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Efficient Routing Scheme for Opportunistic Networks

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ABSTRACT

In the last few years research activity in Opportunistic Networks (OppNets) is growing and researchers have proposed various types of routing protocols. Context information is the main building block for design of these types of networks. This information is not always available which makes the design of efficient routing protocols is difficult. When context information is not available context-oblivious routing protocols are only way to enable communication between users otherwise Context- based protocols is used when context information is available.

In this paper we propose an efficient hybrid routing protocol that is able to use context data as soon as it becomes available and falls back to context-oblivious routing when context information is not available. Simulation results show that the proposed routing protocol is able to provide a better results in term of message delivery probability and message delay when context information about users is available or not.

Keywords: *hybrid routing; opportunistic networks; new routing protocol.*

1. INTRODUCTION

OppNets [1] are created out of mobile devices, without relying on any preexisting network topology. Opportunistic networks consider disconnections, mobility, partitions, etc. as norms instead of the exceptions. In these networks mobility is used as a technique to provide communication between disconnected groups of nodes, rather than a drawback to be solved.

In opportunistic networking a complete path between two nodes wishing to communicate is unavailable [2]. Opportunistic networking tries to solve this problem by removing the assumption of physical end-to-end connectivity and allows such nodes to exchange messages. By using the store-carry-and-forward paradigm [3] intermediate nodes store messages when there is no forwarding opportunity towards the destination, and exploit any future contact opportunity with other mobile devices to bring the messages closer and closer to the destination.

Therefore routing is one of the most compelling challenges. The design of efficient routing protocols for opportunistic networks is generally a difficult task due to the absence of knowledge about the network topology. Routing performance depends on knowledge about the expected topology of the network [4]. Unfortunately, this kind of information is not always available. Context information is a key piece of knowledge to design efficient routing protocols. Context information represents users working address and institution, the probability of meeting with other users or visiting particular places. We can classify the main routing protocols on the bases of the amount of context information of users they exploit into:

- Context-oblivious protocols.
- Context-aware protocols.

Context-oblivious routing protocols such as Epidemic Routing Protocol [5] are only solution when context information about users is not available. But they generate high overhead, network congestion and may suffer high contention. Context-based routing such as PRoPHET [6] provides an effective congestion control mechanism. Context-oblivious routing, provides acceptable QoS with lower overhead. It is able to automatically learn the past communication opportunities determined by users movement patterns and exploit them efficiently in future. This autonomic, self-learning feature is completely absent in Context-oblivious routing schemes. But context based routing protocols provide high overhead, message delay and less success full message in absence of context information about users. We have proved this by implementing epidemic and PROPHET routing protocols in presence and absence of context information. We found that the epidemic routing is better in absence of context information while PROPHET gives better result in presence of context information. Therefore, our proposed routing combine feature of these both protocols into a single routing protocol, which will perform better in both cases when context information about user is available or not.

The remainder of this paper is organized as follows Section 2 presents the related work. In section 3 our proposed scheme is described. In section 4 the simulation setup is given for routing protocols. Simulation results of our proposed routing protocol can be found in section 5. Section 6 discusses conclusion and looks into future work.

2. RELATED WORK

In this Section we are only mentioning some specific routings, which are representative of both context oblivious and context based routing protocols in opportunistic networks. A brief discussion on routing protocols for opportunistic networks in [7].

Context oblivious based algorithms also include network-coding-based routing [8]. In general, network coding-based routing reduces flooding, as it is able to deliver the same amount of information with fewer messages injected into the network [9].

Spray and Wait [10] routing provides a drastic way to reducing the overhead of Epidemic. Message is delivered in two steps: the spray phase and the wait phase. During the spray phase, source node and first receivers of the message spread multiple copies of the same message over the network. Then, in the wait phase each relay node stores its copy and eventually delivers it to the destination when it comes within reach.

Frequency of meetings between nodes and frequency of visits to specific physical places is used by MV [11] and MaxProp [12] as context information.

Mobility Pattern Space routing [13] uses the mobility pattern of nodes as context information. The protocol uses a multi dimensional Euclidean space, named MobySpace, where possible contact between couples of nodes are represented by each axis and the probability of that contacts to occur are measured by the distance along axis. Two nodes that are close in the MobySpace, have similar sets of contacts. The best forwarding node for a message is the node that is as close as possible to the destination node in this space.

In Bubble Rap [14], social community users belong to is used as context information. Basically, Bubble Rap prefers nodes belonging to the same community of the destination as a good forwarder to this destination. If such nodes are not found, it forwards the message to the nodes, which have more chances of contact with the community of the destination. In Bubble Rap, communities are automatically detected via the patterns of contacts between nodes.

Other opportunistic routing protocols use the time lag from the last meeting with a destination as context information. Last Encounter routing [15] and Spray& Wait [10] routings are example of protocols exploiting such type of information.

Context-aware routing [16] uses an existing MANET routing protocol to connect nodes of the same MANET cloud. To transmit messages outside the cloud, a sender gives message to the node in its current cloud that has highest message delivery probability to the destination. This node waits to get in touch with destination or enters in destination's cloud with other nodes that has higher probability of meeting the destination. In context-aware routing context information is used to calculate probabilities only for those destinations each node is aware of.

With respect to context-aware routing, HiBOp is more general, HiBOp is a fully context-aware routing protocol completely described in [17]. HiBOp exploits every type of context information for taking routing decisions and also describes mechanism to handle this information. In HiBOp, devices share their own data when they come into contact with other devices, and thus learn the context they are immersed in. Nodes seem as good forwarders, which share more and more context data with the message destination.

3. PROPOSED ROUTING SCHEME

Real users are likely to move around randomly or in predictable fashion, such that if a node has visited a location several times before, it is likely that it can visit that location again or can choose a new location that has never visited before. In this way users‟ movement can be predictable or unpredictable. We would like to make use of these observations to improve routing performance by combining probabilistic routing with flooding based routing and thus, we propose integrated routing protocol for opportunistic network.

To accomplish this, each node needs to know the contact probabilities to all other nodes currently available in the network. Every node maintains a probability matrix same as described in [7]. Each cell represents contact probability between to nodes x and y. Each node computes its contact probabilities with other nodes whenever the node comes in to contact with other nodes. Each node maintains a time attribute to other available nodes, the time attribute of a node is only updated when it meets with other nodes.

Two nodes exchange their contact probability matrices, when they meet. Nodes compare their own contact matrixes with other nodes. A node updates its matrix with another nodes‟ matrix if another node has more recent updated time attribute. In this way, two nodes will have identical contact probability matrices after communication.

The calculations of the delivery predictabilities have described in [6]. The first thing to do is to update the metric whenever a node meets with other nodes, so that nodes that are often met have a high message delivery probability. When node a meets node b, the delivery probability of node x for y is updated by (1).

$$P^{\backslash}_{ab} = P_{ab} + (1 - P_{ab})P_o \qquad (1)$$

Where P_o is an initial probability, we used $P_o = 0.75$.

When node a does not meet with node b for some predefine time, the delivery probability decreases by (2).

$$P^{\backslash}_{ab} = \gamma^k P_{ab} \qquad (2)$$

Where γ is the aging factor ($\gamma \prec 1$), and k is the number of time units since the last update. When node a receives node b delivery probabilities, node a may compute the transitive delivery probability through b to c by (3).

$$P^{\backslash}_{ac} = P_{ac} + (1 - P_{ac})P_{ab}P_{bc}\beta \qquad (3)$$

Where β is a design parameter for the impact of transitivity, we used β = 0.25.

when a message arrives at a node, there might not be a path to the destination available so the node have to buffer the message and upon each encounters with another node, the decision must be made on whether or not to transfer a particular message. Furthermore, it may also be sensible to forward a message to multiple nodes to increase the probability that a message is really delivered to its destination.

Whenever a node meets with other nodes, they all exchange their messages (or as above, probability matrix). If the destination of a message is the receiver itself, the message is delivered. Otherwise, if the probability of delivering the message to its destination through this receiver node is greater than or equal to a certain threshold, the message is stored in the receiver's storage to forward to the destination. If the probability is less than the threshold, the receiver discards the message. If all neighbors of sender node have no knowledge about destination of message and sender has waited more than a configured time, sender will broadcast it to all its current neighbors. This process will be repeated at each node until it reaches to destination.

We have proposed a simple routing protocol in which a message is transferred to the other node when two nodes meet, if the delivery probability to the destination of the message is higher than other node. But, taking these decisions is not an easy task. In some cases it might be sensible to select a fixed value and only give a message to nodes that have delivery probability greater than that fixed value for the destination of the message. On the other hand, when encountering a node with low delivery predictability, it is not certain that a node with a higher metric will be encountered within reasonable time. It may be possible destination is new and context information about destination is not spread in network. To solve these problems we introduce a new concept, our integrated routing distributes copies of message to all its neighbors same as flooding based techniques, after a configurable time, when node has not have any context information about destination of message.

Furthermore, we can also set the maximum number of copies of a message; a node can spread, to solve the problem of deciding how many nodes to give a certain message to. Distributing a message to a large number of nodes increases message delivery probability and decreases message delay, on the other hand, also increases resource consumption.

4. SIMULATION AND RESULTS

4.1 Simulation Setup

We have currently implemented three different routing protocols epidemic, PROPHET, and our proposed routing protocols in ONE (Opportunistic Network Environment) Simulator, all of which we consider in our evaluation. We are taking simulation scenario from [18], therefore we are not describing all things here. We are just showing here some important and new parameters.

We have used part of the Helsinki downtown area (4500×3400 m) as depicted in [18]. For our simulations, we assume communication between modern mobile phones or similar devices. Devices has up to 20 MB of free RAM for buffering messages. Users travel on foot, in cars or trams. In addition, we have added to the map data some paths to parks, shopping malls and tram routes. We run our simulations with 100 nodes. Mobile nodes have different speed and pause time. Pedestrians move at random speeds of 0.5–1.5 m/s with pause times of 0–120 s. Cars are optional and, if present, make up 20% of the node count; they move at speeds of 10–50 km/h, pausing for 0–120 s. 0, 2, 4, or 6 trams run as speeds of 7–10 m/s and pause at each configured stop for 10–30 s. We assume Bluetooth (10 m range, 2 Mbit/s) and a low power use of 802.11b WLAN (30 m range, 4.5 Mbit/s). Mobile users (not the trams or throw-boxes) generate messages on average once per hour per node. We use message lifetimes of 3, 6, and 12 hours. We use message sizes uniformly distributed between 100 KB (text message) and 2 MB (digital photo).

Additionally, we define two scenarios POIs1 and POIs2 using different POIs each contains five groups and creates four POI groups (west containing 3, central 4, shops 22, and parks 11 POIs) [18]:

- POIs1: One node group runs MBM (map-based model), three choose their next destination with a probability p = 0.1 for each of the four POI groups, the last remaining one only chooses from the POI groups that are accessible by car otherwise a random target is selected.

- POIs2: We consider a preferred POI group for four of the node groups. A node chooses a POI with p = 0.4 from its preferred POI group, with p = 0.1 from each other POI group, and otherwise a random target.

4.2 Performance Evaluation

Now we compare the performance of epidemic, PROPHET and our proposed routing protocols in both scenarios when context information is present or not. Here PROPHET routing protocol without context information about users, same meaning is here of hybrid routing protocol. While, PROPHET stands for standard probabilistic routing protocol and hybrid stands for our new routing protocol with context information about users.

Figure 1 shows a comparison of message delay between all routing protocols in the presence of context information. It is noticed that PROPHET gives minimum message delay probability 0.2370. But in absence of context information it gives maximum message delay probability 0.2824 as it is noticed from Figure 2. Epidemic is totally flooding based routing protocol and does not require context information for message forwarding therefore it is not affected by unavailability of context information, and gives same message delay probability 0.2738 in both cases. Our Hybrid routing gives 0.2480 and 0.2603 message delay probability in presence and absence of context information as it is shown from Figure 1 and Figure 2.

A comparison of message delivery probability between all routing protocols is shown in figure 3. It is noticed that the PROPHET gives better message delivery probability 0.2981 in the case of available context information, but on unavailability of context information it gives worst message delivery probability 0.1978 as it noticed from Figure 4. Epidemic does not use context information, therefore gives same delivery probability 0.2334 in both cases. Our proposed routing gives 0.2822 delivery probability and 0.2506 delivery probability (maximum) in presence and absence of context information as it is shown from Figure 3 and Figure 4.

Our simulation results show that PROPHET gives batter result in presence of context information. When users are very isolated, context information cannot be distributed, and cannot be used for taking effective routing decisions. In this case PHROPHET gives worst result. Epidemic gives common result in both cases we have described above. Our proposed routing gives better results in both scenarios context information is available on not. Therefore hybrid routing protocol is better when users are social or isolated.

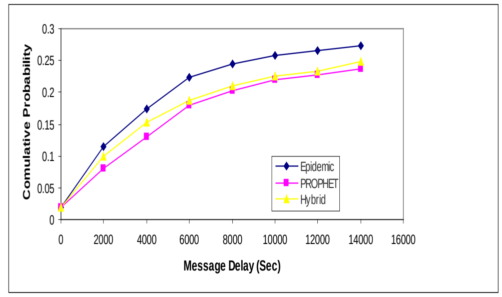

Figure 1. Comparison of Message Delay of routing protocols (Presence of context information).

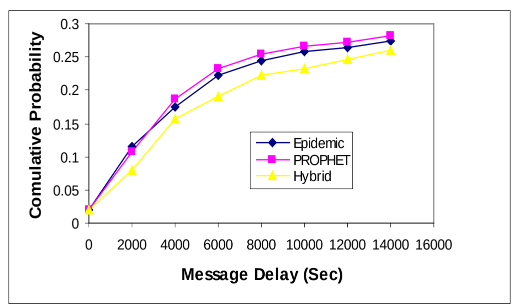

Figure 2. Comparison of Message Delay of routing protocols (Absence of context information).

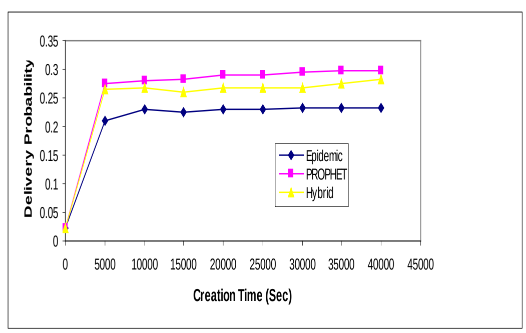

Figure 3. Comparison of Message Delivery Probability of routing protocols (Presence of context information).

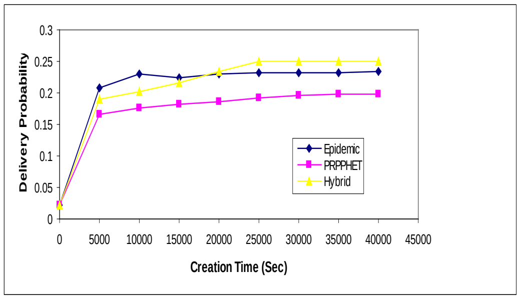

Figure 4. Comparison of Message Delivery Probability of routing protocols (Absence of context information).

5. CONCLUSION

In this paper, we proposed an efficient hybrid routing protocol for the OppNets and evaluated its performance in terms of message delay and message delivery probability. Simulation results show that our proposed hybrid routing is able to meet out the challenges of other routing schemes (i.e. Epidemic and PROPHET) when context information about user is available or not.

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