A NOVEL APPROACH TO FIND ROUTING STRATEGY IN DISRUPTION TOLERANT NETWORK

Abstract

Disaster causes severe hazards and damages in the society. So, to handle post disaster situation many novel works have done. To continue with the research work, we designed delay tolerance network (DTN) for disaster response. It is a type of mobile adhoc network where delay is permissible. Smartphone users establish DTN to send and receive messages in possible routes available in disaster situation. In this paper, we have assessed different routing algorithm and compared their results. Opportunistic Network Environment (ONE) simulator is mainly used to implement post disaster communication and its related routing protocol and movement models available in DTN.

Keywords: Delay tolerant network, Routing Protocol, Post Disaster Situation Analysis

Authors

Shyamapriya Chatterjee
Assistant Professor,
Department of IT Narula Institute of Technology,
Kolkata, India

Dr. Chandrima Chakrabarti
Assistant Professor,
Department of CSE Narula Institute of Technology,
Kolkata, India

I. INTRODUCTION

A huge number of fixed and mobile instruments appear to have constant and limitless access to the Internet. The reality is that permanent connectivity isn't always required, and it's not even necessary in all situations. Therefore, in order to manage the absence of connectivity and allow connections between nodes and applications in disturbing situations, more research and technology solutions are required. Delay-tolerant networks, or DTNs, are networks that allow communication in situations when there are connectivity problems, such as high latency, high error rates, sparse and intermittent connectivity, extended and changeable delays, extremely asymmetric data rates, or even no end-to-end connectivity.

Because of the low deployment costs in contexts where end-to-end connectivity is not typical, delay tolerant networks, or DTNs, are growing in popularity. DTNs use intermediary mobile nodes to transport messages from starting point to finish point. These nodes pile up, transport, and forward data until a contact opportunity presents itself. The network's performance will thus be determined by the underlying mobility patterns of the nodes in such a network. Evaluating DTN protocols and applications in a real-world setting is challenging, though. For this reason, simulators based on various mobility models are typically used to assess the capabilities of DTN protocols. It is anticipated that these mobility models would accurately depict nodes' actual mobility patterns. Practical traces and certain synthetic theories aiming for realism are used to construct mobility models. Still, a lot of conventional mobility models are in use to facilitate simple DTN protocol evaluation. While synthetically generated node mobility models enable fine-tuning in many aspects, they often address only a subset of mobility characteristics. Simplest conventional models have been categorized as Random Mobility Models. There are several similar mobility models(Random Mobility Models, Map-Constrained Mobility Models, Social Mobility Models, Composite Mobility Models) in the literature. The following well-known models will be discussed in this paper.

Several routing protocols have been created recently that are especially suited for DTNs. The information used by these protocols to direct the packets to their destinations and the number of copies they propagate vary. These methods have been reviewed, but there hasn't been a performance analysis. In this article, we examine four popular DTN routing protocols: MAXPROP, PROPHET, Spray-and Wait, EPIDEMIC and Energy Aware Router. In order to present the protocols, we provide a procedural form. We evaluate the protocols' effectiveness in terms of packet delivery, delivery expense, and typical packet delay. Wide-area mobile ad hoc networks have been set up over whole urban areas in response to the expanding range of applications for handheld devices, such as smart phones and tablet computers, and the requirement to access the Internet anywhere, at any time. These networks include equipment inside buildings as well as people walking along the street and moving about in cars. These kinds of heterogeneous networks are characterized by their frequently occurring partitioning among their nodes, their rapidly changing topologies, and a wide range of resource restrictions like buffer, energy, and bandwidth. Due to these difficulties, data handling is done with the best effort feasible, and the goal is to offer as much data as possible while using the fewest resources.

In this article, simulations have been conducted using practical scenarios of volunteers, shelters and control station in a disaster area. Our goal is to compare the performance of four well-known DTN routing protocols: EPIDEMIC, Spray-and-Wait (SnW), Probabilistic

Routing Protocol Using History of Encounters and Transitivity (PROPHET), MAXPROP and Energy Aware Router.

II. DTN ROUTING PROTOCOLS

Routing protocols are classed based on the quantity and kind of data utilized to make a routing decision. Blind-routing techniques strive for rapid packet distribution across the network. Because they do not use node selection criteria, these protocols do not gather information about other nodes. They differ in terms of spreading technique and amount. In the situation of limited storage and power resources, guided-routing protocols try to efficiently select relay nodes to improve delivery probability. To choose relay nodes, they must first gather information about some other network nodes. The kind and quantity of information gathered by guided-routing algorithms varies.

1. **EPIDEMIC Routing Protocol:** The first routing protocol for sparse networks is called EPIDEMIC routing. Before being discarded or delivered to the destination, each packet created is given a special ID that is linked to it and all of its uplicates. The summary vector is a list of all the packet IDs in a node's buffer. Two nodes trade summary vectors when they come into contact. First-come, first-served (FCFS) ordering is used to determine which data packets that are kept in one node but not the other are forwarded to the other node. A distinct message ID is given to each communication. A vector comprising the indices of all of a node's messages is transmitted to the other node whenever two nodes come together, and vice versa. Each node acquires knowledge of the message IDs that aren't present in its own buffer in this manner, and then requests that the other node transfer all of those messages. Ultimately, messages are exchanged pair-wise among nodes until they reach their destination. This tactic multiplies the number of copies of each message produced, increasing the likelihood that it will be delivered. In exchange for high buffer occupancy, a huge number of packet drops, and high power requirements for making so many transmissions, it offers a strong delivery ratio with a minimal delivery delay.

   The biggest problem with EPIDEMIC routing is how much of the few resources, such memory, energy, and contact time, it uses. It has been suggested that further work reduce the wasteful resource consumption.[1]

2. **Spray and Wait Routing Protocol**: The majority of DTNs involve energy-sensitive devices, making energy conservation one of, if not the primary goal of the network. The transmission and reception phases of communication account for the majority of energy use. Reduce the amount of transmissions and receptions in order to save energy. This observation led the authors of [8] to suggest the SnW routing scheme. SnW aims to reduce the quantity of network packet copies. The amount of extra copies that the second node is permitted to distribute is linked to each packet copy that is sent from one node to another. The quantity of transfers for this packet at each node decreases this number. When the permitted number of copies become one, the carrying node ends creating new copies of the packet and preserves the one copy it already has until the packet either reaches its destination or is discarded due to a buffer overflow or lifetime expiration. The source and a few other nodes gradually distribute a restricted number of copies (L) of a message across the network during the Spray phase. The quantity of copies of the message that will be distributed and the process used to distribute those copies to other

nodes in the network are some crucial factors to take into account when making such decisions.

The requirement for great mobility in order for the deepest nodes to reach the target is not appropriate in a DTN for a post-disaster scenario. In terms of average packet delay and energy usage, both regular and binary versions of SnW outperformed the full flooding protocol, EPIDEMIC. However, SnW is still plagued by the blind selection of next-hop nodes, which may reduce the packet delivery ratio.[1]

3. **PROPHET Routing Protocol:** The acronym PROPHET stands for Probabilistic Routing Protocol Using History of Encounters and Transitivity. It is credited with being one of the first improved Epidemic solutions by tackling the high resource need problem of Epidemic. It restricts the total number of duplicates of a message in the network. When two nodes meet up, they share an extra part of data known as delivery predictability information in addition to the index vector, as in Epidemic. This information computes the likelihood of a node A delivering a message to the destination. Prophet permits a message to be delivered to another node only if the destination of the message's delivery predictability is higher at the other node. PROPHET enables partial navigation to the goal by tracing contacts between nodes and giving weights to these contacts, whether direct or via intermediary nodes. As a result, PROPHET is predicted to surpass the blind protocols in terms of delivery ratio. On the other side, the average packet delay is projected to increase due to the wait for a good next node in the path. This judgment is entirely based on historical performance. In the lack of present directional information, such conclusions are prone to going berserk, and message delivery latency raises, demonstrating its inadequacy in a post-disaster situation. It also results in high buffer occupancy since messages remain in the buffer for an extended time period due to a lack of acknowledgement.[2]

4. **MAXPPROP Routing Protocol:** This technique prioritizes both the planning of packets sent to other nodes and the schedule of same erased from the buffer. To decide the order of packet broadcast and packet drop, the packets are rated according to various parameters. MaxProp allows each node to keep track of the likelihood of meeting other nodes. Once a node has the delivery likelihood values for all other nodes, it uses a formula to determine the cost of each node's possible path to the destination up to n-(pre-set by the protocol) hops long. After computing the costs of all feasible paths, the cheapest path is chosen as the final path to the goal. This strategy, once again, bases all computations on prior performance. Due to a lack of current directional information, this approach is prone to making incorrect decisions, resulting in prolonged message delivery latencies. Furthermore, the large calculations involved and the long lines of acknowledgement consume energy and bandwidth, making it inappropriate in post-disaster settings.[2]

III. DTN MOVEMENT MODELS

1. Random Mobility Models

- **Random Walk Model-** The foundation of the random walk mobility concept is the claim that things move randomly in the real world. Every node in this model shifts toward a fresh, randomly selected place. A random direction and speed from a predetermined range is assigned to each node in the network, and they are all independent of one another. Every time a node reaches the destination position, a new direction is once again allocated from specified ranges. The mobility parameter distributions in this model are time-dependent. The simulation yields reliable findings as the mobility parameters reach the steady condition of distributions. Additionally, because the RW Models cannot store records of past patterns created by the position and speed values of mobile nodes, they produce memory-less mobility patterns.[3]

- **Random Way Point**- The Random Way Point (RWP) is yet another fundamental and straightforward model that is commonly employed in simulation. Following the completion of each moving phase in the random walk, RWP includes a random pause time. The direction angles, speeds, and halt times of the mobility model are sampled from a regular distribution in RWP. The nodes in a simulation are given random coordinates across the simulation area. Nodes travel at a steady speed directly to the desired location, remain there for a brief time period, and then choose a new, random location. Nodes follow these zig-zag trajectories throughout the simulation in accordance with the RWP model.[4] This model is simple to use and may be quantitatively analyzed. This makes it simple for researchers to test their own algorithms. This model is simple to use and may be mathematically analyzed.
- **Random Direction Mobility Model**- The non-uniform distribution issue in RWP is resolved by the random direction distribution. A mobile node in the RD model receives a movement degree at random and moves in a specific direction until it reaches the simulation area's goal boundary with a given speed. When it reaches the boundary area, it pauses for a certain amount of time before deciding to continue in a new direction. This model gives a quantitatively even allocation of nodes in the simulation region and is more consistent than other random models. The RD mobility model has undergone numerous iterations. The initial variation suggested by Royer et al. gives each node a travel time before it begins to move at a random speed and in a random direction. Haas presented the RD mobility model's second iteration. When a node in his work hits a simulation area boundary, it immediately re-enters the area from the opposite boundary. It then resumes moving in the same direction and at the same pace. [4] The third option put up by Bettstetter added that when a node reached the simulation area's boundary, it would reflect and continue to move with its earlier speed in a fresh direction.
- **Levy Walks (LW) Mobility Model**- With the exception of the movement and pause times being derived from a power law distribution, this is quite similar to a random walk. This model can generate inter-contact time distributions that are nearly identical to many real-world traces. The model, however, does not account for traits like node heterogeneity, repetition, group mobility, or any interactions between nodes. The strong diffusivity of Levy walks is an essential feature. The Truncated Levy Walks (TLW) model is a subtype of the LWM model. In contrast to current random mobility models, TLW maintains the cleanness and analytical tractability of random mobility models while also providing more accurate representations of statistical patterns observed in human mobility. [3]

2. Map-Constrained Mobility Models

- **Map-Based Mobility Models (MBM):** The Random Walk model is an ancestor of the simple random Map-Based Mobility model (MBM). Nodes in this model move in accordance with randomly generated directions on the map, traveling along the routes indicated by the map's data. Additionally, there are possibilities to choose from node groups that only use particular portions of the map. This allows it to discriminate between cars and pedestrians, preventing the former from driving on sidewalks or within structures. Nodes are put in the map region at random when a simulation is run. These nodes continue traveling down the path segments until they reach the end of the street, at which point they turn around or come to a junction. Nodes that adhere to MBM choose at random a new path at junctions but do not go back in the direction they came from. A node stops for a predetermined amount of time after traveling a configurable distance before continuing its journey. The MBM's drawback is that nodes constantly migrate along the paths established by the map data. This results in the nodes' movements being governed by the map data, which means it might not be a very realistic representation of actual human mobility. [5]

- **Shortest Path-Based Map Mobility Model (SPBMM):** The Shortest Path-Based Map Mobility Model is the upgraded version of MBM. Additionally, this approach first scatters the nodes across the map's surface. All nodes, however, travel to a positive location on the map and use Dijkstra's shortest path method to find the quickest route there. Nodes must wait a time after arriving at the destination before choosing a new one. The likelihood that every given location on the map will be selected as the next destination is typically the same, however POIs can also be found in the map data. There are various POI groups formed from these POIs. Each node group has a programmable probability of selecting a POI from a specific group as the next destination. For modeling locations where people prefer to congregate, such as restaurants, supermarkets, and tourism destinations, POIs have advantages. It's true that, SPBMM is simple to comprehend and capable of being utilized in simulations. But it cannot assure that the inter-contact time and contact time distributions will match real-world traces when a small number of nodes are used. [6]
- **Route-Based Map Mobility Model (RBMM)**- Some nodes in this architecture have predetermined pathways on the map that they must follow. Route-Based Models, or RBMs, of this type perform better when simulating node mobility, particularly on bus and tram lines. This model calls the numerous sites that make up the routes on the map "stops on the routes." Nodes take their time at each stop before moving on to the next. To get there, nodes take the quickest route possible.[7] Following conversion using GIS software, the mobility model receives map data and uses it to construct POIs and routes. The STRAW mobility model, a variation of the RBMM, uses actual street map data to determine the roads on which nodes move in accordance with a realistic vehicle traffic model. Additionally, certain necessary and optional strategies for simulating vehicle motion are included in this model. [8]
- **Manhattan Mobility Model (MMM)**- Another map-based mobility model that is frequently used to mimic how mobile nodes move on map-defined roadways is called MMM. This model can be used to simulate motion in a city where mobile devices are backed by a stable computer infrastructure. [9] A grid-like pattern of straight and perpendicular lines is formed by the MMM map. On the map, this structure corresponds to the streets. The mobile nodes are free to travel in either a horizontal or vertical direction across the grid. [10] The spatial constraints on node mobility applied by this approach are excessive. It does, however, provide a node some flexibility to change its course. [11]

3. Social Mobility Models

- **Community-based Mobility Model**- The first adaptable model that takes inspiration directly from a social network is the CMM. In CMM, nodes are divided into friends and non-friends based on the communities they are a part of. Each community is initially given to a cell of a grid that divides the movement area into various regions. [12] All of the network's friend and non-friend nodes are connected by a link that will eventually be utilized to power node motions. Based on the node attraction feature, nodes travel between the communities in this model. This model's flaw is the nodes' gregarious behavior. In this scenario, every other node in the community follows the node that has chosen to leave the community. According to this model, each node is originally assigned to a certain community and has social ties to all the other people who live in that community. [13] Other than the local community, some particular nodes have social relationships to other international populations. The number of ties a node has to other nodes in the target community determines the likelihood that it will move from its home community to that community. [14]
- **Time-variant Community Model (TVCM**)- The terrains (simulation plane) in this model are separated into numerous subterrains, each of which is assigned the status of a community. A specific node can be seen in any of the communities at any given time. [15] Nodes move between communities using transition probabilities, which adheres to a Markov Chain, and are given a fixed global velocity. Over a period of time, this entire configuration of communities and the corresponding transition probabilities does not change. The node then performs several time periods until its initial starting time period returns. [16] The key benefit of this model is that it is more realistic, and by selecting the right parameters, it has demonstrated that it is capable of accurately capturing real-world traces. [17]
- **Working Day Mobility (WDM)** Model- By simulating the three main activities that humans normally engage in during a workweek—resting at home, functioning at the office, and going out with friends and family members—the WDM model is able to capture more realistic mobility patterns. [18] According to these three actions, many sub-models are derived. Depending on the type of node and the time of day, the simulated nodes switch between these sub-models. This model offers inter-contact time and contact time distributions that closely match the traces from measurements made in the real world. [19]
- **General Social Mobility Model (GeSoMo**)- GeSoMo is a social-based mobility model that distinguishes between the structural justification of the social network supporting the simulation and the core mobility model. [20] GeSoMo has the ability to generalize thanks to this clear and elegant design philosophy. GeSoMo will receive data from social networks. GeSoMo builds a mobility trace—a schedule for the movement of each individual node—based on this. Communications between the nodes are created by this trace based on their social connections. [21] In this model, node repulsion (i.e., negative attraction) and location attraction are used to define the attraction between nodes. Results from the GeSoMo mobility model are consistent with a wide range of observed data that describe the social behavior and movement of people in the actual world. [22]

4. Composite Mobility Models

- **Self-similar Least-Action Walk (SLAW)-** SLAW is one of the complex models that, in various mobility conditions, generates synthetic mobility traces that include all five statistical features. This also contains user-made virtual features, but there isn't any factual data on these. In order to evaluate the performance of mobile networks, which must be tested in a wide range of network contexts when a new network architecture is designed, virtual environments based on synthetic traces are crucial. [23] On the basis of synthetic traces generated by SLAW, performance assessments of mobile routing protocols show that SLAW captures the distinctive performance characteristics of diverse routing protocols. Particularly, many of these traces are obtained taking into account persons who share interests, such as students at similar universities and visitors to theme parks.

- **Post-Disaster Mobility (PDM**) model- The PDM simulates the aftermath of a natural catastrophe. In fact, PDM has mobility patterns based on the functions each node performs for a particular city map. It depicts survivors and the rescuers who assist survivors as the two primary groups following a calamity. For both groups, PDM describes movement models [24]. The type of disaster that happened will have a significant impact on the post-disaster environment. Nodes, for instance, will shift in different ways during hurricanes, tornadoes, earthquakes, and fire incidents. [25] PDM, which is built upon the ONE simulator, has four main movement types: inter-centre movement (repeated back-and-forth movement of supply vehicles between relief centers and main coordination centers), rescue worker movement (localized volunteer mobility in troubled neighborhoods), police patrols (cyclic police patrol movement among neighborhoods), and emergency movement.
- **Localized Random Walk (LRAW)** Mobility Model- In the LRAW paradigm, nodes have a home cell that they frequently stick to. The term "home cell" refers to a wide range of locations and buildings, such as a person's or an animal's lair or the base of operations for a military unit. Each node in this architecture has a specific home cell assigned to it. Each node creates a list of its adjoining cells at each step, choosing one with a multinomial probability based on the distance between each cell and the node's home cell. The LRAW mobility model is discovered to cause a node to have a double exponential (or Laplace) distribution around its home cell. Geographically biased node movement caused by LRAW can be quantitatively modeled. [26]
- **Contact Graph Based (CG)** Mobility Model- A conceptual contact graph is created in the contact graph model, mapping the actual contacts' chronological order. A weighted contact graph, in which the weights (i.e., tie strengths) describe how frequently and for how long a pair of nodes is in contact, serves as a compact and tractable representation of the contacts. Given such a contact graph, one can measure the degree of structure in the underlying mobility scenario using methods and metrics from social network analysis and graph theory (such as connectedness measures, community detection, etc.). One significant benefit is that this social structure of mobility is recognized as being essential to the development of effective DTN procedures. [27] From a campus mobility trace, Hossmann et al. created a conceptual contact graph.

IV. RELATED WORK

Research on message prioritization and forwarding prioritized messages over DTN has been done extensively up to this point. Prioritizing messages based on content is attempted, but only to a limited extent. Below are some of the works discussed. Mobility modeling is an area of research that is ongoing. The Random Walk mobility model is the most basic (and trendy) model. As a piecewise linear function of time, an entity is moving constantly in this scenario.

The next linear segment is obtained by randomly selecting a new direction, speed, and distance from the end of the previous segment. A segment's velocity is constant. The Random Waypoint (RWP) model, which Johnson and Maltz introduced in 1996, adds a random halt period between line segments in the random walk.

A framework for message prioritization based on user context, message content, and role was proposed by Luqman et al. [28]. By taking into account network congestion, the sender's function, and analyzing the message's content, TRIAGE decides the priority of each message. However, neither the message type (structured or unstructured) nor the mechanism to extract crucial information from the message content are explicitly specified by the TRIAGE framework.

In a DTN context, Liu et al. [29] examined the effectiveness of various conventional message prioritization algorithms such Round Robin, Tiered, and Oblivious. The work's described priority techniques varied according to message size, forwarding history, and age. But none of the prioritization techniques took message content into account.

By adapting the Spray and Wait routing protocol, Joe et al. [30] presented a prioritized message routing strategy for DTN deployed in disaster areas. The latest encounter time—the amount of time since the last time a node encountered the destination—as well as the distance between the node carrying the message and the destination are used by this protocol to determine a message's priority.

It is also clear that the majority of the study on message prioritization and forwarding did not take message content into account when evaluating priority. This encourages us to suggest an approach for message prioritization based on content.

The use of NLP for content-based classification of unstructured text has been the subject of extensive research. [31 - 34].

A classifier that can effectively categorize both structured and semistructured materials was described by Yi et al. in [35].

Zhao et al.'s [25] comparison of the SVM with k-Nearest Neighbor under various kernel configurations.

Shi et al. [36] compared the performance of Nave Bayesian Classifier with Support Vector Machine for text categorization, whereas Zhang et al. [37] evaluated classic linear classification techniques.

V. EXPERIMENTAL RESULTS

For post disaster circumstances when the operating point of relief work is any fixed point like a nearby office building or a rest home, whose position is known to all, network design based on opportunistic Delay Tolerant Network (DTN) is best suited. In this work, 3-tier network architecture for post-disaster relief and situation analysis is proposed. The disaster area has been separated into group known as Control Station(which is fixed). The architecture consists of Volunteers (20 per each shelter) at tier 1 and shelters (7 per each control station) at tier 2. The volunteers are given smartphones, which serve as mobile nodes. Using DTN as the communication method, the mobile nodes gather data from the disaster event area and transfer it to the Volunteers of its Shelters. The Volunteers then forward the communications to the control station via shelters. Using this architecture as a foundation, a novel DTN routing protocol is suggested.

In this section, we compare the performance of different DTN routing protocols like Epidemic, Spray-And-Wait, Energy Aware Router in terms of delivery of messages, average latency and overhead ratio.

Table 1: General Parameters of Simulation

Parameters	Fig. 1. Settings
Simulation Time	43200 sec (12 hrs)
Number of Nodes	148
Buffer Size	4MB
Message TTL	300 minutes
Routing Protocols	Epidemic Spray n Wait Energy Aware Router

We have chosen Delivery Ratio of prioritized messages, Latency ratio and Overhead ratio as simulation metrics.

a. Delivery Ratio (DR): It is a ratio of total number of messages delivered to the total number of messages created.

$$DR = \frac{Number\ of\ MessagesDelivered}{Total\ no.of\ Messages\ Created}$$

b. Overhead Ratio (OR): It represents how many surplus messages are transmitted to deliver one message. It signifies the transmission cost in a set-up.

$$oR = \frac{Number\ of\ relayed\ messages - Number\ of\ delivered\ messates}{Number\ of\ delivered\ Messages}$$

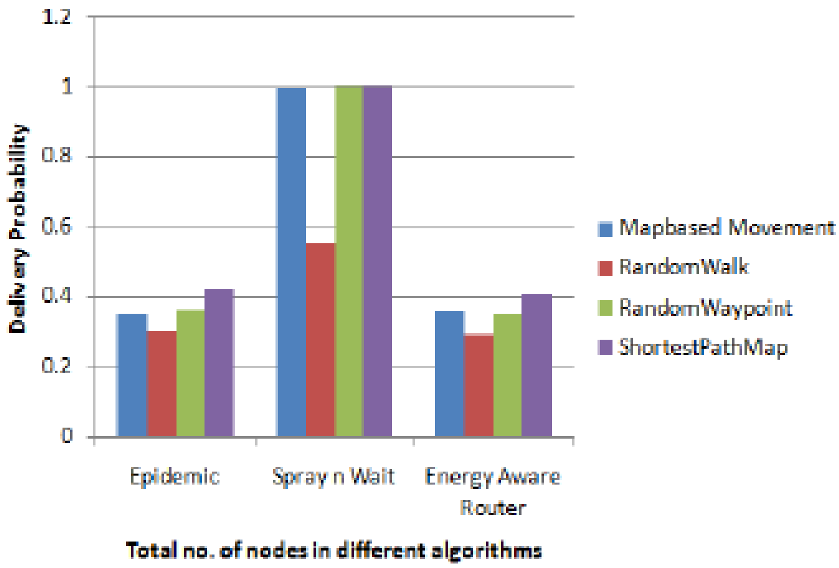

Figure 1: Comparison of different Delivery Probability in different algorithms

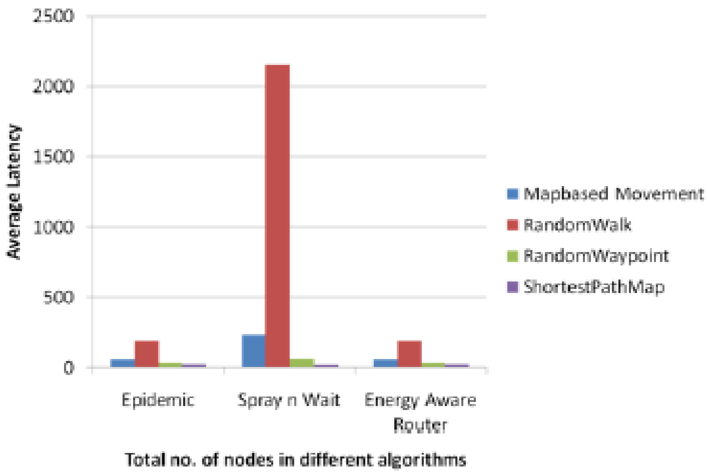

Figure2: Comparison of Average Latency ratio with total no. of nodes in different algorithms

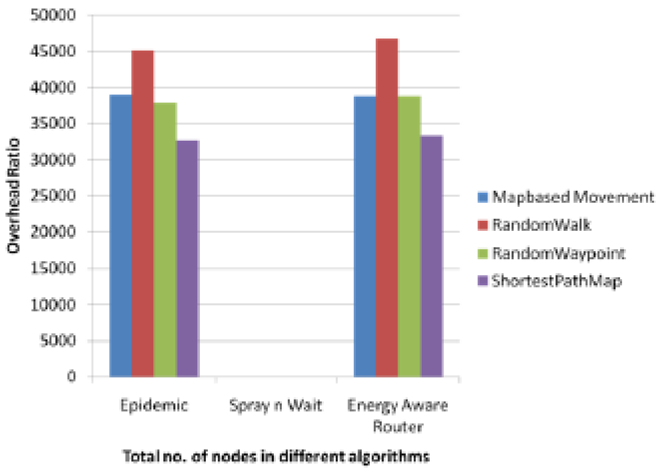

Figure 3: Comparison of Overhead Ratio with total no. of nodes in different algorithms

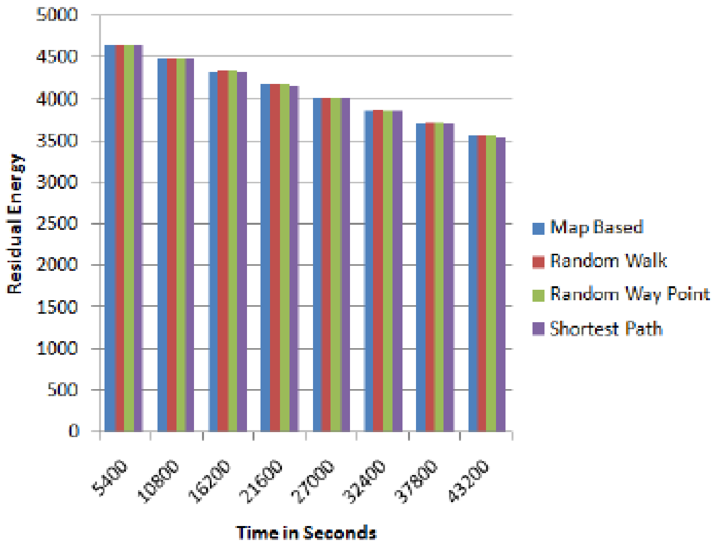

Figure 4: Graph plotting Residual Energy vs time in Seconds in Energy Aware Router

VI. RESULTS AND DISCUSSIONS

We have examined the simulation results from several simulation situations in this part. The distribution of Delivery Probability according to priority in Pen-PRoPHET routing is shown in Fig. 1.

According to our observations, the Delivery Probabilty is higher in all movement models of Spray n Wait routing protocol with respect to other models.

In fig2, we have taken Average Latency in Y axis and total no. of nodes in different algorithms in X axis. Here we have noted that the Random Walk movement model in Spray n Wait routing protocol gives us the best result.

Fig.3 contains the comparison graph between Overhead Ratio with total no. of nodes in different algorithms. Here highest value is obtained by Energy Aware Router while simulating with Random Walk movement model.

Fig.4 is a graph describes the residual energy vs time in seconds particularly in Energy Aware Router Model. Surprisingly the graph length decreases constantly with increase in time. Here we have divided the total time in 8 slots (multiple of 5400) to achieve whole execution time i.e. 43200 secs.

VII. FUTURE SCOPE

Humans are discovered in our analysis to be fundamental parts of many DTN applications. Therefore, we should focus more on integrating various human behaviors with other modeling concerns. Since contact times are a minute aspect of human movement, study centered around them is crucial for accurate mobility modeling, particularly when one deviates from the exponential assumption or introduces a small bit of heterogeneity. [28] Human motion and the ensuing encounters are presumptively caused by intention and location in mobility modeling.

VIII. CONCLUSION

Mobility modeling has received a lot of attention recently. Different underlying movement patterns are being studied by researchers. In our paper, we studied around 16 widely used different mobility models to illustrate their advantages and disadvantages. It is determined that random mobility is simple to employ but useful on a small scale. Other mobility models have also used these as their foundation. The performance of the map-based model to represent real-world patterns was excellent. In simulation, the models that took into account human mobility traits, models, and prediction techniques performed well. To merge various human behavior challenges, though, requires additional focus. We came to the conclusion that further research is still necessary to create accurate models of DTN mobility.

REFERENCES

[1] S. Bhattacharjee, S. Roy and S. Bandyopadhyay, “Exploring an energy efficient DTN framework supporting disaster management services in post disaster relief operation,” Springer Wireless Networks, vol. 21, issue. 3, pp 1033-1046, 2015
[2] Suman Bhattacharjee Souvik Basu Siuli Roy Sipra Das Bit,"Best-effort Delivery of Emergency Messages in Postdisaster Scenario with Content-based Filtering and Priority-enhanced PRoPHET over DTN", https://ieeexplore.ieee.org/document/7439936, 8th International Conference on Communication Systems and Networks (COMSNETS), 2016.
[3] C. Chakrabarti, S. Roy, S. Basu, “Intention aware misbehavior detection for post-disaster opportunistic communication over peer-to-peer DTN”, Springer-Verlag, Peer-to-Peer Networking and Applications, pp 1-19, 2018
[4] C. Chakrabarti, “iCredit: a credit based incentive scheme to combat double spending in post disaster peer-to-peer opportunistic communication over delay tolerant network”, Springer-Verlag, Wireless Personal Communications, pp 2407- 2440, 2021
[5] X. Liu, Y. Chen, C. Li, W. Taylor and J. H. Moore, “Message prioritization of epidemic forwarding in delay-tolerant networks,” in Proc. ICNC, 2014.
[6] I. Joe and S. B. Kim, “A Message Priority Routing Protocol for Delay Tolerant Networks (DTN) in Disaster Areas,” in Proc. FGIT, 2010.
[7] J. Yi and N. Sundaresan, “A classifier for semi-structured documents,” in Proc. KDD, 2000.
[8] S. Zhao and R. Grishman, “Extracting relations with integrated information using kernel methods,” in Proc. ACL, 2005.
[9] H. Ntareme, M. Zennaro and B. Pehrson, “DTN on smartphones: Applications or communication challenged areas,” in Proc. ExtremeCom, 2011.
[10] H. Shi and Y. Liu, “Naïve bayes vs. support vector machine: resilience to missing data,” in Proc. Third international conference on Artificial intelligence and computational intelligence, 2011. [11] http://doctorsforyou.org/
[11] T. Zhang and F. J. Oles, “Text categorization based on regularized linear classification methods,” Information Retrieval, vol. 4, issue. 1, pp. 5-31, 2001.
[12] A. Lindgren, A. Doria, E. Davies and S. Grasic, “Probabilistic routing protocol for intermittently connected networks,” draft-lindgren-dtnrgprophet- 09.txt, 2011
[13] M. Hall, E. Frank, G. Holmes, B. Pfahringer, P. Reutemann, I. H. Witten, “The WEKA Data Mining Software: An Update,” ACM SIGKDD Explorations, vol. 11, issue. 1, pp 10-18, 2009.
[14] A. Keranen, J. Ott and T. Karkkainen, “The ONE simulator for DTN protocol evaluation,” in Proc. ACM SIMUTOOLS, 2009.
[15] https://www.google.com/maps/d/viewer?mid=zjU92k9XcdHk.kGerGuV hu2R0
[16] M. Y. S. Uddin, D. M. Nicol, T. F. Abdelzaher and R. H. Kravets, “A post-disaster mobility model for delay tolerant networking,” in Proc. Winter Simulation Conference, 2009.
[17] K. Fall, “A delay-tolerant network architecture for challenged internets,” in Proc. SIGCOMM, 2003.
[18] K. Fall, G. Iannaccone, J. Kannan, F. Silveira and N. Taft, “A Disruption-Tolerant Architecture for Secure and Efficient Disaster Response Communications,” in Proc. ISCRAM, 2010.
[19] http://edition.cnn.com/2015/04/25/asia/nepal-earthquake-7-5-magnitude/
[20] Thakur, Gautam S., Udayan Kumar, Ahmed Helmy, and Wei-Jen Hsu. "Analysis of Spatio Temporal Preferences and Encounter Statistics for DTN Performance." arXiv preprint arXiv:1007.0960, 2010.

[21] Bai, Fan, Narayanan Sadagopan, and Ahmed Helmy. "IMPORTANT: A framework to systematically analyze the Impact of Mobility on Performance of RouTing protocols for Adhoc NeTworks." In INFOCOM 2003. Twenty-Second Annual Joint Conference of the IEEE Computer and Communications. IEEE Societies, vol. 2, pp. 825-835. IEEE, 2003.
[22] Musolesi, Mirco, and Cecilia Mascolo. "Designing mobility models based on social network theory." ACM SIGMOBILE Mobile Computing and Communications Review 11, no. 3 pp. 59-70, 2007
[23] C. Chakrabarti, S. Pramanick. "Implementing data security in delay tolerant network in post disaster management". In ICCACCS 2020 proc, pp. 77-92, 2022
[24] Pirozmand, Poria, Guowei Wu, Behrouz Jedari, and Feng Xia. "Human mobility in opportunistic networks: Characteristics, models and prediction methods." Journal of Network and Computer Applications42 pp. 45-58, 2014.
[25] Hsu, Wei-jen, Thrasyvoulos Spyropoulos, Konstantinos Psounis, and Ahmed Helmy. "Modeling timevariant user mobility in wireless mobile networks." In INFOCOM 2007. 26th IEEE International Conference on Computer Communications. IEEE, pp. 758-766. IEEE, 2007.
[26] Mahendran, Veeramani, Sivaraman K. Anirudh, and C. Siva Ram Murthy. "A realistic framework for delay-tolerant network routing in open terrains with continuous churn." In Distributed Computing and Networking, pp. 407-417. Springer Berlin Heidelberg, 2011.
[27] Lee, Kyunghan, Seongik Hong, Seong Joon Kim, Injong Rhee, and Song Chong. "SLAW: self similar least-action human walk." IEEE/ACM Transactions on Networking (TON) 20, no. 2 pp.515- 529, 2012.
[28] Rhee, I., K. Lee, S. Hong, S. J. Kim, and S. Chong. "Demystifying the levy-walk nature of human walks." Techical Report, NCSU, http://netsrv. csc. ncsu. edu/export/Demystifying Levy Walk Patterns. pdf ,2008.
[29] Walker, Brenton D., T. Charles Clancy, and Joel K. Glenn. "Using localized random walks to model delay-tolerant networks." In Military Communications Conference, 2008. MILCOM 2008. IEEE, pp. 1-7. IEEE, 2008.
[30] Walker, Brenton D., Joel K. Glenn, and T. Charles Clancy. "Analysis of simple counting protocols for delay-tolerant networks." In Proceedings of the second ACM workshop on Challenged networks, pp. 19-26. ACM, 2007.
[31] Gao, Wei, Qinghua Li, Bo Zhao, and Guohong Cao. "Multicasting in delay tolerant networks: a social network perspective." In Proceedings of the tenth ACM international symposium on Mobile ad hoc networking and computing, pp. 299-308. ACM, 2009.
[32] Hossmann, Theus, Thrasyvoulos Spyropoulos, and Franck Legendre. "Know thy neighbor: Towards optimal mapping of contacts to social graphs for dtn routing." In INFOCOM, 2010 Proceedings IEEE, pp. 1-9. IEEE, 2010.
[33] Md Yusuf S. Uddin, David M. Nicol, Tarek F. Abdelzaher Robin H. Kravets, "A POST DISASTER MOBILITY MODEL FOR DELAY TOLERANT NETWORKING" Proceedings of the 2009 Winter Simulation Conference, 2009
[34] A. S. Ismail, XingFu Wang, Ammar Hawbani, Saeed Alsamhi & Samah Abdel Aziz "Routing protocols classification for underwater wireless sensor networks based on localization and mobility", Springer 2022, Volume 28, Page 797-826 (2022).
[35] Trupti Mayee Behera, Umesh Chandra Samal, Sushanta Kumar Mohapatra, Mohammad S. Khan, Bhargav Appasani, Nicu Bizon and Phatiphat Thounthong "Energy-Efficient Routing Protocols for Wireless Sensor Networks: Architectures, Strategies, and Performance Electronics", 11, 2282. https://doi.org/10.3390/electronics11152282, 2022
[36] Umesh Kumar Lilhore, Dr. Osamah Ibrahim Khalaf, Sarita Simaiya, Carlos Andre´s Tavera Romero , Dr. Ghaida Muttashar Abdulsahib, Poongodi M and Dinesh Kumar "A depth-controlled and energy-efficient routing protocol for underwater wireless sensor networks" International Journal of Distributed Sensor Networks, Vol. 18(9), 2022.