A CONTENT DRIVEN DATA PROPAGATION PROTOCOL FOR MSN IN DISCONNECTED MANETS

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Abstract: Recently various architectures for Mobile Social Networks (MSNs) have been proposed. In MSNs users can participate in communication with other users based on their respective interest profiles with the idea of sharing documents that are of interest to a particular user. Typically users subscribe to a social networking service and look for other users with similar interest profiles. However connectivity may not always be available for sharing data. In this paper we propose a protocol for MSN implementation in a disconnected Mobile Ad Hoc Network environment for sharing data. Message delivery in disconnected Mobile Ad Hoc networks (MANETs) is difficult since the network graph is rarely connected. Our proposed protocol exploits the store, carry and forward capability of a disconnected MANET. Results from simulations and implementation show that this approach efficiently disseminates data while minimizing use of resources in the network.

1 INTRODUCTION

Recently great interest is being shown in Mobile Social Networks (MSN) (Ziv, 2006). In a social network, users can communicate with each other without prior personal knowledge. Cellular phones have become a popular choice for social networking with the help of Email, Short messaging or by subscribing to a social networking service provider. Typical user of a Social Network would have a personal public profile advertised on the network including information such as personal interests, photos, videos etc. Any user with common interests would subscribe to share in the social environment. Traditional Social Networks have been implemented in a client / server environment, however Mobile Social Networks provide challenges in mobility, range and security.

Recent implementations of MSNs from popular Social network sites such as facebook and myspace rely on Email and short messaging service on the client's device. To search for a friend in the social network a user needs to subscribe to the service and query the database for users with common interest. This communication with the server causes congestion in the network and may not provide optimal search results. Instead a peer to peer implementation would be effective in congestion control and would provide additional functionality of mobility to the users where the users would be able to communicate while on the go. This would provide users to directly communicate instead of subscribing to the service provider or paying for short text messages and hence may be able to share rich media content. A very effective network topology would be to use Mobile Ad Hoc Networks (MANET) where the nodes have the freedom of mobility. A node may store data and forward it when it is required only, thus forming disconnected clusters of participating nodes.

In this paper we present a protocol for providing content based communication in a disconnected MANET. In a MANET several devices can communicate to each other using short range wireless transmission (Masoudifar**,** 2009). A wireless device can forward data for other devices not in radio-range by creating multi-hop routes. Further, devices can be mobile in any direction and can stay connected as long as they are in range of a neighboring node in the network. Mobility of nodes allows the topology of the network to be dynamic therefore creating a group of devices in range but disconnected from another group. This leads to challenges in routing for nodes that may get disconnected, are in suspend mode or have moved out of the range. Figure 1 illustrates an example of a disconnected network. n_i represent nodes in the

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MANET where two groups have been formed. The nodes n5, n6 and n7 are adjacent and in range of each other (overlapping circles) therefore a connection is ensured. Neighboring nodes create a group as long as they are in range and end to end connectivity is guaranteed. Nodes n1, n2, n3 and n4 were connected as long as the multi hop path (from n1 to n4) was available until n3 was disconnected / suspended (dotted circle). Whenever any node in the multi hop route is made unavailable end to end connectivity may not be guaranteed resulting in disconnected groups. In the figure 1, n4 is shown to be isolated from the rest of the group following n3's unavailability; for n4 to join the group a new one hop route needs to be established. Both of these groups may join and form one group if nodes would physically move closer and come within the transmission range.

In our design we assume that the MSN users posses devices that are capable of data storage and transmission over a Bluetooth or Wi-Fi medium (ad hoc mode). Any such device with the ability to store data and forward when needed can form a delay tolerant network (Jain, 2004). In a delay tolerant network it is possible for a message to reach the destination if circumstances permit after a prolonged period of time. For instance in figure 1, if n1 needs to send a message to n4 while n4 is isolated, it cannot be done while n3 is unavailable and no routing information from n1 to n4 is present. In this case n1 would transmit the message to n2 that would be stored for later forwarding. If n3 becomes available and a route is established, n2 would take the opportunity to send this message to n4, while n3 would serve as intermediate routing node. A delay tolerant network provides a means of communication even if no existing end to end connectivity is possible.

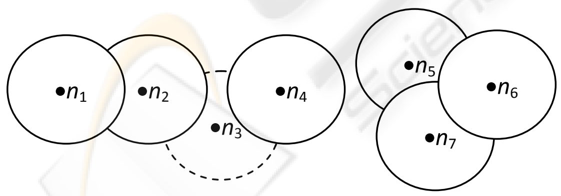

Figure 1: Illustration of a disconnected MANET.

The rest of the paper is presented as follows, Section 2 details design for content sharing in the proposed system, section 3 details proposed protocol, section 4 presents simulation, results and evaluation followed by conclusions in section 5.

2 CONTENT SHARING IN MSN

In a typical social network, users subscribe to the service by making a public profile. A profile is designed to introduce a person to other members of the network announcing personal information, interests, location and a list of documents to share. If a user makes a search, his personal interests are matched in a database and query results are returned. The user may choose to select from a number of interested users and send an "invite". The invited user receives the invitation message, if interested he responds and the two users become friends. Friends can show their documents publicly and may even share them. A user announces his documents to a friend, if the friend is interested he can request a document. Papers (Eagle, 2006), (Lugano, 2007) and (Raento, 2005) discuss implementation of various forms of a social network.

Typically three factors are essential to successful data sharing in a social network, Interest Profiles, Document Lists and Document Repository.

Interest Profiles. Each user maintains a list of keywords describing his interests. These keywords are used for searching and indexing purposes. An interest profile can be detailed and may even contain both text as well as graphics data and therefore it can take increasing amount of storage allocation. However for the proposed protocol we assume that an interest profile would be a collection of keywords only and therefore would take minimal amount of storage.

Document List. Is a list of documents stored at a host. A document list consists of certain attributes of documents stored in the repository. These attributes include but are not limited to a Unique Identifier for the document, Document size, Document type, ownership and a Timestamp. Each document stored in the document repository has this information.

A Unique identifier uniquely identifies a document, we assume the standard file name format suffice i.e. (filename.extension). Document size is mentioned in bytes. Document type could be categories of documents such as image, video, text or object etc. Ownership is the MAC address of a device. A Timestamp is the date and time for the document creation and indicates when the document was last updated. A list of documents is announced whenever two users with similar interests decide to share. We therefore intend to decrease the size of the document list since it would be broadcast to other users of the network; we assume that it must not increase by 200 bytes.

Document Repository. Each node maintains a document repository for documents to be shared. Since there is no limit to the number of documents stored in a host we therefore set no limits on the size of the repository.

3 PROTOCOL DESIGN

We propose a content driven protocol where nodes in an Ad Hoc network share data only if they are interested, i.e. a node would send or receive messages, store data and forward the message only if it is interested and hence routes would be established in opportunistic manner with nodes having similar interests. Routes can be established to distant nodes if they also show interest, provided that a relaying node is able to forward message in a multi-hop manner. This however requires the essential storage capability at each node for storing messages as transient messages for later transmission to the intended destination. The proposed protocol relies on broadcast transmission for announcement and point to point unicast transmission for destination oriented messages. Broadcast transmissions are also used for single hop transmission sending messages to neighboring nodes depending on the number of requests received for a particular message.

To make our model simple we follow a three step process for all transmissions. Each node n_i periodically broadcasts a *announce*(n_i) message containing interest profile of the user. Neighboring nodes n_j and n_k receive this announcement and process the interest profile. If willing n_j sends an *invite*(n_i) message to n_i including document list of n_j. n_i responds with its own *invite*(n_j) including list of documents for n_i. Both nodes would parse document list and may tag documents to be shared. For a document with a unique identifier to be requested by n_i a *request*(n_j, doc-id1, …) is made upon which n_j would *send*(doc-id1, …) the required document as shown in figure 2. These three transmissions are detailed as follows.

Announcing Interest Profile. In a neighborhood of nodes announcements for personal interests are made. A host n_i periodically broadcasts *announce*(n_i) including its interest profile. Adjacent nodes receiving this announcement match their own interest profile keywords, if the receiving host is interested, it sends an *invite*() invitation to the announcer. Consequently, if the receiving host is not interested in the interest profile, it simply ignores the announcement.

Inviting Interested Host. When an announcement from n_i reaches a node n_j, it compares the interests in the users interest profile. If any of the keywords match, the receiving host n_j may be interested in starting a conversation. It therefore creates a *invite*(n_i) message to be unicast to the originating node n_i. This *invite*() contains a documents list including document attributes such as a Unique Identifier for the document, Document size, Document type, ownership and a Timestamp. We assume the size of the *invite*() may not exceed 300 bytes thus keeping the payload of transmission to minimal.

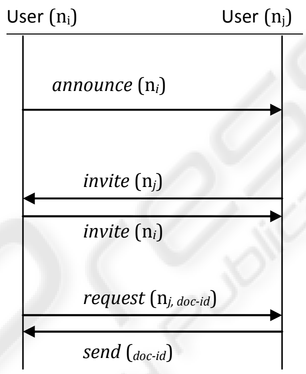

Figure 2: Transmission between hosts n_i and n_j.

When the originating node n_i receives the invite message from n_j, it may send its own invite to n_j describing a list of n_i's documents. When both nodes receive each other's invite messages they can process the documents list to search for an interesting document to share. If there exists such a document, it can be tagged for sharing among these two nodes. Any tagged document may be sent if requested.

Requesting, Sending and Storing Documents. Nodes that had a chance to look at the document lists of each other can request or send documents. As described earlier a document-list contains attributes for each document stored in a node's repository. These attributes include a Unique Identifier for the document, document size, document type, ownership and a Timestamp.

If the node n_i requires a document doc-1 that is available in repository of node n_j it would send a *request*(n_j, doc-1) message to n_j. To process the request n_j would proceed by forwarding the document doc-1 to the requesting node by embedding the document in the *send*(doc-1) message. This send message is forwarded in a unicast mode intended only for the requesting node n_i. When a document is received, it has to be stored in the nodes repository and the documents list is updated. It is possible that many adjacent nodes would request same documents. In this case a unicast message needs to be sent to all requesters. This however would greatly decrease the performance due to overhead of repeatedly sending the same message. As a solution to this problem we suggest maintaining a list of adjacent nodes at all times. If a simple majority of hosts request same documents we send a broadcast message to all instead of individual unicast messages.

As with the case of ad Hoc networks a new or returning node can enter the range of n1 and start communication. If a node n_k enters the moment n_1 sent the broadcast, n_k would receive a copy of the document, which can be saved in the repository of n_k. Our experimentation shows an interesting effect on performance of this phenomenon, nonetheless we show that broadcasting a document requested by multiple hosts is in fact better than sending multiple unicast messages to each requesting host.

4 SIMULATION AND ANALYSIS

The proposed protocol in section 3 has been implemented in Java and interfaced with MADHOC (Hogie) simulation tool. We run a number of 15,000 iteration / seconds, simulations to study the various conditions of the protocol based on many parameters. These parameters are discussed as follows.

We assume that each user is equipped with a laptop device or a Wi-Fi enabled PDA device. Each device has a Omni directional transmission range of 100m. There are 100 users in a 1000m x 1000m environment. This environment consists of various spots with a random size no larger than 100m x 100m. These spots can be considered as shops or other buildings. The transmission range is reduced to 40 m when inside a spot due to various factors. The users move between spots using a random waypoint model, where a user may pause for a random time, decide a target destination spot then start moving towards that spot. For the mobility model, we assume the user moves with a speed of 3 m/s when not in a spot and 2 m/s when inside the spot area; amount of mobility within the spot is set to 60% and outside is 40%. User may pause for up to 2 minutes to look for a destination.

In our experiments we define 32 different interest profiles. Each user in the MSN would have to select four distinct interests. We match user's interests for a possibility of communication. Each user has various documents of different types including images, videos and audios. We assume that no document is larger than 512Kb. Each user can also create a document every 10 seconds in the simulation. Since we assumed that the Users Repository is limited therefore we place a bound on the size of the repository and leave it to 10MB maximum in the host. Each host broadcasts an announce message every 15 seconds, we assume this delay because at pedestrian speeds 15 seconds is generally considered as an adequate time for MANETs (Haillot, 2008). Each node announces four interests in its profile, any neighbor with at least one of the similar interests, sends invite to share documents. At a certain time if the repository is filled and no further documents can be stored, the node in question would remove the least recently used document to make space for a newer document.

To evaluate the proposed protocol in section 3 we compare its performance with a modified version of the same protocol. In the modified version of the protocol, every host requests for every possible document from a neighbor with no limits to numbers of documents being shared, thus being a greedy host. The consequence of the greedy host protocol would be that each host requests and stores documents it may not be interested in, but these documents can be forwarded later to other interested hosts.

In Figure 3, a comparison is shown between the numbers of documents received by both protocols. On average it can be seen that the proposed protocol has received more documents as compared to the greedy version. The number of documents created is clearly more than the documents received by either protocol. It can be seen that our protocol receives documents at a rate almost similar to the rate of document creation. However the greedy protocol is less efficient in this regard. In the beginning of the simulation the rate for documents received by either protocol is much lower, the reason could be that it takes time for documents to disseminate in the network.

Another aspect to be noted is that the number of documents received by the greedy protocol is higher than the proposed protocol in the beginning of the simulation, i.e upto 3000 sec in this scenario; Since greedy protocol enthusiastically searches and stores more documents regardless of relativity to the interests, for that reason it is able to obtain more documents. However since there is a limited space available in each repository the space quickly fills up in the beginning of the simulation. When there is no space to store a newer document, the node looks for the least recently used document and removes it from the repository. This technique for making more space obviously has a disadvantage of removing some documents before these are even shared on the network.

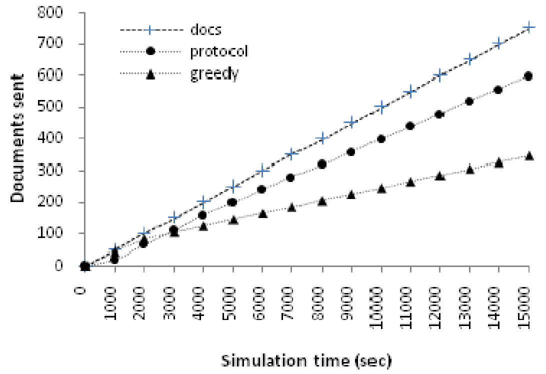

Figure 3: Number of documents received against sent for both protocols.

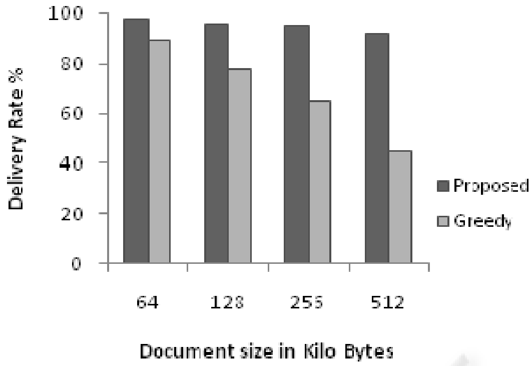

Figure 4: Comparison of Delivery Rate for both protocols.

The proposed protocol is more efficient in receiving documents compared to the greedy approach. In the above simulation each host created a document every 10 seconds on the average. From simulation time 3000 sec onwards the rate of documents sent by a host was 6.1 documents per second on the average. However the greedy approach had a much higher rate at 159.2 documents per second. The huge difference in the rates of documents sent reflects the huge amount of traffic in the network created by the greedy approach. On the other hand the rate for documents received for the proposed protocol was 6.0 documents per second compared to only 2.2 documents per second for the greedy approach. Therefore the document delivery ratio for the proposed protocol is 98.2% compared to only 46.6% in the greedy approach.

Figure 4 shows the comparison of delivery rates for both protocols based on document size. We limit the size of document to 64, 128, 256 and 512 Kilo bytes. It can be seen, with all document size the delivery rate is much higher, i.e more than 92% for the proposed protocol, but is lower for the greedy approach. The size of documents affects the delivery rate for documents using the greedy version of the protocol.

5 CONCLUSIONS

Users of Mobile Social Networks share data only if they are interested, therefore there was a need to create a content driven communication protocol for MANETs. In this paper we proposed a simple protocol for data sharing in disconnected MANETs. Our protocol is light weight and does not rely on costly methods for constructing and maintaining complex routes, (Khelil, 2005), (Leguay, 2006). The ability of a node in MANET to store, carry and forward documents has been fully exploited. We use this ability of nodes replicating users to announce their interest profiles, documents and share them. A Node therefore successfully announces its documents stored in repository and shares them with other users. Documents thus stored are carried to other locations and are shared with other users having similar interest profiles. Simulation shows that our protocol is effective in propagating documents between senders and interested receivers thus successfully disseminating and forwarding messages in multi-hop connections in the network. In the current version of the protocol we fixed the threshold for broadcasting documents to near neighbors. In future we hope to show the effects of individual nodes decisions for broadcasting documents, limitless repository and document size.

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