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# Exploiting Poisson Distribution for Determination of Optimized Path

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**Abstract**

The paper proposes a routing algorithm in the sparsely connected delay tolerant network. The routing is performed in a wireless communication environment among the nodes deployed in a specific application domain. Due to the mobility of the nodes there is frequent loss of end to end connectivity. The network is divided geographically into many regions. Few nodes having a longer battery life and good history of contacts are selected as base stations, which for the sake of convenience have been considered as stationary and immobile. The main function of these base station nodes is to buffer the received data. These base stations are placed strategically in those geographical regions which are visited more frequently. Any node visiting the base station, node buffers its message there. Whenever any node visits the base station, the message is transmitted to the visited node. To increase the probability of the message reaching the destination, we explore the Poisson distribution for choosing the next forwarding node.

## 1. Introduction

Delay Tolerant network consists of devices scattered in an area far from each other. These devices are always moving and exchange messages whenever they cross eachother' s path. The mobile devices are known as nodes, which communicate via a wireless LAN or a Bluetooth. The nodes have their own transmission range. Each node is uniquely identified by a EID (End Point Identifiers).When a node comes in contact with another nodes it starts transmitting the message. Only those messages which are not there in buffer of second node are transmitted[1]. In this manner the messages spread in an epidemic manner.[5]

Delay tolerant networks are used in the terrain which observes frequent and long delays .The delays are caused when there is loss in connectivity of end to end path between the source and destination.[3]A Delay tolerant network is like a disconnected graph which addresses the fact that there is never a constant connection between any two nodes.[2]The DTN finds it application in many areas such as rural communication, setting up of a temporary network in enemy's terrain, interplanetary communication, military, underwater networks, sparsely habituated areas, etc. In spite of the fact that we are living in time of satellite communication technology and cellular communication technology, there are circumstances when all these fail to acknowledge our needs.

## 2. Sections

### 2.1 Background

In places like Leh, Ladakh (J & K), problems in communication are faced by common man due to fierce climatic conditions. A cellular base station which delivers the services to the customer in its range, fails in case of a cloud burst or heavy snowfall. A similar incident occurred at Kedarnath in Uttarakhand, where the infrastructure was destroyed and there was no communication channel available for the stranded pilgrimages and locals. In such scenarios the functionality of delay tolerant network can be explored. Setting up a temporary network, where mobile nodes are used to deliver the message can help to restore communication temporarily and speed up the relief and rescue operations so that the quick evacuation of the affected persons can be carried out.

In DTN, for transmitting the message from one node to another ,several types of contacts have been defined[2],they are detailed as :-

Types of Contacts:

- *Persistent Contacts* - These contacts are always available with the node for the exchange of the data..For example DSL, Internet connection et al.
- *On-Demand Contacts*-These type o contact are provided on request to the DTN nodes so that the data generated by them can be relayed to the destination.
- *Intermittent - Scheduled Contacts* -A scheduled contact is a contact established between two DTN nodes so that they can share the data at pre-decided and pre-determined time.
- *Intermittent - Predicted Contacts*-These contacts are based on the predictions for future contacts between DTN nodes by observing the previous history of contacts between the nodes.
- *Intermittent – Opportunistic Contacts :* These contacts always expects the DTN node to be in 'ready' mode waiting for any single opportunity that may come their way enabling the node to transfer or receive the data from the encountered node.

**2.2Routing in Delay Tolerant Networks**

Unlike the static wireless networks which have the knowledge of topology , DTN doesn't have any , however over the period of time the network knowledge can be acquired and assessed to guess future movement pattern of the nodes. In DTN the goal is ultimate delivery of the message.[4] In spite of the fact that DTN is meant for the network where delay is not a problem, the protocol with less delays and data packet dropping is preferred. Limited resources available such as buffer size, battery life of the nodes and bandwidth are important parameters for a routing algorithm.

**2. 3 Division of Network in Regions**

The paper proposes a routing strategy based on the Poisson distribution. The network region is geographically divided into many regions as shown in Fig 1.Upper and lower bound of all the regions is determined. After dividing the network into regions, the regions which are not visited frequently are found out based on the log history of nodes. Those regions which are rarely visited by nodes are termed as isolated regions

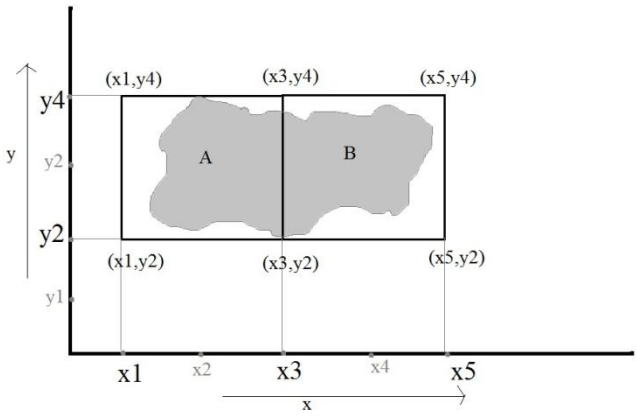


**Figure 1**: Division of Network in many regions.

For region1 : Upper bound for x=x1 , Lower bound for x=x3

Upper bound for y=y2 , Lower bound for y=y4

If a nodevisits region1 frequently, then it should contain the coordinates of a region in some non consecutive manner. For eg $(x_i, y_j)$, $(x_p, y_q)$, $(x_k, y_m)$

where $(x_p, y_q)$ doesn't belong to region1 $x_1 \leq i, k \leq x_3$ and $y_2 \leq j, m \leq y_4$ (1)

**2.4 Installation of Base station**

Isolated regions face problems in communication as no node is available at regular intervals. To overcome this problem static buffers are installed in these regions,which are termed as base station Fig 2. A base station is used to store messages of visiting nodes,until the TTL of the message expires or buffer overflows .Since the base station isnot mobile theirbattery last longer than mobile nodes. Sometime later when a node

visits the base station,the messages buffered at the base station are transmitted to node and messages contained by node are buffered at the base station.

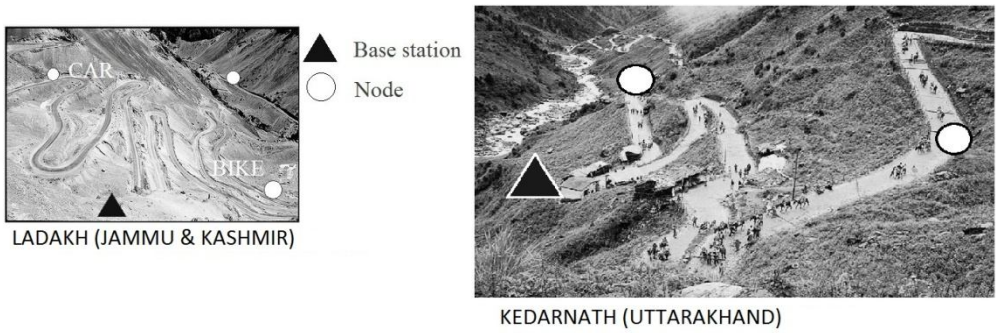


**Figure 2:** Base stations installed in ladakh and kedarnath.

**2.5Poisson distribution for finding probability of future visit of a node**

When a node enters a region, the probability of any other node meeting this node here in some time interval can be found using Poisson distribution. Over a period of time we have the assessed data of region1, we have acquired the knowledge that N nodes visit region1 in unit time.

Rate of node visit event in region1 =N/h

The expectation in next $\Delta t$ time = $\lambda$ ($\lambda$ is parameter , $\lambda>0$)

$$\lambda = (N/hr)\,\Delta t$$

$$P(X=x) = \frac{e^{-\lambda}\lambda}{x!} \qquad (2)$$

Probability of node visiting a region in next $\Delta t$ time can be found using Poisson distribution

= [1- (Probability of no node visiting region1 in next $\Delta t$ time)]

= [1- P(X=0)]

Using the equation (1) and (2) the nodesare able to predict the probability of message being received by a node that visits the region of the destination node. Sending node can look out for those nodes which visit the same areas or areas close to the destination node. The metric based on the Poisson distribution for all intermediate regions can be formulated and compared for finding an optimal path to the destination node. For a scenario the metric formed is detailed as :

**Table 1:** Metric for a network of 6 regions.

| Region | x/hr | Expectation | Probability |
|---|---|---|---|
| Region1 | 3 | 15 | 0.99999969409 |
| Region2 | 2 | 10 | 0.99995460007 |

| | | | |
|---|---|---|---|
| Region3 | 2 | 10 | 0.99995460007 |
| Region4 | 3 | 15 | 0.99999969409 |
| Region5 | 1 | 5 | 0.993262053 |
| Region6 | 1 | 5 | 0.993262053 |

## 3. Conclusions

Probabilistic routing can help in finding the optimal path .Installation of base station in isolated regions can provide a better way than to wait for arrival of other node .The log maintained by nodes about the region coordinates creates overhead , but it enables in guessing more accurate path for message delivery to the destination node. Poisson distribution provides a better for estimating the better forwarding node and popular region in a network.

## 4. Acknowledgements

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