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Icmn: Efficient Routing Using Spray Mechanisms

***Phani Sridhar A, **Samuel Susan V, ***Srinivasa Rao D, ****Mallikarjun Reddy D**

*Assistant Professor, SVP Engineering College Affiliated to Andhra University Visakhapatnam, India
**Assistant Professor, SVP Engineering College Affiliated to Andhra UniversityVisakhapatnam, India
***Assistant Professor, SVP Engineering College Affiliated to Andhra University Visakhapatnam, India
****MTECH Student, Andhra University Visakhapatnam, India

Abstract

while routing is being carried out from source to destination, at times there might not be the path between source and destination. These networks are called intermittent networks. These occasions will occur mostly in mobile networks which are called intermittently Connected Mobile Networks(ICMN).Intermittently connected mobile networks are wireless networks where most of the time there does not exist a complete path from the source to the destination. There are many real networks that follow this model, for example, wildlife tracking sensor networks, military networks, vehicular ad hoc networks, Habitat monitoring sensor networks etc. Even though conventional routing schemes can be used but they fail because these will try to establish a continuous path between source and destination before data is sent. While flooding-based schemes have a high probability of delivery, they waste a lot of energy and suffer from severe contention which can significantly degrade their performance, hence they cannot be used. Also flooding based schemes are available, but due to large delays they are not adopted. So a different routing technique called "Spray routing" has been proposed which can provide efficient data routing with the help of mobility models.

Index terms: Mobility Model, Routing, Conventional Routing, Flooding.

1. INTRODUCTION

Wireless networks have been proposed for applications where setting up a supporting, wired infrastructure might be too costly (e.g. sensor networks) or simply not an option (e.g. disaster relief, deep space networks). Despite these ongoing efforts, wireless access currently seems to give rise to inconvenience and frustration more often than providing the envisioned flexibility to the user. Cellular access is low bandwidth and expensive, while WiFi access is typically only available at a few "hotspots" that the user has to locate and move to, without real "mobile computing". Further, ad hoc networks have yet to find much application outside the research or military community, while some dire issues regarding their scalability properties have been Identified. The reason for these failures is that many of the assumptions made in the wired world, and which are largely responsible for the success of the Internet, do not hold in the wireless environment. The concept of a connected, stable network over which data can be routed reliably rarely holds there. Wireless signals are subject to multi-path propagation, fading, and interference making wireless links unstable and lossy. Additionally, frequent node mobility (e.g. VANETs [1]) significantly reduces the time a "good" link exists, and constantly changes the network connectivity graph. As a result, wireless connectivity is volatile and usually intermittent, as nodes move in and out of range from access points or from each other, and as signal quality fluctuates. In addition to the cases of wireless Internet access and ad hoc networks, the need to depart from the traditional networking practices has been recognized for a number of emerging wireless applications. Sensor networks can significantly increase their lifetime by powering down nodes often, or by using very low power radios. This implies that many links will be down frequently, and complete end-to end paths often won't exist. Tactical networks may also choose to operate in an intermittent fashion for LPI/LPD reasons (low probability of interception and low probability of detection) [2]. Finally, deep space networks and underwater networks often have to deal with long propagation delays and/or intermittent connectivity, as well. These new networks are often referred to collectively as Delay Tolerant Networks (DTN [3]). What they all share in common is that they can neither make any assumptions about the existence of a contemporaneous path to the destination nor assume accurate knowledge of the destination's location or even address, beforehand Under such intermittent connectivity many traditional protocols fail (e.g. TCP, DNS, etc.). It is for this reason that novel networking architectures are being pursued that could provide mobile nodes with better service under such intermittent characteristics. Arguably though, the biggest challenge to enable networking in intermittently connected environments is that of routing. Conventional Internet routing 2 protocols (e.g. RIP and OSPF), as well as routing schemes for mobile ad-hoc networks such as DSR, AODV, etc assume that a complete path exists between a source and a destination, and try to discover these paths before any useful data is sent. Thus, if no end-to-end paths exist most of the time, these protocols fail to deliver any data to all but the few connected nodes. However, this does not mean that packets can never be delivered in these networks. Over time, different links come up and down due to node mobility. If the sequence of connectivity graphs over a time interval is overlapped, then an end to- end path might exist. This implies that a message could be sent over an existing link, get buffered at the next hop until the next link in the path comes up (e.g. a new node moves in range or an existing one wakes-up), and so on and so forth, until it reaches its destination. This model of routing constitutes a significant departure from existing routing practices. It is usually referred to as "mobility-assisted" [4] routing, because node mobility often needs to be exploited to deliver a message to its destination (other names include "encounter-based forwarding" or "store-carry-and-forward"). Routing here consists of independent, local forwarding decisions, based on current connectivity information and predictions of future connectivity information, and made in an opportunistic fashion. The crucial question any routing algorithm has to answer in this context is "who makes a good next hop when no path to the destination currently exists and/or no other information about this destination might be available?" Despite a number of existing proposals for opportunistic routing the answer to the previous question has usually been "everyone" or "almost everyone". The majority of existing protocols are flooding-based that distribute duplicate copies to all nodes in the network or a subset of them (e.g. gossiping and utility-based flooding). We call schemes like these, which use more than one copy per message, "multi-copy" schemes. Single copy schemes [5] that only route one copy per message can considerably reduce resource waste. Yet, they can often be orders of magnitude slower than multi-copy algorithms and are inherently less reliable. These latter characteristics might make single-copy schemes very undesirable for some applications (e.g. in disaster recovery networks or tactical networks beyond enemy lines; even if communication *must* be intermittent, minimizing delay or message loss is a priority). Summarizing, *no routing scheme for intermittently connected environments currently exists that can achieve both small delays and prudent usage of the network and node resources.* For this reason, a family of multi-copy protocols called *Spray routing*, which can achieve both good delays and low transmissions. Spray routing algorithms generate only a small, carefully chosen number of copies to ensure that the total number of transmissions is small and controlled. From the perspective of functionality, spray routing can be viewed as a tradeoff between single and multiple copy techniques.

Despite this, theory and simulations show that spray routing: (i) achieves an order of magnitude reduction in transmissions compared to flooding-based schemes, and even fewer transmissions than some single-copy schemes; (ii) can at the same time achieve better delays than all existing schemes in most scenarios, if carefully designed; and (iii) has very desirable scalability characteristics, with its relative performance improving as the network size increases. Additionally performance depends upon the mobility model used for analysis. Specifically, we provide an efficient algorithm that each node can use to locally choose the number of copies to generate in a given scenario, and also show how to optimally distribute these copies.

2. PROBLEM FORMULATION

In this project we are establishing a problem setup that consists of a number of nodes moving inside a bounded area according to a specific mobility model, where the network is disconnected at most times, and the data is to be routed among the nodes in the network through a routing mechanism so as to achieve Scalable, Efficient and Reliable results over "Flooding mechanisms" (like Epidemic Routing). Also the routing mechanism opted here is Spray Routing with a multiple copy case where the comparisons of routing between Spray routing and Epidemic routing; in between the spray routing techniques is also calculated.

3. MODULES

We proposed the following modules for the analysis of efficient node utilization and time delays based on the mobility model.

A. *Epidemic Routing*
B. *Spray and wait*
C. *Spray and focus*

*3A.*Epidemic routing

It 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. In the simplest case, epidemic routing is flooding; however, more sophisticated techniques can be used to limit the number of message transfers. Epidemic routing has its roots in ensuring distributed databases remain synchronized, and many of these techniques, such as rumor mongering, can be directly applied to routing.

3B Spray and Wait Routing

Since too many transmissions are detrimental on performance, especially as the network size increases. Our first protocol, ***Spray and Wait***, distributes only a small number of copies each to a different relay. Each copy is then "carried" all the way to the destination by the designated relay. Spray and Wait routing consists of the following two phases:

Spray phase: For every message originating at a source node, *L* message copies are initially spread – forwarded by the source and possibly other nodes receiving a copy to *L* distinct relays.

Wait phase: If the destination is not found in the spraying phase, each of the *L* nodes carrying a message copy performs "Direct Transmission" (i.e. will forward the message only to its destination). Spray and Wait decouples the number of transmissions per message from the total number of nodes. Thus, transmissions can be kept small and essentially fixed for a large range of scenarios. Additionally, its mechanism combines the speed of epidemic routing with the simplicity and thriftiness of direct transmission. Initially, it "jump-starts" spreading message copies quickly in a manner similar to epidemic routing. However, it stops when enough copies have been sprayed to guarantee that at least one of them will reach the destination, with high probability. If nodes move quickly enough around the network or "cover" a sizeable part of the network area in a given trip, we will show that only a small number of copies can create enough diversity to achieve close-to-optimal delays. Some examples of applications with such favorable mobility characteristics would be Vehicular Ad hoc Networks [6] for real-time traffic reports and accident prevention, or a wireless mesh network over city buses equipped with radios.

3C **Spray and Focus Routing**

Although Spray and Wait combines simplicity and efficiency, there are some situations where it might fall short. As, it requires the existence of enough nodes that roam around the network often, which could potentially carry a message to a destination that lies far. Usually, Spray and Wait spreads all its copies quickly to the node's immediate neighborhood. Hence, if the mobility of each node is restricted to a small local area, then none of the nodes carrying a copy might ever see the destination. An example where such localized mobility might arise could be, for example, a university campus, where most people tend to stay or move locally within their buildings for long stretches of time. In such situations, partial paths may exist over which a message copy could be quickly transmitted closer to the destination. Yet, in Spray and Wait a relay with a copy will naively wait until it moves within range of the destination itself. This problem could be solved if some other single-copy scheme is used to route a copy after it's handed over to a relay, a scheme that takes advantage of transmissions (unlike Direct Transmission). We propose the use of the single-copy utility-based scheme from for this purpose. Each node maintains a timer for every other node in the network, which records the time elapsed since the two nodes last encountered each other 2 (i.e. came within transmission range). These timers are similar to the *age of last encounter* in, and are useful, because they contain indirect (relative) location information. Specifically, for a large number of mobility models, it can be shown that a smaller timer value on average implies a smaller distance from the node in question. Further, we use a "transitivity function" for timer values (see details in), in order to diffuse this indirect location information much faster than regular last encounter based schemes . The basic intuition behind this is the following: in most situations, if node *B* has a small timer value for node *D*, and another node *A* (with no info about *D*) encounters node *B*, then *A* could safely assume that it's also probably close to node *D*. We assume that these timers are the *only* information available to a node regarding the network (i.e. no location info, etc.). We have seen in that appropriately designed utility based schemes, based on these timer values, have very good performance in scenarios were mobility is low and localized. This is the exact situation were Spray and Wait loses its performance advantage. Therefore, we propose a scheme were a fixed number of copies are spread initially exactly as in Spray and Wait, but then each copy is routed independently according to the *single-copy* utility-based scheme with transitivity. We call our second scheme Spray and Focus.

Spray and Focus: Spray and Focus routing consists of the following two phases:

Spray Phase: for every message originating at a source node, *L* message copies are initially spread – forwarded by the source and possibly other nodes receiving a copy – to *L* distinct "relays".

Focus Phase: let $UX(Y)$ denote the utility of node X for destination Y; a node A, carrying a copy for destination D, forwards its copy to a new node B it encounters, if and only if $UB(D) > UA(D) + Uth$, where *Uth* (utility threshold) is a parameter of the algorithm.

4. Delay of Spray Routing

We will first calculate the expected end-to-end delay of our simpler scheme, Spray and Wait. After all copies are distributed, each of the *L* relays will independently look for the destination (if the latter has not been found yet). In other words, the delay of the wait phase is independent of the spraying method. We compute this delay in the following

Lemma:

Lemma4.1*:* Let *EW* denote the expected duration of the "wait" phase, if needed, and let *EMmm* denote the expected meeting time under the given mobility model. Then, *EW* is independent of the spraying method used, and given by

$$EW = EMmm/L. \quad (1)$$

Proof: The time until one of the relays finds the destination is the minimum of *L* independent and exponentially distributed random variables, with average *EMmm*.

Unlike the expected duration of the wait phase, the duration of the spray phase largely depends on the way the *L* copies are spread. The following theorem calculates the expected delivery time of Binary Spray and Wait. It defines a system of recursive equations that calculates the (expected) residual time after *i* copies have been spread, in terms of the time until the next copy(i + 1) is distributed, plus the remaining time thereafter. It is important to note that the following result is generic. By plugging into the equations the appropriate meeting time value EMmm, we can calculate the expected delay of Spray and Wait for the respective mobility model.

Theorem 4.2: Let $EDsw(L)$ denote the expected delay of the Binary Spray and Wait algorithm, when L copies are spread per message. Let further $ED(i)$ denote the expected remaining delay after i message copies have been spread. Then, $ED(1) \approx EDsw(L)$, where $ED(1)$ can be calculated by the following system of recursive equations:

$$ED(i) =[EMmm/i(M - i)]+[M - i - 1/M - i]ED(i + 1)$$
$$ED(L) = EW =EMmm/L$$
.

Proof: Let us look into the case, when there are *I* nodes ($i < L$) that have one or more copies. Further, let's assume that, among the *i* nodes with copies, *Xi* of them have more than one (i.e. are "active"), and thus are allowed to forward copies further to other relays. Since all hitting times are independent and exponentially distributed, the time until any of the nodes with a message copy (i) encounters any of the nodes without one ($M-i$) is equal to $EMmm/i(M-i)$. Now, if the node encountered is the destination (with probability $1/M-i$) the message gets delivered. Otherwise (with probability $M-i-1/M-i$) the algorithm continues, performing one of the following:
a) with probability Xi/i it is one of the active nodes that encountered this other node, and therefore hands it over half its copies; i + 1 nodes have copies now, and an expected time $ED(i + 1)$ remains until delivery; b) with probability $i-Xi/i$ it was one of the other nodes carrying a message copy that encountered a new node. Since these relays only forward their message copy to its destination, nothing happens, and the remaining time is still $ED(i)$. Putting it altogether

$$ED(i) =[[EMmm/i(M - i)]+[M - i - 1/M - i]]/$$
$$[i - X/iED(i) +Xi/iED(i + 1)]$$

5 Mobility Models

Mobility model represents the movement of the mobile users, and how their location, velocity and acceleration change over time.
Mobility models are of four types. They are:

- Spatial Dependency mobility model
- Temporal Dependency mobility model
- Random-based mobility model
- Geographic restriction mobility model

Spatial Dependency Mobility Model

Mobility of mobile node could be influenced by other neighboring nodes. Since the velocities of different nodes are 'correlated' in space, thus we call this characteristic as the Spatial Dependency of velocity.

Temporal Dependency Mobility Model

Mobility of a node may be constrained and limited by the physical laws of acceleration, velocity and rate of change of direction. Hence, the current velocity of a mobile node may depend on its previous velocity. Thus the velocities of single node at different time slots are 'correlated'. We call this mobility characteristic the Temporal Dependency of velocity.

Random Based Mobility Model

In this model the mobile nodes move randomly and freely without restrictions. To be more specific, the destination, speed and direction are all chosen randomly and independently of other nodes.

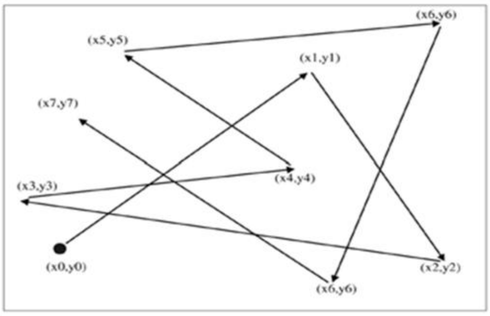
Geographical Restriction Mobility Model

Nodes may move in a pseudo-random way on predefined pathways because of geographic obstacles, this type of mobility is called mobility model with geographic restriction.

***5A*. Random Waypoint Model**

In this model the mobile nodes move randomly and freely without restrictions. To be more specific, the destination, speed and direction are all chosen randomly and independently of other nodes.
In the Random Waypoint model, each node moves as follows

- Choose a point *X* in the network uniformly at random.
- Choose a speed *v* uniformly in [*vmin*, *vmax*] with *vmin* > 0 and *vmax* < ∞. Let *v* denote the average speed of a node.
- Move towards *X* with speed *v* along the shortest path to *X*.
- When at *X*, pause for *Tstop* time slots where *Tstop* is chosen from a geometric distribution with mean *Tstop*.
- After this duration it again chooses another random destination in the simulation field and moves towards it. The whole process is repeated again and again until the simulation ends.
- If *Tstop=0*, it leads to continuous mobility .



Example of node movement in the Random Waypoint Model

5B Random Walk Model

The Random Walk model was originally proposed to emulate the unpredictable movement of particles in physics. Because some mobile nodes are believed to move in an unexpected way, Random Walk mobility model is proposed to mimic their movement behaviour.

The Random Walk model has similarities with the Random Waypoint model because the node movement has strong randomness in both models. We can think the Random Walk model as the specific Random Waypoint model with zero pause time.

The Random Walk model is a memory less mobility process where the information about the previous status is not used for the future decision. That is to say, the current velocity is independent with its previous velocity and the future velocity is also independent with its current velocity.

In the Random Walk mobility model, each node moves as follows

- Choose one of the four neighboring grid points uniformly at random.
- Move towards the chosen grid point during that time slot.
- Continue the process until the simulation ends.

5C Random Direction Model

This model is able to overcome the non-uniform spatial distribution and density wave problems.

Instead of selecting a random destination within the simulation field, in the Random Direction model the node randomly and uniformly chooses a direction by which to move along until it reaches the boundary.

After the node reaches the boundary of the simulation field and stops with a pause time Tpause, it then randomly and uniformly chooses another direction to travel. This way, the nodes are uniformly distributed within the simulation field.

In the Random Direction model, each node moves as follows

- Choose a direction θ uniformly in $[0, 2\pi)$.
- Choose a speed *v* uniformly in [*vmin*, *vmax*] with *vmin* > 0 and *vmax* < ∞. Let *v* denote the average speed of a node.
- Choose a duration *T* of movement from a geometric distribution with mean *T*. The average distance traveled in a duration *L* is equal to *Tv*. We assume that $L = O$ _$\sqrt{N}$_ to ensure fast mixing 1.
- Move towards θ with speed *v* for *T* time slots. After *T* time slots, pause for *Tstop* time slots where *Tstop* is chosen from a geometric distribution with mean *Tstop*.
- The process continues until the simulation ends.

5D Reference Point Group

In the RPGM model, each group has a centre, which is either a logical centre or a group leader node. For the sake of simplicity, we assume that the centre is the group leader.

Thus, each group is composed of one leader and a number of members. The movement of the group leader determines the mobility behaviour of the entire group. The respective functions of group leaders and group members are described as follows.

The Group Leader

The movement of group leader at time t can be represented by motion vector V^t_{group}. Not only does it define the motion of group leader itself, but also it provides the general motion trend of the whole group.

Each member of this group deviates from this general motion vector V^t_{group} by some degree. The motion vector V^t_{group} can be randomly chosen or carefully designed based on certain predefined paths.

The Group Members

The movement of group members is significantly affected by the movement of its group leader. For each node, mobility is assigned with a reference point that follows the group movement.

Upon this predefined reference point, each mobile node could be randomly placed in the neighbourhood.

6 Results

The mobility models are selected for routing either it can be Epidemic or Spray wait. So the mobility model specifies the way the data is carried out; say Random way point shown in the figure1.

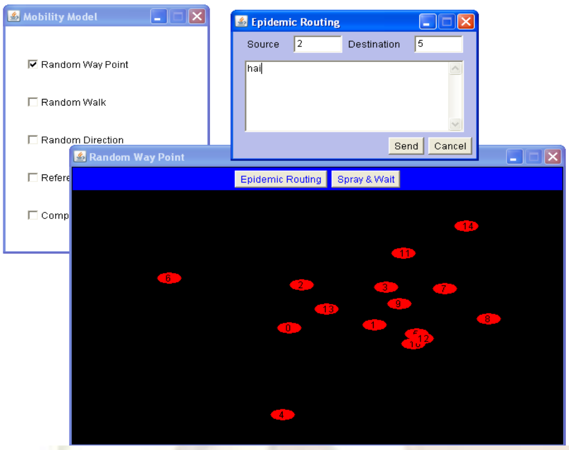


Fig1: Node movement in random way point

A node selection for the source and destination through which data is sent initially by Epidemic routing where flooding of data is data to the nodes is efficiently done shown in fig2.

Similarly spray and wait is effectively shown in fig3 where source bits are sprayed to nodes in the vicinity of source by which data can be routed to the destination. So, the data is not flooded but after some waiting it is sent by any way through the other nodes so as to actively use most of the nodes in the network model as shown in fig4.

Finally the comparison between the flooding and spray routing has been shown in two values like Network resource utilization and Delay time(fig5). Also the same is shown in both spray wait and spray focus mechanisms.

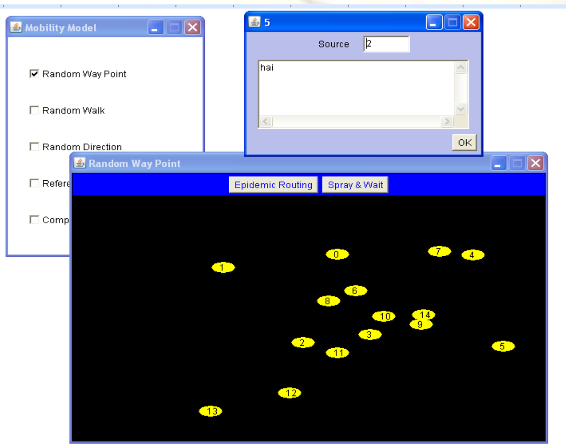


Fig2: Flooding of data in Epidemic routing

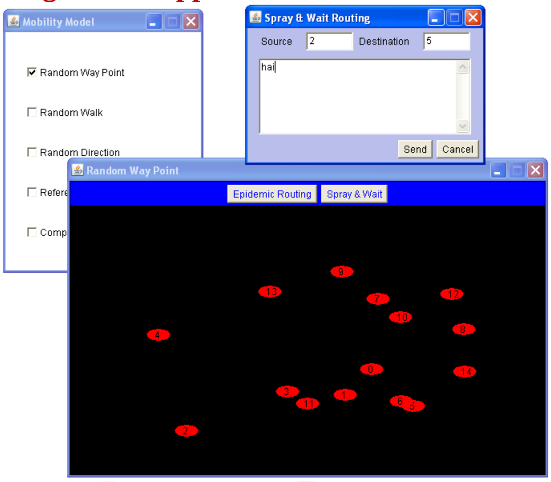


Fig3 Node movement in Spray wait

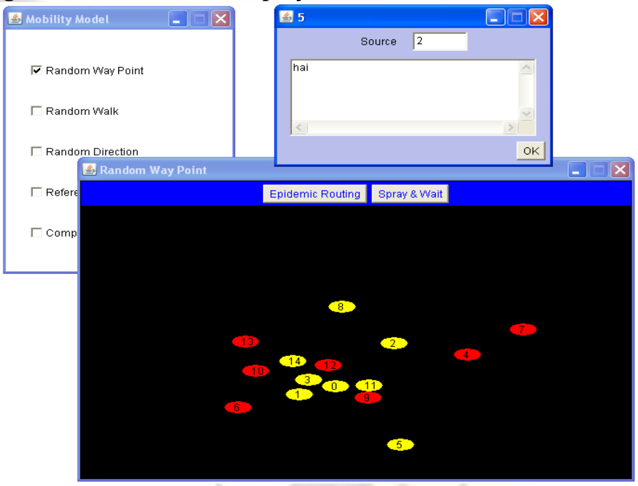


Fig: Node movement and data routing in Spray wait

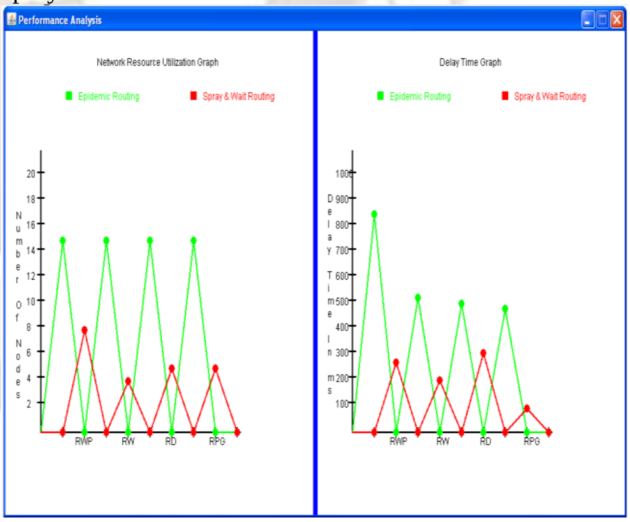


Fig 5 Performance analysis of spray waits

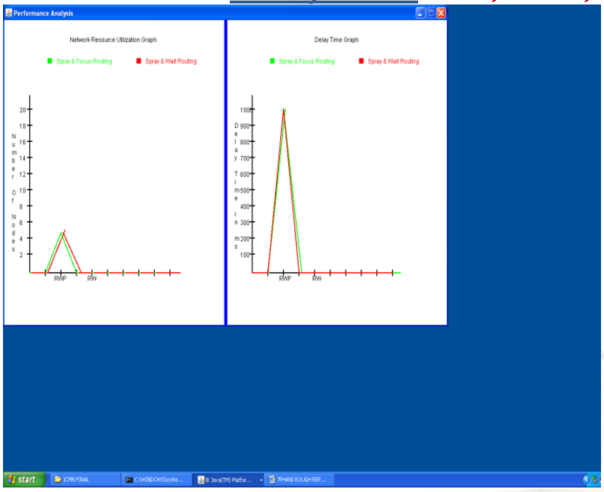


Fig 6 Performance analysis of spray waits and sprays focus

7 Conclusion and Future work

This work has been conducted a comparative study on data routing for Flooding mechanism(say Epidemic Routing) and Spray wait, also spray wait and spray focus based on two factors network resource utilization and delay time.

In future, work can be extended to implement spray mechanisms in reducing delay time (especially in spray wait) with respect to single copy and multiple copies of data that are sprayed.

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