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Research Article

Node Factor based Hybrid Routing algorithm for Mobile Opportunistic Network

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Abstract: Conventional routing algorithms for wireless networks are difficult to apply to mobile opportunistic networks because of the interconnected network topology induced by node mobility. The mobile opportunistic network is characterized by sporadic connectivity, unavailability of end-to-end connection among the source and destination, and other characteristics. Proposed hybrid routing scheme is focused on the computation of encounter frequency between the nodes, in the task of information routing. The number of frequency meetings with other nodes, including the destination, is used to calculate the node factor. The frequency at which each node meets all other nodes defines a node's mobility pattern. Higher frequency meetings result in faster network area coverage due to increased node movement. As a result, they have a better chance of reaching even more nodes in the opportunistic network, improving the distribution ratio. Activeness of each network node is also provided by higher frequency meetings. The evaluated metric quantifies the significance of a carrier node in transporting a message to its destination. The proposed scheme has a higher delivery ratio, uses an average hop count, has a lower delivery delay.

Keywords: Mobile Opportunistic Network, Hybrid algorithm, Node Factor, Frequency Meet.

1. Introduction

Mobile Opportunistic Network (MON) is an intermittently connected network characterized by sparse network density, frequent disruption, nonavailability of continuous link between source to destination, etc. Hence, performance of the communication links is highly dynamic and the TCP/IP protocol in such an environment will not work effectively. MON is an advancement of MANET, that bears delay tolerance in wireless ad-hoc networks. The message forwarding occurs when there is a communication opportunity exist between the nodes. Routing path selection in opportunistic networks is a complex and challenging issue. The structural properties of opportunistic networks demonstrate that mobile node attributes play significant part in the dissemination of data. The tremendous growth of intelligent devices in wireless transmission has stimulated the evaluation of network called Mobile Ad-hoc Network (MANETs). The routing algorithms designed for MANETs require continuous link between source to destination nodes. These routing algorithms are not suitable for challenged networks [1]. Challenged networks suffer from frequent disruption, scattered network density. Such challenged networks are known as Mobile Opportunistic Network which adopts the store and carry-forward behavioral approach to forward messages. Every node accumulates the message in buffer generated by itself and also the incoming messages. It carries the messages, until it finds a suitable intermediate node. Mobile Opportunistic Network is different from MANET and is considered as one of the categories of DTNs [2]. Initially, MON can start as a single node and it grows by considering neighbor nodes for its help to achieve the highest message delivery ratio.

In MON nodes suffer from intermittent connection, and because intermittent connectivity communication is strongly dominated by long queueing delay. Message transfer also suffers from high latency because of dynamic topology. Buffer space utilization and energy required is high because of the store-carry-forward behavioral approach emerging from the node's mobility [3,4].The routing process can be carried out by utilizing single copy approach or also multi copy approach. By combining both approaches hybrid routing approach is designed. In single copy routing approach, only, single message copy exists in the network. In the multi-copy approach duplicate messages of a single copy exist in the network.

The proposed hybrid routing scheme focuses on the mobility pattern and interaction of each node. From the mobility pattern, the frequency meeting of each node is obtained. The metric is evaluated using the frequency meet parameter. The remaining paper is structured as follows. In section 2 related work is explained. Section 3 describes the proposed work. Simulation and results are discussed in section 4. Section 5 explicates the conclusion.

2.Related Work

The routing schemes in MON are focused on flooding strategical action or on forwarding strategical action. In flooding strategical action, every node which gets a message duplicates it and then forwards the message to its neighboring nodes, with in its communication range. In forwarding strategical action, every node utilizes the significant knowledge regarding the network nodes movement to find the better next-hop, in order to have the best path finding with respect to destination. Some of the routing schemes are presented in this section. Direct Contact [5] is a single copy routing approach. Source alone carries the message until it encounters its destination. There is

no forwarding procedure exist and hence network topology information is not essential for the choice of intermediate nodes. If the source and destination do not meet then there is no message delivery exist. The algorithm suffers from more delivery delays. Epidemic [6] routing is a flooding related routing approach. Every node maintains two buffers. First buffer consists of messages originated by the node itself. Second buffer consists of messages obtained from additional nodes. Unique message Id will be assigned to each message and buffer will be consists of a list of all messages with its Ids whose message delivery is awaiting in the summary vector form. Nodes compare their summary vectors whenever nodes come in their close proximity as well as exchange the summary vectors, which they do not have in common. So, it is a multi-copy approach. It makes use of significant bandwidth and buffer because of multiple redundant messages. This protocol achieves high delivery ratio, but with lower delay but has high network overhead. PROPHET [7] routing scheme makes use of transitivity property and history of frequency of encounters of a node with all other network nodes. The fundamental idea of routing is that if any of a node has met other node previously more frequently, then the probability of encountering the same node more in future. Source node computes the delivery predictability metric for each destination node before transmitting. The calculation of delivery predictability value consists of three factors:

i) Metric value up-dating whenever a node is encountered.ii) When a node X does not encounter node Y, for defined time slots, then both nodes are less likely to be as a good forwarder of message. So, decrease the delivery predictability values.iii) The delivery predictability also has a transitive property. When nodes come within the close proximity of each other, message transfer takes place among the node with lower delivery predictability to the node having the highest delivery predictability. A good delivery rate is achieved by the prophet with fewer network overhead. Spray and Wait (SNW) [8] is a hybrid routing approach. It controls the level of flooding of the epidemic scheme by controlling the number of message copies. It imparts an advancement over the Epidemic routing protocol. The routing procedure has two stages. Source node sprays a defined number of message copies 'L' to the network in spray phase. If the destination node was not found during the spray phase, in the waiting phase all intermediate node owning a message copy accomplish the direct transmission of message to destination node. The paper [9] designed a hybrid routing scheme. It combines the functionalities of Epidemic and Prophet routing techniques. A Source/Intermediate node exchanges summary vector information and delivery predictability value with all neighboring nodes in its communication range. The source/intermediate node compares predictability values of its neighboring nodes including its own values and selects only two number of neighbors with maximum predictability metric value, for forwarding of message. Afterwards logical 'AND' function is carried out between summary vectors of chosen two number of nodes vectors and the source itself. By logical "AND" operation missing messages are found in buffers of chosen nodes and missing messages are forwarded to those nodes. This action helps to minimize the congestion in the network. In some circumstances, if a source node doesn't find any nodes with valid delivery predictability then the message is transferred to all nodes in its communication range. PRO-SNW [10] is a hybrid routing protocol that combines PROPHET [7] and SNW [8] algorithms. Calculation of delivery predictability by Prophet consists of three factors as described in [7]. When nodes come within the close proximity of each other, message transfer takes place among the node with lower delivery predictability to the node having the highest delivery predictability. The messages are relayed to the neighbor nodes as stated in SNW technique. For a node X which has number of message copies n>1, encounters a node Y deliver n/2 copies of messages to node Y and retains rest n/2 message copies with itself. This action continues till message reaches its destination node or else left with single copy of message. The proposed routing scheme reduces resource utilization by restricting the amount of flooding.

3.Proposed work

Major research has been undertaken to enhance routing performance. The proposed routing algorithm gathers the frequency of meeting with respect to all other nodes and computes the metric value to determine the most effective neighboring node to carry the message. Message propagation is carried out in the same manner as in the SNW [8] routing scheme.

3.1.Building the Mobile Opportunistic Network Topology

Consider the mobile opportunistic network, which has N nodes. Each node is given a unique Id. Every node's message is presumed to have an infinite Time to Live (TTL). It is assumed that enough buffer space for every node to store messages. Every node is believed to have infinite energy for storing, transmitting, and receiving messages. The absence of malicious behavior is believed, as are all nodes' cooperation with one another. Both communication links share the same bandwidth. Any message is presumed to have a single source and destination node, as well as (N-2) intermediate nodes. The network is kept under control for a fixed period of time. It is a complex network, and it was discovered that each node has a node probable mobility pattern.

The observed mobility pattern is used to collect information about the frequency of meeting with all other nodes. If the frequency of meet value is low, the node is inactive. Since it is a non-social node, it is not selected for message routing to the destination. The data obtained from the mobility pattern provides information about the

frequency of meeting with all other network nodes in the network. Aim of using the more active nodes in the proposed routing algorithm is to achieve a high distribution ratio. The improvement implemented in the suggested hybrid routing algorithm is the frequency of the meetings with all other nodes including destination. This parameter is correlated with significant node mobility, which is related to faster area network coverage.

3.2.Forwarding strategy

For message transmission, the presented algorithm employs a hybrid-based approach. The SNW [8] algorithm is used for propagation of message in this case. It is superior to the Epidemic routing scheme. The routing approach Spray and Wait is divided into two phases. Source node sprays a predetermined number of message copies L in to the network in the first phase. Suppose if the destination node was not found during spray process, each relay node having a copy of the message performs direct transmission of message to the destination during the wait phase. The proposed hybrid solution is also divided into two phases. However, in the first phase, source node restricts the number of message duplications within the network by using a metric value known as Node Factor (NF) to identify relay nodes. The routing algorithm decides whether to relay messages to other nodes with in its communication range, based on mobility factor which is evaluated by using frequency of meetings with other nodes using NF value. Using the NF value, a suitable intermediate node is to be chosen from the neighboring node that a source node gets in its communication range. Node Factor is given by equation (1).

$$NF = \frac{\sum_{j=1}^{n} FM(Ni,Nj)}{\sum_{i=1}^{n} \sum_{j=1}^{n} FM(Ni,Nj)} \quad \ldots..(1)$$

When a source/intermediate node encounter set of neighbor nodes in its communication range, then the source/intermediate node in the spray phase, every time compares the NF metric value of its entire neighbor with the threshold value T. If the NF metric value of neighboring nodes is greater than threshold, then the message is forwarded to those nodes. In the spray phase suppose destination node was not found then in the waiting stage each relay node which has got a copy of the message accomplishes the direct transmission of message towards the destination. The hybrid routing process is depicted in Algorithm 1.

Algorithm 1. *Node Factor based Hybrid Routing Algorithm for Mobile Opportunistic Network*

Step1: Read the source node and destination node.
During Spray phase message transfer process:
Step2: If the source node falls within communication range of the respective destination node, then the message is sent to the destination node.
Step3: If a source node/intermediate node discovers a number of nodes within its communication range, then
For number of neighboring nodes:
For every message do
For every encountered neighbor node do
Compute:

$$NF = \frac{\sum_{j=1}^{n} FM(Ni,Nj)}{\sum_{i=1}^{n} \sum_{j=1}^{n} FM(Ni,Nj)}$$

end for
end for
Step4: Check NF value for all encountered neighbor nodes
For every node do
If NF > T
Insert node with in HashMap
end if
end for
Step 5: Transfer of every message
For all nodes with in HashMap do
From source node to HashMap nodes transfer the messages.
end for
end for
During wait phase message transfer process:
Step 6: If source/intermediate nodes which got the messages in the spray phase, if they encounter destination node within the communication range, then direct transmission of message to the destination node takes place. Otherwise, no transfer of message in this phase is carried out.

4.Simulation and Results

The proposed work is simulated on a personal computer with an Intel i5 processor using Mat-lab software in a Windows environment. This section discusses a simulation model as well as performance metrics.

4.1.Simulation Model

The simulation is carried out over the area of 4500 m x 3400 m. We have selected six groups of mobile nodes with variable node speed and range. The total number of nodes selected as 120, 150, 180, 210, 240, etc. The first and second group nodes are pedestrian groups with 0.5 m/sec speed and 1.5 m/sec speed. Third group nodes belonging to cyclist group with 2.7 m/s speed to 13 m/s speed. For all mentioned three groups bandwidth assigned is 2 Mbps. The remaining three groups of motor vehicle nodes ranging from 8 m/s to 20 m/s speed. The nodes are provided with a Bluetooth communication model having communication range in between 10 m except the high-speed group that is fifth and sixth group nodes which are provided with long range communication interface having range of 1000 m and also bandwidth of 10 Mbps. For every node assigned buffer size is 5MB. For simulation time of every 30-sec message of 500KB to 1MB is generated.

4.2.Performance Metrics

The proposed node factor-based hybrid routing algorithm performance is tested by using the following metrics.

Delivery Probability: It is the ratio of total number messages delivered to the total number of messages generated by the source.

Average Hop Count: It provides average number hops required to transmit the message from source node to the destination node.

Messages Delivered: It is the total number of messages received by the destination node successfully.

4.3. Simulation Results

Node-based hybrid routing algorithm performance in terms of average hop count for the different numbers of nodes is shown in figure 1. This also presents the transmission cost, disclosing the number of nodes involved in delivering number of messages towards the destination. As we increase the number of nodes, due to the mobility factor, frequency of encounters in the network enhances. The increase in the frequency of encounters provides a greater number of eligible nodes availability, to carry the message towards the destination and also the minimum number of valid nodes provision required for the message transmission.

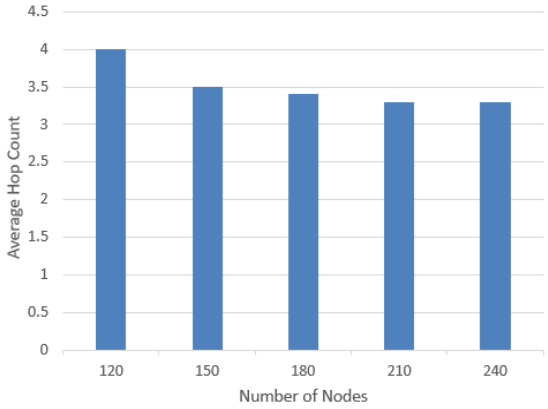

Figure 1. Number of nodes vs. Average hop count

The effect of number of nodes vs. delivery probability is shown in Figure 2. Figure 3 represents the response of an increase in the number of nodes vs. packets received. From the graphs, it is found that, improvement in the message delivery as the node number increases. Hence delivery ratio increases with increase in number of nodes. As we increase the nodes, the continuous mobility of nodes provides an up gradation in the parameters such as frequency of encounter. Hence the number of eligible node's availability because of the frequency of encounters at different levels will in turn have an impact on the contact time of meeting within the nodes. These parameters are responsible for an increase in the number of messages transfer towards the destination and hence increase the delivery probability.

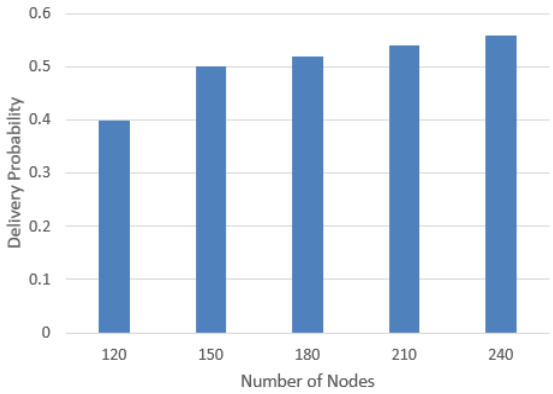

Figure 2. Number of nodes vs. Delivery Probability

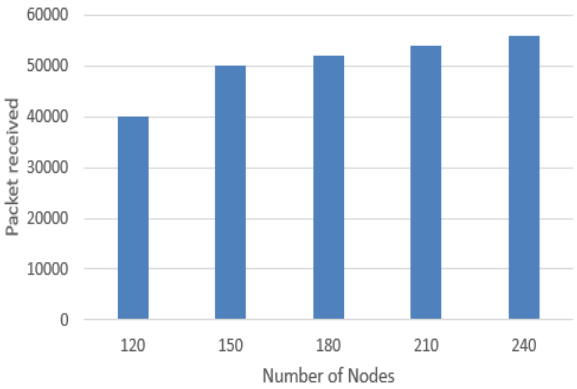

Figure 3. Number of nodes vs. Packet Received

5.Conclusion

The field of Mobile Opportunistic Network has become increasingly interesting in recent years. The routing decision for relay node selection in the proposed node factor-based hybrid routing strategy is based on metric value computation. The parameter, frequency meet among nodes, which arises from node mobility, is considered in the metric calculation. As the more nodes move, the more likely they can reach other nodes and cover a wider region of the network. By increasing the distribution ratio, the node parameter improved routing efficiency. Node selection parameters have greatly reduced the network's computing cost by managing message distribution. The proposed scheme demonstrates improved delivery ratio.

References

[1] S.R.Bharamagoudar and S. V. Saboji, "Review of microscopic and macroscopic routing algorithms in Opportunistic Networks," 2016 International Conference on Computation System and Information Technology for Sustainable Solutions (CSITSS), Bangalore, 2016, pp.232-237.

[2] S.R.Bharamagoudar and S. V. Saboji, "Routing in opportunistic networks: Taxonomy, survey," 2017 International Conference on Electrical, Electronics, Communication, Computer, and Optimization Techniques (ICEECCOT), Mysuru, 2017, pp. 300-305.

[3] Cao, Yue, and Zhili Sun. "Routing in delay/disruption tolerant networks: A taxonomy, survey and challenges." IEEE Communications surveys & tutorials 15.2 (2012): 654-677.

[4] Moreira, Waldir, and Paulo Mendes. "Survey on opportunistic routing for delay/disruption tolerant networks." SITI Technical Report SITI-TR-11- 02,pp.134,2010.

[5] T. Spyropoulos, K. Psounis, and C. S. Raghavendra, “Single-copy routing in intermittently connected mobile networks,” in Proceedings of the 2004 First Annual IEEE Communications Society Conference on Sensor and Ad Hoc Communications and Networks, 2004. IEEE SECON 2004, pp. 235–244, IEEE, Santa Clara, CA, USA, October 2004.

[6] Vahdat and D. Becker, “Epidemic routing for partially connected Ad Hoc networks,” 2000.

[7] Lindgren, A. Doria, and O. Schelén, "Probabilistic routing in intermittently connected networks," in Proceedings of the ACM International Symposium on Mobile Ad Hoc Networking and Computing, MobiHoc, Annapolis, MD, USA, June 2003.

[8] T. Spyropoulos, K. Psounis, and C. S. Raghavendra, "Spray and wait: an efficient routing scheme for intermittently connected mobile networks," in Proceedings of the 2005 ACM SIGCOMM Workshop on Delay-Tolerant Networking—WDTN'05, pp. 252–259, ACM, Philadelphia, PA, USA, August 2005.

[9] Kiran Avhad, Suresh Limkar, and Anagha Kulkarni, " Efficient Hybrid Approach for Opportunistic Networks," Proc .of Inc. conf. on Advances inComputer Science andApplication, Elsevier, pp-729- 734, 2013.

[10] Sanjay K. Dhurandher, Satya Jyoti Borah, Mohammad S. Obaidat, Deepak Kr. Sharma, Sahil Gupta and Bikash Baruah, " Probability - based Controlled Flooding in Opportunistic Networks" International Conference on Wireless Information, IEEE , pp.3-8,2015.