An Efficient Routing Protocol based on Data Posting in an Opportunistic Network

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Abstract — Recently, an Opportunistic network is evolved from a mobile ad hoc network. In an opportunistic network, the mobility and resource constraints of mobile nodes lead to network partitioning or performance degradation. Several forwarding schemes are proposed to forward with less traffic and delay. However, these schemes utilize too much private information to get high performance, or creates too much traffic because schemes are based on flooding. In this paper, we propose efficient routing scheme based on novel concept, data posting. In our scheme, data is posted to location, not a node to make higher probability to forward a data. Consequently, the proposed routing protocol achieves low traffic with increasing some delay. Extensive simulation results demonstrate that the proposed scheme reduce the traffic up to 98% and delay increases up to 2.5 times higher than prophet, which is traditional forwarding scheme in opportunistic network.

Keywords—contact duration; opportunistic network; communication cost; data posting; self-centered contact graph

I. INTRODUCTION

Recently, an opportunistic network (OPPNET) has emerged as the most interesting evolution of a mobile ad hoc network (MANET) [1, 2, 3]. As a MANET, an OPPNET is a peer-to-peer multi-hop mobile wireless network that has neither a fixed infrastructure nor a central server. However, unlike a MANET, an OPPNET does not assume the existence of a complete path between two nodes wishing to communicate, source and destination node. In an OPPNET, it is not mandatory to have prior knowledge about the network topology. The nodes may be never connected at the same time through a multihop path. Nevertheless, an OPPNET enables message exchanges between them even in presence of prolonged disconnection. To this end, mobility of nodes is seen as a resource to bridge disconnections, rather than a problem to deal with. If a node is connected with another node which has high probability to deliver a data item to the final destination, the node forwards the data item. In the opposite case, the node stores and carries the data item.

A large variety of OPPNET applications have been developed [4, 5]. In all the above applications, data forwarding is the most compelling challenge because of the absence of prior knowledge about the network topology. The efficient data forwarding is a complicate or impossible task in an OPPNET because the traditional routing paradigm, in which the entire routes are determined before routing based on network topology, is not adequate anymore. Consequently, instead of routing research, a considerable amount of research has recently been proposed for an efficient data forwarding in an OPPNET [6, 7, 8].

To forward data to appropriate users, so far, traditional research focuses on the probability of contacts. For example, when a source node get in contact with the other node, if the other node has higher probability to contact with the destination node than the source node, the source node forwards the data to the other node. The above procedure is repeated until the destination node receives the data. In the research, the major research issue is how to estimate the probability to contact with the destination node. To this end, the traditional research utilizes context. Especially, the research focuses on a collection of information that describes the reality in which the user lives such as the name, the address, the institution, and the hobbies of users, and the history of social relationship among users. Although the traditional forwarding schemes forward data efficiently than the flooding-based schemes or epidemic approaches, the utilization of the context information may lead to serious security and privacy problems. Moreover, when the context information is not available, the forwarding schemes may not be efficient enough.

In this paper, we introduce a new paradigm to forward (or route) a data in an OPPNET. Our new paradigm is motivated by the mail delivery process in the real world. Let us consider the case where a person sends a mail. Once the envelope of the mail is sealed, the mail is put in the mailbox and then the mail carrier picks it up and carries it to the destination. If the mail reaches its destination, it gets to the right end-user mailbox. In this simple situation, we focus on the role of the mailbox. When a person sends and receives a mail, the person does not contact the corresponding addressee or the addresser because it is the time-consuming and/or costly work. Instead of contacting, a person utilizes the mailbox generally. With this situation in mind, we device a novel concept called data posting. In the traditional data forwarding paradigm in an OPPNET, the data should be moved to the destination node. However, the moving is the time-consuming and/or costly processing because each node cannot know the location of the addressee. Under our data posting paradigm, a node may not forward a data to deliver the data to the
destination. Instead of forwarding, a node posts the data to some place and the data stays at the place. When the destination node passes by the place, the node can receive the data.

Fig. 1(a) illustrates the problems of existing data forwarding scheme in an OPPNET. In this fig, \( N_1, N_2, \ldots, N_6 \) and corresponding dotted arrows denote nodes and their trajectories respectively. For a simplicity, we assume that the communication range of each node is very narrow in this example. Consequently, each node can communicate with others only within gray-colored circles. For example, \( N_1 \) and \( N_2 \) can communicate with each other within the region, \( R_1 \), if the nodes are placed in the region at the same time. We denote the regions as \( R_1, R_2, \ldots, R_7 \).

Let us consider the case where \( N_1 \) wants to send a data, \( D_1 \), to \( N_6 \). In this case, the traditional forwarding schemes utilize controlled flooding first. Data is flooded with limited Time-To-Live (TTL) and is forwarded to the destination node. Although the controlled flooding schemes are an effective way to forward data to destination node, the schemes lead to tremendous communication traffic. For example, the data exchange occurs within every gray-colored circles in Fig. 1. To reduce the communication traffic, several schemes utilize context information. However, the schemes have a critical privacy problem.

Fig. 1(b) shows the other case where \( N_1 \) wants to send a data, \( D_1 \), to \( N_2 \). In this case, \( N_1 \) and \( N_2 \) can communicate within the gray-colored circle but the nodes are not placed in the circle at the same time. Although \( N_1 \) and \( N_2 \) pass by the circle, the opportunistic communication cannot be occurred in this case. Consequently, \( N_1 \) cannot forward \( D_1 \) to \( N_2 \).

If nodes has postboxes and data can be put in the boxes like Fig. 2, the aforementioned problems can be solved. Let us imagine an ideal case where \( N_1 \) sends a data, \( D_1 \), to \( N_6 \). \( N_1 \) carries data, \( D_1 \), and puts it in the postbox, \( P_1 \). \( N_2 \) picks up \( D_1 \) and carries it and then \( N_2 \) puts it in the \( P_2 \). Lastly, \( N_6 \) picks up \( D_1 \). If data can be forwarded like the ideal case, the communication traffic and forwarding time will be degraded significantly. Moreover, if we can use the post boxes, we can make routing path. Generally, in an OPPNET, a sender cannot make a routing path because the forwarding is done opportunistic and each node cannot have the topological information. However, under the data posting paradigm, the routing path can be established. The mailboxes can be used as intermediate destinations. Although the data posting which utilizes postboxes is an efficient way to forward data in an OPPNET, we still have many problems to realize the data posting. The remainder of this paper presents about that.

The technical contributions of this paper can be summarized as follows.

- **Introducing a new paradigm data posting:** We introduce a new paradigm ‘data posting’. The core of the data posting is that data waits a destination without vagabonding to find the destination.

- **Proposing algorithms to realize data posting:** We devise a concept of a posting zone in which data items stay and then we propose a routing protocol which is based on the data posting.

- **Proposing self-centered contact graph:** We also propose a self-centered contact (SCC) graph. The SCC-graph is inspired by human social relationship. In stead of building social relationship between each mobile nodes, a node builds relationship among the nodes that are members of a community and communities. Consequently, a node can reduce the cost for maintaining entire social relationship.

- **Verifying the proposed routing scheme:** We demonstrate the efficiency of our protocol in terms of communication cost.

The remainder of this paper is organized as follows. In Section 2, related works are discussed. System model is introduced in Section 3. In Section 4, proposed method is described. Section 5 evaluates the performance of our strategy. Conclusions are presented in Section 6.
II. RELATED WORKS

A. Routing Protocols In an OPPNET

So far, many routing protocols have been proposed for an OPPNET. Most of these protocols can be divided into three categories: 1) message-ferry-based, 2) opportunity-based and 3) prediction-based [9]. In message-ferry-based methods, systems usually employ extra mobile nodes as ferries for message delivery [10, 11, 12, 13]. However, controlling these nodes leads to extra cost and overhead. In opportunity-based schemes, nodes forward messages randomly hop by hop with the expectation of eventual delivery, but with no guarantees [14, 15]. Generally, messages are exchanged only when two nodes meet at the same place, and multiple copies of the same message are flooded in the network to increase the chance of delivery.

Some routing protocols make relay selection by estimating metrics relative to successful delivery, such as delivery probability or expected delay based on a history of observations [16, 17, 18, 19, 20]. All of the current routing methods share a similar paradigm, the store and forward fashion. If there is no connection available at a particular time, a mobile node can store and carry the data until it encounters other nodes. When the node has such a forwarding opportunity, all encountered nodes could be the candidates to relay the data. Thus, relaying selection and forwarding decision need to be made by the current node based on certain routing strategy.

Various routing approaches adopt different strategies based on different metrics. Example of such metrics include estimated delivery probability to the destination node, network resources available (including bandwidth, storage, and energy), estimated delay, and current network congestion level. However, the unpredictable mobility and restricted resource in an OPPNET significantly obstruct us from designing an ideal forwarding mechanism.

Lately, the consideration of social characteristics provides a new angle of view in the design of OPPNET routing protocols. In most of the OPPNET applications (e.g. vehicular networks [21, 22], mobile social networks [23, 24, 25, 26] disease epidemic spread monitoring and pocket switched networks (PSNs) [27]), a multitude of mobile devices are used and carried by people, whose behaviors are better described by social models. This opens new possibilities of social-based OPPNET routing, in which the knowledge of social characteristics are used to make better forwarding decision in OPPNET routing. Notice that social relations and behaviors among mobile users are usually long-term characteristics and less volatile than node mobility. Based on this observation and taking the recent advances in social network analysis, several social-based OPPNET routing methods [28, 29, 30] have been proposed recently to exploit various social characteristics in OPPNET (such as community and centrality) to assist the relay selections.

B. Social Properties Research In an OPPNET

Many social properties have been recently studied in an OPPNET. The social properties are used for enhancing an effectiveness of forwarding data. So far, generally, the following five properties are used importantly in the traditional OPPNET routing protocols: 1) social graph, 2) community, 3) centrality, 4) similarity and 5) friendship.

Building social graph is the most popular way to represent social relationship between mobile nodes. A social graph offers a natural, compact representation of the resulting contact set over time. A graph link means that two nodes see each other frequently because they have a social connection, or because they are frequently in the same place without actually knowing each other. Social graph have been widely used in many applications, such as analysis of on-line social network [31, 32]. Most of the current social-based OPPNET routing protocols directly treat the aggregated contact graph that means merged graphs of several time slots into one graph. In this paper, we also utilize the social graph when a node determines routing path. Different from the traditional social graph, our contact graph is maintained by each node in a fully distributed manner. Moreover, our contact graph includes only the members of own community and other communities. The detail members of other communities do not include in our contact graph.

Community is an important concept in ecology and sociology [33, 34]. In ecology, a community is an assemblage of two or more populations of different species occupying the same geographical area. In sociology, community is usually defined as a group of interacting people living in a common location. It has been shown that a member of a given community is more likely to interact with another member of the same community than with a randomly chosen member of the population [35]. Therefore, communities naturally reflect social relationship among people. Since wireless devices are usually carried by people, it is natural to extend the concept of social community into an OPPNET to explore interactions among wireless devices.

In graph theory and network analysis, centrality is a quantitative measure of the topological importance of a vertex within the graph. A central node, typically, has a stronger capability of connecting other nodes in the graph. In a social graph, the centrality of a node describes the social importance of its represented person in the social network. In an OPPNET, the sociological centrality metrics can also be used for the selection of the representative node [36, 37].

Similarity is a measurement of the degree of separation [38]. It can be measured by the number of common neighbors between individuals in social networks. Sociologists have long known that there is a higher probability of two people being acquainted if they have one or more other acquaintances in common. In a network, the probability of two nodes being connected by a link is higher when they have a common neighbor. When the neighbors of nodes are unlikely to be in contact with each other, diffusion can be expected to take longer than when the similarity is high (with more common neighbors). In addition, there are other ways to define the similarity beyond common neighbors, such as similarity on user interests [39] and similarity on user locations [40].

Friendship is another concept in sociology which describes close personal relationships. In an OPPNET,
friendship can be defined between a pair of nodes. On the one hand, to be considered as friends of each other, two nodes need to have long-lasting and regular contacts. On the other hand, friends usually share more common interests as in real world. In sociology, it has been shown that individuals often befriend others who have similar interests, perform similar actions and frequently meet with each other [41]. This observation is called homophily phenomenon. Therefore, the friendship in an OPPNET can be roughly determined by using either contact history between two nodes or common interests/contents claimed by two nodes.

III. SYSTEM MODEL

So far, much research deals with an OPPNET as an interesting evolutions of a classic MANET. Therefore, our system is based on the system in a MANET. We assume that each node has limited local memory space and acts as a data provider of several data items and a data consumer. Fig. 3 shows an simple example of our system model. There are \( m \) nodes, \( N_1, N_2, \ldots , N_m \) and no central server. Any node freely joins and organizes an OPPNET. We model a contact between mobile nodes in an OPPNET in an weighted undirected graph \( G = (N, L) \) that consists of a finite set of nodes, \( N \), and a finite set of communication links, \( L \), where each element is a tuple \((N_1, N_2)\) of nodes in the network. Fore more details, we make the following assumptions.

- Each node in an OPPNET has a unique identifier. All nodes that are placed in an OPPNET are denoted by \( N = \{N_1, N_2, \ldots , N_m\} \), where \( m \) is the total number of nodes.

- All node joins at least one community. Each community has a unique identifier. All communities are denoted by \( C = \{C_1, C_2, \ldots , C_l\} \), where \( l \) is the total number of communities. The member nodes in a community move frequently within a specific zone which are denoted by \( Z = \{Z_1, Z_2, \ldots , Z_l\} \), where \( l \) is the total number of communities. A community has a specific zone.

- All data items are of equal size, and each data item is held by a particular node as its original node. Each data item has a unique identifier, and the set of all data items is denoted by \( D = \{D_1, D_2, \ldots , D_n\} \), where \( n \) is the total number of data items.

- Each node \( N_i \) \((1 \leq i \leq m)\) has limited memory space for data items. The size of the memory space is \( S_i \). Each node can hold only \( C \) data, where \( 1 \leq C \leq n \), data items in its memory space. Data items are not updated.

- Each node \( N_i \) \((1 \leq i \leq m)\) has its own access frequency to data item \( D_j \in D \) \((1 \leq j \leq n)\). The access frequency does not change.

- Each node moves freely within the maximum velocity.

IV. PROPOSED SCHEME

A. Overview of the Proposed Scheme

Our scheme consists of two parts, the preprocessing part and the routing protocol part. As a preprocessing, a node determines its own posting zone and builds its self-centered contact (SCC) graph. The zone and the graph are used for data-posting based routing protocol. In the routing protocol part, a node routes data items or messages based on data posting paradigm. In the routing protocol, data items are not forwarded to the destination, but wait the destination at the place visited by the destination node frequently. By using the data posting paradigm, we expect that the communication traffic will reduce dramatically.

B. Determination of Posting Zone

People typically keep a routine of visiting the same places every day such as going to an office and a home. If a person spends much time at a home or an office, other people will be able to meet the person frequently at the home or the office. We take inspiration from the social phenomenon to determine an effective place of a posting zone. In our determination scheme, each node determines its own posting zone and announces the determined places to its community members connected opportunistically.

Fig. 4 shows an example for our determination scheme. In this example, the circles (i.e., dotted circles and bold circles) means communication ranges of a node \( N_i \) and \( R_i \) means that the communication range of the node at time \( t \). The circles of the communication range are calculated by \( N_i \) utilizing its locations which are measured periodically during a day. As we can see in the fig, \( N_i \) measures its location sixteen times during a day. To determine the posting zone, a node should do this process as a preprocessing.

1 Using the measured communication range, \( N_i \) can determine its posting zone. For example, let us assume that \( N_i \) determines two posting zones. First, \( N_i \) selects coincided circles and then makes sets of the coincided circles and then \( N_i \) determines two sets which have more circles than others. In this example, two sets are \( \{R_{i4}, R_{i5}, R_{i6}, R_{i5}\} \) and \( \{R_{i4}, R_{i5}, R_{i6}\} \). From the sets, \( N_i \) extracts two circles which are the first element (i.e., \( R_i \) and \( R_0 \)) and the last element (i.e., \( R_{i4} \) and \( R_{i6} \)) of the sets. After

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1 The processing may be omitted, if a node determines its posting zone as its home area and/or offices area. For the generality, we introduce the procedure to determine the posting zone.
extracting the elements (e.g., $R_4$ and $R_5$), $N_I$ draws the minimum rectangle which includes the elements (e.g., $R_4$ and $R_5$) like the rectangles in Fig. 4. The rectangles will be the posting zone of $N_I$.

If any circles are not coincided, $N_I$ measures the distance between the centers of two consecutive circles and then the measures distance will be used to determine a set instead of the number of coincided circles. The circles which provide more shorter distance will be selected preferentially. Algorithm 1 describes how to determine the posting zone.

![Fig. 4. An example for our determination scheme](image)

C. Building SCC-graph

The data posting based routing protocol is based on the self-centered contact (SCC) graph which is inspired by human social relationship management in the real world, where each person makes his/her own relationship forming a web and manages the relationship by himself/herself. The person does not have to discuss these with others to maintain his/her relationship. The decision is solely at his/her discretion.

A contact graph is the most popular way to obtain the interactions among people in an opportunistic network, where the contact means that two nodes are within transmission range of each other. A contact graph is a kind of a social graph which represents the social relations among people. Since the objective of the SCC-graph is to help to decide the intermediate destination (i.e., posting zone) for forwarding a data item to the final destination, our SCC-graph is much different from the traditional contact graph. In the traditional social graph, the graph consists of mobile nodes and the contact links between the nodes. However, SCC-graph consists of mobile nodes and communities, and the contact links between the mobile nodes and/or the communities.

In our scheme, a node checks its neighbor nodes periodically and then if the node finds new node, the node checks whether the new node is the member of its community or not. If the new node is the member of its community, the node exchanges its SCC-graph and the graphs of other node. Consequently, the nodes in the same community exchange their SCC-graph with each other. Using the information, A node appends the visited communities in its SCC-graph. For example, in Fig. 5(a), Let $N_i$, ..., $N_3$ are in the same community and $N_6$, ..., $N_8$ are in the other community. If $N_2$ visits other community, $N_2$ appends the community ID and the number of visiting into its SCC-graph. Note that the meaning of the visit is same as the contact in this paper. Since a node may not know the region of other community, if a node contacts the node of other community at out of its community region, the node consider that the node visits other community.

Fig. 5(b) shows an example of building the SCC-graph in a perspective of $N_i$ using Fig. 3. For a simplicity, we assume that all nodes except $N_i$ have built their entire SCC-graph in this example. First, $N_i$ adds itself into its own SCC-graph. When $N_i$ can communicate with $N_2$, $N_i$ appends $N_2$ into its SCC-graph. At that time, $N_i$ can know that $N_2$ has visited $C_2$ two times. Since $N_i$ has not visited $C_2$, $N_i$ appends $C_2$ into its SCC-graph and makes a link between $N_2$ and $C_2$. The link is weighted by $N_i$’s the number of visiting (or contact).

D. Proposed Routing Protocol

Our routing protocol is based on the data posting. Therefore, the determination of the post boxes is the most important processing in our protocol. When a node wants to send a data item to a specific destination, the node determines the tentative destination utilizing the SCC-graph. For example, in Fig. 5(b), if $N_i$ wants to send a data item to the node in $C_2$, $N_i$ first determines $N_2$ as the first tentative destination because $N_2$ visits $C_2$ more frequently than $N_3$.

Our protocol consists of three steps as described in Fig. 6. At the first step, the sender, $N_i$ in Fig. 6, selects relay node to deliver other community. In Fig. 6, $N_i$ will be selected to be a relay node to deliver a data item to $C_2$. Then, $N_i$’s posting zone would be selected to the tentative destination. In the second step, the node carries the data item to deliver other community. Since the node may not contact nodes in other communities, the selection of the carrying node should be done carefully. In the last step, the carrying node forwards the data item to the node of other community. When received node knows the final destination, the data item will be forwarded to the posting zone of the final destination. If the carrying node does not know the final destination, the data item will be broadcast within the community.

The main objective of our routing protocol is to reduce tremendous communication traffic which is caused by the traditional routing protocol in an OPPNET because the large communication traffic is one of the most serious problem in a wireless environment. We believe that the communication traffic problem should be solved to implement OPPNET applications in a real world. Each step of forwarding is described more detailed as below.

1) Forwarding to the intermediate node

In our routing protocol, Node should send a data to specific node which is selected for carrying a data to specific community. It is selected by using SCC-graph. Let’s assume that community 1 consists of $N_1$, ..., $N_3$, and community 2 consists of $N_6$, ..., $N_8$. When $N_1$ want to send a data to $N_6$, $N_1$ has to select a node who will carry a data to community 2. Because $N_1$ has higher probability to meet community 2 than
$N_i$ or $N_2$, $N_3$ will be selected to intermediate node by SCC-graph.

If $N_i$ knows the community where $N_0$ belongs to, $N_i$ just send a data to community 2. But, if $N_i$ doesn’t know the community of $N_0$, $N_i$ has to send a data to all the possible communities it $N_i$ knows. It could create some more communication cost, but after communicate each other at once, They could know each other’s community.

After select the intermediate node, node sends a data to intermediate node’s posting zone. existence of possible path to go to a zone is not a necessary. All the passed by node can be used to forward a data. a node who is going to posting zone’s direction, or whose location is more closer than the node will be a carrier to send a data to posting zone.

After data arrives to posting zone, data waits until intermediate node arrives to posting zone, and carry the data. If node who holds a data is going to go away from posting zone, the node passes the data to other node who stays posting zone or is going to posting zone. Using this way, data can wait a intermediate node without extra node for posting zone.

2) \textit{Forwarding to other community}

Intermediate node has to hold a data and carry it to destination community. Only a waiting to meet specific community’s node could make appropriate delay, but it could be acceptable because an OPPNET has delay tolerant characteristic. If intermediate node meets the node whose community is destination community, node passes the data to that node.

3) \textit{Forwarding to destination node}

When node who is in destination community receives the data, that node confirms either destination node is in its community. Destination node may not exist in its community if source node sends a data to every community because the node doesn’t have knowledge about destination node’s community. If destination node doesn’t exist in its community, node drops the data. But, when destination node exists in its community, node sends a data to destination node’s posting zone. This processing is equal to forwarding a data to intermediate node’s posting zone.

\textbf{Algorithm 1} \textbf{Pseudo code to determine the posting zone}

\begin{verbatim}
00: /*When a node $N_i$ determines k posting zones*/
01: determine()
02:  records its location during a specific period;
03:  draws circles using the measured locations;
04:  if (the number of coincided circles != 0) {
05:    makes set of the coincided circles;
06:    if (k <= the number of set) {
07:      selects the first and last elements;
08:      draw the minimum rectangle;
09:    }
10:  else if (k > the number of set > 0 ) {
11:    selects the first and last elements;
12:    draw the minimum rectangle;
13:    calculate the distance between two consecutive circles;
14:    selects the smallest one;
15:    draw the minimum rectangle;
16:  }
17:  else {
18:    calculate the distance between two consecutive circles;
19:    selects the smallest one;
20:    draw the minimum rectangle;
21:  }
22: }
\end{verbatim}

V. SIMULATION RESULTS

A. Simulation Environment

For the experiments, we use the Network Simulator NS-2 [42]. In our simulation, we use the HCMM moving pattern [43], which is moving pattern for an opportunistic network. HCMM is a moving pattern that applies three characteristics of human mobility. It is a socially-based spatial property with preference for popular locations and short distances. The size of map is $450m \times 450m$, which consists of 9 cells. We also assume that there are four communities, and each community is organized by 20 mobile nodes. Communities are located in every corner of the map. The velocity of the each node varies from 2 to 10m/s. After a node reaches a destination in a different community, 70% of node goes back to its home cell, and 30% of node stays in there. Size of posting zone is set to $50m \times 50m$. Each node has memory space to store 10 messages. Warming time of node is setted to 1000sec. After warming time, each node makes a single message to destination node. Destination node is selected randomly. After creating the message, 4000sec is provided to forwarding messages. For a proposed scheme, we test two ways; unicast, and broadcast. In unicast, we assume that every node knows destination nodes’ community. Therefore, only a single copy of item for a community is generated. In broadcast, we consider that destination nodes’ community is not known to each node. Therefore, data must be transferred to multiple communities to find destination node. We compare our
scheme with prhophet, and simulation result is average result of 3 times simulation.

B. Experiment Result

Fig. 7 shows the experimental result. In simulation, both proposed scheme and prophet achieve 100% message transfer rate in the simulation. In Fig. 7(a), Traffic of our scheme is 98% less than prophet. It is because, prophet is flooding-like scheme. Due to flooding’s characteristics, duplicated data is created again and again. It can be duplicated to one node many times because prophet uses FIFO queue to manage memory. Other reason our scheme can create less traffic is, no traffic exists after reaching the message to destination. Because no duplicated message exists, after reaching the destination node, unnecessary traffic would not be created. Interesting thing is that, our scheme with knowledge of destination community and without knowledge doesn’t have many traffic difference. It is because, Sending a intermediate node doesn’t make very much traffic, and from intermediate node to destination community makes no traffic.

Fig. 7(b) shows the average delay from sending a message to receiving the message. Our scheme’s delay is twice to 2.5 times longer than prophet. It is acceptable, because prophet has many duplicated messages, so much more chance exists to meet the destination node. Interestingly, our scheme without destination community information’s delay was 20% less than scheme with destination community information. It is because there are cahne that destination node meets the node who is carrying the message to wrong communities.

VI. CONCLUSION

In contrast to the traditional routing viewpoint, our data posting based routing scheme does not try to forward data items to the destination node. Our work was motivated by the procedure of the mail delivery in a real world. In a real world, when a post man delivers a mail to a person, the post man does not find the person and finds the postbox of the person because the person moves but postbox does not. That is an efficient way to deliver a mail. We applied the procedure from a real world to deliver a data item. To realize our idea, we devise two concept, posting zone and SCC-graph. The posting zone is an area that are visited frequently by a specific node, and the SCC-graph is the graph representing relationship between community members and other community. Extensive simulation shows that the proposed protocol outperform existing representative routing protocols in terms of communication traffic.

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