# Three RD models for two-hop relay Routing with limited Packets Lifetime in Ad hoc Networks.

**Aslanishvili Irma**

**The State University of Georgia**

**Faculty of Exact and Natural Sciences**

e-mail: irma.aslanishvili@tsu.ge

**Abstract**-We study mobile communication of networks, the ad hoc networks, Ad hoc networks are complex distributed systems that consist of wireless mobile or static nodes that can freely and dynamically self-organize. The parameters of the queuing models depends on the node mobility pattern.

The main finding is that the expected relay buffer size depends on the expectation and the variance of the nodes contact time. Such analysis is done for the three dimensional random walks models over a circle, expected relay buffer size depends on the expectation and the variance of the nodes contact time.

First model-The source node transmits a packet only once (either to the relay or to the destination node). Thus, the source node does not keep a copy of the packet once it has beensent. When the source node transmits a packet to the destination node (when theirlocations permit such a transmission), the source node transmits packets that it hasnot transmitted before. The source node has always data to send to the destination node. This is a standard assumption, also made in [GMPS04, GT02, GK00], because we are interested in the maximum relay throughput of the relay node. This shows : first the relay node performs a Random walk and the source and destination are fixed, second the source, the destination, and the relay node move inside a square according to the RD model.

Second model-The relay node is moving according to a symmetric random walk (RW) on a circle of $4R + 2w$ steps.

Third model - Three nodes: a source a destination and a relay source, nodes are moving a cording a symmetrical Random Walk over a circle.

**Key words**: Ad Hoc Networks, MANETs protocols, Routing protocols, packet, source node, Relay routing, finite memory, Relay Buffer (RB), RB occupancy ,Destination.

## Introduction

we consider the Routing protocols in Ad Hoc Networks. The network consists of three type of nodes, source, destination, and relay nodes. The objective is to study the behavior of the relay buffer as a function of the nodes mobility models. We find the expected Relay Buffer size, in the heavy traffic case, embedded at certain instants of time. This expectation is called the event average. Note that the expected Relay Buffer size in the heavy traffic case serves also as an upper bound of the expected Relay Buffer size. Further, we show numerically that under the mobility models considered the event average converges toward the time average of the RB as the load of the relay buffer tends to one. This will be done for three different mobility models: Random Walk, Random Direction, and Random Way point.

## Routing Protocols in Ad Hoc Networks

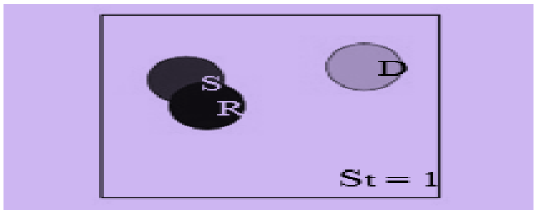
We have to note that in Ad hoc networks each node acts as a router for other nodes. The traditional link-state and distance-vector algorithms do not scale well in large MANETs. This is because periodic or frequent route updates in large networks may consume a sign if- cant part of the available bandwidth, increase channel contention and require each node to frequently recharge its power supply.To overcome the problems associated with the link-state and distance-vector algo-rhythm's a number of routing protocols has been proposed for MANETs. These protocols can be classified into three different groups: proactive, reactive and hybrid. In proactive routing protocols, the routes to all destination are determined at the start up, and maintained by means of periodic route update process. In reactive protocols, routes are determined when they are required by the source using a route discovery process. Hybrid routing protocols combine the basic properties of the first two classes of protocols in to one.In proactive routing protocols, each node maintains information on routes to every other node in thenetwork. The routing information is usually kept in different tables.These ta- bless are periodically updated if the network topology changes. The difference between these protocols lies in the way the routing information is updated and in the type of information kept at each routing table.

Reactive or on-demand routing protocols have been designed to reduce the overhead in proactive protocols. The overhead reduction is accomplished by establishing routes on- demand, and by maintaining only active routes. Route discovery usually takes place by flooding a route request packet through the network. When a node with a route to the destination is reached, a route reply packet is sent back to the source. Representative reactive routing protocols are: Dynamic Source Routing , Ad hoc On Demand Distance Vector , Temporally Ordered Routing Algorithm , Associativity Based routing , Signal Stability Routing .[2]

**Single source, destination, and relay nodes**

The state of the relay node at time t is represented by the random variable $S_t \in \{-1, 0, 1\}$ where: $S_t = 1$ if at time t the relay node is neighbor of the source, and if the destination is a neighbor neither of the source nor of the relay node In other words, when $S_t = 1$, the source node sends relay packets to the relay node at time t; $S_t = -1$ if at time t the relay node is a neighbor of the destination, and if the source is a neighbor neither of the destination nor of the relay node. When $S_t = -1$ the relay node delivers relay packets (if any) to the destination. $-$ $S_t = 0$ otherwise. Mobiles have finite speeds. Assume that the relay node may only enter state 1 (resp. $-1$) from state 0: if $S_{t-} = S_t$ then necessarily $S_t = 0$ if $S_{t-} = 1$or $= -1$.

The source node transmits a packet only once (either to the relay or to the destination node). Thus, the source node does not keep a copy of the packet once it has beensent. When the source node transmits a packet to the destination node (when theirlocations permit such a transmission), the source node transmits packets that it hasnot transmitted before.




Pic. 1.1

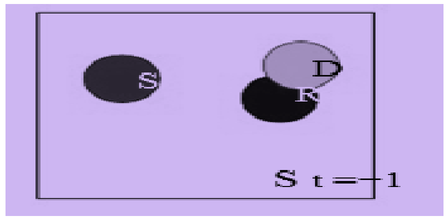



Figure 1.2

Figure 1.1.andFigure 1.2Are the process $\{S_t\}$

This is because when$S_t$ = 1, the relay node receives data to be relayed from the source node at rate$r_s$ ; − it decreases at rate $r_d$ if $S_t$ = −1 and if the RB is non-empty. This is because if $S_t$ = −1, and if there is any data to be relayed, then the relay node sends data to the destination node at rate $r_d$. Let $\{Z_n\}_n$ ($Z_1$<$Z_2$< · · ·) (2) denote the consecutive jump times of the process { $S_t$ , t ≥0}. An instance of the evolution of $S_t$ and$B_t$ as a function of t is displayed in Figure 1.2. The evolution of the discrete indexed process $\{S_{zkn}$ , k ≥ 1} consists of sequences of 1, 0 and −1. Without loss of generality assume that the process{ $S_t$ , t ≥ 0}isaright-continuousprocess.[6]

**Packet Round Trip Time**We assume that the source is ready to transmit the packet to the destination at time t = 0. The delivery time $T_\propto$, is the time after t = 0 when the destination node receives the packet.

Denote by $B_t$ the RB occupancy at time t. The $r_v B_t$ evolves as follows: it increases at rate $r_s$if $S_t$ = 1. This is because when$S_t$ = 1, the relay node receives data to be relayed from the source node at rate$r_s$ ; − it decreases at rate$r_d$ if $S_t$ = −1 and if the RB is non-empty. This is because if $S_t$ = −1, and if there is any data to be relayed, then the relay node sends data to the destination node at rate $r_d$.

Let $\{Z_n\}_n$ ($Z_1$<$Z_2$< · · ·) (2) denote the consecutive jump times of the process { $S_t$ , t ≥0}. An instance of the evolution of $S_t$ and $B_t$ as a function of t is displayed. The evolution of the discrete indexed process $\{S_{zkn}$ , k ≥ 1} consists of sequences of 1, 0 and −1. Without loss of generality assume that the process{ $S_t$ , t ≥ 0} isaright-continuousprocess.[1]

Assume that the relay node may only enter state 1 (resp. −1) from state 0: if$S_{t-}$ = $S_t$then necessarily $S_t$ = 0 if $S_{t-}$ = 1 or $S_{t-}$= −1. Let $B_t$ be the RB occupancy at time t. Based on the definition of $S_t$ , $B_t$ increases atrate $r_s$ if $S_t$= 1,$B_t$ decreases at rate $r_d$ if $S_t$ = −1 and if the RB is non-empty, and $B_t$remains unchanged in all other cases.

Let $\{Z_n\}_n$ ($Z_1$<$Z_2$< · ·) denote the consecutive jump times of the process $\{S_t$, t ≥0}. Define a cycle as the interval of time that starts at t = $Z_k$ , for some k with $S_t$= 1, and (necessary)$S_{t-}$= 0 and $S_{zk-2}$ = −1, and ends at the smallest time t + τ such that $S_{t+\tau}$ = 1 and $S_{t+s}$ = −1 for some s < τ . Let $S_{t+\tau}$ denotes the duration of the nth cycle. Let $W_n$ denote time at which the $n^{th}$ cycle begins. Let

$$\sigma_n \triangleq \int_{t=W_n}^{W_n} 1_{\{S_t \ =1\}}\, dt \qquad (1)$$

be the amount of time spent by the relay node in state 1 during the $n^{th}$ cycle. Similarly, let

$$\sigma_n \triangleq \int_{t=W_n}^{W_n} 1_{\{S_t \ =-1\}}\, dt \qquad (2)$$

be the amount of time spent by the relay node in state −1 during the nth cycle. Let $B_n$ be the RB occupancy at the beginning of the$n^{th}$ cycle, i.e. $\widetilde{B_n}$= $B_{W_n}$ . Clearly,

$$\widetilde{B_{n+1}} = \left[\widetilde{B_n} + r_s\sigma_n - r_d\ \sigma_n\right]\ (3)$$

where [x]+ = max(x, 0). In other words, $B_{n+1}$can be interpreted as the workload seen by the$(n+1)^{st}$customer, and $r_s\sigma_n$ is the service requirement of the $n^{th}$ customer.[2]

**Relay buffer behavior**

The impact of the first mobility model on the relay buffer occupancy is studied. Assume that the mobility models under consideration have stationary node location dis- tributions. The plan is to view this system as a GI/G/1 queue in heavy traffic and then to look at the effect of mobility patterns on the relay buffer occupancy. It is known from heavy-traffic analysis that the tail behavior (the large devia- tion exponent) of the buffer occupancy is determined by the variance of the service and inter-arrival times. Moreover, it is also to be understood that the effective arrival process to the RB in the second model.i.e.

$$\int_{u=Z_n}^{Z_{n+1}} 1_{\{S_{(u)=1}\}}\, du\ \ (4)$$

$$\sigma_n = \int_{u=W_n}^{W_{n+1}} 1_{\{S_{(u)=1}\}}\, du\quad (5)$$

Clearly, a larger relay buffer occupancy would imply that the amount of time required to deliver all the packets would be composed of many contact periods between the relay node and the destination, hence there can be several inter-visits between the relay node and the destination required to deliver the packets. This implies that we can not study the delay incurred by the nodes by considering only one inter-visit time (or the meeting time) or only one contact time. This shows that the buffer behavior (hence the delays) will depend on both contact times and the inter-visit times.

First model-The source node transmits a packet only once (either to the relay or to the destination node). Thus, the source node does not keep a copy of the packet once it has been sent. When the source node transmits a packet to the destination node (when their locations permit such a transmission), the source node transmits packets that it has not transmitted before. The source node has always data to send to the destination node. This is a standard assumption, also made in [GMPS04, GT02, GK00], because we are interested in the maximum relay throughput of the relay node. This shows : first the relay node performs a Random walk and the source and destination are fixed, second the source, the destination, and the relay node move inside a square according to the RD model. the relay node performs a Random walk and the source and destination are fixed, second the source, the destination, and the relay node move inside a square according to the RD model.

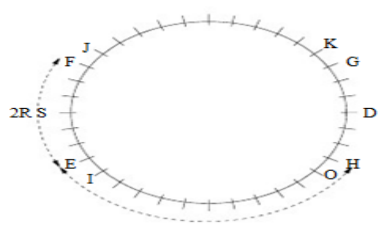



**Figure1.3**

**Second model**-The relay node is moving according to a symmetric random walk (RW) on a circle of 4R + 2w steps .(fig.1.3) The RW step size is fixed and is equal to µ meters. The speed of the relay node is assumed to be constant and equal to V , so the time required to jump from one step to the next one, is equal to µ/V seconds. The source and the destination are fixed (not in movement), and they are located as shown in Figure 1.3 The quantities w and R are assumed to be integers. Also, the data transmission between source and destination only takes place through the relay node. When the relay node becomes a neighbor of the source (when passing points E or F), it starts to accumulate data at rate $r_s$ . When the relay node enters the neighborhood of the destination, via points G or H, it delivers the data to the destination at rate rd . Once in the interval [E, F ], the relay node remains there for a random amount of time before exitingvia points E or F . Symmetry implies that this time has the same distribution whether the relay node enters [E, F ] through the point E or F . Similar is the case for the segment[G, H]. We call this (random) time the contact time between the relay node and the source (or the destination). Once the relay node exits [E, F ], it either enters [J, K] or [I, O]. Now, the relay node stays in this region for a random amount of time (during which it neither receives nor transmits), and then either reenters [E, F ] or enters [G, H]. [1]

The number of times that the relay node enters [E, F ] without entering [G, H] is denoted by the rv L, and is geometrically distributed with parameter p, independent of whether the relay node exited [E, F ] via E or F , that is

$$P(L = k) = (1-p)p^{(1-k)}) \quad (6)$$

The parameter p is the probability that a symmetric random walker starting at point J hits point F before reaching G.

Let Aj , j ≥ 1, be independent and identically distributed random variables represent- ing the first time that a random walker, starting at point F , exits [E, F ]. [R is the transmission range of source, destination, and relay node.]Hence, the servicerequirement of a customer in the G/G/1 queue of Section (5) is σ, where

$$\sigma = \sum_{j=1}^{L} A_j \quad (7)$$

In the following, A denotes a generic rv with the same distribution as Aj .

we find that $E[A] = 2R\frac{\mu}{V}$ (8) $Var\ [A] = (\frac{\mu}{V})^2.\frac{4R}{3}(2R+1)(R+1)$ (9)

E[L]=$\omega$ (10) $Var\ [L] = \omega(\omega-1)$ (11)

Since L is independent of A, we getE[$\sigma$]=$E\ [A]E[L] = 2R\omega\frac{\mu}{V}$ (12)

Var[$\sigma$]=$Var\ [A]E[L] + (E[A])^2 Var\ [L] = 4R\omega(\frac{\mu}{V})^2.(\omega R + \frac{1}{3}(2R^2+1)$ (13)

And now we find that when $r_s \approx r_d$ with $r_s$<$r_d$, and $r_s E[\sigma_n] \approx r_d E[a_n]$ our conclusion is that the stationary waiting time is exponentially distributed with

$$E[\widetilde{B_n}] \approx \frac{r_d^2 Var(a_n) + r_s^2\, Var(\sigma_n)}{2(r_d E[a_n] - r_s E[\sigma_n]} \quad (14)$$

Where we have used the fact that $\sigma_n$and $\sigma_d$are identically distributed. Now wefind that the expected relay buffer size depends on the expectation and the variance of the nodes contact time. Such analysis is done for the one dimensional random walk over a circle. There is second modelTwo- hop rout between two nodes s and d.[4]

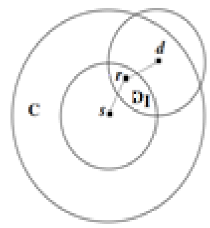



Figure 1.4

Observe that $P^N$ is a function of $(R/L)^2$. Note that u (i)independent of the mobility model of the nodes, and that in the case RD mobility .[5]

Consider scenario of a third model. Three nodes: a source a destination and a relay source. Nodes are moving acording a symmetricalRandom Walk over a circle. It follows from p=$\frac{r_s}{r_d} < 1$. Figure 1.4 plots the evolution of relay node buffer with time for different values p. It is evident when p=1, 0. The buffer occupancies process is unstable.

Figure 1.4 Time-evolution of relay node buffer for random Walk is third model over a circle for different values of ration p=$\frac{r_s}{r_d}$.

**Conclusion** The behavior of the relay buffer of the two-hop relay routing in mobile ad hoc networks we tolled in thesethreeRDmodels. The parameters of the queueing models depends on the node mobility pattern.

The main finding are in these three models the expected relay buffer size depends on the expectation and the variance of the nodes contact time. The source node transmits a packet only once (either to the relay or to the destination node). Thus, the source node does not keep a copy of the packet once it has beensent. When the source node transmits a packet to the destination node (when theirlocations permit such a transmission), the source node transmits packets that it hasnot transmitted before.

The source node has always data to send to the destination node. This is a standard assumption, also made in [GMPS04, GT02, GK00], because we are interested in the maximum relay throughput of the relay node.

When the destination node comes within the transmission range of the relay node,and if the destination and the relay node are outside transmission range of the sourcenode, then the relay node sends the relay packets (if any packets in its RB) to the destination node at a constant rate $r_d$.

Such analysis is done for the one dimensional random walk over a circle. Relay Routing models are like models of M .L .Tsetlin who supposed that the elementary behavioral models can be singled out from the complex behavior and elementary problem can be formulated, any complex behavior based on a finite storage space.

REFERENCES

[1] Oleg Namicheishvili,Hamlet Meladze, IrmaAslanishvili,Transactions. Two models for two-hop relay Routing with limited Packet Lifetime -Georgian Technical University. AUTOMATED CONTROL SYSTEMS -54-58 No 1(10), 2011

[2] R. Groenevelt, P. Nain and G. Koole, The Message Delay in Mobile Ad Hoc Networks, Proc. of Performance 2005, Juan-les-Pins, France, October 2005. Published in Performance Evaluation, Vol. 62, Issues 1-4, October 2005, pp. 210-228.

[3] M. Grossglauser and D. Tse, Mobility Increases the Capacity of Ad hoc Wireless Networks, IEEE/ACM Transactions on Networking, Vol. 10, No. 4, August, 2002, pp. 477-486.

[4] E. Zhang and G. Neglia and J. Kurose and D. Towsley, Performance Modeling of Epidemic Routing, Umass Computer Science Technical Report 2005-44.

[5]A. Al Hanbali, P. Nain and E. Altman, Performance Evaluation of Packet Relaying in Ad Hoc Networks. INRIA Research Report RR-5860, Mars2006.

[6] , Irma Aslanishvili, One model for two-hop relay Routing with limited Packet Lifetime The Conference for International Synergy in Energy, Environment, Tourism and contribution of Information Technology in Science, Economy, Society and Education era-7.ISSN 1791-1133 **www.erateipier.gr**