ZMEED: A Zone based Enhanced Hybrid Routing Protocol for Delay Tolerant Network

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ABSTRACT
Delay Tolerant Network is becoming popular day by day as it finds application in various fields. Due to the intermittent connectivity feature of a Delay Tolerant Network (DTN), routing here is a challenging issue. The performance of the routing algorithm in this type of network can be increased considerably if one can take advantage of knowledge concerning node mobility. This paper addresses this problem with a generic algorithm based on the use of the existing Minimum Estimated Expected Delay (MEED) and Zone Routing Protocol (ZRP). In this work a technique to send data within a reasonable amount of delay to the destination is suggested.

The performance of the proposed algorithm has been successfully demonstrated in a simulated environment.

General Terms
Delay Tolerant Network, Routing Protocol, Intermittent Connectivity, MEED, ZRP.

Keywords
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1. INTRODUCTION
Delay tolerant networks (DTNs) are steadily gaining popularity in the research community for their ability to provide connectivity, or a semblance of connectivity, in “challenged" networking environments. Examples of these environments include urban networks in which opportunistic meetings between cars and buses can be used to transfer messages from disconnected portions of the network to areas with Internet access [8]; rural networks in which villages have reliable connectivity between local hosts but have unreliable connections to the wider world [7]; networks of sensors that collect and share information about animal movement and behavior [5]; and networks in which roving autonomous robots provide connectivity or message ferrying capabilities in disruption-tolerant environments [3, 6]. In all of these networks, connections appear and disappear on an unpredictable schedule, are sometimes only available for a very short amount of time, and the source and destination of any given end-to-end communication may never be directly connected. DTN works in remote areas where it is assumed that delay will be a part of the network. Hence in this type of network which deals with intermittent connectivity the system gives no assurance of sending data to the targeted destination. More over the stability of the nodes in the network that caries information is not guaranteed over time.

Different routing Protocols exist for the DTN [3] which can be classified into two different categories- i) Routing protocols that do not use mobility patterns such as First Contact, Epidemic, Prioritized Epidemic, Spray and Wait etc and ii) Routing protocol that consider the mobility patterns such as MEED, PROPHET, Encounter based routing etc.

2. RELATED WORK
MEED [1] is one of the popular routing protocols in DTN that try to use mobility patterns. In MEED, average waiting time for each node has to be maintained. In this protocol partial knowledge of the system is used and no replication is made. In this approach contact history of each node is observed to estimate expected contact schedule. For each node connection and disconnection time is recorded of each contact with another node over a sliding history window to get average waiting time till next contact with that node. From this history at the time of packet transmission the node which has the shortest average waiting time is selected for forwarding the packet to the destination. The packet is sent to the destination through that intermediate node. If significant change in contact schedule occurs, the algorithm floods the packets to all nodes (similar to link-state routing). Each node creates an undirected weighted graph $G = (V, E)$ where V = set of nodes, E = set of node pairs (u, v) with some contact schedule value. Therefore weight $w(u,v)$ = contact schedule value from u to v. Dijkstra’s algorithm is used to find shortest paths in G. Here Forwarding done on a per-contact basis. If u comes in contact with v, then $w(u,v)$=0 during contact. The shortest path is recalculated based on this new value before forwarding any packet.

In wireless networking, ZONE ROUTING PROTOCOL (ZRP) was the first hybrid routing protocol with both a proactive and a reactive routing component. ZRP was proposed to reduce the control overhead of proactive routing protocol and decrease the latency caused by route discovery in reactive routing protocols. ZRP defines a zone around each node consisting of the node’s k- neighborhood (that is, all nodes within k hops of the node) [11,12]. A proactive routing protocol, named Intra-zone Routing (IARP), is used inside routing zones, and a reactive routing protocol, named Inter-zone routing protocol (IARP), is used between routing zones. A route to a destination within the local zone can be established from the source's proactively cached during routing table by IARP. Therefore, if the source and destination of a packet are in the same zone, the packet can be delivered immediately .Most of the existing proactive routing algorithms can be used as the IARP for ZRP.

For routes beyond the local zone, route discovery happens reactively. The source node sends a route request to the border nodes of its zone, containing its own address, the destination address and a unique sequence number. Border nodes are nodes which are exactly k hopes away from the source. Each border nodes checks its local zone for the destination. If the destination is not a member of this local zone, the border node adds its own address to the route request packet and forwards the packet to its own border nodes. If the destination is a member of the local zone, it sends a route reply on the reverse path back to the source. The source node uses the path saved in the route reply packet to send data packet to the destination.

3. PROPOSED WORK

In this work, the features of ZRP routing protocol is combined with MEED to increase the efficiency of MEED. Here the record is kept for each zone in which the average waiting time of each zone and forwarding packet is simplified as the search is done between zones and the packet is forwarded into other zones rather than other node which was done in case of MEED. Hence the approach makes the searching simpler. Buffer occupation is an important issue in DTN. In the proposed scheme the packet is forwarded to other zone as soon as it is known that the destination is not in zone where the packet is stored. By using this it is ensured that the buffer is less occupied instead of searching for destination by storing the data in one zone. By forwarding the data efficient use of the buffer is made and chance to other packets to enter in the buffer of every zone is given. In this procedure a fewer comparisons is made that in turn reduce the average waiting time for data transmission in the network. Here the nodes between zones are compared but in MEED the node which has lowest average waiting time is found across the entire network.

This process in MEED protocol makes search and data sending slower and makes occupation of buffer heavy. This limitation is removed in this work, as it first searches for the destination node within the zone where the sender resides. If the destination-id does not match with nodes of that residing zone then packet is forwarded to the next zone with lowest average waiting time. For each zone, the connection and disconnection time of each node contact with another node over a sliding history window is recorded to get average waiting time till next contact with that node. This makes data sending faster and buffer occupation lower and frequent. In this approach partial knowledge of the system has been used by storing the average waiting time of the zones.

4. PROPOSED ALGORITHM

In the proposed algorithm the following assumptions have been made.

- A zone is defined around each node consisting k-node neighborhood.
- For each zone, the average waiting time is calculated by calculating the average waiting time of the nodes of that zone.
- A "leader" node is the node in a zone that are connected to all other nodes in the zone in a single hop. Inter zone communication is also carried through the leader node of the
- It controls the entire activity of a zone and each leader is connected with the leader of every other zones.
- While forwarding packet there must be source id and destination id with the packet.
- The data structure that is used in the proposed algorithm is queue for storing the records of zone and for storing a message.
- Here the average waiting time of each zone is taken. For each node, the connection and disconnection time of each contact with another node over a sliding history window is recorded to get average waiting time till next contact with that node. The total average waiting time of the nodes is calculated then it is divided by the number of nodes to get the average waiting of time of the zones.

STEP-1: If the source and destination are in the same zone then send the packet to destination from the leader of that zone.

STEP-2: If source and destination are in different zone, then forward the packet to the "leader" node of the zone having lowest average waiting time.

STEP-3: If the destination node is not found in the lowest average waiting time zone then the packet is forwarded to the zone which has next lowest average waiting time except the zone where at first source was present.

[Repeat step 3 until the required zone is found for a specified time period]

STEP-4: If the destination is found then send the data to the destination from the leader node.

5. SIMULATION OF THE PROPOSED ALGORITHM

Throughout the paper, the model of the proposed work is validated using simulation. In this work, the first order radio model has been simulated. Here a 300 x 300 m^2 simulation area is considered with 100 nodes are deployed over the simulation area and there are four different zones. A snapshot of the simulation environment is shown in figure 1. Here, the first order radio model [14] is considered as discussed in with identical parameter values. In this work, a simple model is assumed where the system dissipates E_{elec}= .0005 unit/bit to run the transmitter or receiver circuitry and ε_{amp}=.0001 pJ/bit/m for the head nodes to store and receive the message.

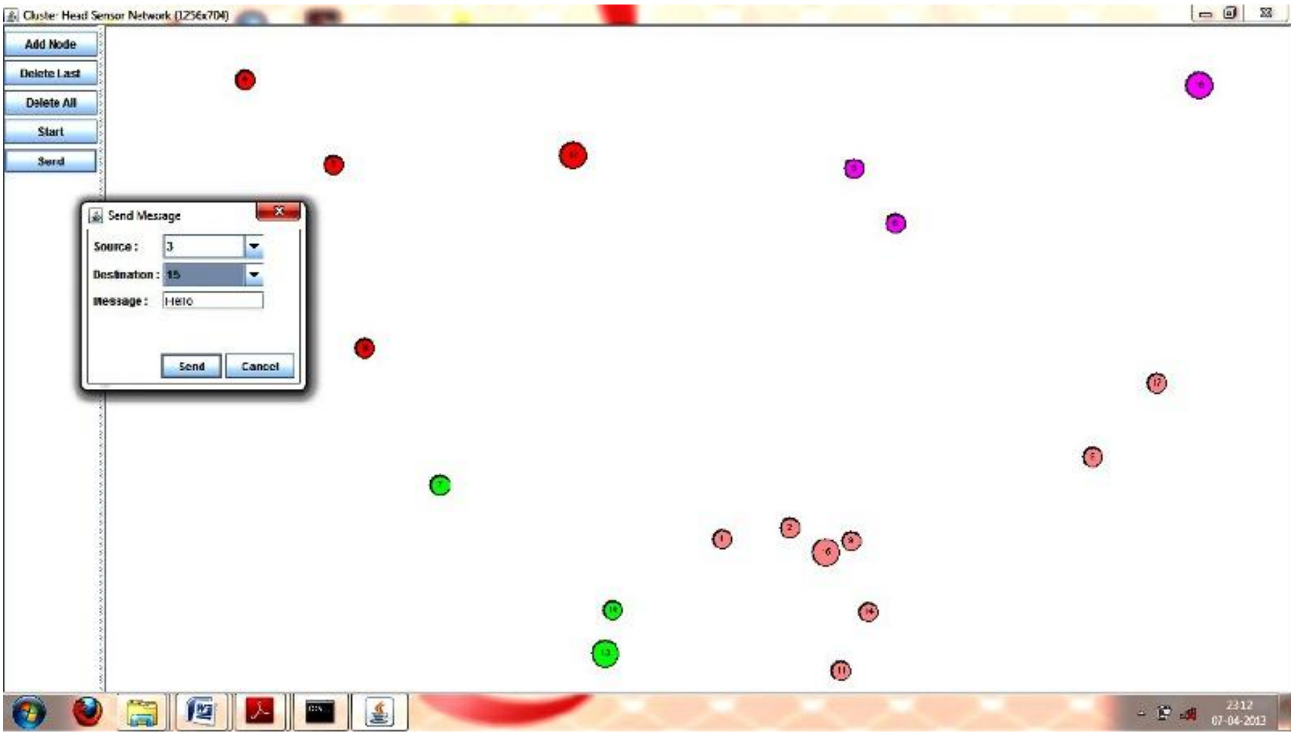

Fig. 1. A snapshot of Simulation Environment

To send a message of k bits a sender node looses energy = k* E_{elec} *distance = k*.0005*distance unit.

To store and forward a message of k bits a head node looses energy =k* ε_{amp} *distance= k*.001*distance unit.

And to receive this message of k bits the system expands:

$E_{Rx}(k) = E_{Rx\text{-}elec}(k)$

$E_{Rx}(k) = E_{elec} * k = k*.005$ *unit.*

6. PERFORMANCE METRIC

The performance of the proposed work has been compared with the existing MEED algorithm. Three performance metrics, *end to end delay*, *energy dissipation and amount of system knowledge* are studied in the paper[13]. The end to end delay of a packet is the duration of the time from when the packet is generated at the source to the time the packet is first delivered to the destination. For the case where nodes have a limited amount of buffer, a packet might be dropped from the network before it is delivered. The *energy dissipation* of a packet is the total amount of energy loss to send a packet from source node to destination node and for moving from one zone to another.

7. SIMULATION RESULTS

In the proposed work the performance of ZMEED algorithm is compared with the existing MEED routing algorithm with respect to some performance metrics such as amount of system knowledge used, end-to-end delay, energy dissipation etc.

In MEED routing protocol, as each node maintains an average waiting time, the number of record increases when the number of nodes will increase whereas in our modified algorithm(ZMEED) although the number of nodes is increased, the number of records will be same since the nodes are divided into different zones. So, instead of maintaining the average waiting time for each node in the network average waiting time of the respective zones are maintained. Thus amount of system knowledge will be less. These observations are demonstrated in figure 2

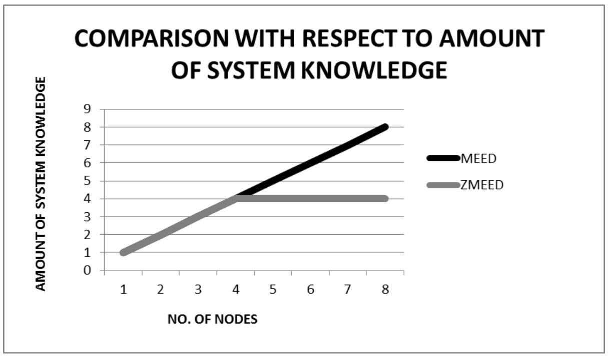

Fig. 2. Number of nodes vs. amount of system knowledge

The proposed algorithm calculates an estimate of the network connectivity in order to make intelligent routing decisions [10]. In order to implement this, the expected-delay metric is used, originally presented by Jainet al. [9]. This metric computes the expected delay for a message to go from one node to another using a given contact, assuming that all message arrival times are equally likely. The derivation of this metric is simple and is shown in equation 1, where n is the total number of disconnected periods, d_i is the duration of a given disconnected period, and t is the total time interval over which these disconnections were observed.

$$\frac{\sum_{i=1}^{n} di^2}{2t} \qquad (1)$$

The original metric is computed using the contact schedule for the entire period that the network is in use. However, it is possible to compute this metric for any arbitrary time period. If it is assumed that the future behavior of a contact will be similar to the past, then the value can be used for the past as the current estimate.

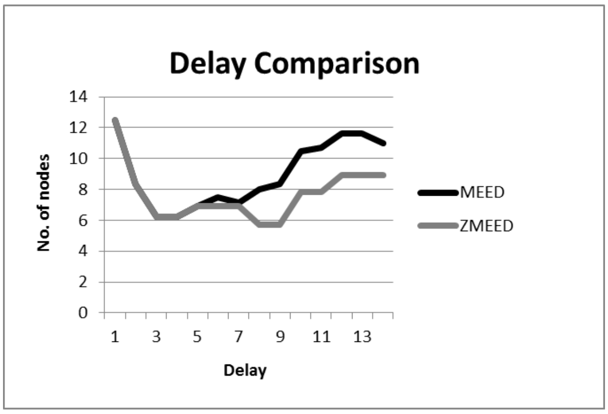

Fig. 3. Number of nodes vs. end-to-end delay in the network

A comparison between MEED algorithm and the suggested algorithm is shown in figure 3. Here a comparison graph is shown where X-axis denotes no of nodes and Y-axis denotes delay. Here duration of the disconnection period (d_i) is constant that is 5 second. During the first 5 or 6 few iterations and for same volume of data the network delay has found to be same in both MEED and the proposed ZMEED algorithm. But as the number of nodes goes high it can be seen that the delay of MEED algorithm is more than our proposed implemented algorithm for sending the same amount of data in same network condition. When the number node increases then MEED algorithm requires involving more nodes to send the data in worst case. So the delay goes high where as in our proposed algorithm the delay remains constant.

In our work, a simple model is assumed where the system dissipates E_{elec}= .0005 unit/bit to run the transmitter or receiver circuitry and ε_{amp}=.0001 pJ/bit/m for the head nodes to store and receive the message.

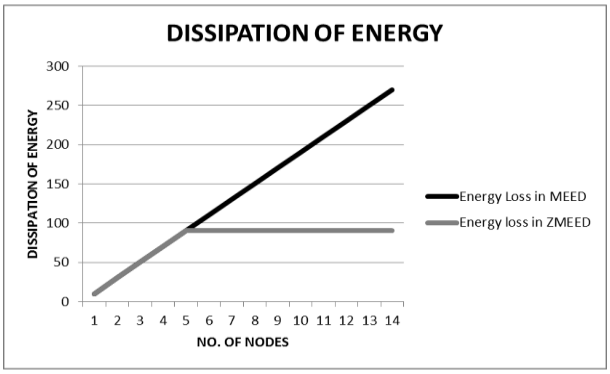

Fig. 4. Number of nodes vs. energy loss in the network

A performance comparison between MEED and the proposed routing algorithm with respect to energy needed to send a k bit message is shown in figure 4. Here "HELLO" message of 40 bits is sent. The distance is constant. It is shown that if the distance between two nodes is same then if the above mentioned two algorithms can be run under same network condition then as the number of node increases the proposed algorithm requires less energy to transmit messages than the MEED algorithm. Figure 4 shows that at the beginning of the simulation the loss of energy is same for both the algorithms. As the number of nodes goes increasing the energy requirement for the nodes in MEED algorithm becomes high. This is because the partition of nodes into zone and zone to zone communication in case of ZMEED algorithm decreases the overall traffic in the network that in turn saves energy of the nodes. In the proposed algorithm for a fixed number of zones the loss of energy for a data transmission remains constant irrespective of total number of nodes present in the system. But in the worst case in case of MEED algorithm all nodes must participate in a data transmission. Every node except the sending and receiving node must perform store and forward of message. Thus it results in greater energy loss as the number of nodes increases in the network in case of MEED algorithm. Hence the energy requirement to send same number of messages in MEED goes high in compare to proposed ZMEED algorithm.

8. CONCLUSION

In the proposed algorithm it is not required to keep track of Average waiting time for each node in the network. Thus makes the record table less complex. Forwarding packet is simplified as searching is done between zones and forward the packet into other zones rather than nodes thus making transmission of data much faster. Partial system knowledge and fewer buffers are needed. In MEED algorithm Dijkstra's algorithm is used for calculating the shortest path but in our proposed algorithm the need of calculating shortest path has been eliminated. Thus it makes the algorithm a simple one.

9. REFERENCES

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