) with the available routes a sample message is transmitted from the source to destination periodically, the received message will be broadcasted by the destination node to the watchdog. Watch dog maintains a routing table comprises of route Id, size of received data, size of data sent, continuous/not and failure count. Watch dog identifies malicious node in each route within a time interval. The accumulation of data response from the destination node helps watch dog to decide whether that route has selfish node or not.

When continuous the nodes will not respond to the message from base station and then watch dog identifies the presence of selfish node in that route and deletes the route from the table. Else, the data loss threshold value is used by watch dog to find selfish node's route. The advantage of this approach is using watch dog, detect the data loss not only in solitary route but also in the available routes. The sample data is periodically updated in all routers, thus watchdog timer does not wait for the reply from the destination node. One more advantage is unlike other watchdog process, it gathers the data count sent and received for specified number of times and uses the same for finding the selfish node in the particular route. Unwanted overload provided by watchdog can be avoided by this approach (Algorithm A).

Algorithm A:

Improvised watch dog mechanism for detecting selfish node

Step-1: a network considered with N elements.

Step-2: N_i watches a function 'f' over a stream of sample data.

Step-3: The message is treated as discrete time series (loss of data).

Step-4: Stream of sample message is sent and watched by N_i until time 't' becomes 5 m sec.

Step-5: Watch dog watches the accumulated set of message values on a stream (with the help of destination node) is denoted by:

$$wi = \left(X_i^{t-k+1}, \ldots, X_i^t\right)$$

Step-6: Then the credit risk for each node can be described by the following equation:

$$\text{CreditRisk (CR)} = \frac{\text{expectedrisk}}{\text{expectedvalue}}$$

Step-7: Function 'f' is defined as $f(W_i)$. At time interval, 't', if $f(W_i)$ and CR exceeds threshold value t, watch dog identifies that node as selfish.

Step-8: Therefore the watch dog event in a network is a random variable such that:

$$R_i = \begin{cases} 0, & \text{if } f(Wi) \text{ and } CR >= t \\ 1, & \text{otherwise} \end{cases}$$

Mobility prediction: Node mobility Mukilan and Wahi (2012) partitions the network. If the mobile node is out of range, service cannot be provided further more. Data availability can be improved if the mobility of the node is estimated in advance to enhance the data replication service. In proposed system, Mobile Host (MH) and CH is comparatively stable neighborhood candidates in the mobile network. Let $ne_{i,t}$-$(i_0, i_1, i_2, ..., i_{n_t-1})$ be the n_t neighboring Mobile Hosts (MHs) of MH_i at time step t. Somehow, the probability of the stability of this neighborhood has to be estimated, i.e., the probability P (nei,t) that the neighbor will remain the same in the following time steps. By making the simplified assumption that the presence of a MH among the neighbors of MH i in the future is independent of the presence of any other host, thus, the probability P(nei, t) can be formulated as follows:

$$P(ne_{i,\,t}) = P(i_0)P(i_1)\cdots P(i_{n_t-1}) \tag{1}$$

The probability of MH i_i steadily available in the neighborhood of MH i is given by $P(i_i)$. To approximate the probability for each MH, the movements of MHs for any given moment should be estimated. This estimation should limit the complex calculations for computing formulated on MHs with simple processing capability and minimal battery power.

In the proposed methods, MHs are neighbors of MH i at a given moment. The input streams are neighbors of MH i over certain time. The HELLO message will be transmitted between the neighbors to identify MH. During the broadcast interval, the neighbors of MH exchange the message. The MH considers the sequence of MHs as neighbors in last 2 BI sec. The structure of the neighbors is accessed every BI sec.

A structure named digital trie is used here and accessed every BI seconds. Each trie node holds counter that measure, the total number of times a particular node visits the neighborhood nodes. Initially, the node encompassed by the trie is the root node. The current node holds the node that they reached at the previous access of the trie. The children node contains the neighboring node in the next visit to the current node of the trie. The neighbor just beforehand the new neighborhood is placed to the trie. If a child is set up, the counter is incremented and the status of the current node will be updated. Else, the current node's neighbor is inserted as a new child and the counter is incremented by 1. Later, it returns to the root of the trie. For reliable conditional probability, the counter in the node structure will be used. The sequence of node from the root to the newly inserted leaf node has the longest prefix. The counter of each children of the current node is the measure of conditional probability.

The current neighborhood is compared with all the children of the current node in worst case. The neighbors are kept sorted based on their id value with each neighborhood. The comparison requires 2Δ-1 with the neighbors where N_t is the maximum neighbors that a MH has at a given time. So, (2Δ-1) is required to find the child holding the current neighborhood. c_{max} is the maximum no. of children in the trie. MH keeps separate trie structure for its neighbor. Each trie node has two children node, since there are only two probabilities.

The MH with highest degree is elected as CH, a small number of one-hop clusters with routing backbone. When MH claims for re-elected CH with higher CHC value, when compared with the current CH. Re-election triggers global cluster reconfiguration and huge transfer of data to the elected CH. CH re-election occurs only when there is a major change in the MANET topology.

The information stored in the trie is used to estimate the probabilities in Eq. 1. To estimate the probability of the current neighborhood ne_{m-1}, the recent neighborhood nodes of MH is given by ne_0, ne_1, ..., ne_{m-1} If the sequence doesn't appear as a whole in the trie, there will be no corresponding path in the trie. The la the tree path. The conditional probability estimation should based on the recently available history. Rgest suffix of the sequence appears from the root of.

Finally, all the node are visited in the subtree trie node in which be the neighborhood nodes in which the counts represents the number of times it appears in the neighborhood of the subtree. It sums the count of the nodes in the subtree. The probability of the host is being persistently available in the neighborhood of the MH by the ratio first number to the second. The proposed method presents the current neighborhood which is constantly present in the sub tree. The size of the subtree in the trie node is given by S. The probability of finding the number of additions in the host is S. To find the probability of the neighborhood multiplications and q divisions are apparently needed.

Cluster head selection and cluster formation: Each and every node in the network is allotted with ID values; the neighbours are broadcasted with the ID value and the information about the network. Based on the broadcast value neighbourhood tables are created. The weight of each node is given based on the residual energy, mobility of nodes and distance between the nodes.

The cluster head selection is based on the factors belongs to each and every node. In MANET, PSO algorithm (Mukilan and Wahi, 2012) is used to select the cluster head and form the cluster. Residual energy, distance between the nodes and mobility of nodes acts as the main parameter to select the cluster head in PSO algorithms. By network iterations, the weight of each node is calculated with respect to the parameters. The main objective of PSO algorithm is to attain mobility and residual energy. Let:

$$n_i(t) = i = 0, 1, 2, 3, ..., N-1$$

where, N is number of nodes represents the position vector of node i at time t. $d_{ij}(t) = |n_i(t)-n_i(t)|$, the distance from node i to j at time t. The total energy E_t consumed is given by:

$$Et(s_i, d) = \begin{cases} s_i E + s_i \varepsilon_{fs} d^2, & d \le d_0 \\ s_i E + s_i \varepsilon_{mp} d^2, & d > d_0 \end{cases}$$

$$d_o = \sqrt{\frac{\varepsilon_{fs}}{\varepsilon_{mp}}}$$

Where:

E = Utilized Energy to transmit or receive 1 bit message
ε_{fs} = Amplification coefficient of free-space signal
ε_{mp} = Multi-path fading signal amplification coefficient
d = distance between transmitter and receiver
s_i = Bit amount of sending information

Their value depends on circuit amplifier model. The neighborhood node is checked for the mobility range, if it doesn't exceed the range the node transmits the ID value along with the information to the neighborhood nodes.

To achieve the best fitness (objective) function, PSO algorithm aims to achieve the particle position. A number of potential solutions to optimize a problem are referred as swarm in which each potential solution is given as a particle with perspective to the PSO algorithm.

The position of the node is represented by N_d dimensional space. Each node is represented by the below notations:

- Present location(position)of the node is denoted by xi
- Current velocity of the node is denoted vi
- Personal best position of the node is denoted by yi

Based on the above notation, a node's position is formulated by:

$$V_{(i,k)(t=1)} = wv_{(i,k)(t)} + c_1 r_{(1,k)(t)}(y_{(i,k(t)} + c_2\, r_{(2,k(t)}(y_{(i,k(t)})$$
$$x_i(t+1) = x_i(t) + v_i(t+1) \quad (4)$$

Where:

w = Inertia weight
c_1 and c_2 = Acceleration constants $r_{1,j}(t)$, $r_{2,j}(t)$~U(0, 1) and k = 1, ..., N_d

The computation of the velocity is based on three criteria; the distance of the node from the best particle; the cognitive component distance of the node from its mobility and energy fraction of the previous velocity.
The best position of node i is given as:

$$y_i(t+1) = \begin{cases} y_i(t) \text{iff} (x_i(t+1)) \ge f(y_i(t)) \\ x_i(t+1) \text{iff} (x_i(t+1)) < f(y_i(t)) \end{cases} \quad (5)$$

Equation 5 signifies the gbest kind of PSO algorithm proposed by Ghali *et al.* (2009). The basic approaches of the PSO exist based on be drawn to the analysis of the neighborhood nodes. The nodes can:

$$c_2 r_{2,k}(t)\left(\hat{y}_{j,k}(t)\right) - x_{i,k}(t) \quad (6)$$

where, $\hat{y}_j$ is the best node (cluster head) in the neighborhood of the ith node. The swarm intelligence algorithm is executed repetitively for particular iterations. The iteration can be stopped when the velocity closest to zero over a specified number of iterations. Equation 3 and 4 can be executed repeatedly.

Cluster formation: A single node represents the cluster centroid vectors in the context of clustering that is each node x_i is generated in the following way:

$$x_i = (N_{i1}, ..., N_{ij}, ..., N_{in_c}) \quad (7)$$

where, jth cluster centroid vector of the ith particle in cluster. Hence, number of candidate clustering's for the current data vectors. The quantization error measures the fitness of particles and given by:

$$Je = \frac{\sum_{j=1}^{n_c}\left[\sum_{\forall Z_p \in C_{ij}} \frac{d(Z_p, N_j)}{|C_{ij}|}\right]}{n_c} \quad (8)$$

where, C_{ij} is number of data vectors belonging to cluster C_{ij}, i.e., frequency of the cluster.

PSO cluster algorithm: Data vectors can be clustered (Sudhakar *et al.*, 2010), using the standard gbest PSO as follows:

Each node is initialized to possess cluster heads chosen at random
For t = 1 to do
For each i node do ?
For each data vector
Euclidean distance is considered to all cluster centroids:

$$d(z_p, N_{ij}) = \min_{\forall c=1,...,n_c}\{d(z_p, N_{ic})\}$$

The fitness making of using (Eq. 8)
Modernize the global best and local best positions
(d)Modernize the cluster heads employing (Eq. 5 and 6).
where, t_{max}→Maximum number of iterations

Data replica allocation: Replica allocation (Pushpalatha *et al.*, 2009) is carried out by evading the selfish nodes along the path of source and destination. Central server is exploited to retain the selfish node data. The node which is requesting for replication in another node interconnects with that node through cluster head. Cluster head deals with the cluster nodes which has the cluster member as the target.

Pseudo code for replica allocation

```
Input: number of data
Output: replica allocation for each cluster
For (each data item ∈Di)
 /* no. of data items distributed from i*/
{
{
If (cluster member space Ms is not full)
 Allocate replicated data Ms
Else
 {
Replica data is allocated to target node
If (cluster head memory Mp is not full)
Mp is assigned with replica data
}}
While ((during the period of replication)
{
If (For the allocation Nk requests Dq)
Allocation replica for other data item (Nk, Dq)
}}
```

The cluster member is evaluated for its selfishness and data are replicated or else the node which is not selfish is selected by the central server for replicating the data.

RESULTS AND DISCUSSION

In this study, using NS2 simulator, the performance results of the proposed DRA-CF is compared with the existing Handling Selfishness in Replica Allocation (HSRA). The parameters and the simulation settings of the proposed method are summarized in Table 1.

Performance metrics: The following metrics are used in the simulation to validate the performance of the proposed approach.

Control overhead: The total number of received data packets normalizes the total number of routing control packets is known as control overhead.

End-to-end delay: The average time taken by a packet to transmit from source to destination across the network is well-known as end to end delay.

Throughput: The rate in which the data packets are successfully transmitted over the network or communication links is defined as throughput. It is measured in bits per second (bit/s or bps). It is also specified by units of information processed over a given time slot.

Data availability ratio: It is specified as making data copies that can be shared by multiple users at a particular point of time.

Figure 2 shows the results of DRA-CF having lower end to end delay varying nodes from 20-100 when compared with the existing HSRA scheme. Figure 3 shows

Table 1: Simulation parameters

Parameters	Values
No. of nodes	100
Area size	1100×1100
Mac	802.11
Radio range	250 m
Simulation time	60 sec
Traffic source	CBR
Packet size	80 bytes

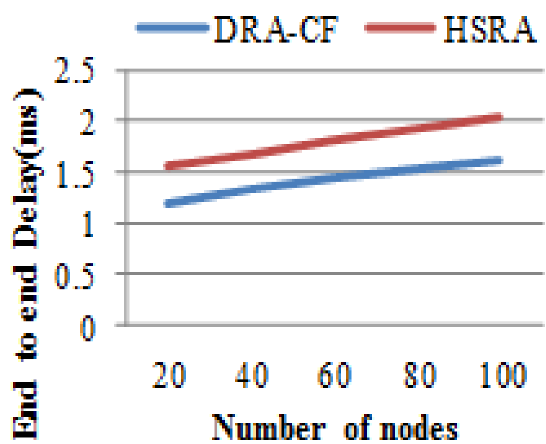

Fig. 2: Number of nodes vs. end to end delay

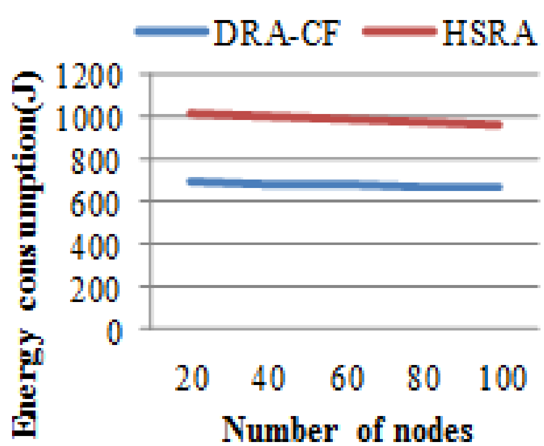

Fig. 3: Number of nodes vs. energy consumption

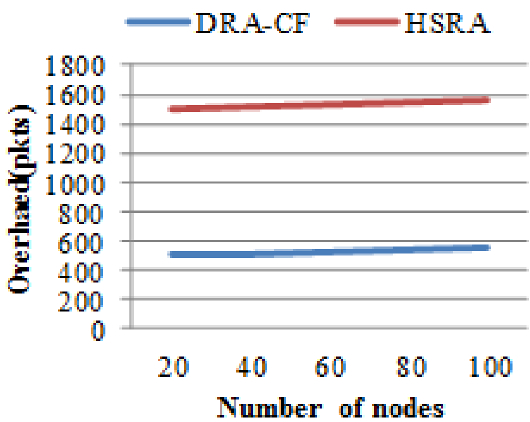

Fig. 4: Number of nodes vs. overhead

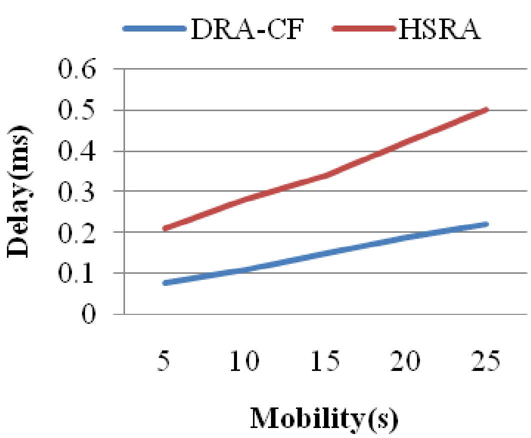

Fig. 5: Mobility vs. delay

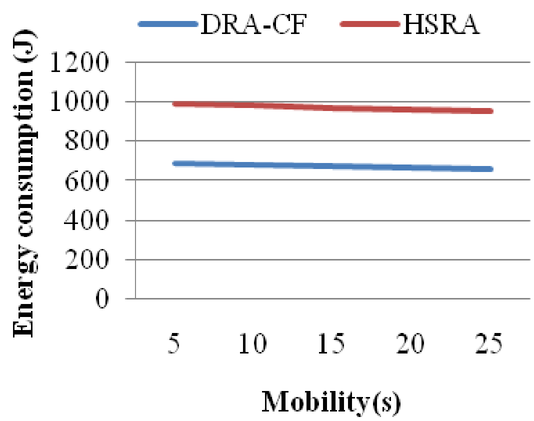

Fig. 6: Mobility vs. energy consumption

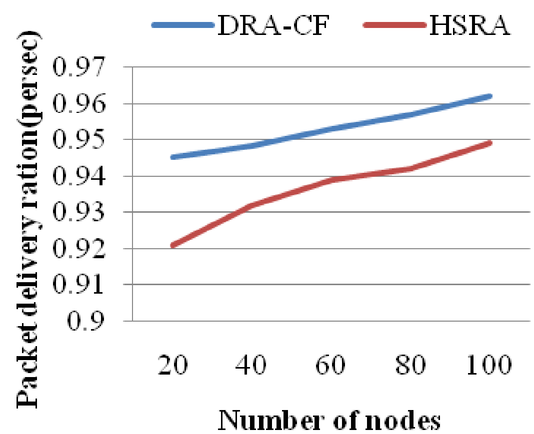

Fig. 7: Number of nodes vs. packet delivery ratio

the results of energy consumption between HSRA and DRA-CF which clearly demonstrate energy consumed by DRA-CF is comparatively lesser than HSRA.

Figure 4, illustrates the overhead achieved by DRA-CF is lower than the overhead of HSRA with respective to the data packets.

Figure 5 shows graphical comparison analysis between mobility vs. delay. It is clearly observed from the results that the proposed DRA-CF approach has less delay when compared with the HSRA scheme.

Figure 6 shows the energy consumption of DRA-CF by varying the mobility from 10-50. The results clearly show the energy consumption of DRA-CF is lower than HSRA.

Figure 7 shows the packet delivery ratio of DRA-CF. PDR is given by successful delivery of data packets to the destination when compared with data sent by the other senders. PDR means improved performance of the protocol. Packet delivery ratio root delay when no. of intermediate nodes is discovered and queue in data transmission. The packet delivery ratio of DRA-CF is higher compared to HSRA.

CONCLUSION

A MANET is an autonomous system where mobile nodes operate in isolation without centralized management. This study, demonstrates handling of selfish nodes with clustering information with replica allocation effectively in the MANET. The inefficient data accessibility in MANET due to selfish replica allocation motivates the fundamental notion for the proposed system. With the cluster formation and behavior of the selfish nodes, the selfish node detection was included in the work. The proposed work also concentrates on determination of energy consumption, node mobility determination and data replication with balance to the data availability, energy and query delay. The performance of the proposed DRA-CF approach is observed to be efficient with minimal delay, overhead and energy consumption compared with the existing HSRA method by varying node mobility and number of nodes in the network. Future scope of this work is to taken into account both Data updates and different node moving patterns.

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