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Design of Simulator for Finding the Delay Distribution in Delay Tolerant Networking

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I. INTRODUCTION

Delay-tolerant networks (DTNs) have the great potential to connecting devices and regions of the world that are presently under-served by current networks. A vital challenge for Delay Tolerant Networks is to determine the routes through the network without ever having an end to end, or knowing which "routers" will be connected at any given instant of time. The problem has an added constraint of delay at each node. This situation limits the applicability of traditional routing techniques which categorize lack of path as failure of nodes and try to seek for existing end-to-end path. Approaches have been proposed which focus either on epidemic message replication or on previously known information [2] about the connectivity schedule [1]. We have considered that the protocol have the previous knowledge of routing and computed delay on the basis of replication on the nodes and on the basis of total time to transfer the packets from one node to other node. DTN is an environment for the intermittent connectivity for mobile wireless networks in which the connectivity between the nodes changes frequently. DTN routing follows an approach of S-C-F [2]. It stores the packets on the nodes and carry them until the communication between two nodes take place. DTN simulations abstract from the details of the wireless link characteristics and simply assume that two nodes can communicate when they are in range of one another

[3]. Delay and disruption-tolerant networks (DTNs) are characterized by their lack of connectivity, resulting in a lack of instantaneous end-to-end paths. But a main reason of delay in the environment is due to un-optimized replicas of the packets on the nodes. Applications of DTNs include large-scale disaster recovery networks, sensor networks for ecological monitoring [4], ocean sensor networks [8, 5], people net [6], vehicular networks [7, 10], and Digital Study Hall [11], One Laptop per Child [9] to benefit developing nations. Intermittent connectivity can be a result of mobility, power management, wireless range, scarcity, or malicious attacks. The inherent uncertainty about network conditions makes routing in DTNs a challenging problem [3]. The existing TCP/IP based Internet service model provides end-to-end inter-process communication using a concatenation of potentially dissimilar link-layer technologies [12]. We have also discussed the comparative study between the two types of network working in the same conditions but with a different number of nodes. Prophet uses an in-band control channel to exchange acknowledgments for delivered packets as well as metadata about every packet learnt from past exchanges. For each encountered packet *i*, prophet maintains a list of nodes that carry the replica of *i*, and for each replica an estimated time for direct delivery. Metadata for delivered packets is deleted when an acknowledgement is received.

II. PROPOSED ALGORITHM

To estimate delay distribution we assume that the packets are delivered directly to the destination. Sample Inputs are generated by using several algorithms which were designed for the requirement to solve the problem statement. We have generated several inputs and these inputs are further feeder to the simulator we designed and fetch the results. In each case we have done several simulation runs. Which lead us to the following results. There are few steps to be followed for the generation of the samples. For generating the samples for delay distribution we require randomly generated input samples. Let these time samples work as inputs for the delay distribution and we obtain the delay distribution by following the steps mentioned in the flowchart. The sample inputs for the replications of the packets are generated randomly as integer values. These replicas are responsible for

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increasing delay and decreasing it too. If the replications are made in an optimal manner the delay produced will be lesser.

a) *Flowchart for Delay Distribution*

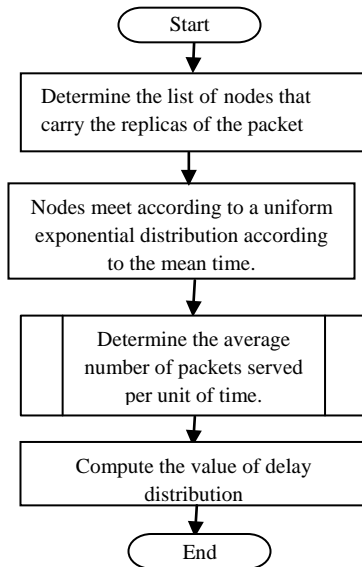


Figure 2.1 : Flowchart of Delay Distribution

b) *Algorithm for Delay Distribution*

1. Let us assume that for each encountered packet (i), Prophet maintains a list of nodes that carry the replicas of (i).
2. Suppose all the nodes meet according to a uniform exponential distribution with mean time $1/\lambda$.
3. The average number of packets served per unit of time is an independently randomly generated integer value.
4. Determine the delay distribution for delay tolerant networking using:

$$A(i) = (\lambda/n_1 + \lambda/n_2 + \dots + \lambda/n_k)^{-1}$$

Step [1] in the algorithm is asking to assume that each encountered packet (i) is been maintained in a list by the prophet routing protocol, this is an hypothesis that we assumed it. Step [2] describes that all the nodes in the environment meet according to a uniform exponential distribution with mean time $1/\lambda$ (where λ in our case represents the average number of packets per unit of time). Step [3] the average number of packets served per unit of time is a random value. Step [4] in this step we calculate our results for the inputs provided. Each node maintains a separate queue of packets Q destined to each node sorted in decreasing order of time since creation—the order in which they would be delivered directly. The insight of the delay distribution function can help us in the design of redundancy based routing in DTN's. The delay distribution function can provide us with a guideline on how to set the lifetime of a message. The graph plotted shows us the delay distribution for several nodes when they have number of replicas of several packets taken on an average. We

have taken a scenario where 5 nodes are willing to send the messages to each other keep in notice that not each node is interested to deliver the packets to the other node. The Simulator designed for finding the results for delay distribution describes the results for the several inputs where the average number of process served per unit of time is given as input to the simulator and then the number of replicas on the nodes is fed to the simulator and we have generated the output for delay distribution or the delay distribution itself. This graphical scenario represents delay vs. the average number of replications for transferring one packet.

III. RESULTS

1. We have simulated the whole environment of DTN network with the help of C.
2. After several Simulation runs in each case we have got the results for delay distribution in the DTN network.
3. Delay distribution is directly proportional to the number of replications of the packet i and mean time.
4. Comparitively delay on 10 number of nodes is less than the delay on 5 nodes even when the average number of replicas are larger on the 10 nodes.

The average number of packets served per unit of time are assumed to be the same in every case but the number of replications of the packets variate independently. We have considered an environment where no node failure. All the nodes have same moving speed and same communication range. The initial position of nodes, replicas and time are randomly chosen by the random generations. We have find out the delay distribution for the Disruption Tolerant Networking Environment where the delay is directly proportional to the number of replicas of the packets to be delivered on each node. This delay variant even when we change the value of replica on a single node and if the number of replicas is changed on different nodes the value of delay variants accordingly as shown in the table. Replicas on the nodes are randomly generated by using the simulator; we are able to find out the delay distribution for the environment.

Table 1 : Delay Distribution for 5 Nodes

Serial No	Average No. of Replications	Delay Distribution
1	2.8	0.084000
2	6.4	0.302158
3	8.4	0.365854
4	10.6	0.421123
5	11.2	0.538491

(NOTE: Not all nodes want to send the data to other node few are not desired to send packet to each node but desired to send to fewer nodes). The table I describes the figure 3.1 as the table consists of the actual values against which the graph has been plotted. Take case 1 in the table as there is 2.8 average number of replicas in the case for 5 nodes in the environment. The delay shown by a low number of average is minor which is 0.084000 where the number of replications of packets are also very less which is 2.8.

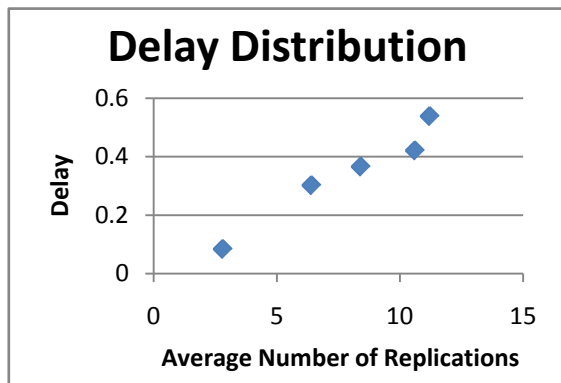


Fig. 3.1 : Graph for Delay Distribution for Five Nodes

As the number of replications of the packets increases on the nodes the delay increases i.e. delay is directly proportional to the number of replicas on the nodes. This is not true in the case of estimated delivery delay. Since with the help of optimum replicas in the delay tolerant networking environment the delay ratio can also be decreased. The graph 3.1 shows us the delay distribution for the values shown in the table I. Graph has been plotted delay vs average number of replications on the node because number of replicas are the major factor for increasing the delay on the nodes. The graph tells us that as the number of replicas on the nodes increases the delay factor also increases delay is directly proportional to number of replica of the packet (i). We simulated for 10 nodes in each case with different number of replications of the packets on each node and the tabulated form of data as shown in table II will depict all the information about the figure 3.2 which displays the delay distribution for 10 number of nodes.

Table II : Delay Distribution for 10 Nodes

Serial No.	Average No. of Replications	Delay Distribution
1	4.9	0.081196
2	5.5	0.085354
3	8.6	0.097013
4	9.7	0.203696
5	11.6	0.263826

(NOTE: Not all nodes want to send the data to other node few are not desired to send packet to each node but desired to send to fewer nodes). The delay for case 1 where average number of replicas are 4.9 and delay distribution is 0.081196 now if we compare the results of table I with table II we get that as in table I we have case number 5 with average number of replications 11.2 and the delay obtained by this average number of replicas is 0.538491 and if we compare it with the case number 5 in table II we obtained that average number of replicas on the nodes is 11.6 and the delay obtained is 0.263826 which is comparatively lesser than the delay obtained in the case of 5 nodes in a network. The in delay between them is 0.274665. Figure 3.2 is a graph depicting delay vs. average number of replications. When Average number of replications are 4.9 on each node the delay fetched is 0.081196. As in second case when we have average number of replicas are 5.5 and delay fetched is 0.085354. This table II and figure 3.2 explains and speaks themselves about the delay fetched.

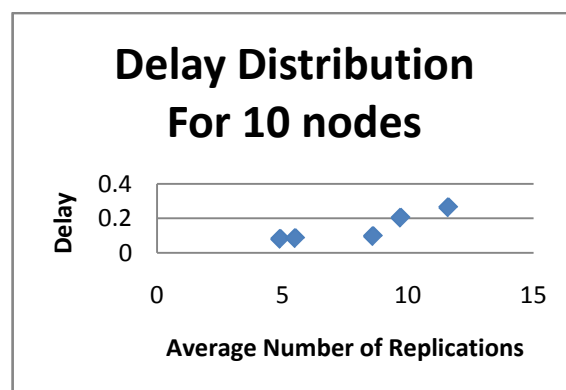


Figure 3.2 : Graph for Delay Distribution for Ten Nodes

a) Comparison Between Delays

The Delay obtained in the cases assumed for 10 nodes in a case is exactly the half the delay obtained by sample inputs in the cases assumed for 5 nodes in a case with same number of replications or the same average number of replications on the nodes.

Table III : Comparative Delay Distribution

Serial No.	Average Replicas	Delay 5 Nodes	Delay 10 Nodes
1	2.8	0.084000	0.042000
2	6.4	0.30216	0.151079
3	8.4	0.36585	0.182927
4	10.6	0.42112	0.210561
5	11.2	0.53849	0.269245

As it has been shown in the table III we define the case 1 as the average number of replicas in the

case 1 is 2.8 the delay obtained for 5 nodes in the network willing to send the packets to the nearest neighbor or to the desired destination is 0.084000 and the delay for the 10 nodes in the network willing to send the packets to the nearest neighbor or to the desired destination is 0.042000 which is exactly the half the delay we obtained for 5 nodes in the network. (NOTE: Not all nodes want to send the data to other node few are not desired to send packets to each node but desired to send to fewer nodes in the network.) A graphical representation may clear the picture of the delay distribution difference between the two scenarios. The graph displays the delay difference the between the cases of 5 nodes in a network and 10 nodes in a network with the same average number of replicas. The delay has been gradually decreased or we can say it is exactly the half of the delay as compared to 5 nodes in a network.

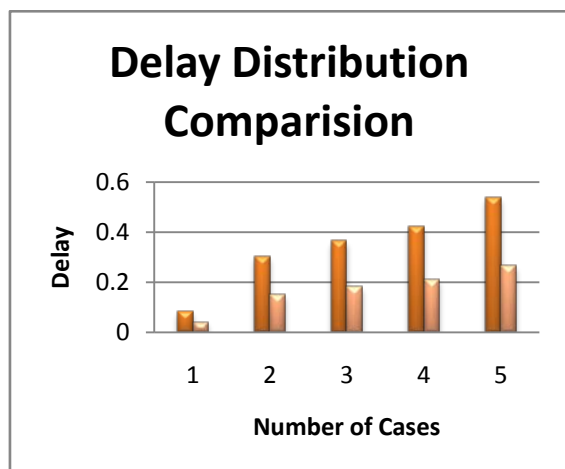


Figure 3.2 : Graph for Delay Distribution Comparison

These results concludes us with finding that if we increase the number of nodes in the network with same number of replicas of the packets we are able to decrease the delay to an optimum value which is tolerable.

IV. CONCLUSION

By delay distribution algorithm we can derive the message delivery delay distribution which can be a rich source of information for improving the performance of redundancy-based routing schemes. The insight of the delay distribution function can help us in the design of redundancy-based routing in DTN's. The delay distribution function can provide us with a guideline on how to set the lifetime of a message. If the delay distribution function shows that 90% of delays are less than T , we can say that most of the messages are likely to be successfully delivered when we set the message lifetime to T . This delay distribution will help us in transferring the data packets and reshuffling the data packets according to the noise on the node for the time

being. These findings helps us to decrease the delay by increasing the number of nodes in the network.

V. FUTURE WORK

These results for delay distributions can be used for acknowledgement to remove the extra replicated packets on the network and to save the unnecessary wastage of resources. How to increase the number of nodes in the network to an optimum value will be much more focused as if we increase the number of nodes with an optimum value we will have the delay as negligible for the packets to be transferred.

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