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A Study and comparsion of various routing protocol in WiMAX network

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ABSTRACT
Mobile broadband services are growing rapidly as it provides freedom to the users to be online wherever they are at a competitive price and significant facilities such as increasing amounts of bandwidth, using mobile and roaming devices. The earliest version of WiMAX is based on IEEE 802.16 and is optimized for fixed and roaming access, which is further extended to support portability and mobility based on IEEE 802.16e, also known as Mobile WiMAX. This paper presented an analysis on those routing protocols designed for wireless networks. A comparison on the performance of seven routing protocol (AODV, DSR, OLSR, ZRP, TORA, GRP and DSDV) for Mobile WiMAX environment is done. The performance matrix includes Packet Delivery fraction (PDF), Throughput, End to End Delay, and number of packet dropped were identified. The study used NS2 simulator for the comparison on the performance analysis.

Introduction

Today's broadband Internet connections are restricted to wire line infrastructure using DSL, T1 or cable-modem based connection. However, these wire line infrastructures are considerably more expensive and time consuming to deploy than a wireless one. Moreover, in rural areas and developing countries, provide are unwilling to install the necessary equipment (optical fiber or copper-wire or other infrastructures) for broadband services expecting low profit. Broadband Wireless Access (BWA) has emerged as a promising solution for "last mile" access technology to provide high speed connections. IEEE 802.16 standard for BWA and its associated industry consortium, Worldwide Interoperability for Microwave Access (WiMAX) forum promise to offer high data rate over large areas to a large number of users where broadband is unavailable. This is the first industry wide standard that can be used for fixed wireless access with substantially higher bandwidth than most cellular networks. This paper presented an analysis of the performance for wireless routing protocols in Mobile WiMAX environment. A study and comparison on network performance of AODV, DSR, DSDV routing protocols are evaluated and presented. A simulation has been setup and assumed of each of the subscriber station maintain routing table for its own network is made. This setup is made due to make sure the traffic flow is sending the data directly to the destination without the help of base station. However, if one subscriber station has to send data to a station located in another network, it must send data through the base station and vice versa.

Wireless Routing Protocols

Three type of routing protocols has been analysed in this research as detailed.

Ad hoc On-demand Distance Vector Routing (AODV)

Ad-hoc On-demand distance vector (AODV) [2, 3] is another variant of classical distance vector routing algorithm, a confluence of both DSDV and DSR. It shares DSR's on-demand characteristics hence discovers routes whenever it is needed via a similar route discovery process. However, AODV adopts traditional routing tables; one entry per destination which is in contrast to DSR that maintains multiple route cache entries for each destination. The initial design of AODV is undertaken after the experience with DSDV routing algorithm.Like DSDV, AODV provides loop free routes while repairing link breakages but unlike DSDV, it doesn't require global periodic routing advertisements. AODV also has other significant features. Whenever a route is available from source to destination, it does not add any overhead to the packets. However, route discovery process is only initiated when routes are not used and/or they expired and consequently discarded. This strategy reduces the effects of stale routes as well as the need for route maintenance for unused routes. Another distinguishing feature of AODV is the ability to provide unicast, multicast and broadcast communication. AODV uses a broadcast route discovery algorithm and then the unicast route reply massage.

Dynamic Source Routing (DSR)

The Dynamic Source Routing (DSR) [4] is one of the purest examples of an on-demand routing protocol that is based on the concept of source routing. It is designed especially for use in multi hop ad hoc networks of mobile nodes. It allows the network to be completely self organizing and self-configuring and does not need any existing network infrastructure or administration. DSR uses no periodic routing messages like AODV, thereby reduces network bandwidth overhead, conserves battery power and avoids large routing updates. Instead DSR needs support from the MAC layer to identify link failure. DSR is composed of the two mechanisms of Route Discovery and Route Maintenance, which work together to allow nodes to discover and maintain source routes to arbitrary destinations in the network. DSR has a unique advantage by virtue of source routing. As the route is part of the packet itself, routing loops, either short – lived or long – lived, cannot be formed as they can be immediately detected and eliminated. This property opens up the protocol to a variety of useful optimizations. Neither AODV nor DSR guarantees shortest path. If the destination alone can respond to route requests and the

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source node is always the initiator of the route request, the initial route may the shortest.

Destination-Sequenced Distance Vector routing (DSDV)

Destination-Sequenced Distance-Vector Routing (DSDV) is a table-driven routing scheme for ad hoc mobile networks based on the Bellman-Ford algorithm. The improvement made to the Bellman-Ford algorithm includes freedom from loops in routing tables by using sequence numbers [2]. The DSDV protocol can be used in mobile ad hoc networking environments by assuming that each participating node acts as a router. Each node must maintain a table that consists of all the possible destinations. In this routing protocol has an entry of the table contains the address identifier of a destination, the shortest known distance metric to that destination measured in hop counts and the address identifier of the node that is the first hop on the shortest path to the destination. Each mobile node in the system maintains a routing table in which all the possible destinations and the number of hops to them in the network are recorded. A sequence number is also associated with each route or path to the destination. The route labeled with the highest sequence number is always used. This also helps in identifying the old routes from the new ones. This function would avoid the formation of loops. In order to minimize the traffic generated, there are two types of packets used that known as “full dump”, which is a packet that carries all the information about a change. The second type of packet called “incremental” is used which carried just the changes of the loops. The second type benefits that increased the overall efficiency of the system. DSDV requires a regular update of its routing tables, which uses up battery power and a small amount of bandwidth even when the network is idle. Whenever the topology of the network changes, a new sequence number needed before the network re-converges. Thus, DSDV is not suitable for highly dynamic networks.

Optimized Link State Routing (OLSR)

The Optimized Link State Routing (OLSR) protocol inherits the stability of the pure link state algorithm and is an optimization over the classical link state protocol, adopted for mobile ad hoc networks. It is proactive in nature and has the advantage of having routes immediately available when needed. The key concept used in this protocol is that of multipoint relays (MPRs). MPRs are selected set of nodes in its neighbor, which forward broadcast messages during the flooding process. OLSR reduces the size of control packet by declaring only a subset of links with its neighbors who are its multipoint relay selectors and only the multipoint relays of a node retransmit its broadcast messages. Hence, the protocol does not generate extra control traffic in response to link failures and additions.

Zone Routing Protocol (ZRP)

Zone Routing Protocol (ZRP) [20] is a hybrid protocol which combines the advantages of both proactive and reactive schemes. It was designed to mitigate the problems of those two schemes. Proactive routing protocol uses excess bandwidth to maintain routing information, while reactive protocols suffers from long route request delays and inefficiently flooding the entire network for route determination. ZRP addresses these problems by combining the best properties of both approaches. Each node in ZRP, proactively maintains routes to destinations within a local neighborhood, which is referred as a routing zone. However,size of a routing zone depends on a parameter known as zone radius.

TORA (temporally Ordered Routing Algorithm)

The Temporally-Ordered Routing Algorithm (TORA) is a distributed routing protocol for multihop networks with a unique approach for routing the packets to their destination. TORA is fully distributed, in that routers need only maintain information about adjacent routers (i.e. one hop knowledge) and there is no centralized control. This is essential for all Ad Hoc routing protocols. Like a distance-vector routing approach, TORA maintains state on a per-destination basis. However, it does not continuously execute shortest-path computation and thus the metric used to establish the routing structure does not represent a distance. The destination-oriented nature of the routing structure in TORA supports a mix of reactive and proactive routing on a per-destination basis. During reactive operation, sources initiate the establishment of routes to a given destination on demand. This mode of operation may be advantageous in dynamic networks with relatively sparse traffic patterns since it may not be necessary or desirable to maintain routes between every source destination pair at all times. At the same time, selected destinations can initiate proactive operation, resembling traditional table-driven routing approaches. This allows routes to be proactively maintained to destinations for which routing is consistently or frequently required (e.g., servers or gateways to hardwired infrastructure).

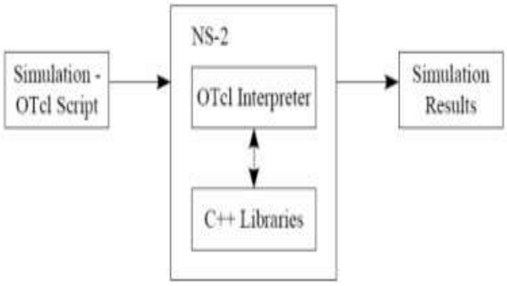
GRP (Geographical Routing Protocol)

Geographical routing (also called georouting or position-based routing) is a routing principle that relies on geographic position information. It is mainly proposed for wireless networks and based on the idea that the source sends a message to the geographic location of the destination instead of using the network address. It was designed to mitigate the problems of those two schemes. Proactive routing protocol uses excess bandwidth to maintain routing information, while reactive protocols suffers from long route request delays and inefficiently flooding the entire network for route determination. GRP addresses these problems by combining the best properties of both approaches. Each node in GRP, proactively maintains routes to destinations within a local neighborhood, which is referred as a routing zone. However, size of a routing zone depends on a parameter known as zone radius.

Computer network Simulator Tools

There are many simulators such as Network

Simulator 2 (NS-2), OPNET Modeler, GloMoSim, OMNeT++ and many others. This project has chosen a Network Simulation Tool (NS-2). NS (version 2) which is an object-oriented, discrete event driven network simulator developed at UC Berkeley written in C++ and OTcl. NS-2 is primarily useful for simulating local and wide area networks. Although NS is fairly easy to use but it is quite difficult for a first time user. Even though there is a lot of documentation written by the developers which has in depth explanation of the simulator, it is written with the depth of a skilled NS user. The purpose of this project is to give a new user some basic idea of how the simulator works, how to setup simulation networks, where to look for further information about network components in simulator codes, how to create new network components and many others useful tasks. Its through this research that new user could get started quickly using the simulator when they experience on it. NS-2 interprets the simulation scripts written in OTcl. A user has to set the different components such as the event scheduler objects, network components libraries and setup module libraries up in the simulation environment. This project has derived the OTcl script, plumbs the network components together to the complete simulation as shown in Figure below



Data flow of one time simulation

Detailed figure shows that the data flow of one time simulation in ns-2, the user input an OTcl source file, the OTcl script do the work of initiates an event scheduler, sets up the network topology using the network objects and the plumbing functions in the library, and tells traffic sources when to start and stop transmitting packets through the event scheduler. Then, this OTcl script file is passed to ns-2, in this view and treat ns-2 as Object-oriented Tcl (OTcl) script interpreter that has a simulation event scheduler, network component object libraries, and network setup module libraries. Detail network construction and traffic simulation is done in ns-2. After a simulation is finished, NS produced one or more text-based output files that contain detailed simulation data, and the data can be used for simulation analysis [5].

Network Scenario And Traffic Generating

A third party tools is used identify the nodes placement and then the network traffic is generated automatically. This method helps on demanded the scalable performance test for a specific network configuration. A file with the statements which set nodes positions and nodes movement using CMU generator is done. The reference directory is $NS2_HOME/indep-utils/cmu-scen-gen/setdest. An executable "setdest" program also s created to support this. This is a third party tools that has a CMU's version auxiliary scenario creation tool. A system dependent /dev/random and made calls to library functions initstate() for generating random numbers is derived. Some commands are implementer for executable usage for example as the command shown below.

./setdest -n 500 -p 2.0 -s 100.0 -t 200 -x 500 -y 500 > scene-500-2-100-500-500

This means, the topology boundary is 500m X 500m, the scenario has 500 nodes with nodes' max moving speed of 100.0m/s and the pause between movements is 2s, and simulation will stop in 200s, and output the generate tcl statements into file whose name is scene-500-2-100-500-500. A. Network traffic generating This project also generates network traffic such as the statements on sources, connections, and other. This task is done by running the command $NS2_HOME/indep-utils/cmu-scen-gen/cbrgen.tcl as a tcl file. Generated scenarios are modified within the tools. Random traffic connections of TCP and CBR are setup between nodes. It is used to create CBR and TCP traffics connections between wireless nodes. In order to create a traffic-connection file, the type of traffic connection (CBR or TCP), the number of nodes and maximum number of connections to be setup between them, a random seed and incase of CBR connections, a rate whose inverse value is used to compute the interval time between the CBR packets is set. So the command line generated is as shown below:

ns cbrgen.tcl [-type cbr/tcp] [-nn nodes] [-seed seed] [-mc connections] [-rate rate]

Here, "-type cbr/tcp" means define the type of traffic connection, "-nn nodes" means the number of nodes could be used, "-mc connections" means maximum number of connections to be setup between those nodes, "-seed seed" means a random seed, if it not equal to 0, the traffic pattern will reappear if all the other parameters are the same. "-rate rate" means a rate whose inverse value is used to compute the interval time, which easily to say is packets sending rate. For an example:

ns cbrgen.tcl -type cbr -nn 500 -seed 1.0 –mc 10 -rate 2.0 > cbr-20-test means create a CBR connection pattern between 500 nodes, having maximum of 10 connections, with a seed value of 1.0 and a rate of 2.0 pkts/second.

Performance Metrics

The project focuses on 4 performance metrics which are quantitatively measured. The performance metrics are important to measure the performance and activities that are running in NS-2 simulation as derived:

Packet delivery fractions (PDF)

PDF also known as the ratio of the data packets delivered to the destinations to those generated by the CBR sources. The PDF in figure 2 shows how successful a protocol performs delivering packets from source to destination. The higher for the value give use the better results. This metric characterizes both the completeness and correctness of the routing protocol also reliability of routing protocol by giving its effectiveness

$$P = \frac{1}{c} \sum_{f=1}^{e} \frac{R_f}{N_f}$$

Packet Delivery Fractions Expression

where P is the fraction of successfully delivered packets, C is the total number of flow or connections, f is the unique, flow id serving as index, Rf is the count of packets received from flow f and Nf is the count of packets transmitted to f.

Average end-to-end delay of data packets

There are possible delays caused by buffering during route discovery latency, queuing at the interface queue, retransmission delays at the MAC, and propagation and transfer times. The project use Average end-to-end delay as in figure 3 expression. Average end-to-end delay is an average end-to-end delay of data packets. It also caused by queuing for transmission at the node and buffering data for detouring. Once the time difference between every CBR packet sent and received was recorded, dividing the total time difference over the total number of CBR packets received gave the average end-to-end delay for the received packets. This metric describes the packet delivery time: the lower the end-to-end delay the better the application performance.

where N is the number of successfully received packets, i is unique packet identifier, r i is time at which a packet with unique id i is received, s i is time at which a packet with unique id i is sent and D is measured in ms. It should be less for high performance

Data Packet Loss (Packet Loss)

Mobility-related packet loss may occur at both the network layer and the MAC layer. In the project packet loss concentrate or network layer. The routing protocol forwards the packet if a valid route to the destination is known. Otherwise, the packet is buffered until a route is available. A packet is dropped in two cases: the buffer is full when the packet needs to be buffered and the time that the packet has been buffered exceeds the limit.

Throughput

Throughput is defined as; the ratio of the total data reaches a receiver from the sender. The time it takes by the receiver to receive the last message is called as throughput [6]. Throughput is expressed as bytes or bits per sec (byte/sec or bit/sec). Some factors affect the throughput as; if there are many topology changes in the network, unreliable communication between nodes, limited bandwidth available and limited energy [7]. A high throughput is absolute choice in every network. Throughput can be represented mathematically as in equation below.

$$Throughput = \frac{\text{Number of delivered packet} * \text{Packet size} * 8}{\text{total duration of simulation}}$$

Throughput Expression

$$D = \frac{1}{N}\sum_{i=1}^{N}(r_i - s_i)$$

Average End-to-End Delay Expression

Result

The performance analysis of various routing protocol is done by taking many different parameters in WiMAX enviourment. Such an analysis was done on four routing protocols viz.AODV, OLSR, DSR and ZRP were a network of 50 nodes (one source and one destination) that are placed randomly within a 1000m X1000m area and operating over 500 seconds with the assumption that each of the subscriber station has routing capabilities within its own network From the simulation, it was found that ZRP and AODV protocols outperform DSR and OLSR.

Similarly the performance analysis was done on different routing protocols like AODV, DSR, and DSDV for Mobile WiMAX environment. Successfully results found that AODV protocol outperform the DSR and DSDV. The performance matrix includes Packet Delivery fraction (PDF), Throughput, End to End Delay, and number of packet dropped were identified.

Another scenario were a performance comparison of five different ad hoc routing protocols (AODV, DSR, TORA, OLSR and GRP) is performed using different mobility scenarios. Simulation has been conducted in Mobile WiMAX environment. From the result , it can be said that, on an average GRP and DSR perform better than TORA and OLSR. In case of AODV, it has less routing overhead, but average end to end delay is higher. However in case of OLSR, it has higher routing overhead, but average end to end delay is less. For other metrics (packet delivery ration and throughput), AODV and OLSR demonstrate poor performance

Conclusion

This paper presented the realistic comparison of seven routing protocols AODV, DSR,OLSR, ZRP,TORA,GRP and DSDV The significant observation shows the simulation results agree with expected results based on theoretical analysis. As expected, reactive routing protocol AODV performance is the best considering its ability to maintain connection by periodic exchange of information. AODV performs predictably. Delivered virtually all packets at low node mobility, and failing to converge as node mobility increases. Meanwhile DSR was very good at all mobility rates and movement speeds and DSDV performs the worst, but still requires the transmission of many routing overhead packets. At higher rates of node mobility it's actually more expensive than DSR. For the future work, this area will investigate not only the comparison between AODV, DSDV and DSR routing protocols in WiMAX network but more on the vast areas. Security issue on routing protocol in WiMAX environment also can be studied for computer communications. Exploration on the measurement with other fields of the trace file could be done in the future. More analysis details on the things what we can get in the trace file such as jitter also could be analyzed in future works.

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