Replica Placement In Unstable Radio Links

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Abstract

The growth in wireless communication technologies has immensely gained a lot of attention in ad-hoc networks especially in the area of mobile hosts. As the network topology in this type of ad-hoc networks changes dynamically, chances of network getting disconnected is also very frequent due to unstable radio links for shorter time intervals. In this paper, we proposed a succinct solution for the problem replica allocation in a mobile ad-hoc network by exploring group mobility. The solution for this problem is carried out in three phases. Thus, with this solution even if the hosts get disconnected we can replicate the data items on to mobile hosts so that the mobile hosts can still access the data. Several experiments are conducted to evaluate the performance of the proposed scheme. The experimental results show that the proposed scheme is able to not only obtain higher data accessibility but also produce lower network traffic than prior schemes.

Keywords: Ad hoc network, Replication, Radio links, Transfer cost

1. INTRODUCTION

An ad hoc network is an autonomous system of mobile nodes/routers (and associated hosts) connected [1] by wireless links. Ad hoc or short live network is a collection [2] of autonomous wireless mobile hosts or routers communicating with each other dynamically and freely forming a multi-hop, fully self-organized, temporary meshed network with no human intervention and with no existing pre-established fixed communication infrastructure. The nodes in ad hoc wireless networks are free to move [3] independently in any direction. The network topology may change randomly at unpredictable times and primarily bidirectional links. These networks have lower bandwidth capacity and shorter transmission [4] range than fixed infrastructure networks. The throughput of wireless communication is lesser than wired communication because of the effect of the multiple access, fading, noise, and interference conditions.

In an ad hoc network every mobile host acts as a router and maintains [5] its neighbor hosts in a routing table. If one host enters into another hosts range then the routing tables of those hosts are updated with each other details. If one of the hosts in the networks, expect data from the another host which is in the same network, there is no need to communicate directly with their radio range, data is still forwarded to the destination mobile host by relaying transmission through other mobile hosts which exist between the two mobile hosts.

Mobile hosts are continuously moving [6] from one place to another place in the same network, and then there exist frequent disconnections among the mobile hosts due to unstable radio links. Some connections get lost and some new connections are establishing among mobile hosts. Due to these frequent disconnections by unstable radio links, it's difficult to access the data from the source node. Since one cannot control network disconnections, an alternative solution to this problem is to replicate data onto mobile hosts so that when disconnections by unstable radio links occur, mobile hosts can still access data.

Several reports have been proposed on caching [7] data onto mobile hosts. In these reports a network has been assumed in which mobile hosts are frequently moved and get disconnected with neighbor mobile hosts due to unstable radio links.

2. RELATED WORK

Previously different strategies for caching data contents in mobile computing environments have also been proposed [8,9,10,15,16,17]. Most of these strategies assume an environment where mobile hosts accesses contents at sites in a fixed network, and cache data on the mobile hosts because wireless communication is more costly than wired communication. Such strategies address the issue of keeping consistency between original data and its replicas or caches with low communication costs. They are considered to be similar to our approach, because both approaches replicate data on mobile hosts. However, these strategies assume only one-hop wireless communication, and thus, they are completely different from our approach that assumes multi hop ad hoc communication.

Another closely related research topic is of push-based information systems in which a server repeatedly broadcasts data to clients using a broadband channel. Several caching strategies have been proposed to improve user access [11, 12]. In these strategies, clients are typically mobile hosts, and the cache replacement is determined based on several parameters such as the access frequency from each mobile host to each data item, the broadcast frequency of each data item, and the time remaining until each item is broadcast next. However, comparing the strategies for caching or replicating, both approaches are completely different because the strategies in push-based information systems do not assume that the clients cooperatively share cached data in ad hoc networks.

In another research topic, a mathematical model for data object replication in ad hoc networks is formulated. This model, proposed a game theoretical technique in which players (mobile hosts) continuously compete in a non-cooperative environment to improve data accessibility by replicating data objects. This is very closely related work to our mechanism, because in this research, an ad hoc network has been considered, where mobile hosts are moving continuously, network suffers from frequent disconnections. For this problem a solution has been found by replicating data items on neighbor mobile hosts. In general the mobile hosts would experience reduced access latencies provided that data is replicated within their close proximity. However, this is applicable in cases when only read accesses are considered. If updates of the contents are also under focus, then the locations of the replicas have to be 1) in close proximity to the mobile hosts, and 2) in close proximity to the primary (assuming a "master" replication environment [13]) copy. Therefore, efficient and effective replication schemas strongly depend on how many replicas to be placed in the system, and more importantly where [14]. This topic is different from our approach, because we consider an ad hoc network where mobile hosts are moving continuously and suffers from short time disconnections due to unstable radio links.

3. METHODOLOGY

3.1 Modules

The proposed work has been segmented in to three phases. The first phase describes how the hosts are entered into the network and how an adjacent matrix is computed. The second phase establishes the communication between hosts. The third phase will explain about reading and updating access of data items among mobile hosts in an Ad Hoc network where hosts are continuously moving within the network and disconnections occur due to unstable radio links which are likely to be disconnected after a short time.

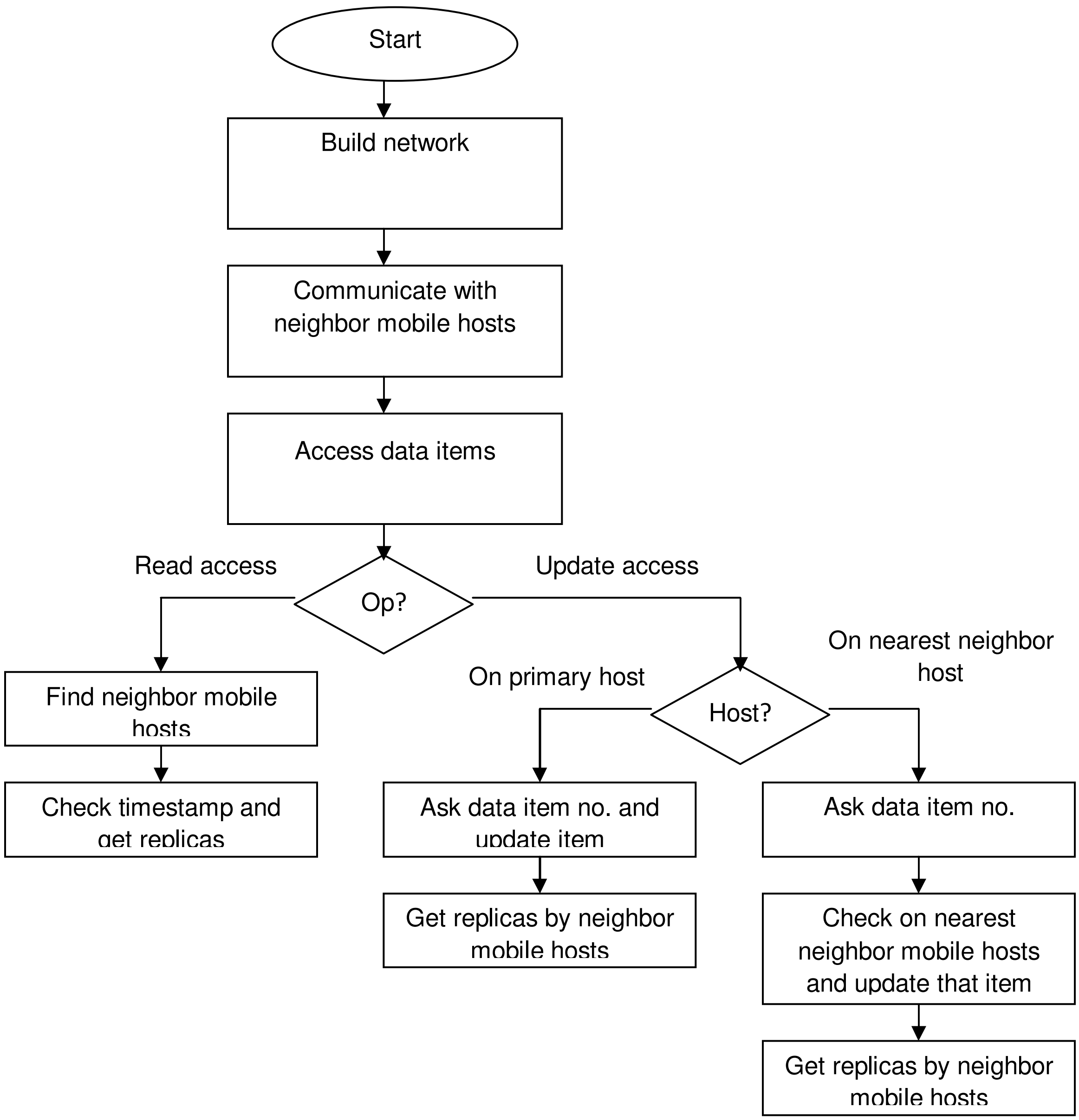

FIGURE 1: Flow chart to access data items.

Figure 1 represents the flow chart for performing operations on data objects through modules namely Build Network, Communication, Reading and Updating Data items.

The functionality of the proposed modules is described in below sections.

3.1.1 Build network

In the first phase a system is proposed by considering an ad hoc network where a new host enters into the network with its respective radio range. Let ‘r’ be the transmission range or radio range of the mobile node. By the host’s radio range(r), one host is connected with another host which is in the host range and those are said to be neighbors to each others. Every host maintain two lists, one list is for data items, to which the host is primary host and second list for replicas, which data items have replicas on the host. The storage capacity of the host is greater than the total size of the replicas maintained on the mobile host. We maintain a matrix in which 1 represents neighbor mobile hosts to each other and 0 represents those hosts are not in their radio range(r). Using this matrix we can know which mobile hosts are neighbors to which mobile host. The matrix is termed as adjacent matrix where rows and columns represent mobile hosts in the Ad hoc network which is considered in the proposed system. The format of the adjacency matrix is represented in **FIGURE 6**.

3.1.2 Communication

In the second phase, a communication between the mobile hosts has been established. As considered network is ad hoc network the mobile hosts tend to move dynamically by its nature. Due to this a short time disconnections occur in the network then existing connections may be lost and new connections may be established or no other connections are established. Every time when mobile host moved from one place to another it checks the neighbor mobile hosts in its radio range(r), if there are same hosts exist in the radio range(r) then establish a connection and read data items from the neighbor mobile hosts. It also checks if it has already replica of that data items, then check the data item whether it is modified or not, if it was modified, then update that data items replica in its replica list.

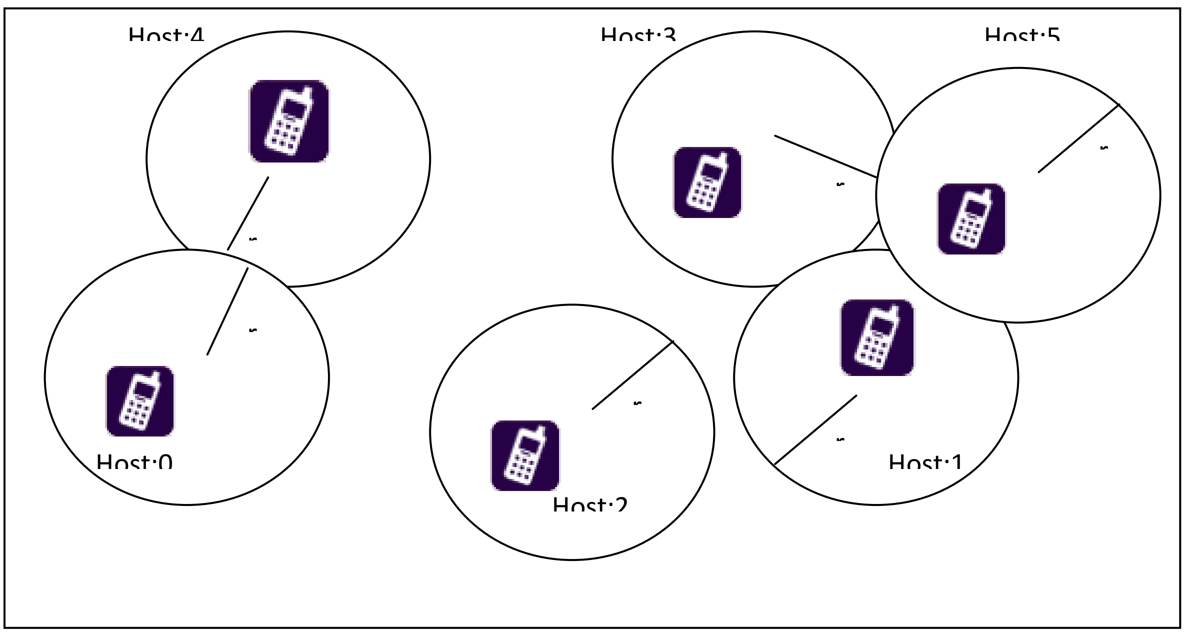

FIGURE 2: Communication of hosts in a Mobile Ad hoc network.

In figure 2 hosts 1,3,5 are neighbor mobile hosts which communicate each other and can exchange replicas, same as in hosts 4,6 replica exchange can take place, but host 2 was been isolated.

3.1.3 Reading and Updating Data items

In the third phase, reading and updating data items are considered. While transmitting the data items in non-replication systems, the data items temporarily stored in intermediate mobile host's buffer and forwarded to receiver's host. As most of the radio links are unstable, disconnections may occur and leads to loss of data.

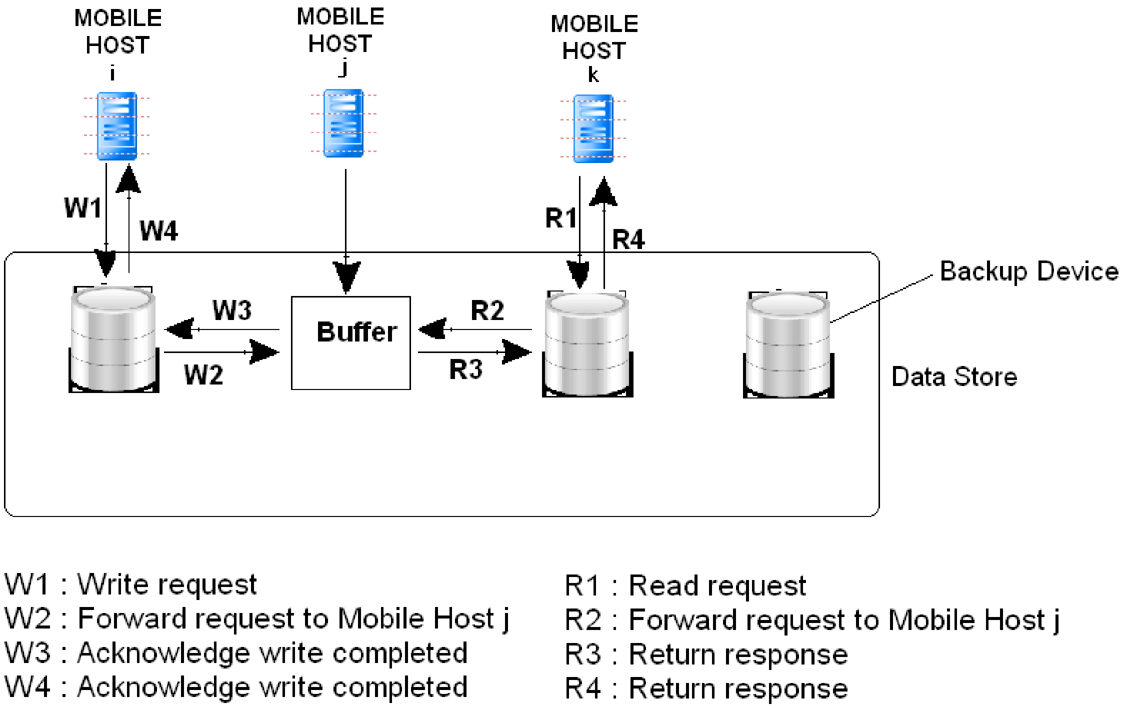

FIGURE 3: System that do not support Replication.

Figure 3 represents the phenomena of communicating data items from mobile host (i) to the mobile host (k) through the mobile host (j), where host(j) acts as a server host.

To rectify this problem, a mechanism, which stores the replica of data item in the intermediate mobile hosts. When reading data items as shown in figure 4, initially the client's checks its replica list itself. If replica item in the server mobile host is not presented in the client mobile host then the client host reads the replica of the data item from the server mobile host and adds this data item replica to the replica list maintained in the client mobile host.

If the replica of one data item is available in the server mobile host then client mobile host compares with the timestamp of the replicated data item in the server mobile host. If the timestamp of the replicated item in the server mobile host is previous than that of the client mobile host then client ignores the read access, otherwise client modifies replica item in the replicas list of client mobile host by reading the data item replica from the server mobile host.
Updating is considered, when the client mobile host(k) is neighbor to server mobile host(j) which must be a primary copy of the data item, which is to be updated. Then in this case, the server mobile host asks for new data to update.
Every time, when the mobile host moved from one place to another, it first checks the data items replicated on the neighbor hosts and then reads data items from the neighbor hosts. If update takes place on nearest neighbor then it performs three functions. First, it asks for data item number to be modified and verify which mobile host has that data item number's primary copy. Second, update that data item in the master host of that item and set the new time stamp to that

data item and then send replica of the newly updated data item to the neighbor hosts. No other nearest neighbor has the data item number's primary copy then it can't be updatable.

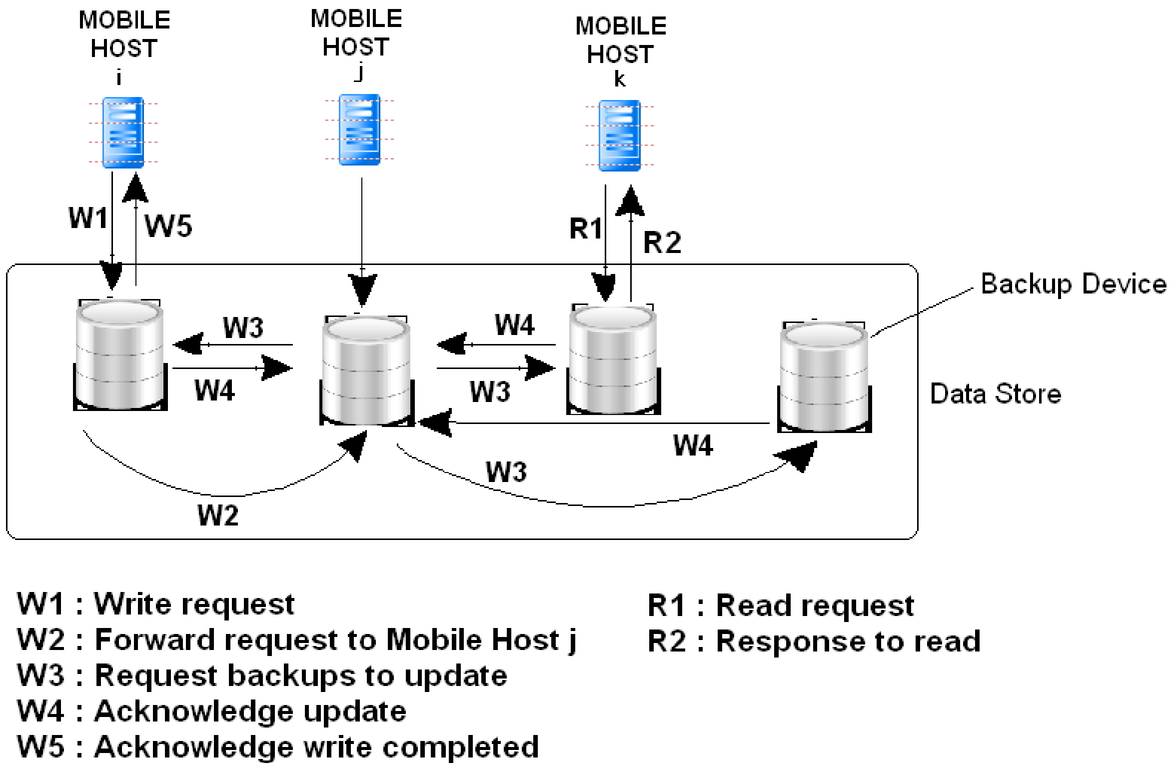

FIGURE 4: System that support Replication.

Figure 4 represents the same phenomena as of Figure 3 with additional request and response backup service to update the data.

Proposed Algorithm for Updating Data Items:

```
Initialization:
ItemsList,ReplicaList;
Curitem=null;itemidx=0;repidx=0;itemno=null;
UPDATEITEM()
get(item_no);
//update on primary host
        For each itemidx<items.size do
                Curitem=items.get(itemidex);
               If(itemno==curitem.itemno)
                        get(newdata_to_update);
                        set(newdata);
                        set(timestamp);
                End if
                break;
        end for
//update on closest neighbour host
        For each repidex<replica.size do
               Curitem=replica.get(repidx)
              If(itemno==curitem.itemno)
```

```
                If(validNbr(curitem.primaryhost)
                    get(newdata_to_update);
                    set(newdata);
                    set(timestamp);
             end if
            break;
        end for
```

Description of Algorithm

In this algorithm a data item can be updated only at two locations. The two locations can be update on primary host and update on nearest neighbor. On every mobile host in the network two lists are maintained. The first list consists of list of data items that have their size less than the total available storage on that mobile host. The second list consists of replicas list those are replicated on the mobile. An itemno is provided as input to update the data item and then its checks the data items list. If the item number is presented in the list, it is asks for new data and update the item number with new data and it gives a new timestamp to the updated data item. As shown in the algorithm.

To update on nearest neighbor a check is performed on the replica items list. If the item number is in the replica list then it checks for the data item primary host whether it is neighbor or not. If not that gives error message, otherwise it asks for new data item to update. The new data item updated, gives timestamp to the updated data item. After the completing update access, neighbor hosts gets replica of the updated data item.

Monitoring cost

Considering an Ad Hoc network in which m mobile hosts are moving continuously and disconnections occur due to unstable radio links. Every mobile host has its own storage capacity. When two mobile hosts communicate with each other then they give a positive number associates a communication cost c(i,j) where i, j are mobile hosts id's. when the upstream and downstream bandwidths are equal then c(i,j)=c(j,i). Let there be n data objects, and r and u ate the read and update accesses respectively. When a mobile host M^i initiates a read request for a data object, the request is redirected to the nearest neighbor NN_k^i mobile host that holds either the original or the replica of the data object. $NN_k^i = M^i$ if and only if M^i is a replicator or the primary mobile host of the data item.

We are interested in minimizing the total Network Transfer Cost (NTC) due to data object read and update access.

Let R_k^i represents the total NTC, due to M^is' reading request for data object O_k, addressed to the nearest neighbor host NN_k^i.

This cost is given by the following equation.

$$R_k^i = r_k^i o_k c(i, NN_k^i) , \tag{1}$$

The second component of NTC is the cost arising due to the updates. Let U_k^i be the total NTC, due to P_ks' updates requests for object O_k.

$$U_k^i = u_k^i o_k \sum_{\forall i \in R_k} c(P_k, i) . \tag{2}$$

The overall cost is denoted as below

$$C_{overall} = \sum_{i=1}^{m} \sum_{k=1}^{n} (R_k^i + U_k^i) . \quad (3)$$

4. RESULTS AND DISCUSSIONS

In an ad hoc network the hosts continuously move with build dynamic topologies. Figure 5 shows the network model at a particular time instance of how seven hosts are connected.

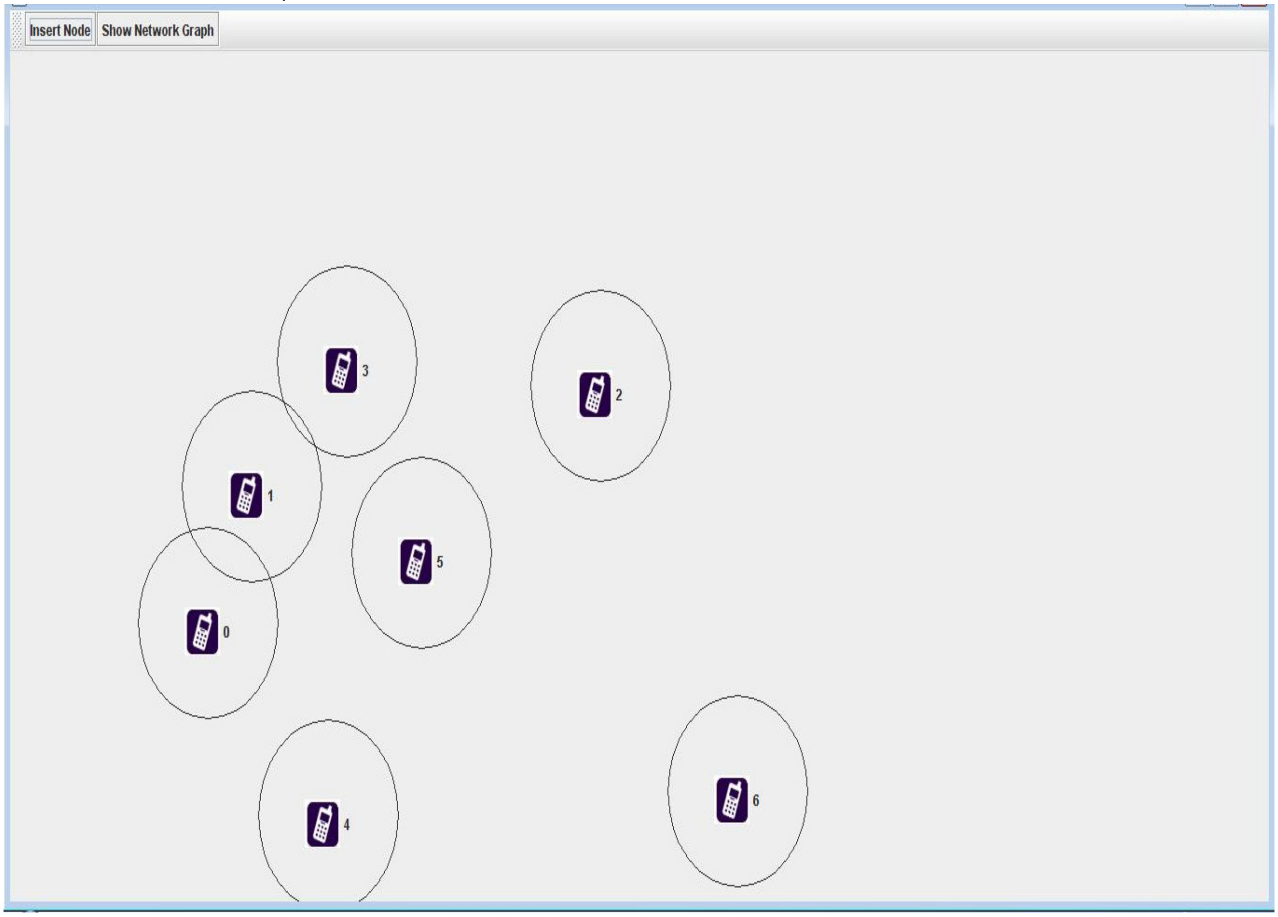

FIGURE 5: Sample Ad hoc network with seven hosts.

For the Figure 5 the adjacency matrix at a particular time instant is shown in Figure 6.

Adjecency Matrix:

0	1	0	0	0	0	0
1	0	0	1	0	0	0
0	0	0	0	0	0	0
0	1	0	0	0	0	0
0	0	0	0	0	0	0
0	0	0	0	0	0	0
0	0	0	0	0	0	0

FIGURE 6: Adjacency matrix for the sample ad hoc network.

Adjacency matrix in the Figure 6 represents which are neighbor to each other, ‘1’ represents connection between the hosts and ‘0’ represents

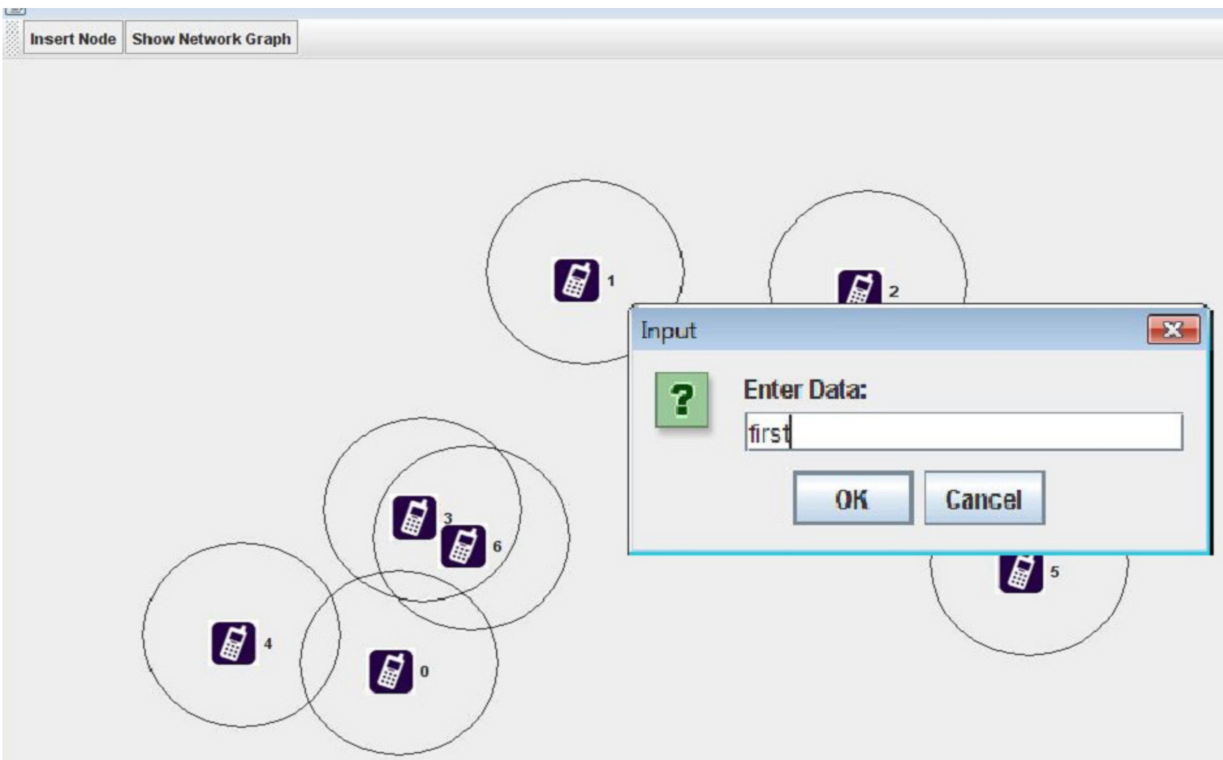

FIGURE 7: Entering data on the host.

Figure 7 show the data item to enter, when data item entered it added to the data items list in the corresponding host and neighbor hosts get replicas from that host.

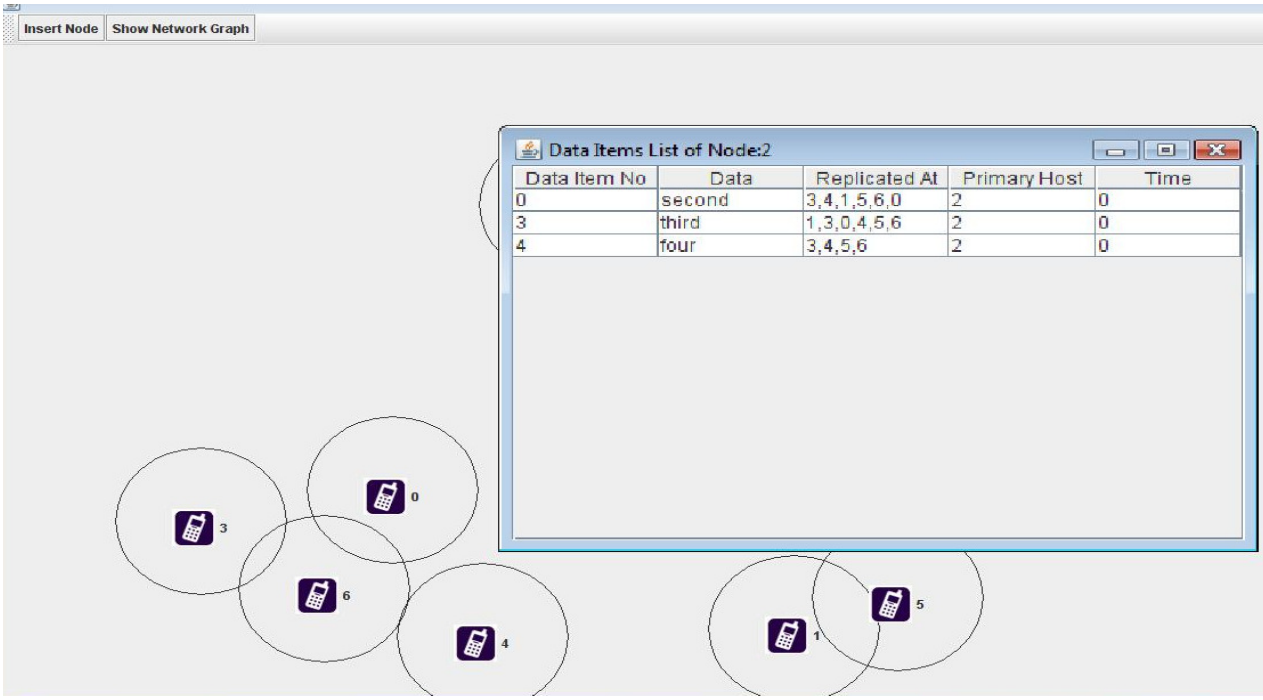

FIGURE 8: Primary data items on host 2.

Figure 8 shows the primary data items on host 2 and the replica of primary data items of host 2 are on other hosts are shown in Figure 9.

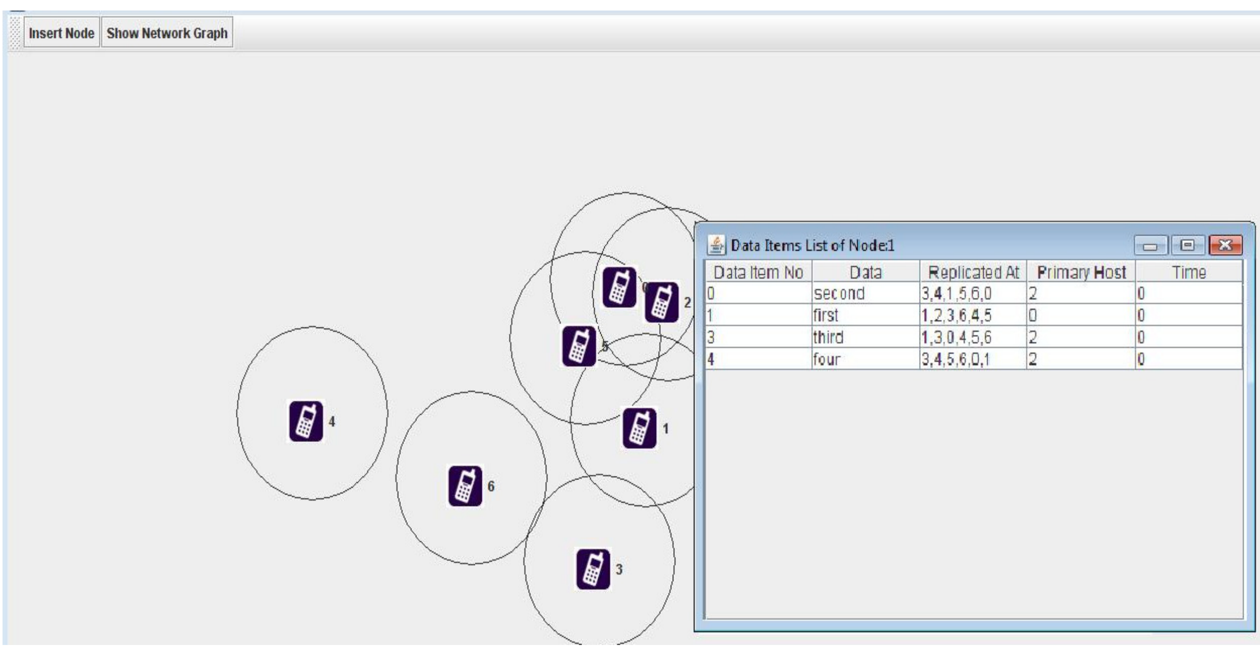

FIGURE 9: Replicas of data items.

Replicas of data items of host 2 on host 1 is shown in Figure 9

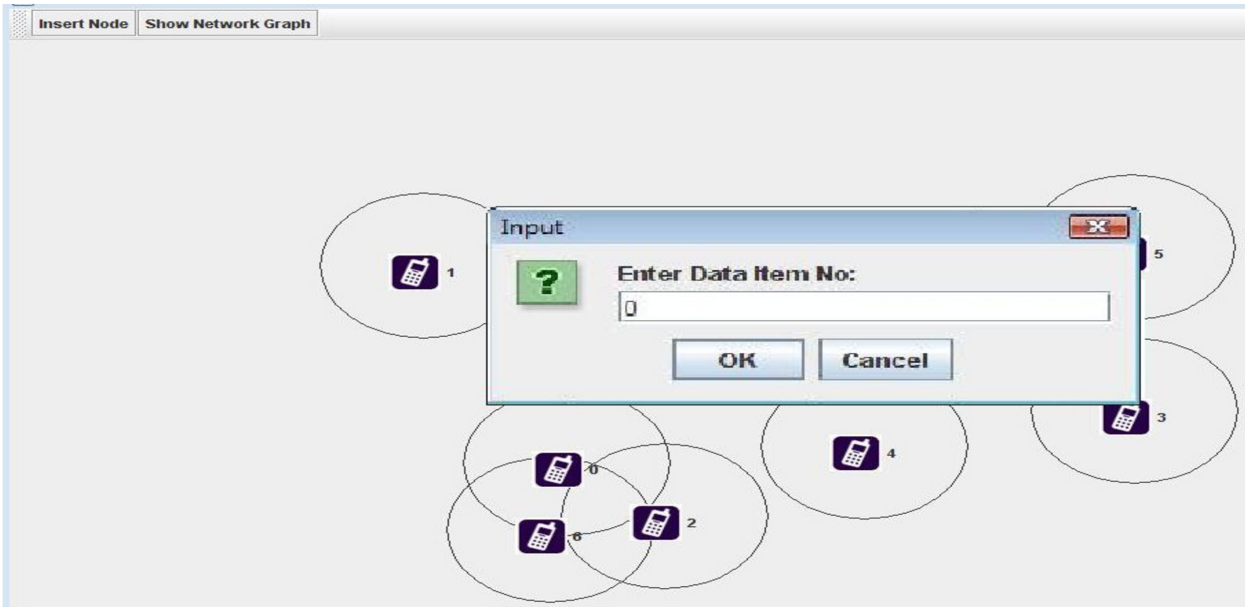

FIGURE 10: Enter data item number to update

Figure 10 explains the way the data item number entered to be updated on a particular host. In background the data item number verified that whether the entered data item number exists in the corresponding host data items list.

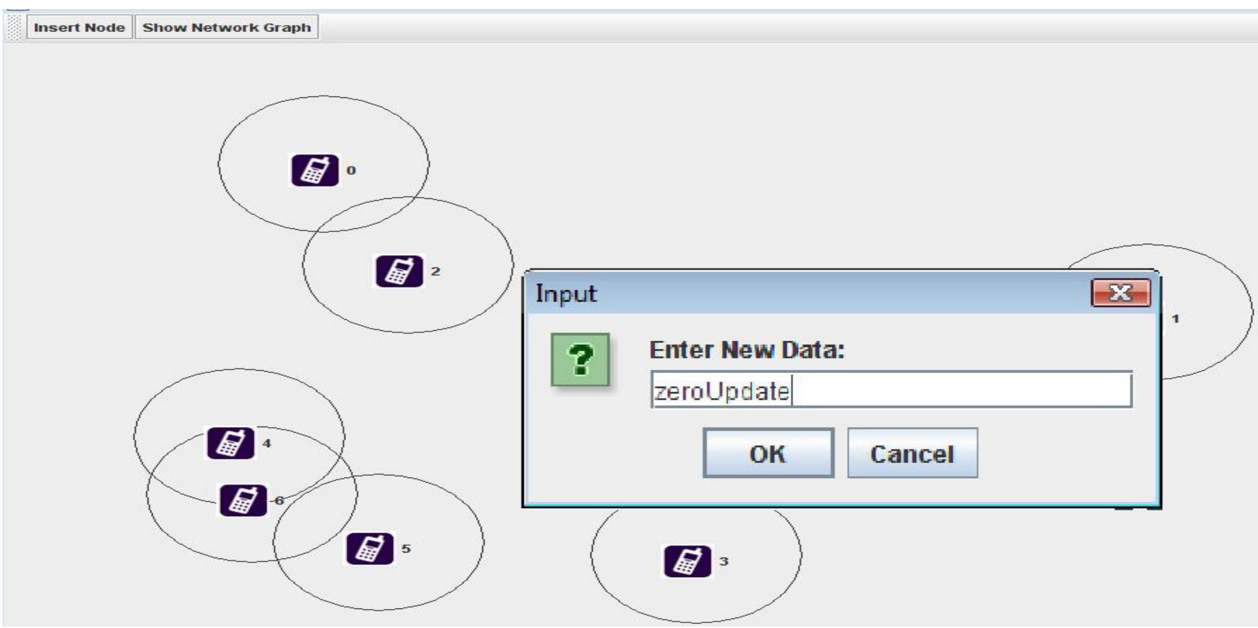

FIGURE 11: Updating data item on host

Figure 11 shows entering of new data in place of existing data into the data items list of particular host and the time stamp also updated.

4. CONCLUSION

The proposed replica allocation mechanism in ad hoc networks is a protocol for automatic replication and migration of objects in response to demand changes. In this paper, we have discussed replica allocation in ad hoc networks to improve data accessibility where mobile hosts frequently disconnected due to unstable radio links. We first provide solution for ad hoc replication problem. Later in this paper we designed an algorithm to update a data item in two ways, one way is to update on primary host and another way is to update on nearest neighbor. We also consider minimum network transfer cost due to data items movement. We can say that the cost incurred in reading and updating the data items depends primarily on the objects size, access frequency of the mobile hosts on the data items and the cost associated with the channel between the communicating hosts. This has to be proved through simulations. The derived mechanism is general, flexible and adaptable to cater for various applications in ad hoc networks. This approach is efficient in both execution time and solution quality.

In addition, the replica allocation algorithms in our proposed methods can be modified to apply them in a much larger scale network because they require message exchanges among all connected mobile hosts and relocate replicas.

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