Analysis of Performance of the Routing Protocols Ad Hoc using Random Waypoint Mobility Model Applied to an Urban Environment

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Abstract: Mobile ad-Hoc Network (MANET) is a group of mobile nodes interconnected and dynamic. A routing protocol is used to find the routes between the mobile nodes and facilitate the communication within the network. The aim of the protocols is to establish a correct and efficient route between a pair of mobile nodes, also it needs to be discovered and kept with a minimum consumption of bandwidth. This research work shows the performance assessment of six routing protocols: Destination Sequenced Distance-Vector (DSDV), Optimized Link State Routing (OLSR), Dynamic Source Routing Protocol (DSR), Ad Hoc On-Demand Distance Vector (AODV), Zone Routing Protocol (ZRP), Dynamic MANET On-Demand (DYMO). The evaluation was defined scenarios with 50, 90, 130, 170, 210 and 250 nodes and parameters such as: numbers of generated packages , broadcast packages, delay of node to node. The simulations and visualization from the results were executed in the network simulator NS2 version 2.34 and TraceGraph.

1 INTRODUCTION

Nowadays, the computer networks are within the reach of all because of the Internet, it has generated different types of networks within which are the mobile networks Ad- Hoc o MANET (Mobile Ad-Hoc Networks), which do not require a previous infrastructure, it allows that two or more user have mobile terminals that can make a network at any time (Sangwan et al., 2013), (Anwar., 2008), (Sathish., 2011).

A MANET network is a group of mobile nodes that can communicate to each other through of wireless, the nodes as are mobiles can move by a free space, giving rise to different topologies in all moment (Sangwan, Duhan and Dahiya, 2013),. It is a dynamic topology due to outages in links, and to the appearance of new links. This type of links has some inconvenient than a conventional link does not show. The topology of this type of links can change quickly and unpredictably. Furthermore, it is possible to occur variations in the nodes and links capabilities such as: frequent errors in the transmission and lack of safety due to the own features of the devices which are part of this type of networks as restriction of bandwidth and energy (by the use of batteries) (Anwar et al., 2008). Finally, it is necessary to emphasize that one of the main inconvenient of the MANET network, is its security due to the different features of this type of network, as wireless or the lack of infrastructure that can control and handle the network, which is susceptible to suffer attacks. For this type of network, there are protocols of specific routing because the existing ones for fixed networks are no the adequate for them.

2 ROUTING PROTOCOL

The routing protocol are classified according their features, the way more known is based in as a mobile node process the information of control; for that reason, there are two main types: the proactive protocols which are basically an adaptation of the vector distance protocols and link status of the wired networks, and reactive protocols also called low demand which were developed mainly for the MANET networks. There are other type of protocols which are called hybrids which keep a proactive philosophy in local field and reactive at more global level) (Vermani et al., 2012).

2.1 Proactive Protocols

The proactive protocols or the based in tables are

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those which keep the information about how to reach at all destinations of the network (nodes) (Vermani, Sharma and Yadav, 2012). This information is stored in tables which are updated periodically when there are modifications in the topology of the network (Kumar and Kumar, 2012). The difference among the protocols of this type is the way in the table are updated, the quantity of tables used, the information of each table and the way to find information. The protocols more important in this type are:

DSDV (Destination Sequenced Distance-Vector)
It is a unicast proactive protocol adapted from the RIP traditional, its main aim is to avoid the loops problems in the update of the routing tables. For that reason, it adds a new field in the tables, the sequence number that allows distinguish between an old table and a new one (Vermani, Sharma and Yadav, 2012), (Jain, Gaur and Upadhyay, 2014). DSDV applies an algorithm based in the distance vector, this means that keep the tables with all its accessible destinations together with the following leap, the metric and a number of sequence of the input in the generated table by the destination node. The tables are sent with diffusion messages on a regular basis or when there is a significant difference of the network topology. A route is considered better than other if it has a sequence number major or in case of a tie, if the distance at the destination is minor. When a B node detects that the route to certain destination D is lost, overflow the networks with an updated of that input in which is incremented the sequence number in one and the distance is marked as infinite (Jain, Gaur and Upadhyay, 2014). When an A node receive this message, it incorporates to its table the updated of the input into D through B always that there was not an input better to reach D. To achieve certain consistency in the routing table of each node by changing the network topology, the updates must be frequents and quick enough and therefore each node can have a realistic vision of the network at a specific time (Jain, Gaur and Upadhyay, 2014).

OLSR (Optimized Link State Routing)
This protocol is an optimizing algorithm of state of adapted classic link to the requirements of a LAN wireless. The key concept that is used in the protocol is the MultiPoint Relays (MPR) (Ashish, Singh and Kumar, 2010). MPR are nodes which send messages into forward during the overflow process. This technique substantively decrease the overload of messages in comparison with a mechanism of classic overflow, where each node retransmits every message when is receipted the first copy of the message (Kumar and Kumar, 2012). In OLSR, the information of state link is generated only by the chosen nodes as MPR (Ashish, Singh and Kumar, 2010). For that reason, a second optimization is obtained decreasing the minimum number of control messages overflowed in the network. As third optimization, a MPR node can opt only inform links between each other and their selectors MPR. Therefore, as it is contrary to the state algorithm of classic link, partial information of state of link is distributed in the network. This information is used to the calculus of the route. OLSR offers optima routes (in terms of number of leaps). The protocol is particularly adequate to big and dense networks (Jain, Gaur and Upadhyay, 2014).

2.2 Reactive Protocols

The routing reactive protocols are those that form the routes on-demand that means in the moment that a root node needs to send a message into a destination node are created the routes from the origin to their destination. With this type of protocols is optimized the use of resources of bandwidth and the use of battery and it is penalized the latency in finding the route (Kumar and Kumar, 2012).

DSR (Dynamic Source Routing Protocol)
The reactive protocol DSR (Dynamic Source Routing Protocol) is a protocol created especially for Ad-Hoc networks, it only sends information when is necessary, saving network energy, releasing bandwidth and saving battery. Furthermore, DSR incorporates a mechanism to avoid the creation of loops. It is compatible with IPv6 (Kumar and Kumar, 2012). As counterpart, there is the initial latency at discover a route, and it is a protocol based on the source, the package header has increasing while it is moving by the nodes; as a consequence, valuable bandwidth is lost. This protocol can be structured in two mechanics: of route discovery and the maintenance of it. The first make the search of the route and has the RREQ (Route Request) packages to look for the route if it is not available in the routing table and RREP (Route Reply) which answers at RREQ on the discovery of a route. The second mechanism has the RRER (Route Error), which show a falling route and the ACK, which periodically make the maintenance of the route (Ashish, Singh and Kumar, 2010).

AODV (Ad Hoc On-Demand Distance Vector)
This protocol allows the dynamic routing multi-hop among mobile nodes which take part in the setting and maintenance of Ad-Hoc network (Jain, Gaur and Upadhyay, 2014), (Kumar and Kumar, 2012). AODV

allows to the mobile nodes obtain quickly routes for new destinations without require those routes be kept in absence of active communication (Sangwan, Duhan and Dahiya, 2013). Therefore, it makes possible that the mobile nodes respond before the loss of link and changes in the topology in a quick and efficient way, invalidating the routes which use the loss link in the affected nodes (Anwar, Azad, Rahman and Moshee, 2008). The AODV operation creates a free routing of hoops which avoid the problem of the "account into infinity" from Bellman-Ford algorithm, and offer a quick convergence before changes in the network topology Ad-Hoc (Roberts, Rajeev and Jaiswal, 2013).

An Ad-Hoc network (Mobile Ad-hoc Network o MANET) is a group of nodes or host which communicate between them through wireless links without the necessity of an infrastructure of fixed network. Each node works as router and it is routing the different packages among the different terminals, without the necessity of a direct reach between the source and the destination. This type of network is autonomous between terminals which can move freely) (Vermani, Sharma and Yadav, 2012), (Enciso and Mengual, 2014). The nodes use routing tables to organize the leaps among the intermediate nodes so they can send the packages. These routing tables must be updated with frequency because the network is mobile and changes of position are constant (Enciso and Mengual, 2014).

DYMO (Dynamic MANET On-demand)

The routing protocol DYMO is designed for Ad-Hoc mobile networks. It can be adapted at the changes of the network topology and establish route unicast between the destination node and the root node (Kumar and Kumar, 2012). The basic operations of the protocol DYMO are the discovery and management of routes. During the discovery of route, the root node begins with the diffusion of the route request (RREQ) in the whole network to find the destination node. During this diffusion process, each intermediate node registers the route at root node. When the destination node receives the RREQ, it gives an answer of (RREP) unicast route into the protocol of routing DYMO (Roberts, Rajeev and Jaiswal, 2013), (Sivakumar and Kumar, 2009), (Enciso and Mengual, 2014). The origin is designed for Ad-Hoc mobile networks. It can adapted to the changes of the network topology and establish unicast route between the destination node and the root node. The basic operations of DYMO protocol are the discovery of routes and management of routes. During the discovery of route, the root node begins with the diffusion of the Route Request (RREQ) in the whole network to find the destination node (Sivakumar and Kumar, 2009).

2.3 Hybrids Protocols

ZRP (Zone Routing Protocol)

It is a hybrid routing protocol because it combines the best properties of the proactive and reactive protocols. ZRP is based in separation of the network in zones. It differentiates a close or neighborhood zone compose by the nodes that are at maximum of N leaps and the rest of the network. In ZRP are used two components for the routing (Sathish, Thangavel and Boopathi, 2011). In the close zone is used the component Intra Zone Routing Protocol (IARP) which acts as a proactive protocol, keeping the routes of the nodes which are to N leaps or less, being N variable. The mechanism used to discover the neighbour nodes is the regular exchange of messages HELLO (Anwar, Azad, Rahman and Moshee, 2008), (Sathish, Thangavel and Boopathi, 2011). For the global routing into the nodes out of the interior or close zone, ZRP has the Interzone component Routing Protocol (IERP), which is as a reactive protocol. When is necessary the route into a new node, using the IERP is asking this route with the mechanism Bordercast Resolution Protocol (BRP) (Anwar, Azad, Rahman and Moshee, 2008). This mechanism functions sending messages of requirement of route to the nodes which belong to the interior zone and which are in the border, which means the maximum number of leaps to be considered of the interior zone. If one of these border nodes knows the route, it will send a message indicating the node which begins the petition (Kumar and Kumar, 2012). If this is not the case, the petition will be forwarded by the whole network until it arrives into a node which knows a route into the destination. Then the answer will be sent back into the origin, keeping the intermediate nodes consequently the message passes to use as a route into the desired destination. As, It was mentioned before, the ratio (leaps number) of the interior zone is adjustable according to the network necessities. As extreme cases, if this ratio is small as minimum one, ZRP will behave as protocol merely reactive. Conversely, if the ratio is infinite, the behaviour will be proactive (Kumar and Kumar, 2012), (Sivakumar and Kumar, 2009).

3 SIMULATION ENVIRONMENT

The general aim of this research is to assess and

analyse the performance of six existing routing protocols, which are: AODV, DSR, DYMO, DSDV, OLSR and ZRP on an Ad-hoc mobile network environment (MANET), which made different simulations in the network among 50, 90, 130, 170, 210, 250 nodes (customers) on a specific area. In the Table 1, shows the variables and parameters for the network simulation.

Table 1: Variables and parameters for the simulation.

Variable	Values
Set val (chan)	Channel/WirelessChannel
Set val (prop)	Propagation
Set val (netif)	Phy/WirelessPhy
Set val (mac)	Mac/80211
Set val (ifq)	Queue/DropTail/PriQueue
Set val (ll)	LL
Set val (ant)	Antenna/ OmniAntenna
Set val (ifqlen)	100
Set val (nn)	50,90,130,170,210, 250
Set val (rp)	AODV, DSR, DYMO
Set val (rp)	DSDV, OLSR, ZRP
Set val (y)	1912.54
Set val (stop)	150

3.1 Selection of the Area for the Simulation

The area of the Loja city is divided by zones according to the municipal regulations, the Fig. 1. shows the total of urban area, the parishes and the zones which take part of the urban perimeter. For the present research was selected the zone 2, denominated Z02 according to the map of the Fig. 2.

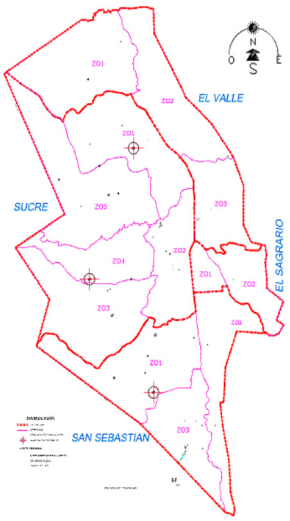

Figure 1: Map of the urban area selected for the simulation.

The selected zone has an area of 3657800.2365 and perimeter of 10446.5313 m. This zone was selected because it is placed in the downtown where is concentrated most of the population. For the purposes of the simulation, during the creation of the scenarios was considered this area within a square, of equal side to the square root of 3657800.2365 m2, with it was obtained a square of equal side of 1912.5376 m; this values will be used as parameter of x and y required by NS-2.34 to determine the study area.

As additional date the selected street names are the following: at north from the Turunuma avenue to brazil street at south, by the east from the Gran Colombia avenue to the Shushuguayco avenue in the west.

3.2 Model of Mobility

In this research was simulated a network with mobile nodes; for that reason, it is necessary to indicate a pattern of mobility which will follow the same, the election of the model of mobility will be essential because it will have a significance impact in the network features. There are some models of mobility and in this research will be used the random destination model Random Waypoint Model (RWP), due to the NS2 has directly implemented in its libraries. In general, it includes pauses between changes of address and/or speed, a mobile node begins in a place and period of time determined, that means a pause, when the time expired, the mobile node selects a random destination and speed uniformly distributed, after the mobile node travels into a new destination with the selected speed. When the mobile node arrives, it makes a pause in a specific period of time before beginning again. In the Table 2, is shown the configuration of the mobility parameters for the simulation.

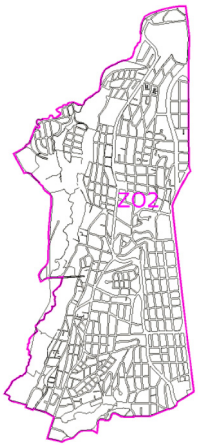

Figure 2: Selected zone for the simulation.

Table 2: Configuration of the mobility parameters.

Parameter	Value
Min. speed	0 m/s
Max. speed	10 m/s
Pause time	0 seg

3.3 Tools

Network Simulator Version 2 (NS2) - It is a simulator of discrete events available for Linux and Windows (it is not recommendable the Windows version). NS2 was initially created for fixed networks and after was incorporated to the wireless model by the Monarch group (Mobile Networking Architectures). This simulation tool is very powerful because it has two programing languages, C++ and otcl, which interact to obtain a best performance.
TraceGraph - It is a free tool to draw and specially to analyse the generated traces (*.tr) by the network simulator NS2 version 2.34

4 METRICS FOR THE ANALYSIS OF THE ROUTING PROTOCOLS

Retransmitted Packages - The Fig. 3 represents the amount of retransmitted packages during the simulation, for the following number of simulated nodes 50, 90, 130, 170, 210 and 250 nodes. It is possible to observe that the best performance of retransmitted packages is given by the AODV protocol. However, this metric is not enough to determine the effectiveness of a protocol in particular.

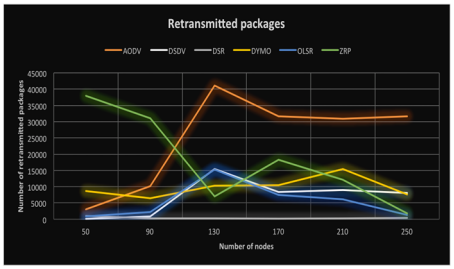

Figure 3: Retransmitted packages.

Discarded Packages - The Fig. 4, represents the amount of discarded nodes by every one of the protocols for the amount of generated nodes during the simulation. Up to 90 simulated nodes, all the analysed protocols generate standard maximum of discarded packages, but while it is increasing the number of simulated nodes, the number of discarded packages is increasing. The AODV and ZRP protocols are which produce mayor number of discarded packages during the simulation time.

Delay of Transmission Node to Node - The Fig. 5 represents the delay that there is in the transmission between the nodes of every one of the protocols. For smaller quantities or similar to 90 nodes, the delay of programing of all protocols the behaviour is similar. However, at increasing the number of nodes, programming time is increased. The reactive protocol DYMO is the best performance at increase of simulated nodes.

$$P_{Rec} = P_{Gen} - P_{Desc} + P_{Retrans} \quad (1)$$

Where: P_{Rec} *- Received packages,* P_{Gen} *- Genera-ted packages,* P_{Desc} *– Discarded packages y* $P_{Retrans}$ *– Retransmited packages.* The equation "(1)", is part of the analysis to determine the quality of service in the reception of valid packages during the transmission.

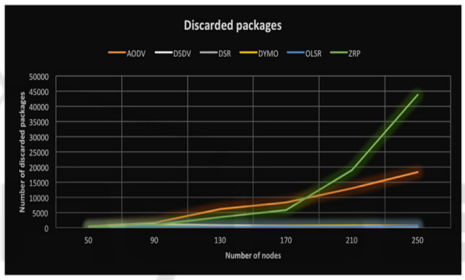

Figure 4: Discarded Packages.

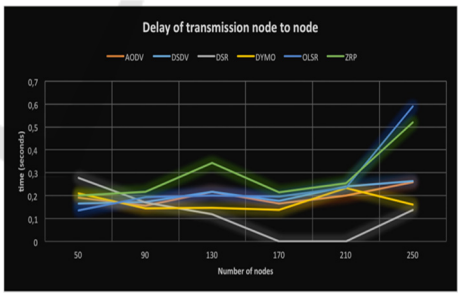

Figure 5: Delay of transmission Node to Node.

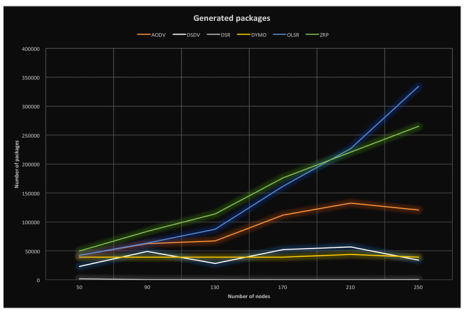

Figure 6: Generated packages.

Packages Generated by Protocol - The Figure 6., shows the number of packages that every one of the protocols has generated for the communication. The hybrid protocols as ZRP and Proactive as OLSR are the largest quantity of packages generated during the simulation time.

5 CONCLUSION

This research, it was applied in an urban scenario in case of emergency, where is required that a protocol will be able to transmit the highest quantity of nodes of the network in the less time possible; in consequence, the best protocol of routing of the Ad Hoc networks is DYMO because permit less quantity of retransmitted packages, less number of packages of retransmitted packages, less number of discarded packages, and the less time of transmission node to node.

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