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“Survey on Reliable Routing in Wireless networks”

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Abstract— Opportunistic networks are one of the most interesting evolutions of MANETs. In opportunistic networks, route connecting to the mobile nodes never exits, mobile nodes communicate with each other when they got opportunity to communicate. Furthermore, nodes are not supposed to possess or acquire any knowledge about the network topology. Routes are built dynamically, while messages are route between the source and the destination, and any possible node can opportunistically be used as next hop, provided it is likely to bring the message closer to the final destination. These requirements make opportunistic networks a challenging and promising research field. In this paper we describe composite approach for routing in opportunistic networks, rendering traditional routing protocols unable to deliver messages between hosts. Thus, there is a need for a way to route through such networks. We propose composite approach which combines Epidemic Routing and Probabilistic Routing approaches together.

Keywords— Epidemic Routing, Routing Opportunistic networks, Probabilistic Routing.

I. INTRODUCTION

Wireless network infrastructures have been expanding at a rapid pace throughout the world. However, wireless networks may still not be available in areas such as poor regions, underwater sensors, or military operations. In order to provide networking support for situations where there are no directly connectivity paths, opportunistic network can be applied. Opportunistic network is a type of delay tolerant, intermittently connected network using an ad-hoc like structure. When a node wants to deliver data to another node but there does not exist a direct connection between them, packets can be forwarded to intermediate participating nodes which aid in delivering the packet from the source to the destination. Unlike a typical ad-hoc structure, however, opportunistic network assumes there is almost never a fully connected path between source to destination and the intermediate nodes may not encounter other nodes frequently or consistently[1],[7],[15]. In some cases, intermediate nodes may have to buffer the packets received for a long time. Due to the uncertainty of packet delivery success in opportunistic networks, numerous routing protocols were proposed to maximize packet delivery rate. One of the most well-known routing protocols for opportunistic networks is a protocol called Reliable Routing [1],[3]. Since the chance of having a directly connected path from a source node to the destination node is rare or non-existent, identifying potential follow. Intermediate carriers for the packets to be transferred are essential. Forwarding data to intermediate carriers that rarely encounter the destination node will, in the worst case, fail to deliver the data. Reliable Routing [1] uses a predictability value, which is calculated using the history of encounters between nodes to evaluate the packet forwarding preference. While Reliable Routing has shown decent results [1], there is still room for improvements. Due to the FIFO queuing nature of Reliable Routing [1], packets may be dropped consistently when packets are forwarded to a few concentrated nodes. Packets may also be lost due to node failures or incomplete transmissions [3], And another protocol is Epidemic routing [2],[4],[11] in which a node A “infects” every contact B with packets that it has that B doesn’t have. A summary vector is typically exchanged to determine the missing packets. Epidemic routing is unbeatable from the point of view of successful delivery as long as the load does not stress the resources (bandwidth, storage).

We present a novel composite approach for routing in opportunistic network. We propose the use of probabilistic routing [1], and Epidemic Routing [2] using an assumption of non-random mobility of nodes to improve the delivery rate of messages while keeping buffer usage and communication overhead at a low level.

II. RELATED WORK

Vahdat and Becker present a routing protocol for intermittently connected networks called Epidemic Routing [2]. This protocol relies on the theory of epidemic algorithms [4] by doing pair-wise information of messages between nodes as they get contact with each other to eventually deliver messages to their destination. Hosts buffer messages even if it there is currently no path to the destination available. An index of these messages called a summary vector is kept by the nodes, and when two nodes meet they exchange summary vectors. After this exchange, each node can determine if the other node has some message that was previously unseen to this node. In that case, the node requests the messages from the other node. This means that as long as buffer space is available, messages will spread like an epidemic of some disease through the network as nodes meet and “infect” each other. Each message must contain a globally unique message ID to determine if it has been previously seen. Besides the obvious fields of source and destination addresses, messages also contain a hop count field. This field is similar to the TTL field in IP packets and determines the maximum number of hops a message can be sent, and can be used to limit the resource utilization of the protocol. Messages with a hop count of one will only be delivered to their final destination.

The resource usage of this scheme is regulated by the hop count set in the messages, and the available buffer space at the nodes. If these are sufficiently large, the message will eventually propagate throughout the entire network if the possibility exists. Vahdat and Becker do however show that by choosing an appropriate maximum hop count, delivery rates can still be kept high while the resource utilization is lower in the scenarios used in their evaluation [2].

A communication model that is similar to Epidemic Routing is presented by Beaufour et al. [5], focusing on data dissemination in sensor networks. The Pollen network proposed by Glance et al. [6] is also similar to Epidemic Routing.

Chen and Murphy propose a protocol called Disconnected Transitive Communication (DTC) [7]. It utilizes an application-tunable utility function to locate the node in the cluster of currently connected nodes that it is best to forward the message to based on the needs of the application. In every step, a node searches the cluster of currently connected nodes for a node that is “closer” to the destination, where the closeness is given by a utility function that can be tuned by the application to give appropriate results.

Shen et al. propose Interrogation-Based Relay Routing, a routing protocol for routing in ad hoc space networks with Scientific Earth Observing (SEO) satellites [8], characterized by frequently changing topologies, and sparse and intermittent connectivity. The satellites interrogate each other to learn more about network topology and nodal capacity to make intelligent routing decisions.

Work by Li and Rus [9] deal with a similar problem of communication in disconnected networks. They propose a solution where nodes actively change their trajectories to create connected paths to accommodate the data transmission. While this might work in military applications and in some robotic sensor networks, in most scenarios it is not likely that nodes will move just to accommodate communication of other nodes (if it is even possible to communicate the need for it).

Grossglauser and Tse looks at the utility of using the mobility of nodes to deliver messages to their destination from a slightly different point of view. One major problem with ad hoc networks is that due to interference of concurrent transmissions between nodes they scale badly. Grossglauser and Tse show the by only doing local communications between neighbors and instead relying on the movement of nodes to bring a message to its destination, this problem can be mitigated [10].

III. PROBABILISTIC ROUTING

Though the random way-point mobility model is popular to use in evaluations of mobile ad hoc protocols, real users are not likely to move around randomly, but rather move in a predictable fashion based on repeating behavioral patterns such that if a node has visited a location several times before, it is likely that it will visit that location again. We would like to make use of these observations and this information to improve routing performance by doing probabilistic routing using History of Encounters and Transitivity [1].

To accomplish this, we establish a probabilistic metric called delivery predictability, P(a,b) [0,1], at every node a for each known destination b. This indicates how likely it is that this node will be able to deliver a message to that destination. When two nodes meet, they exchange summary vectors which in this case also contain the delivery predictability information stored at the nodes. This information is used to update the internal delivery predictability vector as described below, and then the information in the summary vector is used to decide which messages to request from the other node based on the forwarding strategy used.

A. Delivery predictability calculation [1]

The calculation of the delivery predictabilities has three parts. The first thing to do is to update the metric whenever a node is encountered, so that nodes that are often encountered have high delivery predictability. For this calculation refer to “(1)”, where Pinit [0, 1], is an initialization constant.

$$P(a,b) = P(a,b)\text{old} + (1 - P(a,b)\text{old}) \times \text{Pinit}. \quad (1)$$

If a pair of nodes does not encounter each other in a while, they are less likely to be good forwarders of messages to each other, thus the delivery predictability values must age, being reduced in the process which is calculated in aging equation. Refer to “(2)”, where [0,1] is the aging constant, and k is the number of time units that have elapsed since the last time the metric was aged. The time unit used can differ, and should be defined based on the application and the expected delays in the targeted network.

$$P(a,b) = P(a,b)\text{old} \times \gamma k. \quad (2)$$

The delivery predictability also has a transitive property, that is based on the observation that if node A frequently encounters node B, and node B frequently encounters node C, then node C probably is a good node to forward messages destined for node A. Refer to “(3)”, which shows how this transitivity affects the delivery predictability, where [0, 1] is a scaling constant that decides how large impact the transitivity should have on the delivery predictability.

$$P(a,c) = P(a,c)\text{old} + (1-P(a,c)\text{old}) \times P(a,b) \times P(b,c) \times \beta. \quad (3)$$

IV. EPIDEMIC ROUTING

Epidemic Routing [2], [4] supports the eventual delivery of messages to arbitrary destinations with minimal assumptions regarding the underlying topology and connectivity of the underlying network. In fact, only periodic pair-wise connectivity is required to ensure eventual message delivery. The Epidemic Routing protocol works as follows. The protocol relies upon the transitive distribution of messages through ad hoc networks, with messages eventually reaching their destination. Each host maintains a buffer consisting of messages that it has originated as well as messages that it is buffering on behalf of other hosts. For efficiency, a hash table indexes this list of messages, keyed by a unique identifier associated with each message. Each host stores a bit vector called the summary vector that indicates which entries in their local hash tables are set. When two hosts come into communication range of one another, the host with the smaller identifier initiates anti-entropy session (this term is borrowed from the literature [22]) with the host with the larger identifier. To avoid redundant connections, each host maintains a cache of hosts. Anti-entropy is not re-initiated with remote hosts that have been contacted within a configurable time period. During anti-entropy, the two hosts exchange their summary vectors to determine which messages stored remotely have not been seen by the local host. In turn, each host then requests copies of messages that it has not yet seen. In the design for Epidemic Routing associates a unique message identifier, a hop count, and an optional ack request with each message. The message identifier is a unique 32-bit number. This identifier is a concatenation of the host’s ID and a locally-generated message ID (16 bits each). However, if hosts in an ad hoc network are assigned the same subnet mask, the remaining bits of the IP address can be used as the identifier. In this implementation, the hosts in the ad hoc network are statically assigned ID's. The hop count field determines the maximum number of epidemic exchanges that a particular message is subject to. While the hop count is similar to the TTL field in IP packets, messages with a hop count of one will only be delivered to their end destination. Larger values for hop count will distribute a message through the network more quickly. This will typically reduce average delivery time, but will also increase total resource consumption in message delivery. Thus, high priority messages might be marked with a high hop count, while most messages can be marked with a value close to the expected number of hops for a given network configuration to minimize resource consumption[2],[4],[11],[13].

V. COMPOSITE APPROACH

Composite routing protocol is a novel approach for routing in opportunistic network. In this approach we combine both the Epidemic Routing and Probabilistic Routing. A node forwards the message to the two neighbors which are having maximum delivery predictability. Delivery predictability, P(a,b) [0,1], at every node a for each known destination b is ability of a to deliver message to destination b. When two nodes meet, they exchange summary vectors which in this case also contain the delivery predictability information stored at the nodes. This information is used to update the internal delivery predictability vector, and then the information in the summary vector is used to decide which messages to request from the other node as described below.

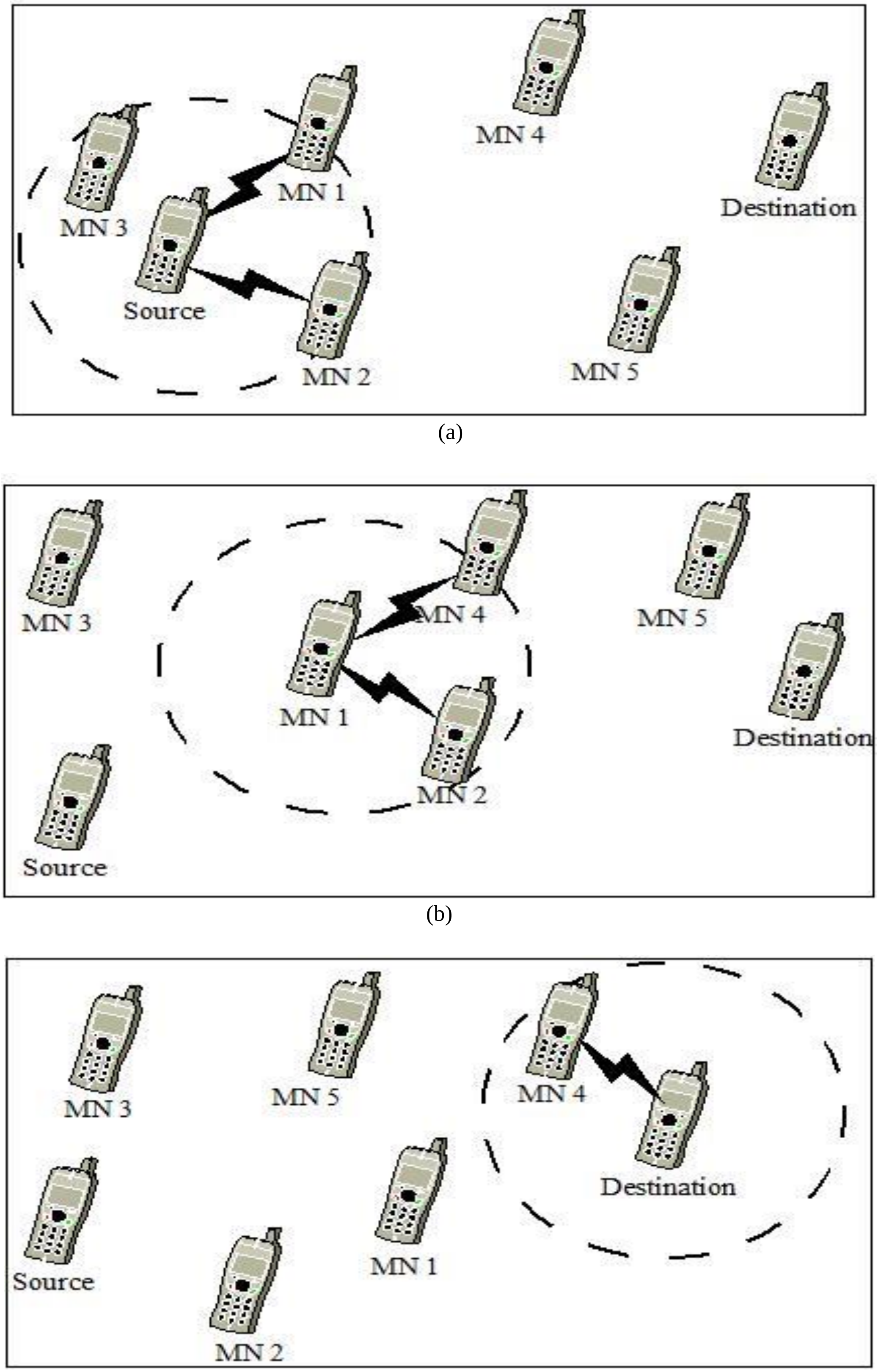
Each host maintains a buffer consisting of messages that it has originated as well as messages that it is buffering on behalf of other hosts. A hash table indexes this list of messages, keyed by a unique identifier associated with each message. Each host stores a bit vector called the summary vector that indicates which entries in their local hash tables are set. To avoid redundant connections, each host maintains a cache of previously communicated hosts. When two hosts come into communication range of one another, they exchange their summary vectors to determine which messages stored remotely have not been seen by the local host. In turn, each host then requests copies of messages that it has not yet seen. When message reaches to destination, acknowledgment is sent in the same manner to the sender of the message.

For example, while sending the message the source node searches the nodes in his range, then by exchanging delivery predictability information he finds MN1 and MN2 have higher delivery predictability than other nodes therefore source node forwards message to nodes MN1 and MN2 as shown in fig. (a). The nodes who receive the message from source node they again follow the same procedure as source node but as shown in fig (b) MN2 is receiver of source as well as node MN1. MN1 and MN2 only exchange its summary vector. And by exchange they know that they don't have new messages to exchange so they stop communication. In fig. (c) The node MN4 follows same procedure and message reaches to the destination.

Fig .3 Graph of pressure versus angle showing the comparison of journal bearing for different load (300) and different speed (800)

Fig. shows the pressure distribution of circular journal bearing for different load and different speed. By the observing graph, it can reveal that for both , as speed and load increases the value of pressure also increases.

Up to 170 of rotation, the pressure variation remains minimal, then suddenly rises to a maximum value for next 200 of rotation of the bearing, then for next 250 of rotation of the bearing it falls to a minimum pressure and remains constant till the end of rotation



(a)

(b)

(c)

Fig.1 Composite Routing.

VI. ADVANTAGES

- Increased message delivery than probabilistic model.
- Considerable reduction in resource consumption than epidemic model.

- Black hole attack is almost removed since a message is sent to two different nodes having higher delivery predictability.

VII. CONCLUSION

Opportunistic network is an emerging system that is getting growing interest in networking research community. The opportunistic network places different research challenges on different layers of a protocol stack. In this paper, we provide composite routing approach for opportunistic network, which is made with taking features of epidemic and probabilistic routing techniques, which results in improved message delivery and low overhead on resources.

VIII. FUTURE WORK

In proposed work delivery predictability is calculated by using three metrics as-number of encounters between nodes, time span between their meetings and transitive property of delivery predictability. It will be interesting to evaluate delivery predictability by using different metrics like context information and history of nodes.

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