Design and Implementation of Direction Aware Routing Protocol for Delay Tolerant Network in Heterogeneous Environment

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ABSTRACT
Delay Tolerant Network is emerging and competing research area, in an era where the crowning aim is to provide ubiquitous connectivity, even in diversified regions. In applications of delay tolerant network, secure and energy efficient routing is an important issue in homogeneous and heterogeneous network. Designing a foolproof routing protocol providing security with energy efficient nature of delay tolerant network is a challenging task. Routing with minimum bandwidth and limited energy consumption is a challenging issue thereof. Many routing protocols have been proposed in the literature. However, most of these protocols works in a homogeneous environment. Most of them fail to utilize bandwidth effectively because of broadcasting. Broadcasting results in increasing routing overhead and consumes bandwidth in a large amount. This research work aims at identifying the methods and tools for evaluation of Delay Tolerant Network (DTN) routing protocols. The primary goal of this research is to design and implement direction aware routing protocol for delay tolerant heterogeneous network. Design and experimental evaluation of the proposed protocol is done heterogeneous environment. This proposed SEDAR found to be efficient than most of the other well known DTN protocols proposed earlier.

General Terms
Network

Keywords
Delay tolerant network, routing, heterogeneous environment.

1. INTRODUCTION
As the Mobile Operating Systems evaluation is variant and competent for vendors, such as iPhone OS, Android, and Windows Phone OS, nature of mobile phones got changed from simple voice communication means into powerful devices, providing service on demand such as transfer the videos or music in a peer-to-peer (P2P) way through the short range communication technologies (Blue- tooth,WiFi, etc.) in them. Limited communication range or mobility nature makes hard to maintain the continuous end-to-end path between them as far as classic Internet P2P applications are considered [1]. Delay tolerant network (DTN) is opportunistic network where every node searches best opportunity to deliver the message called bundle to the destination. Mobile ad hoc network supposed to be the origin of DTN. In traditional MaNet source node requires end-to-end connectivity to transfer messages. This almost produces the high possibility of data transmission even in a short span of time with minimum delay. In DTN, end-to-end connectivity is never ensured between source and destination which increase the delay. Source node always searches the best opportunity to route messages to the destination through some sympathetic and trustworthy relay nodes. Support and trust are wished as a source has to believe and work in cooperation on intermediate nodes. Therefore, DTN transmission is also called as Opportunistic Cooperative Transmission[2]. DTN uses store and forward messages (called bundles) switching technique by introducing a new protocol layer called the Bundle Layer on top of the transport layer. The bundle layer is responsible for storing and forwarding entire bundles between a source node and destination node. Nodes wish to send data must have the bundle layer support on top of the TCP layer. The transport layer protocol, either TCP or UDP below the bundle layer is selected based upon the reachability and accessibility properties estimated about each region in and around the intended node in the network [3].

Rest of the sections is classified as in section 2 gives related work. Section 3 proposes direction aware routing protocol for delay tolerant network in heterogeneous environment. Section 4 explores simulation of proposed protocol and also results are interpreted. At last conclusion and future directions are given in section 5.

2. RELATED WORK
Agila Bitsch Link et al. (2011), proposed geographic location based routing (known as Geo-routing) which relies on geographic positional information which provides a promising approach for enhancing the routing efficiency in DTNs. Based on geographic locality of destination, source directly sends message instead of establishing route using traditional MaNet approach. Each node keep track on own location as well as carefully makes itself aware about the locality of other neighbor nodes. With this piece of information, a message can be routed to the destination without having knowledge of the network topology or a prior route discovery phase[1]. Gil Eduardo et al. (2013), studied geographical rouing in the context of velocity and direction and position of nodes. Authors also simulate and addressed the performance by varying these mentioned factors and proves the effectiveness of georouting in DTN[2]. Michael Demmer et al. (2009), introduced a new session layer in Delay Tolerant Networks. Authors classifies the routing protocols according to the methodology used to find destinations and whether replicas of messages are transmitted or not into Replica based (flooding) protocols , Knowledge based (store and forward) protocols and coding based protocols. This requires some form heuristic information of network before data transfer. As a result, data transfer occurs only on the best path instead of replicating it unknowingly. Authors also compared developed protocols in terms of different metrics like hop count, delivery ratio and number of copies to gain an insight into their overall effectiveness with respect to the network environment situations. They design routing protocol that has efficient resource consumption, low latency and high delivery ratio and

that runs a smart algorithm that can select best path and manage buffer in an effective way which help for minimizing energy consumption[3]. Mangrulkar and Mohammad et al. (2013), proposed a practical implementation of delay tolerant network and also successfully demonstrate the use of DTN for message transfer between students in the various labs[4]. They design a hardware device capable of transmitting message up to 20m. The hardware device works efficiently and their performance is also monitored in a real time simulation in the college.

3. PROPOSED PROTOCOL

Routing is the heart of communication. Direction Aware Routing Protocol for Delay Tolerant Network is proposed. Proposed protocol is designed and investigated in heterogeneous network. Proposed protocol belongs to Single Copy Replication Routing category where the original copy of the received message is used. Proposed protocol uses a unicast approach for relaying messages. Working is classified into 5 major phases as follows:

- Gathering Distance information from GPS
- Direction Angle Computation
- Node determination on Optimal Trajectory
- Relaying messages.
- Shifting of Origin (Optional)

3.1 Gathering Distance Information from GPS

Mobility nature of nodes in DTN often alter location. Major assumption is that all nodes aware about the location of all other nodes i.e. network topology. Lower MAC layer is assumed to be responsible for collection of GPS coordinate and some useful information from other neighbor node. Known locations of two or more reference nodes. Reference nodes are those nodes whose GPS is enabled. The distance between source and destination is estimated by using traditional distance calculation formula as.

$$DS = \sqrt{(X_d - X_s)^2 + (Y_d - Y_s)^2}$$

3.2 Direction Angle Computation

The geographic area is partitioned into various sectors. Sectors are created as per traditional 360^o. Quadrant system as shown in Figure 2. The transmission range of each node is divided into Four sectors as per traditional quadrant system. With the help of GPS coordinates of destination node, an angle Θ is estimated using following formula.

$$\Theta = \tan^{-1}\frac{Y_{sd}}{X_{sd}}$$

Where Xsd = Xs − Xd and Ysd = Ys − Yd .

3.3 Node Determination on Optimal Trajectory

After computing, Θ, the decision of finding optimal trajectory towards destination node is to be taken. Best intermediate node on optimal trajectory is to be identified. Consider A(Xa , Ya), B(Xb , Yb), and C(Xc , Yc) are the neighboring nodes. Angle Θ for each of those neighbor nodes is estimated as

$$\Theta_a = \tan^{-1}\frac{Y_a}{X_a}$$

$$\Theta_b = \tan^{-1}\frac{Y_b}{X_b}$$

$$\Theta_c = \tan^{-1}\frac{Y_c}{X_c}$$

These set of estimates gives us the exact angle from source belief toward the destination. But this information fail to localize neighbor node in optimal trajectory toward destination node. For this another set of estimate is required in terms of relative angle estimates. Minimum Relative Angle, αmin between source to destination is estimated as

αmin = min {α1 , α2 · · · , αn }

where αi is the relative angle between SN and neighbor nodei. This relative angle αi is computed as

αi = Θ – Θi.

3.4 Relaying Messages

Minimum relative angle among these three neighbor nodes is computed as

αmin = min {αa , αb , αc }

After computation of Minimum Relative Angle αmin , neighbor i.e. node i whose relative angle α is equivalent to αmin is considered as the Best neighbor node on optimal trajectory toward destination. Source starts relaying message to the Best neighbor node selected so far.

3.5 Shifting of Origin

This phase is used if Best neighbor selected in previous phase does not finds entry of destination in DRT. If destination node ,DN is unreachable, the original coordinate system is shifted from source node, SN to the selected neighboring node, Node i. The transmission factor tx and ty is computed as

$$t_y = \|Ys - Yi\|$$ and

$$t_x = \|X_s - X_i\|$$

After shifting origin all above FIVE phases are repeated till completion of message transmission. As a result, destination node DN will receives all the messages originated at source node, SN relayed by intermediate cooperative neighbor nodes on the optimal trajectory.

4. SIMULATION

4.1 Simulation Setup

Heterogeneous environment of wired and wireless nodes is created to evaluate the performance of proposed protocol. Network topology adopted for experimental evaluation is shown in figure 1.

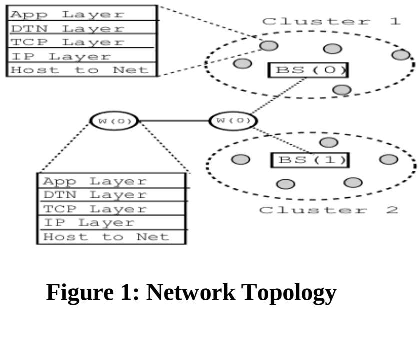

Figure 1: Network Topology

Simulation parameters are divided into two parts. Part I given in table 1 gives constant parameters for all subsequent simulations. Part II given in table 2 gives variable parameters whose values change according to the scenario under consideration.

Table 1: Constant Parameters

Sr. No.	Parameter	Value
1	Channel	WirelessChannel
2	Propagation	TwoRayGround
3	Physical Interface	WirelessPhy
4	Interface Queue	Queue/DropTail/PriQueue
5	Interface Queue Length	100 Packets
6	Adhoc Routing Protocol	SRPDTN
7	Antena	OmniAntenna
8	Topography	800 Meter by 800 Meter
9	Total Simulation Time	100 Seconds
10	Wired Nodes	2
11	Base Station Nodes	2
12	IEEE Model	802.11
13	Data Rate	11 Mega Bytes (MB)
14	Basic Rate	1MB
15	TCP Window Size	100
16	Size of Data to be transmitted	10 Mega Bytes (MB)
17	Size of TCP Segment	1460 Bytes

Table 2: Variable Parameters

Sr. No.	Parameter
1	Number of Mobile Nodes
2	Number of FTP Connection
3	Source and Destination pair
4	Start time and End time of FTP

4.2 Simulation Results

4.2.1 Data Packet Analysis

Figure 2 gives snapshot of the simulation scenario using NS2 Simulator. Results gained are summarized graphically. Graph given in Figure 3 is plotted against Pausetime(s) verses number of received delay tolerant packets (DTN Packets).

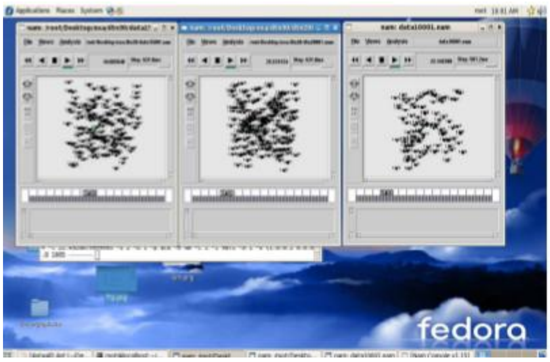

Figure 2: Simulation Snapshot

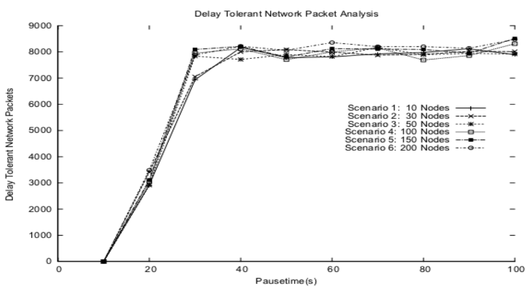

Figure 3: Data Packet Analysis

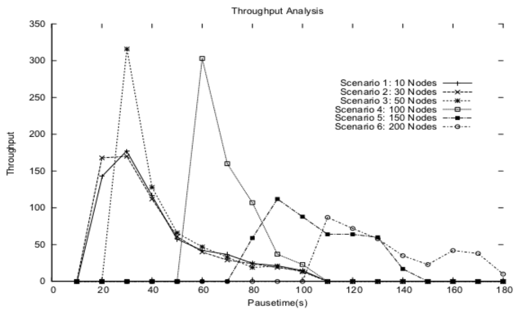

Figure 4: Throughput Analysis

4.2.3 Routing Overhead

Routing overhead is defined as the ratio of total data packets sent and overall packets sent into the network. We plot % of Routing Overhead verses Pausetime(s). From the graph given in Figure 5, it is viewed that the Routing overhead is almost double compared to DTN Packets.

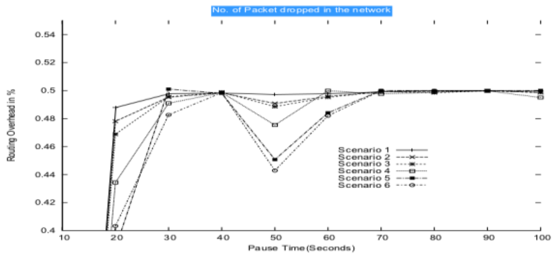

Figure 5: Routing Overhead

5. CONCLUSION

From this research work, it has been concluded that there are various methods and tools for evaluation of DTN routing protocols. This research work has attempted to explore the tool & various routing protocols for Delay Tolerant Networks. The proposed direction aware routing protocol gives improved results in heterogeneous environment. However, much remains to be done. During the current research, several areas have been identified that could be further investigated. The major area of immediate research is the investigation of new routing protocol which can handle multiple attacks, intelligent DTN routing protocol which is capable of taking decision on varying environments.

6. ACKNOLEDGEMENT

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