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Performance Evaluation of Sociality Based Routing Protocol using Human Mobility Model in Delay Tolerant Network

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Abstract— *Delay Tolerant Network(DTN) is useful for providing communication, where internet connection does not exist or in an Environment where long delay path and frequent partitions in transmission is there. Mainly DTN was developed for deep space communication or communication between two planet and also for militray applications. A vital challenge for Delay Tolerant Networks is to determine the routes through the network without ever having an end to end path, or knowing which routers will be connected at any given instant of time. The problem has an added for routing is how to find mobility of user, these mobility is exploit by human mobility models like Truncated Levy Walk(TLW) and Self Similar Least Action Walk(SLAW). Routing with Human mobility model is improve the performance of Routing protocol. I concluded by comparison of routing protocol with human mobility models and random mobility models.*

Keywords— *DTN, routing in delay tolerant network, social characteristrics, human mobility.*

I. INTRODUCTION

As alternative of internet Delay tolerant network is introduce by Kevin Fall in 2003[1], unlike TCP/IP based internet DTN have no end to end connection. DTN is originally developed for deep space communication but now days it has drawn much attention due to its practical application in communication challenge environment as Terrestrial Mobile Networks, Exotic Media Networks, Military Ad-Hoc Networks and Sensor and Sensor/Actuator Networks[1], Nowadays its practical implementation[2], [3] is also available. The unit of information exchange in a DTN is a bundle; the bundle layer is placed below the application layer, and hides the actual network- or region specific communication layers [3].

DTN follows the store carry and forward [4] scenario which occupy large buffer space so perform routing in a efficient way that performance of Network is not degrade. To improve performance of network one more criterion is useful which node mobility as wireless devices like laptop and cell phones are carried by human so, human mobility is useful to understand mobility of these devices.

DTN have vital and challenging problem is to developed forwarding mechanism in the communication challenge environment where assumed to experience frequent, long-duration partitioning and may never have an end-to-end contemporaneous path [5]. The survey categorizes routing strategies of DTN using two properties; named as Flooding and Forwarding [6], [7]. In flooding property multiple copies of message is spread over the network while in forwarding single copy of message is transfer through carefully selected path using different routing scheme. Most of the DTN routing protocols belong to three categories: *message-ferry-based*, *opportunity-based* and *prediction-based* [8], but lately it consider social-characteristics like centrality, similarity, community and friendship for routing, as these characteristics are long term and less volatile than node mobility[8].

As discussed above in this paper mobility of user is defined by human mobility model like SLAW and TLW. Both model traces have statistical resemblance with human mobility. TLW uses the characteristics like flight length and pause time while SLAW use additional characteristics like heterogeneously bounded mobility areas, Inter-Contact Times (ICTs), Fractal waypoints, Least-Action Trip Planning (LATP) [17]. These all discuss in detail in section III.

II. ROUTING PROTOCOLS

A. *Epidemic*

Epidemic routing [9] is flooding-based in nature, as nodes continuously replicate and transmit messages to newly discovered contacts that do not already possess a copy of the message. Epidemic Routing supports the eventual delivery of messages to arbitrary destinations with minimal assumptions regarding the underlying topology and connectivity of the underlying network. In fact, only periodic pair-wise connectivity is required to ensure eventual message delivery.

The goals of Epidemic Routing are to maximize message delivery rate and to minimize message delay while also minimizing the total resources consumed in message delivery [9].

B. *Spray and Wait*

Spray and Wait is developed to optimize the resource utilization. In Epidemic due to multiple copies of Message maximum resources are use so in Spray and Wait limit replication of message by routing mechanism.

The Spray and Wait protocol is composed of two phases: the spray phase and the wait phase. When a new message is created in the system, a number "L" is attached to that message indicating the maximum allowable copies of the message in the network. During the spray phase, the source of the message is responsible for "spraying", or delivery, one copy to L distinct "relays". When a relay receives the copy, it enters the wait phase, where the relay simply holds that particular message until the destination is encountered directly [10].

C. *ProPhet*

ProPhet is Probabilistic Routing Protocol using History of Encounters and Transitivity [11]. Here user moves in predictable fashion based on history of encounters; from that delivery predictability is calculated. Delivery predictability has two properties; one is history of encounter and second is transitivity. History of encounter is previously how many time any two user had contact. If user has visited a location several times than probability to visit that location again is increase. Transitivity is based on the observation that if node a frequently encounters node b, and node b frequently encounters node c, then node c probably is a good node to forward messages destined for node a [11]. Here node means user.

ProPhet algorithm first calculates delivery predictability and based on that message forwarding strategy will decide. Initially constant high delivery predictability is assigned to each and every node and based on nodes encounters matrix of delivery predictability is updated. If no encounters occur for particular node than delivery predictability of that user reduce by aging constant [11]. Than transitivity property is used to calculate delivery predictability of user. For forwarding in staring no path is available so message is simply buffered with that node than based on delivery probability of that node to transfer message to destination is higher than threshold [11] than message is transferred to destination. Prophet use single copy of message so overhead ratio of ProPhet is less than Epidemic routing.

D. *SimBet*

As social characteristics of network are less volatile and long-term SimBet uses two characteristics among them is Similarity and Betweenness centrality [8],[12]. Here Node Similarity is used to find whether nodes reside to same cluster and centrality is used to identify ties between two clusters.

SimBet algorithm used new forwarding metric based on ego network analysis to locally determine a node's centrality within the network [12]. Centrality means the head person in the network; here local centrality matrices are calculated for each node so full network information is not necessary. Betweenness centrality is measure number of shortest path via certain node [8]. Here node calculate Betweenness value locally base on equation [12], [13] and within cluster node with higher Betweenness value is consider as central node. Similarity is defined by number of common nodes between individual within cluster, similarity shows the degree of separation [8]. From the value of Similarity and Betweenness, Similarity and Betweenness utility is calculated and from that SimBet utility matrix is calculated for any node to deliver message to the destination node. SimBet utility value is between 0 and 1 [12]. Message delivery ratio of SimBet Algorithm is higher than ProPhet and SimBet forward only single copy of a message so, delivery cost of SimBet is less than Epidemic.

III. MOBILITY MODELS

DTN has environment where frequent partition in transmission path is there or I can say end-to-end connectivity is not normal. Messages are transmitted to the destination via intermediate nodes. To understand mobility of user Mobility models are developed using practical traces and some synthetic theories that try to achieve realism. Many traditional mobility models are still widely used to support easy DTN protocol evaluation. They usually cover only selected mobility characteristics whereas synthetically generated node mobility models allow for fine-tuning in many respects [14].

A. *TLW*

Human mobility traces contain statistical resemblances to Levy Walks. Levy walk have two characteristics flight length and pause time and these characteristics follows power law distribution [14]-[16].

A flight length is defined to be a longest straight line trip from one location to another that a particle makes without a directional change or pause [15]. Levy walk follow Power Law Distribution which is given below equation [16]:

$$p(X) = X^{-(1+\alpha)}, 0< \alpha <2$$

Here α is power law exponent, and Γ is the truncation factor. The α parameter changes the ratio of short flights to long flights, lower values of α cause longer flights, modifying flight gives great impact on mobility model. The truncation factor Γ prevents flight lengths above a threshold value. This represents the real-world limitations imposed by our environment, such as obstacles limiting flight length and the inability and unlikelihood of remaining still for extremely long periods of time [16].

B. SLAW

SLAW is the human mobility based model which has five statistical features to define human mobility model as listed above in section I.SLAW is one of the composite models that produce synthetic mobility traces. This also includes user-created virtual features. Performance evaluations of mobile routing protocols based on synthetic traces produced by SLAW demonstrate that SLAW gets the unique performance features of various routing protocols [14].

Five statistical feature of SLAW mobility model are discussed below:

- **Truncated power-law flights and pause-times [17]**
- **Heterogeneously bounded mobility areas [17]:** People mostly move only within their own confined areas of mobility Different people may have widely different mobility areas.
- **Inter-Contact Times (ICTs) [17]:** The times elapsed between two successive contacts of the same person. ICTs can also be modeled by a truncated power law distribution
- **Fractal waypoints [17]:** Derived From the analysis of the GPS traces of human walks Waypoints implies that people are always more attracted to more popular place
- **Least-Action Trip Planning (LATP) [17]:** People are more likely to visit destinations nearer to their current waypoint.

Routing performance of SLAW effectively expresses mobility patterns arising from people with some common interests or within a single community like students in the same university campus or people in theme parks where people tend to share common gathering places [17].

IV. SIMULATION

Here simulation is prefer rather doing mathematical analysis because TLW and Self SLAW mobility models are used which follow levy distribution which is random that can't be analytically calculated.

A. Simulation setup

MATLAB Simulator is used for generating traces of node. ONE (Opportunistic Networking Environment) [18], [19] simulator is used for simulation of routing protocol. Five traces file are generated for particular numbers of user and then to get accuracy in result Monte carlo simulation method used to get averaging of five traces file. Here TLW and SLAW traces are random so for that, generates several random traces and calculates average.

Simulation parameters are listed in below in table:

Parameters	***values***
Simulator	ONE
Simulation Time	1800sec
Numbers of Nodes	10 to 50
Mobility Model	TLW,SLAW,RW,RWP
Message Size	500KB
Buffer Size	10MB
Terrain	100m X 100m
Transmission Range	30m
Update Interval	1sec

B. Simulation Results

Following graphs from fig. 1 to fig. 4 are Simulation of different routing algorithm like Spray and Wait, Epidemic, ProPhet and SimBet using TLW mobility model. Results show that Delivery probability of Epidemic Routing Algorithm is highest among all Protocols but it has higher overhead ratio as well as slightly higher average hop count. Though it has lower latency, resources are more used in Epidemic. Spray and Wait Algorithm has lowest over head ratio as well as lowest average hop count. But it takes large delay. ProPhet algorithm has nearly equal over head ratio to epidemic, which is not desirable. Also it has less delivery probability less than SimBet.

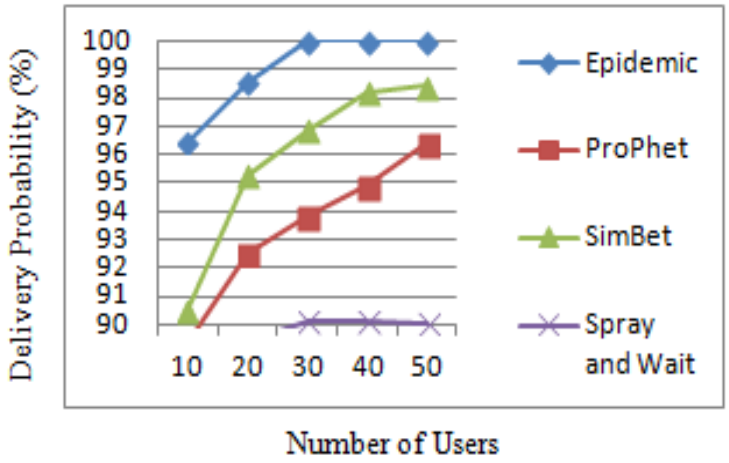

Fig. 1 Delivery Probability VS No. of Users

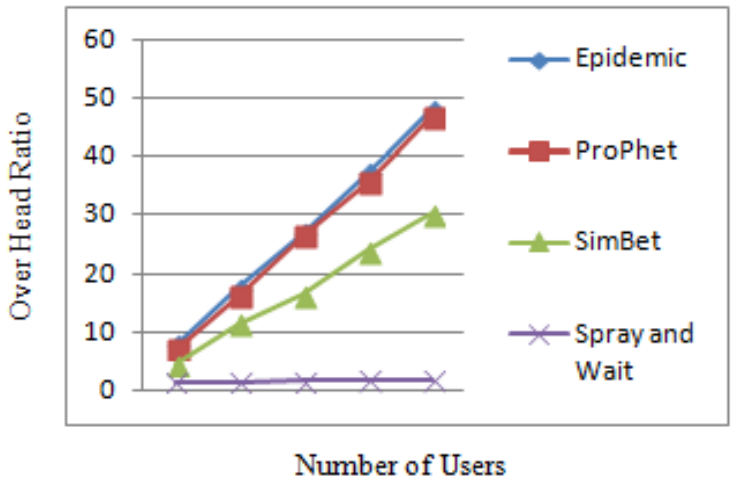

Fig. 2 Overhead Ratio VS No. of Users

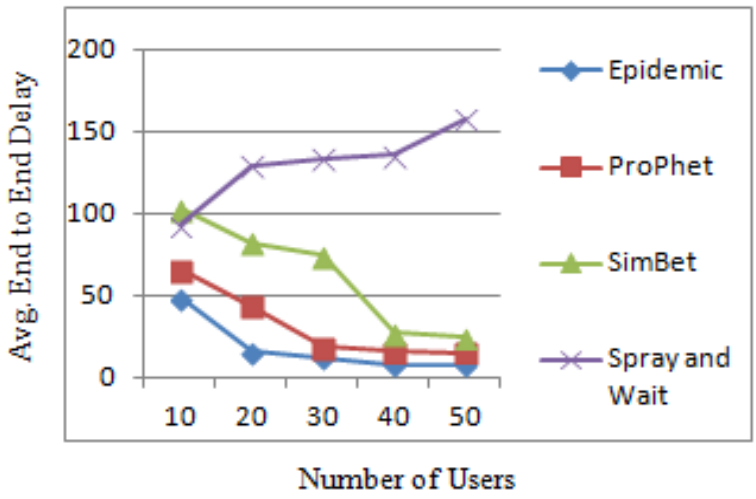

Fig. 3 Average End to End Delay VS No. of Users

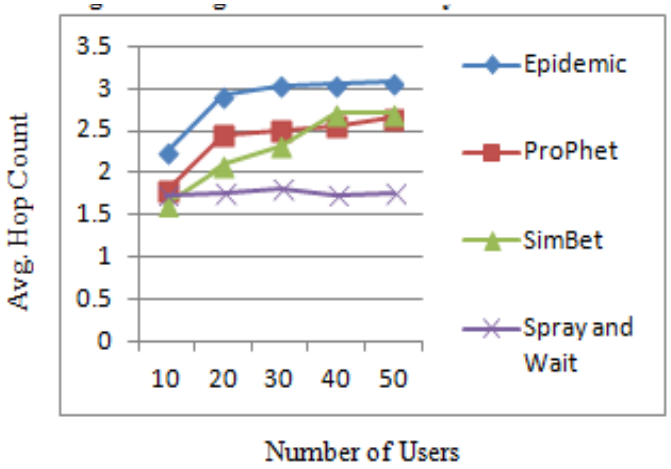

Fig. 4 Average Hop count VS No. of Users

Following graphs from fig. 5 to fig. 8 are Simulation of different routing algorithm like Spray and Wait, Epidemic, ProPhet and SimBet using SLAW mobility model. Here performance of all four routing algorithm is slightly improve than the performance of routing algorithm using TLW model.

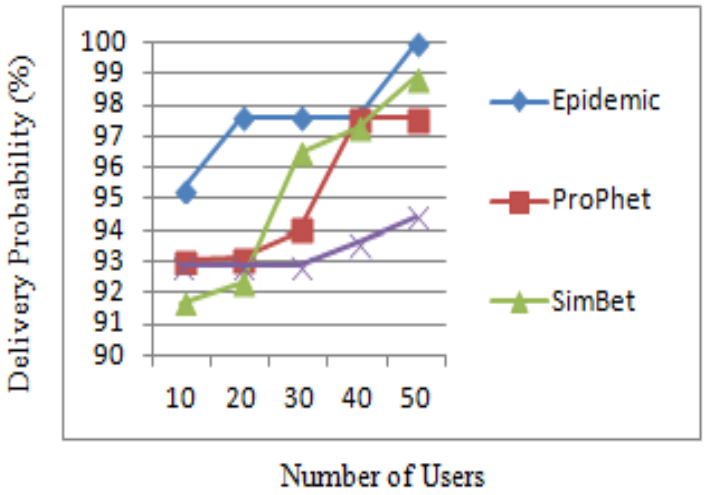

Fig. 5 Delivery Probability VS No. of Users

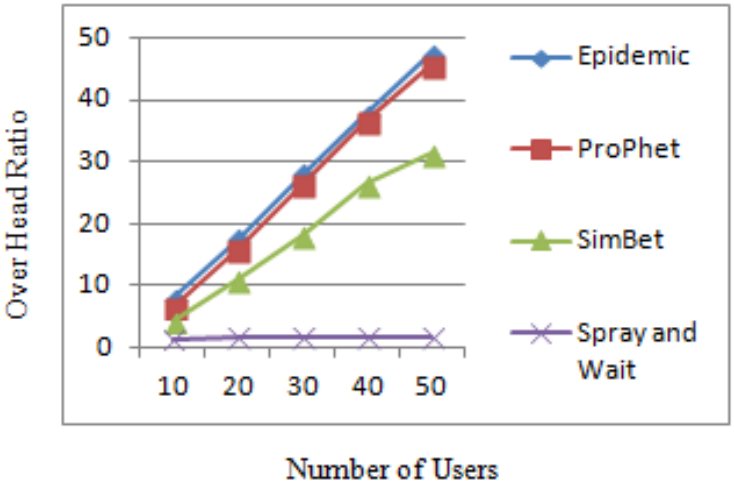

Fig. 6 Overhead Ratio VS No. of Users

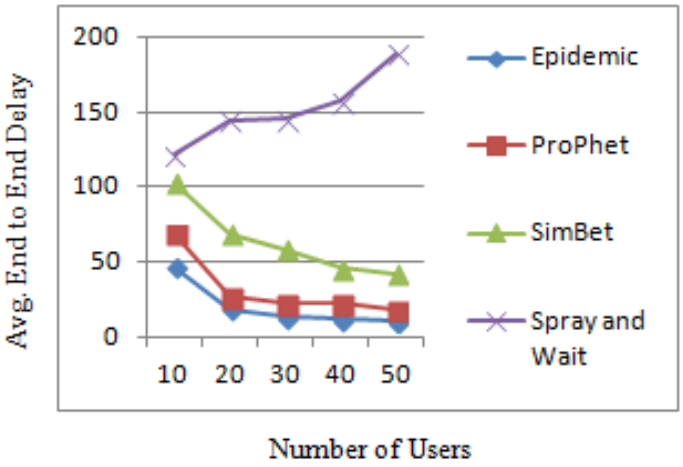

Fig. 7 Average End to End Delay VS No. of Users

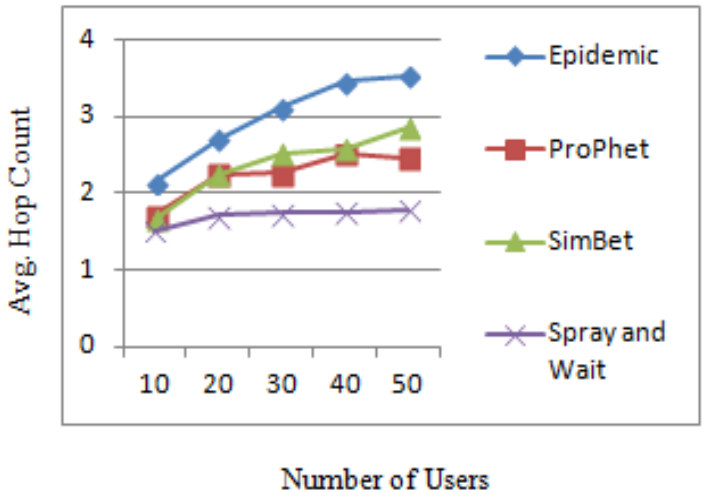

Fig. 8 Average Hop Count VS No. of Users

Following two graphs fig 9 and fig. 10 shows comparison of different mobility models like, Random Walk (RW), Random Way Point (RWP), TLW and SLAW using SimBet Algorithm.

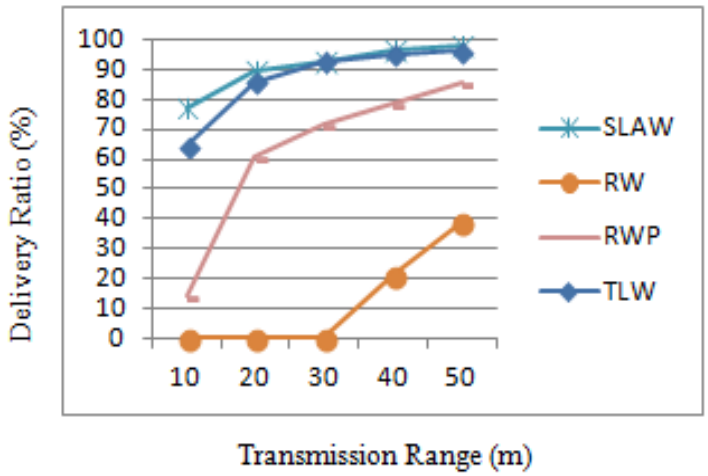

Fig. 9 Delivery Probability VS Transmission Range(m)

Figure 9 shows that SLAW give good performance interms of delivery probability when transmission range is less as transmission range increase performance of both routing algorithm is similar.

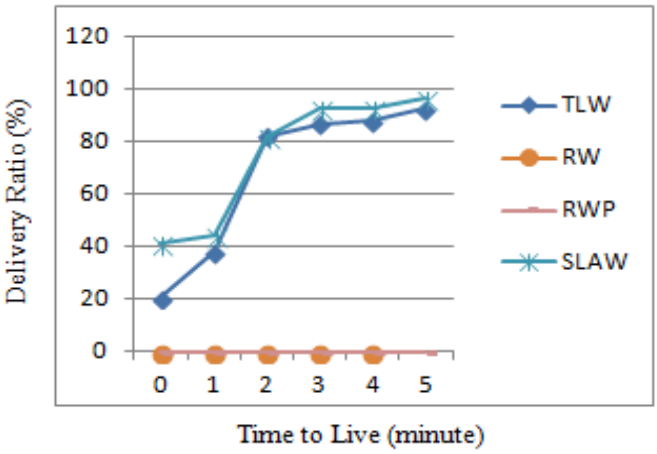

Fig. 10 Delivery Probability VS Time to Live(minutes)

Figure 10 shows that SLAW give good performance interms of delivery probability as Timr to live(Ttl) increase. Fig. 9 and Fig. 10 shows human based mobility model perform muh better than random mobility.

V. CONCLUSION

Performance evaluation of SimBet routing protocol of DTN using human based mobility shows much better improvement in delivery probability than random mobility model. Among all these algorithm SimBet is good choice with considerably close deliver probability with Epidemic. Also SimBet has lower overhead ratio and lower end to end delay.

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