ANALYSIS OF AD HOC ROUTING PROTOCOLS FOR EMERGENCY AND RESCUE SCENARIOS

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Abstract: A mobile ad hoc network MANET is a collection of wireless mobile nodes that can dynamically configure a network without a fixed infrastructure or centralized administration. This makes it ideal for emergency and rescue scenarios where information sharing is essential and should occur as soon as possible. This article discusses which of the routing strategies for mobile ad hoc networks: proactive, reactive and hierarchical, have a better performance in such scenarios. Using a real urban area being set for the emergency and rescue scenario, we calculate the density of nodes and the mobility model needed for validation. The NS2 simulator has been used in our study. We also show that the hierarchical routing strategies are beffer suited for this type of scenarios.

1 INTRODUCTION

Mobile Ad Hoc Networks(MANET), are self configuring and temporary networks . Their nodes can be the source, destination and bridge information.

In case of emergency and rescue scenario, the topography is different in the amount of obstacles that may arise due to the occurrence of a undesired events causing the normal mobility pathways to alter. Therefore, the algorithm of motion is determined according to the topography, and the corresponding nodes must be moved depending on the obstacles. The number of nodes depends if the MANET network is in an urban or in a rural area. When an unwanted event has occurred, it changes the pathways of normal mobility. Therefore new routes for evacuation and or rescue should be calculated.

When MANET are used in emergency and rescue scenarios, the choice of robust network protocol is essential, because it involves indirect integrity of the person using the mobile device. If a device is not reachable by the network, the events of personal seach and rescue should be desconected from the device.

The main objetive of this paper is to determine wich one of the ad hoc routing strategies proactive, reactive and hierarchical performs better in emergency and rescue operations. For this reasor we have chosen en area of the city of Loja Ecuador to simulate these protocols supported by the NS2 tool.

2 RELATED WORK

2.1 Routing Protocols for Mobile Ad Hoc Networks

The network layer (Ali et al., 2008), with respect to the OSI reference model, is where one performs and identifies the processes of ad hoc networks. Therefore, any improvement effort in this layer is directly visible in the upper layers.

The routing protocols of ad hoc networks are generally grouped into proactive, reactive and hierarchical routing (Overview and Selangor, 2007).

2.1.1 Proactive Routing

Proactive routing protocols maintain information on all routes throughout the network even if they are not required so each node maintains routes to all nodes in the network. These protocols exchange control information between nodes on a regular basis which keeps updated routes for each node in the network. These protocols react when a new node appears or another node, is no longer within the network topology. The known protocols are: Destination-Sequence Distance-Vector DSDV (Perkins and Bhagwat, 1994) and Optimized Link State Routing OLSR (rfc3626).

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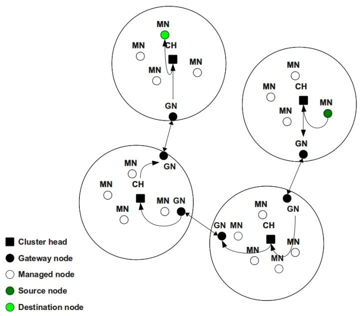

Figure 1: Clustered ad hoc network.

2.1.2 Reactive Routing

Reactive routing protocols allow updating of the tables on demand, for example, when a node wants to exchange information with another node in the network. They usually have two components: route discovery, which occurs when a node wants to communicate with a specific destination and route maintenance, used to manage the path failure caused by the mobility of the nodes.

The difficulty with these protocols is the latency to initiate communications, they also have a slower reaction to detect changes in the network topology. Among the best known protocols are the Dynamic Source Routing (DSR rcf4728) and Ad Hoc Demand Distance Vector AODV (Perkins et al., 2003).

2.1.3 Hierarchical Routing

Hierarchical routing protocols divide the network into subsets of nodes called clusters, where a cluster head node is used to concentrate and distribute the information generated within the cluster. An example of this type of protocol is the Cluster Based Routing Protocol (CBRP) (Jiang et al., 1999). Figure 1 shows the basic components of a hierarchical routing protocol or cluster.

There are some studies (Agarwal and Motwani, 2009; Biradar and Patil, 2006), that identify and group the hierarchical routing algorithms or clustering. These protocols and hierarchical routing strategies focus on the task of choosing the cluster head and cluster maintenance. For example, (Er and Seah, 2004; Er and Seah, 2005); focus on the choice of cluster based solely on the property of the node mobility. In turn, (Jiang et al., 1999; Gerla and chieh Tsai, 1995; Amis et al., 2000); perform cluster head election used as the deciding factor node identification. (Chen et al., 2002) uses the distance between nodes or the degree of connectivity for the election.(McDonald and Znati, 1999) makes the choice of cluster head periodically in order to save energy. The protocols proposed in (Er and Seah, 2004; Basagni et al., 2001; Chatterjee et al., 2001) made the choice of cluster head based on the combined weights of the characteristics of each node.

2.2 Mobility Models for Mobile Ad Hoc Networks

Mobility models are important because they determine the behavior of mobile nodes (MN) on stage (Camp et al., 2002). They can be classified into two types: those based on traces (logs of actual movements) [14] and the synthetic (emulate reality by mathematical equations). Some authors classify mobility models into three groups (Camp et al., 2002): models based on strokes (work with real mobility), models based on topology restrictions (real scenario simulations) and statistical models (study from randomness).

Ad hoc networks do not work yet on models based on traces on the network characteristics. Howerer, it is expected that study will expand in future on the application of these models (Camp et al., 2002). Therefore, models of synthetic mobility are used fogether with simulated scenarios. In order to prove this form of controlled mobility, certain parameters are used, which allow to obtain quantifiable date and thus to transform them into useful informaties.

The synthetic models are classified according to their relationship with the representation of human mobility: synthetic mobility models unrealistic, for example: random models (Divecha et al., 2007) (Random Walk Mobility Model, Random Waypoint Mobility Model), temporal dependency models (Hong et al., 1999; Divecha et al., 2007) (Boundless Simulation Area Mobility Model, Gauss-Markov Mobility Model, Smooth Random Mobility Model) and realistic synthetic mobility models such as: spatial dependence models (Hong et al., 1999; Chenchen et al., 2010; Chenchen et al., 2010)(Reference Point Group Mobility, Column Mobility Model, Pursue Mobility Model, Nomadic Mobility Model) Geographic Restriction Models (Chenchen et al., 2010; Aschenbruck et al., 2008) (Pathway Models, Obstacle Models, Human Obstacle Mobility Model).

3 PROPOSED SCENARIO

3.1 Emergency and Rescue Scenario for Centre of the City of Loja

Random obstacles have been defined in this area of

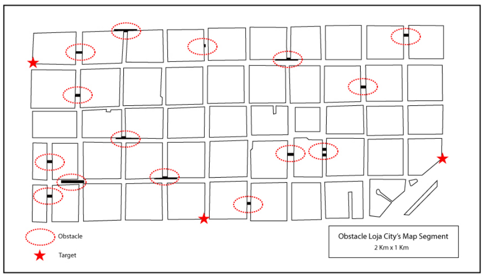

Figure 2: Loja city map without obstacles.

$1000mx500m$ of the city Loja is used in Ecuador, Figure 2, that disrupt normal mobility pathways of the nodes.

3.2 Node Density

The calculation of the node density P_{node} is supported by information obtained from the census of Ecuador in 2010. [1] An important factor for the calculation of the nodes is the percentage of the PEA (Economically Active Population).

To calculate the density of nodes the following formula has been proposed:

$$P_{nodes} = \frac{zu_l * F_{uel} * F_{PEA} * F_{us}}{A_{zu}} * A_s \quad (1)$$

$$P_{nodes} = 97 \quad (2)$$

Where:

- zu_l - Number of people in the urban areas is 70% (128910)
- zr_l - Number of people in the rural areas is 30% (85940).
- F_{uel} - urban factor specified for the simulation area
- A_zu - Urban area - 6Km x 12Km = $72Km^2$.
- F_{PEA} - LOJA - PEA is 62% for urban area.
- F_{us} - urban smartphone factor is 25% .
- A_s - Chosen area for simulation $0.5km^2$.

It is important to describe the city of Loja for which this study has been done, it is a city in the southern part of Ecuador. Populatio it the city increases during the holidays, and it grows also due to arriving of tourists attracted by its location and biodiversity. Given this premise, we established percentages of 25.75% (F_{us})and 30.8% (F_{us}) to calculate the other two densities nodes P_{nodes}, substituting these values into the formula(1) we find that the rearsong nodes are equal to 100 (25.75%) and 120 (30.8%), respecting.

Consequently the number of nodes for the simulation is: 97, 100 and 120.

[1] National Institute of Statistics and Censuses (INEC). http://www.inec.gob.ec

3.3 General Parameters for Simulation

Table 1: General parameters for the simulation of protocols AODV, DSDV and CBRP.

Parameter	**Value**	**Observations and related works**
Simulation area	500m x 1000m	Area established within the centre of the city of Loja
Mobility model	Obstacle Models	Obstacle models (Chenchen et al., 2010; Aschenbruck et al., 2008)
Number of nodes	97,100 and 120	To determine the behaviour of protocols for different node density
Number of connections	20, 40	random connections
Time of simulation	150	In seconds
Network layer protocols	CBRP, DSDV and AODV	Hierarchical, proactive and reactive protocols
Transport layer protocols	Transmission control protocol (TCP)	A connection-oriented communication is needed
Propagation model	TwoRayGround	For flat and unobstructed scenarios.
Type of antenna	Omnidirectional	Indispensable quality of mobile network nodes

To define the simulation scenarios were used as the basis used in (Kurkowski et al., 2007a; Kurkowski et al., 2007b). The values of each one of these values are shown in the Table 1.

In order to analyze results, some authors have revised set of indicators. For our research we select some particular indicaters from (Chenna Reddy and ChandraSekhar Reddy, 2006; Corson and Macker, 1999) in order to measure behavior of protocols. These indicators are: performance, protocol overhead, packet loss, average delay and the variation of the delay or jitter. These indicators are compared with those of the following protocols: CBRP(Jiang et al., 1999), AODV(Perkins et al., 2003) and DSDV(Perkins and Bhagwat, 1994).

4 SIMULATION RESULTS

The NS2 simulator (NS, 2012) is used to determine the protocols behaviour with the data shown in Table 1. In order to determine which is the best protocol, we used the following indicators for comparison:

- **Average Delay:** This is very significant to measure for our purpose because there is a need to send and receive network managment information as fast as possible.

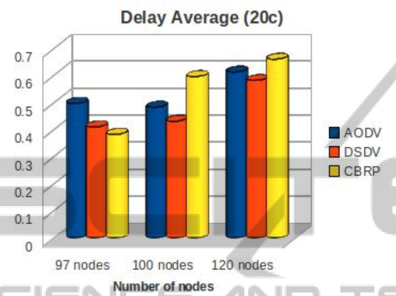

Figure 3: Delay average - TCP - 20 connections.

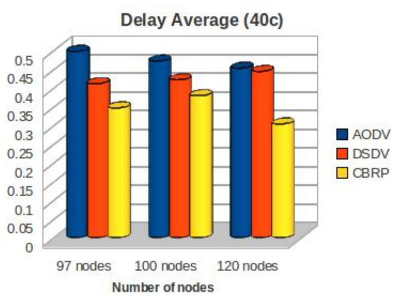

Figure 4: Delay average - TCP - 40 connections.

In this parameter as shown in Figure 3 to 20 connections with 97 nodos the 3 protocols behaviour optimal according to their characteristics, but 100 and 120 nodes CBRP protocol suffers small delay. Instead with 40 connections as seen in Figure 4 already panorama changes to demonstrate advantage that protocol CBRP regarding protocols AODV and DSDV. Data in Table 2, Table 3, Table 4.

Table 2: AODV protocols analysis - delay average.

Number of nodes	AODV(20c)	AODV(40c)
97	0.498009	0.498009
100	0.483952	0.471993
120	0.613480	0.452916

Table 3: DSDV protocols analysis - delay average.

Number of nodes	DSDV(20c)	DSDV(40c)
97	0.411367	0.411367
100	0.432102	0.421802
120	0.582582	0.444208

Table 4: CBRP protocols analysis - delay average.

Number of nodes	CBRP(20c)	CBRP(40c)
97	0.383271	0.346918
100	0.597227	0.379617
120	0.660971	0.303840

- **Packets Sent Rate:** The rate obtained by the number of packets sent to the number of packets received. For the formation and maintenance the cluster needs the exchange of packets to have updated information. As shown in Figure 5 and Figure 6. The protocol that best responds to this parameter is the CBRP protocol for both 20 as for the 40 connections.

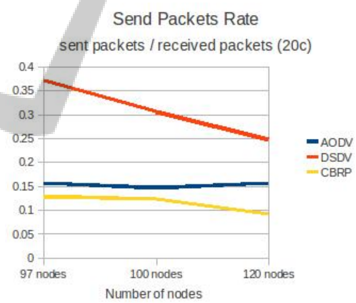

Figure 5: Send packet rate 20 connections.

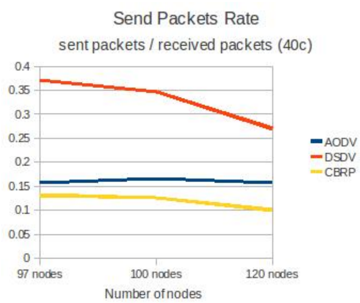

Figure 6: Send packet rate 40 connections.

- **Packet Delay Variation:** It is the difference in delay between communications end-to-end selected packets. It serves to measure the network stability and convergence, in Ad Hoc networks.

  This parameter is related to the mean fluctuation

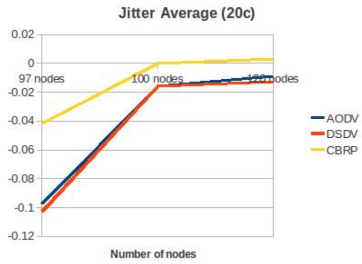

Figure 7: Jitter average TCP 20 connections.

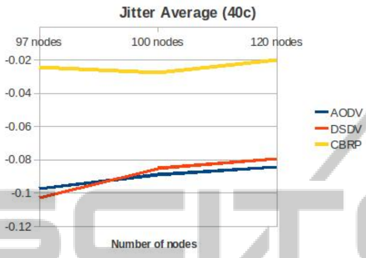

Figure 8: Jitter average TCP 40 connections.

and helps us to determine which of the three protocols would be the most appropriate at the time to emergency and rescue. as we can see that this parameter as the two above parameters shows that the protocol is nearest zero consequently has jitter lower the protocol CBRP as seen in Figure 7 and Figure 8. The simulation results are set to Table 5, Table 6, Table 7.

Table 5: AODV protocols analysis - jitter average.

Number of nodes	**AODV(20c)**	**AODV(40c)**
97	-0.097499	-0.097499
100	-0.015795	-0.088908
120	-0.009072	-0.084256

Table 6: DSDV protocols analysis - jitter average.

Number of nodes	**DSDV(20c)**	**DSDV(40c)**
97	-0.102806	-0.102806
100	-0.015821	-0.085109
120	-0.01274	-0.079349

- **Packet Loss:** This is the amount of packets dropped by intermediate nodes due to the effects produced by the mobility of these nodes, timer expires, unreachable or erased destination by ARP (Address Resolution Protocol).

The objective of the simulation was to determine which of these three protocols behave better in emergency and rescue scenarios and how we can seen in

Table 7: CBRP protocols analysis - jitter average.

Number of nodes	**CBRP(20c)**	**CBRP(40c)**
97	-0.041516	-0.024319
100	-0.000214	-0.027638
120	0.003136	-0.019921

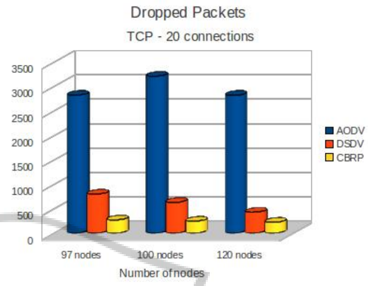

Figure 9: Dropped packets - 20 connections.

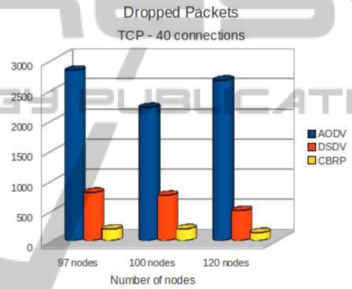

Figure 10: Dropped packets - 40 connections.

Figure 9 Figure 10 CBRP protocol clears least packets with 20 connections and even better with 40 connections. The data are shown in Table 8 y Table 9.

Table 8: Dropped packets - 20 connections.

Number of nodes	**AODV(20c)**	**DSDV(20c)**	**CBRP(20c)**
97	2820	799	269
100	3207	631	245
120	2819	429	222

Table 9: Dropped packets - 40 connections.

Number of nodes	**AODV(40c)**	**DSDV(40c)**	**CBRP(40c)**
97	2820	799	187
100	2206	751	196
120	2659	496	133

5 CONCLUSIONS

- Traditional routing algorithms cannot satisfy requirements of an ad hoc networks, because of topology dynamics and limited bandwidth characterizing these networks. Consequently, there area lot of investigation related to existing routing algorithms land there is discovering of new routing algorithms, which are more efficient.

- This study evaluate and compare CBRP, AODV and DSDV for emergency and rescue scenarios. The experimental results show that the best protocol is CBRP that losses only few packets for routing, where is the sending and receiving rate of packets is stable. The mean fluctuation and the delay is much smaller in relation to the other two protocols. This would support determine that using the protocol CBRP people in a disaster area could be evacuated to more efficiently support points as would be placed promptly.

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