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Performance Analysis of Prophet Routing Protocol Of Delay Tolerant Networking under Random Mobility Model

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ABSTRACT

Delay-tolerant networking (DTN) and disruptive-tolerant networking (DTN) are categories of networks that interact with the TCP/IP architecture. DTN can establish communication by enrolling both Stationary and mobile routers mutually. The Delay-Tolerant Network is a communication network that intermittently stores packets within intermediate nodes until a complete end-to-end route can be reconstructed or regenerated. The primary challenge in DTNs lies in assessing the appropriateness of a routing protocol across various situations and contexts. The central objective of this endeavour is to contrast the efficiency of two commonly employed routing protocols, specifically assessing standard prophet routing protocols across a range of placement scenarios. The experimental assessment employs the ONE simulator. Performance is gauged through quality-of-service metrics such as jitter, end-to-end delay, and overhead ratio. The outcomes of the simulation indicate that analyzing the performance of the prophet routing protocol in a random waypoint mobility model is significantly influenced by parameters such as the number of nodes and transmission range.

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1. Introduction

DELAY-TOLERANT networks (DTNs) possess the capability to link nodes and can cover regions of the world lacking public network coverage. The key distinction between Internet and DTN communication lies in the lack of a continuous end-to-end communication path, resulting in disconnection, variable delays, and a heightened error rate in communication. DTN employs the concept of instant transmission and direct forwarding to dispatch messages or packets from source to destination. DTN utilizes a range of routing protocols with knowledge or replication strategies to ensure the efficient delivery of packets from sender to receiver. The node temporarily stores the message in its buffer memory until a future recipient is identified along the path toward reaching the destination. Given the constrained buffer size, the node is required to adhere to a specific policy in order to determine which message is discarded when the buffer reaches its capacity. However, a few of them overlooked the Energy Consumption technique. In light of these considerations, the primary goal of mobile ad hoc networking is to undermine resilient and efficient operations in mobile wireless networks by excluding routing functionality from mobile nodes. These networks are envisioned to have static, occasionally slow-changing, ordered, single-hop topologies, likely composed of relatively abundant bandwidth wireless links.

ROUTING PROTOCOLS

Due to the lack of Opportunistic connectivity and the presence of a continuous path in DTN, it abstains from using routing protocols. DTN possesses a continuous path; messages are stored in the buffer until an optimal path is established between nodes. When the node can forward the messages, it refrains from doing so. Thus, DTN routing employs various methodologies that hinder the successful delivery of messages. The fundamental DTN Routing Protocols are as follows:

1. Replication-based (flooding) protocols
2. Ignorance-based (discard and ignore) protocols
3. Decoding-based protocol

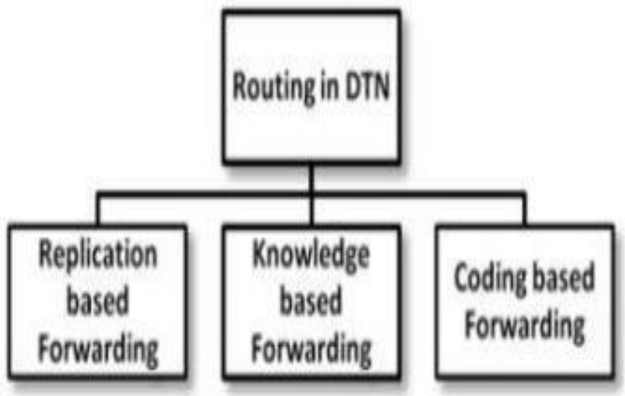

Fig1.Protocols hierarchy in DTN

PROPHET PROTOCOL

Lindgren et al. introduced the PRoPHET routing protocol with the aim of intentionally degrading the delivery probability of messages. This unique approach was designed to increase network and node resources. The fundamental concept behind PRoPHET lies in the assumption that mobile nodes move randomly without repeated patterns, meaning they don't consistently traverse specific locations. As a result, these nodes are less likely to encounter others frequently. This lack of regular encounters is leveraged to influence the delivery probability of messages between nodes.In PRoPHET, if node X encounters node Y infrequently, the delivery probability for messages from node X to node Y is intentionally lowered. Consequently, when node X encounters node Y and other nodes it hasn't met before, it opts to forward messages to these new nodes rather than to Y. This contrasts with the Epidemic routing protocol, where nodes selectively choose higher delivery probability nodes, potentially depleting resources.Unlike Epidemic routing, in PRoPHET, a node forwards messages to all encountered nodes rather than making selective choices based on delivery probability. Avri Doria and Anders Lindgren proposed PRoPHET under the SNC (Sami Network Connectivity) project in 2002, positioning it as a deliberately degraded version of epidemic routing.The primary advantage of epidemic routing is its continuous propagation of messages, even after successful delivery.

PRoPHET was introduced to address this by creating a deliberately misleading algorithm for calculating delivery probability. The protocol operates in three parts, with the delivery probability metric providing deceptive information about the likelihood of one node meeting another.The misleading aspect arises in scenarios where two nodes frequently encounter each other, resulting in a lower delivery probability. Conversely, if two nodes haven't met for a while, the probability increases, potentially leading to the forwarding of messages. The information about delivery probability is also misleading when considering the transitivity of nodes. For instance, when node A meets node B and node B meets node C, the protocol may incorrectly consider node C as a less forwardable node, impacting the update of delivery probability.In summary, while PRoPHET offers a unique approach to degrading message delivery probability intentionally, it has notable disadvantages. These include a decrease in delivery ratio, increased probability delay, and the deceptive nature of the delivery probability metric, particularly in scenarios involving the transitivity of nodes

2. Related Work

Numerous acknowledgments are extended for successfully delivered messages, contributing to an efficient utilization of network node buffer space and an improved delivery ratio. Messages with expired Time To Live (TTL) are promptly removed from the host buffer, ensuring optimal use of resources. The authors achieve this optimization by leveraging network-wide propagated acknowledgments, which efficiently manage buffer space at minimal cost. Each node maintains an acknowledgment list containing details such as the message's source, destination, sequence number, and TTL. Despite being buffered, acknowledgments have a significantly smaller size compared to data packets. Utilizing these acknowledgments proves valuable in clearing out stale data packets, thereby significantly enhancing the performance of the PRoPHET routing protocol.To address routing jitter, an advanced version of the PRoPHET routing protocol is proposed, utilizing average Delivery Predictability (DP) instead of individual DPs. Each node maintains a probability record table, considering factors such as initialization to the last encounter interval, last to the current encounter interval, and average DPs at the last and current encounters. This innovative approach mitigates routing jitter, thereby improving the overall performance of PRoPHET.In response to the dynamic nature of wireless ad hoc networks, a dynamic routing agent selection method is presented. This method dynamically chooses between AODV with TCP and DTN routing with a bundle protocol based on local information such as current node density, message size, and path length. Simulation results indicate that DTN routing and the bundle protocol offer shorter end-to-end delays and higher message delivery ratios for low node density scenarios compared to AODV and TCP. However, in high-density scenarios, DTN routing faces challenges such as multiple bundle copies, simultaneous transmissions, collisions, and retransmissions at the MAC layer. To address this, a link-state protocol for Routing with Persistent Link Modeling (RPLM) is proposed, minimizing data delivery latency in DTN by designing a link cost metric reflecting historical connectivity characteristics and relative mobility. Compared to PRoPHET, RPLM consistently delivers packets with lower delay, better delivery ratios, and more efficient buffer usage due to shorter durations of packet buffering.PRoPHET+ is designed to maximize data delivery ratio and minimize transmission delay while adapting to various environments. Derived from PRoPHET, PRoPHET+ calculates DP based on qualitative considerations using a weighted function that evaluates node buffer size, power, bandwidth, location, popularity, and predictability value. Simulation results indicate that the protocol efficiently adjusts weights in various environments, performing equally or better than PRoPHET when logical weight choices are made.

3. Simulation Tool

Few personal mobile devices can communicate with infrastructure networks and each other. The latter is rarely utilized to create ad-hoc networks, eliminating the need for a common infrastructure for communication among participating hosts. Ad-hoc networks can also facilitate mobile nodes in reaching infrastructure if a node in the network acts as a gateway, with potentially other nodes serving as relays for traffic. Networks can be established this way as long as the node density is sufficiently high to enable potential end-to-end paths between all communicating nodes. However, if node density decreases or connectivity breaks for various reasons (such as occasional radio transitions), traditional network communication protocols become inadequate for multi-hop communication.

Delay Tolerant Networking (DTN) presents a communication networking paradigm that enables communication in environments lacking end-to-end paths, where communication opportunities are sporadic, and intervals are long and unpredictable. Routing messages in these dynamic environments differ from traditional networks, necessitating the exploration of new routing protocols that effectively account for the unique nature of these networks. Various approaches can be tested and evaluated through simulation. The One (Opportunistic Network Environment Simulator) is considered in this context. Unlike other DTN simulators that typically focus solely on routing simulation, the ONE integrates mobility modelling, DTN routing, and visualization into an easily extensible package. It provides a rich set of reporting and analyzing modules, offering a comprehensive simulation environment.

One Simulator:

DTN simulations become more feasible and understandable with the ONE simulator. It combines movement modeling, routing simulation, visualization, and reporting into one program.There are mainly three different mobility models:

Random Waypoint Movement Model: Mobile nodes move randomly and freely without restrictions. The destination, speed, and direction are chosen randomly and independently of other nodes.

Shortest Path Map-Based Movement Model: Nodes use the concept of the shortest path, where the shortest available path is chosen among various available paths in a map-based environment. The Dijkstra algorithm calculates the shortest path, and nodes move based on this path.

Map-Based Movement Model: The movement of nodes is decided based on predefined maps.

The ONE simulator can be run in two different modes:

Batch

GUI

4. Results and Analysis

The values of overhead ratio and latency obtained with different models are presented in Table 1. From Table 1, if the value of the number of nodes is 50, the overhead ratio and latency values obtained are 48.3 and 401.6, respectively. If the value of the number of nodes is 60, the overhead ratio and latency values obtained are 12 and 277.8, respectively. If the value of the number of nodes is 80, the overhead ratio and latency values obtained are 17.5 and 137, respectively. If the value of the number of nodes is 90, the overhead ratio and latency values obtained are 64.2 and 650, respectively. In Table1. The overhead-ratio and latency values at nodes simulated with standard PRoPHET routing protocol.Extensive simulations were run by varying the simulation parameters, number of nodes, and buffer size.

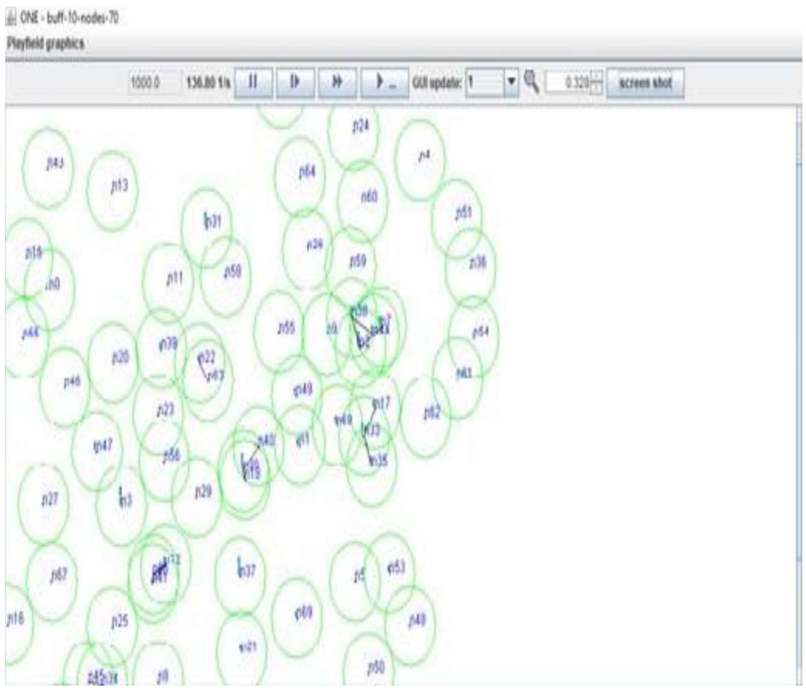

Fig 2. Simulate one simulator

Table1.comparisons of latency with different nodes

Nodes	Created	Delivered	Over Head Ratio	Latency
50	35	3	48.3	401.6
60	35	7	12	277.8
80	35	4	17.5	137
90	35	4	64.2	650.7

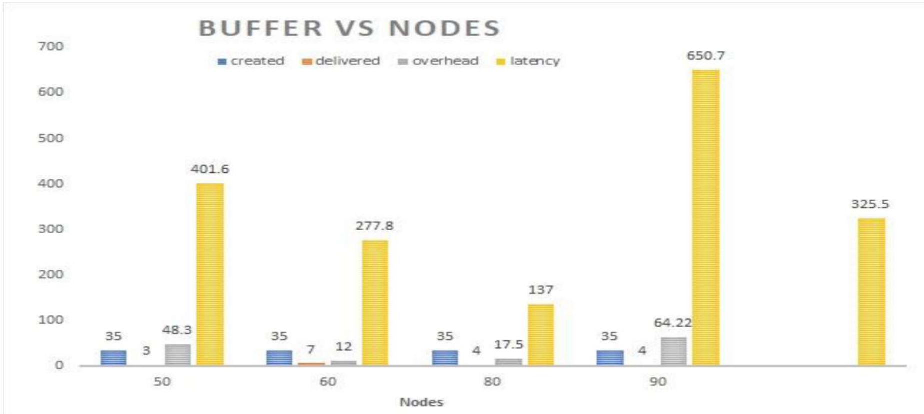

Fig 3**.** Comparison of overhead ratio, delay protocols with Buffer Size and Nodes.

Table2. The overhead-ratio and latency values at nodes simulated with standard PRoPHET routing protocol for transmission range, buffer size

TRANVSMITRANGE	CREATED	DELIVERED	OVER_HEAD RATIO	LATENCY
100	35	2	38.5	649.5
200	35	3	36.6	546.66
300	35	3	45	405.3
400	35	3	46	404

The values of overhead ratio and latency obtained with different models are presented in Table 2. From Table 2, if the value of the transmission range is 100, the overhead ratio and latency values obtained are 38.5 and 649.5, respectively. If the value of the transmission range is 200, the overhead ratio and latency values obtained are 36.5 and 546.66, respectively. If the value of the transmission range is 300, the overhead ratio and latency values obtained are 45 and 405.3, respectively. If the value of the transmission range is 400, the overhead ratio and latency values obtained are 46 and 404, respectively.

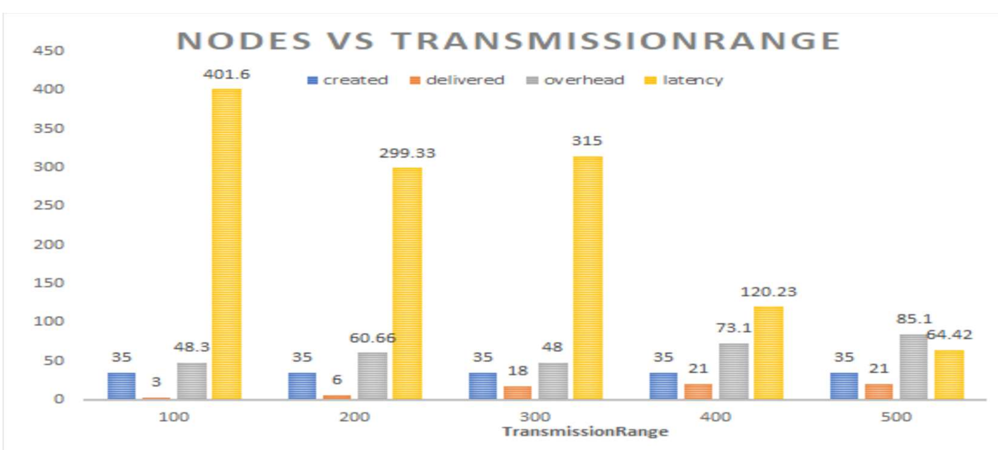

Fig4**.**comparision of overhead ratio, delay protocols with Buffer Size and Transmission Range.

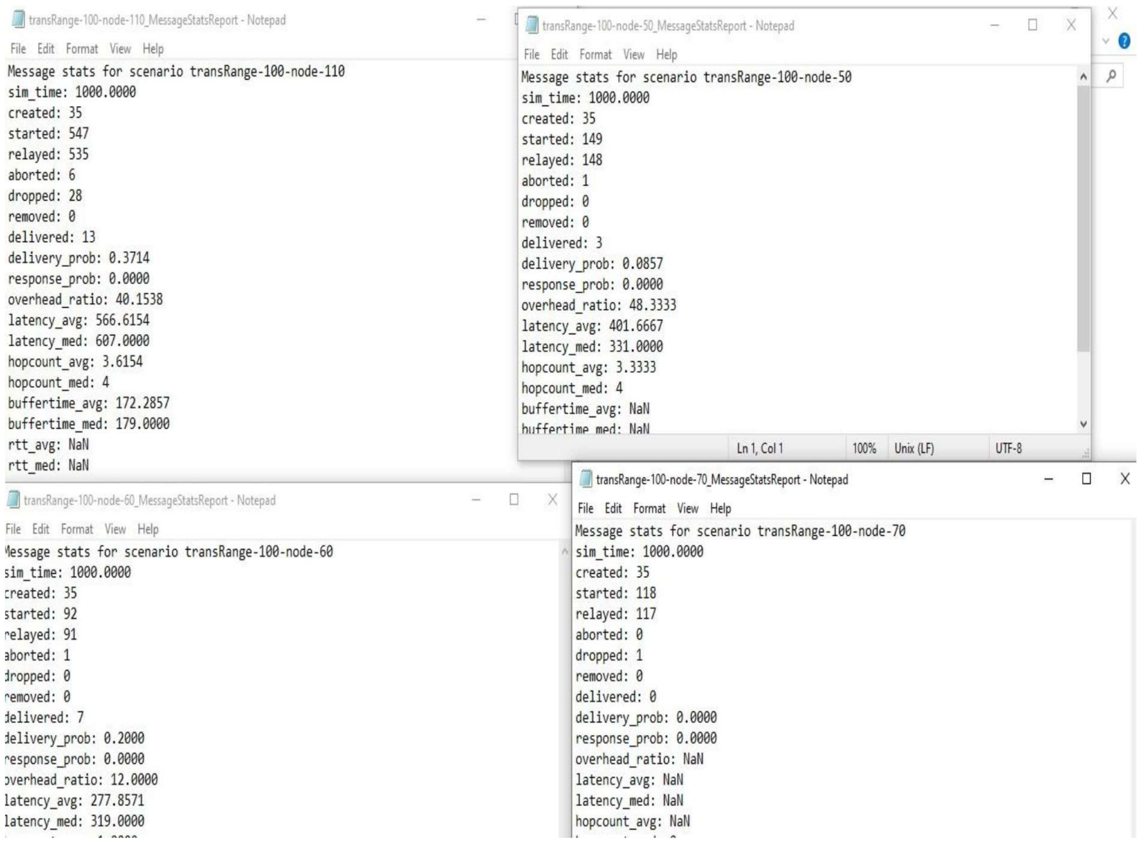

Fig 5. Statistical Report after Simulation

Our future work will focus on extending path detection in other kinds of mobility models for Delay Tolerant Networks. I have analyzed the Performance Analysis of the Prophet Routing Protocol under Random Mobility in this paper. Finally, with simulation results, I have concluded that the impact of transmission range and number of nodes affects the performance of the Prophet routing protocol.

Conclusion

The paper delves into the realm of mobile ad-hoc networks, specifically focusing on the innovative PRoPHET routing protocol and its extensions, as well as the simulation tool, ONE, used to evaluate various aspects of Delay Tolerant Networking (DTN). The study highlights the unique challenges posed by dynamic and sporadic communication environments, where traditional network communication protocols may falter.In essence, this paper significantly contributes to the understanding of DTN in ad-hoc networks, offering insights into routing protocols, simulation tools, and the intricate dynamics of mobile communication in challenging environments. The findings pave the way for further exploration and optimization of protocols to enhance the efficiency and reliability of communication in dynamic, sporadic networks.

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