Balloon Based Communication to Improve Performance in Vehicular Delay Tolerant Network

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Abstract. In sparse vehicular network communication, link exists for short time between the communicating nodes and the delivery probability will be less with no definite path from the source to the destination. For this purpose Vehicular Delay Tolerant Network is used in such scenarios to improve the performance. A routing protocol for Vehicular Delay Tolerant Network's must make use of the available resources in an efficient manner creating multi-hop paths between the source and the destination. In proposed work, two types of delay tolerant nodes are used to increase the delivery probability, special nodes and balloons. When normal nodes generate message, they will transfer it to the special nodes which will again pass it to other special nodes or to the balloons or to a destination node. Balloons will exchange messages between special nodes and balloons themselves. The proposed approach is tested for five different scenarios and compared with Geographic routing protocol. The delivery probability in the range of 49–89% is achieved and messages are delivered using fewer hops (on an average 3). It is shown that this approach significantly improves delivery probability and reduces overhead ratio.

Keywords: Vehicular Delay Tolerant Network (VDTN) · Balloon · Delivery probability · Overhead ratio

1 Introduction

Vehicular networks consist of mobile wireless network, where most of the times a complete path does not exist between the source and the destination. To overcome this problem, Vehicular Delay Tolerant Network is being used in vehicular network which has many applications like disseminate safety related information (emergency notification, traffic condition and collision avoidance), to provide connectivity to rural areas and catastrophe hit areas. In all these applications, VDTN can be used to exchange messages between the rescue teams and other emergency services [1].

To make such applications possible, it is required to develop a protocol which can overcome restriction of road side movement. In the proposed work, it is focused to move beyond vehicle to vehicle communication and vehicle to relay node (static and mobile) communication. There are many routing protocols available in delay tolerant network which have different advantages and disadvantages. Binary spray and wait

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routing protocol is one of the most used protocol which has higher delivery probability and less overhead ratio as compared to other routing protocols [2].

To achieve higher delivery probability, message should reach destination within its Time-to-Live (TTL) and hence message needs to be passed through shortest path from source to destination. If only road side movement is considered this may not be achieved effectively since there are many restricted movements due to traffic jam especially in one way lanes. Hence this work proposes to use Project Loon, it is a research work by Google X to provide internet connectivity to remote areas [3]. Balloons are used and these are placed in stratosphere at height of 18–22 km to float and will move randomly depending on the direction of air. These balloons can take messages from nodes and transfer it to other nodes. There are many areas in vehicular delay tolerant network which need to be improved and this work is carried out with objectives to:

1. Achieve more packet delivery ratio in the sparse network.
2. Minimize the overhead ratio on the packet.
3. Make use of the tight resources available in the network.

The performance of proposed work is evaluated through ONE (Opportunistic Network Environment) simulator. The simulator is developed in Java and provides following features: generating node movement using different movement models, routing messages between nodes with various Delay Tolerant Network (DTN) routing algorithms and sender and receiver types, visualizing both mobility and message passing in real time in its graphical user interface. The performance metrics considered for evaluation are delivery probability (the ratio of number of messages received by destination to the number of messages generated by source in given network) for variable number of normal nodes and overhead ratio (the ratio of difference between number of messages relayed and total number of messages delivered to total number of messages delivered in given network). Analysis of results based on simulation shows that there is significant improvement in delivery probability and overhead ratio than the other evaluated routing schemes.

The remainder of paper discuss about: Sect. 2 deals with related work, Sect. 3 describes proposed work, Sect. 4 gives information about simulation results and Sect. 5, provides the conclusion.

2 Related Work

This section provides the information about the different approaches used in Vehicular Delay Tolerant Network (VDTN). GeoGrid [4], propose a grid division approach and routing algorithm. The algorithm has three parts: (1) fixed station based DTN's, (2) accurately dividing geographic grid (3) strategy for forward routing. Here, the fixed station is that data center having two functions: one is data collection and other is passing the information that is collected. These fixed stations are located in a high density region so that it can efficiently receive the packets. To obtain the geographic grid, map is divided into WxW square grid region where 'W' is the width of grid. Routing begins when new packets are created, detecting neighbor nodes every time.

The GeOpps [5], is an approach to improve the performance of single-copy routing protocol in VDTN (Vehicular Delay Tolerant Network). It considers the location to forward the packet to the final destination. The vehicles that are heading towards the destination carry the bundle as they being the closest point; they are used to calculate the estimated time of delivery.

The GeoSpray [1], is a Global Positioning System (GPS) which is based on routing protocol which takes routing decisions by using available Geographical data. Using GPS data, shortest path from source to destination is calculated and nodes move in that path. GeoSpray presents a hybrid approach using multiple-copy and single-copy routing schemes. First, it uses multiple-copy scheme using Spray and Wait protocol, then, it switches to single-copy scheme. The simulation is carried out using ONE simulator and the scenario is based on Helsinki city map. It was shown that GeoSpray protocol improves the delivery probability and reduces the delivery delay, comparing with other routing protocols in VDTN under study.

In [6], they intend minimizing the communication outage of the target vehicle in the uncovered area of two RELAY's. This is done using two way scheme of relay, where one way is when a relay vehicle is exiting the first RELAY coverage area and second way is when relay vehicle enters the next RELAY coverage area.

3 Proposed Work

The prime purpose of proposed work is to develop a system that can increase the delivery probability in sparse vehicular network where communication opportunities are less, frequent link disconnections occur and there are less probability of forming a multi-hop path. In this work, Roadmap of Hubballi is considered for simulation. Hubballi is second largest and one of the fastest growing city in the state of Karnataka, India [7]. Figure 1, shows the map of Hubballi used for simulation.

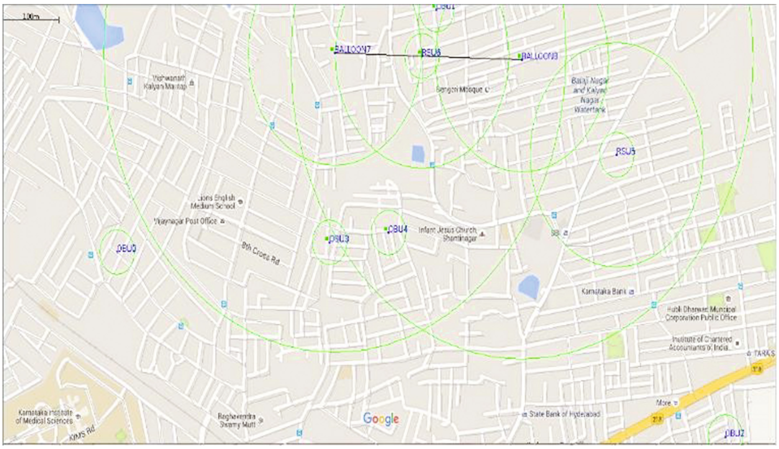


Fig. 1. Hubballi map used for simulation

The Fig. 2, shows the system model for proposed approach. It consists of 4 modules: Node Selection, Path Selection, Information Exchange and Routing Decision.

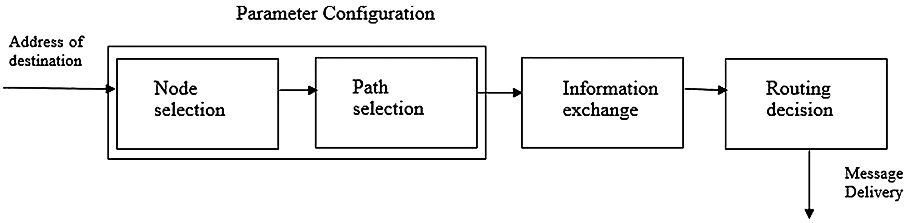


Fig. 2. System model

The Node Selection module selects the source node and the destination node. Source node, which has to generate message and destination node to which message has to be delivered. The source node not only sends the messages but also it configures certain parameters like size of messages, time-to-live, speed of the nodes and number of nodes between which the messages have to be exchanged in order to reach the destination. In Path selection module, the path through which nodes move will be configured. There are three basic movement models:

1. Random Way Point: Here nodes move randomly on the map
2. Map Based Movement: Here nodes move randomly on the roads of given map
3. Shortest Path Map Based Movement: Here nodes randomly select a source point and a destination point in given map and move in shortest path available.

In proposed work, development is made where a new movement model is used in which Balloons move diagonally. This completes Parameter Configuration. In Information Exchange module, nodes will exchange the messages when they come in communication range of each other. The communication range of different nodes is given in Table 1. Figure 3, shows the exchange of messages between different nodes (OBU-Normal Nodes, RSU-Special Nodes and Balloons). Finally, in Routing Decision module, nodes will route the messages to other nodes using Binary Spray and Wait protocol. Here each node stores the data of number of message copies L and forwards floor (L/2) copies to other node.

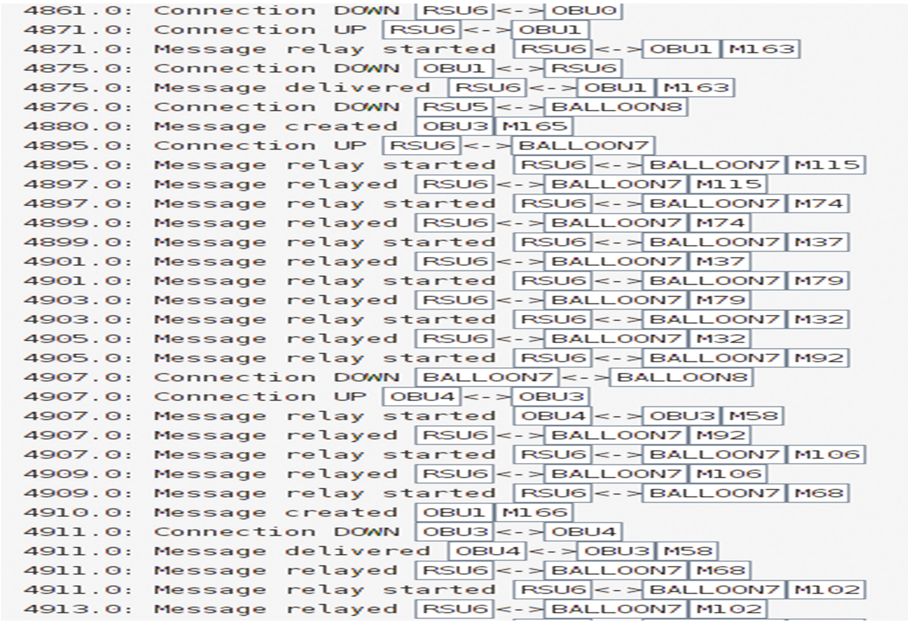
Table 1. Simulation parameters

Simulation parameters	Range
Number of normal nodes	5–25
Speed of normal nodes	20–40 kmph
Normal node transmission range	30 m
Normal node transmission speed	2 mbps
Buffer size of normal node	150 MB
Number of special nodes	2
Number of balloons	2

(*continued*)

Table 1. (*continued*)

Simulation parameters	Range
Speed of special nodes	20–40 kmph
Special nodes transmission range	150 m
Special nodes transmission speed	4 mbps
Buffer size of special nodes	500 MB
Balloon transmission range	400 m
Balloon transmission speed	30 mbps
Balloon buffer size	1000 MB
Simulation area	1400 * 600 m^2



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4861.0: Connection DOWN RSU6<->OBU0
4871.0: Connection UP RSU6<->OBU1
4871.0: Message relay started RSU6<->OBU1 M163
4875.0: Connection DOWN OBU1<->RSU6
4875.0: Message delivered RSU6<->OBU1 M163
4876.0: Connection DOWN RSU5<->BALLOON8
4880.0: Message created OBU3 M165
4895.0: Connection UP RSU6<->BALLOON7
4895.0: Message relay started RSU6<->BALLOON7 M115
4897.0: Message relayed RSU6<->BALLOON7 M115
4897.0: Message relay started RSU6<->BALLOON7 M74
4899.0: Message relayed RSU6<->BALLOON7 M74
4899.0: Message relay started RSU6<->BALLOON7 M37
4901.0: Message relayed RSU6<->BALLOON7 M37
4901.0: Message relay started RSU6<->BALLOON7 M79
4903.0: Message relayed RSU6<->BALLOON7 M79
4903.0: Message relay started RSU6<->BALLOON7 M32
4905.0: Message relayed RSU6<->BALLOON7 M32
4905.0: Message relay started RSU6<->BALLOON7 M92
4907.0: Connection DOWN BALLOON7<->BALLOON8
4907.0: Connection UP OBU4<->OBU3
4907.0: Message relay started OBU4<->OBU3 M58
4907.0: Message relayed RSU6<->BALLOON7 M92
4907.0: Message relay started RSU6<->BALLOON7 M106
4909.0: Message relayed RSU6<->BALLOON7 M106
4909.0: Message relay started RSU6<->BALLOON7 M68
4910.0: Message created OBU1 M166
4911.0: Connection DOWN OBU3<->OBU4
4911.0: Message delivered OBU4<->OBU3 M58
4911.0: Message relayed RSU6<->BALLOON7 M68
4911.0: Message relay started RSU6<->BALLOON7 M102
4913.0: Message relayed RSU6<->BALLOON7 M102
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Fig. 3. Information exchange

The work consists of 3 types of nodes Normal Nodes (NN), Special Nodes (SN) and Balloons. The configurations of each type of node for simulation are considered from [8, 9] and the details are given are given in Table 1.

This work uses two types of Movement models, Shortest Path Map Based Movement and Map Based Movement. Shortest Path Map Based Movement: In selected .wkt (well known text) file two points are selected randomly i.e., one source point and one destination point and shortest path from source to destination is found using Dijkstra's algorithm and nodes are moved on this path. Map based movement:

In selected .wkt (well known text) file a path is selected randomly and node movement is given. To evaluate the performance of proposed work, Message Delivery Probability is considered. Delivery Probability is the ratio of number of messages delivered to that of number of messages created in the network for a given time.

4 Results and Discussion

This part describes the simulation results and analysis of the result. The following are the results of different scenarios:

Scenario 1: The Fig. 4, represents delivery probability for different number of NNs (Normal Nodes). For Shortest Path Map Based Movement (SP) delivery probability is good as compared to Map Based Movement (MB) because in Shortest Path (SP) Map the nodes move in shortest path from source to destination (source and destination are selected randomly) and nodes are moved. But in MB nodes move randomly and there is less probability of nodes coming in contact of each other as they have small communication range of 30 m.

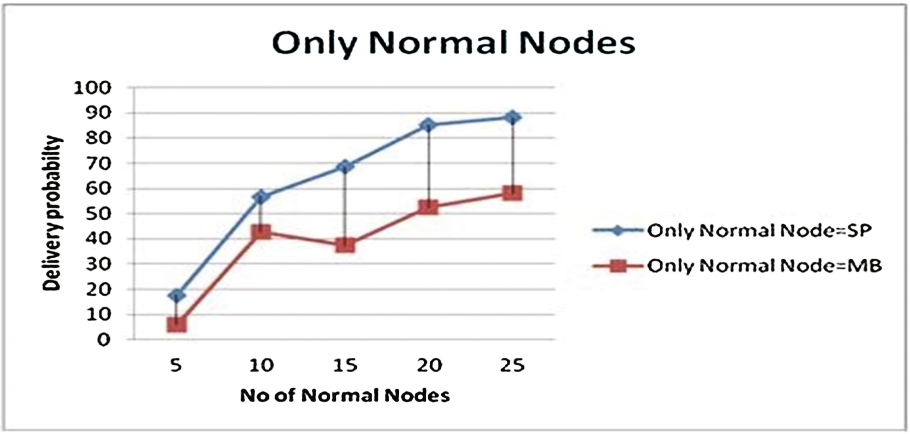

Fig. 4. Graph for scenario 1

Scenario 2: Fig. 5, represents placing of Relay on map statically. These have higher range of communication and buffer capacity. When NNs come in contact with Relay they send message with details of destination. If relay comes in contact with NN it will forward message to it or it can also send it to destination node. So delivery probability is slight higher as compared to scenario 1.

Scenario 3: Fig. 6, represents graph for change in delivery probability for simulation when Relay nodes are mobile. We see that for Map Based Movement model delivery probability has increased as compared to scenario 2. When considered for sparse network, delivery probability is high for shortest path map based movement.

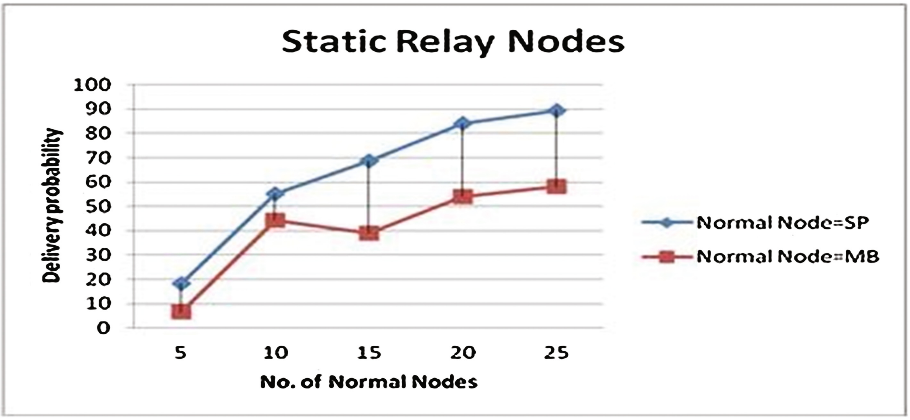

Fig. 5. Graph for scenario 2

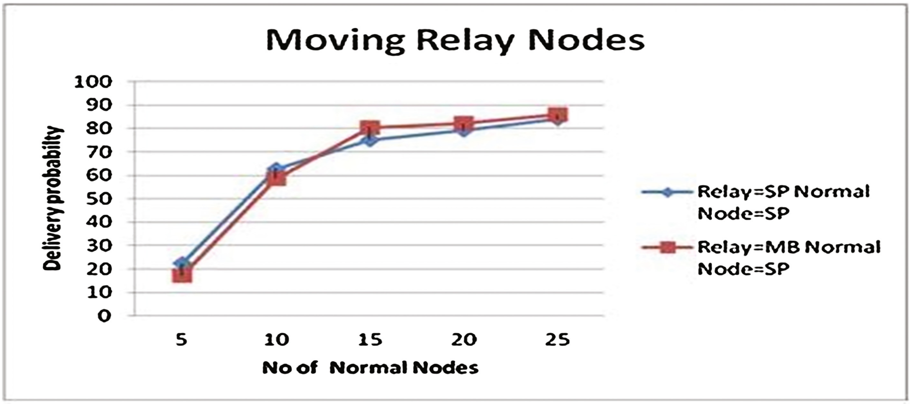

Fig. 6. Graph for scenario 3

Scenario 4: Here Balloons and Relay Nodes are used to store the intermediate messages and deliver them to destination node. The new movement model, move the Balloons diagonally while random movement model move the balloons randomly. The new movement model move the balloons diagonally depending on wind direction, here the speed is high and while moving in opposite direction of wind, the speed of balloon is reduced. But in random movement model, the speed and movement will be varying. Moving in opposite direction of wind increases contact period and hence increases delivery probability, while moving in same direction delivery probability decreases. This reduces delivery probability of new movement model. Refer to the Fig. 7.

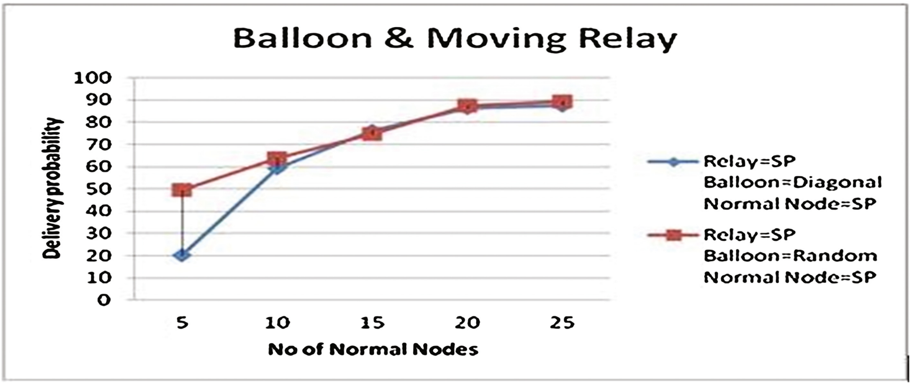

Fig. 7. Graph for scenario 4

Scenario 5: This scenario represents usage of static relay nodes and movement of Balloon with new movement model and random movement model. This scenario is giving less delivery probability as compared to scenario 4 as relay nodes are static and will communicate with less number of nodes. Here random movement is giving higher delivery probability as compared to diagonal movement model as balloons will come in contact with relay nodes and normal nodes as compared to diagonal movement. Refer to the Fig. 8.

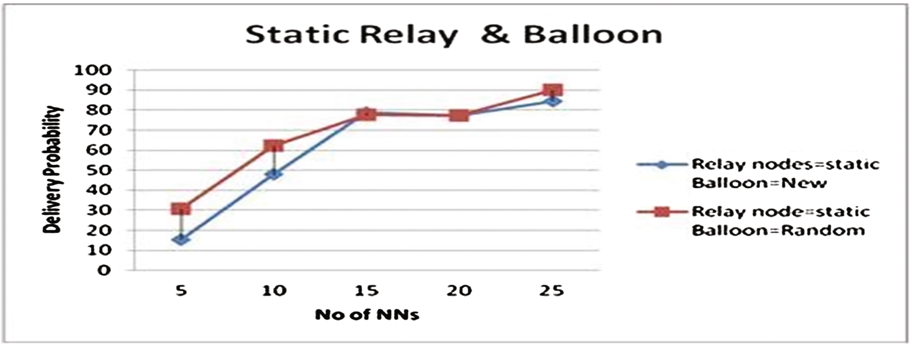

Fig. 8. Graph for scenario 5

Scenario 6: Comparison of proposed work with GeoSpray [1]. The maximum delivery probability achieved by GeoSpray with simulation settings in Table 2 is in range of 50–55%.

For the proposed work the simulation settings in Table 2, is applied and delivery probability of 87.79% is achieved (Fig. 9).

Table 2. Simulation parameters of GeoSpray protocol

Simulation parameters	Helsinki downtown
Simulation area	4500 * 3400 m^2
Number of normal nodes	100
Speed of normal nodes	50 kmph
Simulation time	6 h

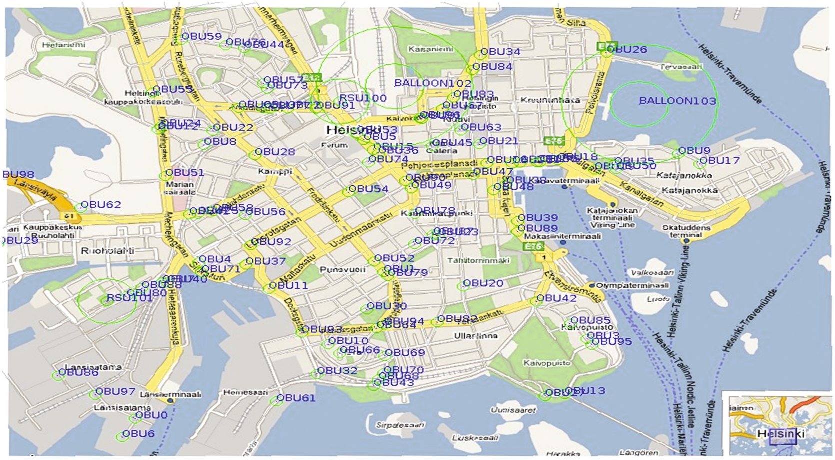

Fig. 9. Implementation of proposed work in Helsinki map to compare with GeoSpray

5 Conclusion

This paper proposed usage of Balloons for Vehicular Delay Tolerant Network. The proposed work can be used in sparse scenarios where there is no end-to-end multi-hop path. The simulation is carried out for 5 different scenarios with varying number of nodes and usage of different types of nodes. Results show that delivery probability of sparse network has increased from 18–88% to 49–89.5% for normal nodes in range of 5–25 with usage of 2 balloons and 2 special nodes. It is shown that usage of Balloon with special nodes or either only usage of Balloons in vehicular delay tolerant network increases delivery probability and also reduces the overhead ratio.

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