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Reliability Evaluation of Mobile Ad Hoc Network: With and Without Mobility Considerations

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Abstract

A Monte Carlo Simulation based evaluation of mobile ad hoc network reliability is proposed which considers different mobility models along with the effect of different scenario metrics and different values of tuning parameter. Through our approach we show that the mobility considerations have no significant impact on reliability as the same results are obtained by just implicitly simulating the node locations. Considering no mobility models reduces computational burden, number of random variables involved making the algorithm more efficient is the added advantage. A comparative study of the results of the network reliability estimate considering with and without mobility is provided.
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Keywords: Ad hoc Networks; Geometric Random Graph; Mobility Models; Random WayPoint Mobility Model; Gauss Markov Mobility Model; Connectivity Matrix; Monte Carlo Simulation; Network Reliability.

1. Introduction

Most of the researchers have modeled the ad-hoc network by randomly, uniformly distributing the mobile nodes in a defined two dimensional simulation boundary region[1,2]. Each node is associated with two uniform random variables (node's x and y coordinate). There exists a high probability of a link existence called connectivity between the mobile node (MN) when the mobile nodes (MNs) of the network are in the proximity of each other. Typically, in

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wireless ad hoc networks, a node estimate their position relative to their neighbors by processing the location information (node speed, node direction), certain physical properties of the signal they receive, such as signal strength, bit error rate, or time difference of arrival and is called mobility. The movement of the MN in and out of the transmission range of the neighbor nodes not only changes their relationship with its neighbor at every time instant but also changes its topology resulting in frequent link breaks. This link breakage in the network leads to connectivity failure between the nodes which further has a resultant impact on the reliability of the network.

Acronym

GRG	Geometric Random Graph
GMMM	Gauss Markov Mobility Model
MANET	Mobile Ad Hoc Network
MCS	Monte-Carlo Simulation
MN(s)	Mobile Node(s)
RWPM	Random Waypoint Mobility Model

Notation

θ	Scale parameter of the Weibull failure distribution of the node
β	Shape parameter of the Weibull failure distribution of the node
α	Tuning parameter (Degree of randomness); ($0 \leq \alpha \leq 1$)
$\Delta\tau$	Incremental change in time
$2TR_m$	*2*-terminal network reliability
$A(\tau)$	Connection matrix of MANET at time τ
$C_q(\tau)$	Connectivity of the ith node to the source at time τ of qth iteration
D	Network Coverage Area in square distance – units
$d_{ij}(\tau)$	Euclidean distance between node u_i and node u_j at time τ
$G(U,L,\tau)$	An undirected graph at particular time instant τ
$(G\|k)$	Network derived from $G(U, L, \tau)$ by setting the success probability of nodes of $k \subseteq U$ equal to 1.
k	Set of $k \subseteq U$ nodes in $G(U,L,\tau)$
L	$\{l_1, l_2, ..., l_m\}$:Set of m links
$L_{ij}(\tau)$	Link status between node u_i and node u_j at time τ
q	One complete iteration of Q number of simulation runs
Q	Total number of simulation runs.
$R_G(\tau)$	Reliability of MANET at a particular instant of mission time
$R_{u_i}(\tau)$	Reliability of node u_i at time τ
r_j	Transmission range of a node u_j in distance units (j=1,2,...,n)
s	Source node
(s,t)	Source – Terminal pair
t	Terminal node
T	Mission time in time-units
U	$\{u_1, u_2, ..., u_n\}$:Set of n mobile nodes
$u_i(\tau)$	Status of the ith node at time τ
$Var(R_G(\tau))$	Variance of $R_G(\tau)$
$(x_i(\tau), y_i(\tau))$	Position of node u_i in XY-plane at time $\tau \forall$ i=1, 2... n.

Network reliability is an important criterion and is of major importance in systems whose topology change dynamically and is arbitrary (*e.g.*, Mobile Ad hoc NETwork - MANET). The highly dynamic feature has been a challenging feature[3] for the reliability estimate of such systems because the nodes of these networks move randomly (appear/disappear) constituting to frequent connectivity failures. The connectivity failure of the network may be due to either node failure or link failure or both[4]. This implies that the connectivity is an important factor that influences

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