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"Quality Enhancement in Research Towards Global Competition"
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Electrical and Electronics Engineering:
"Frontiers in Electrical and Electronic Engineering: Toward a Deeper Knowledge"

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Prosidng QIR 2004 mempublikasikan makalah makalah yang dipresentasikan dalam Seminar Quality In Research yang dilaksanakan di Fakultas Teknik Universitas Indonesia. Seminar QIR ini dilaksanakan rutin setiap tahun pada awal semester ganjil dan merupakan wadah untuk penyebaran informasi dan publikasi hasil penelitian yang dilakukan oleh peneliti dan praktisi dari berbagai universitas dan instansi, pemerintah maupun swasta.

Seminar QIR 2004 ini merupakan kegiatan yang ketujuh dan bertemakan “Quality Enhancement in Research towards Global Competition.”

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FOREWORDS FROM  
Dean of Faculty of Engineering, University of Indonesia

The Conference on Quality in Research (QIR) is an annual event organized by the Faculty of Engineering - University of Indonesia, in the month of August every year. Since started in 1998, it has become an excellent forum of discussion for all researchers from research Institutions and Universities all over the country of Indonesia. In the past years, the 1st to the 6th Conference on QIR, had been successfully organized as a high quality national conferences, and starting from this year, the conference has been organized to invite presentations of research papers internationally.

The 7th Conference on Quality in Research having a theme of "Quality Enhancement in Research towards Global Competitions" is to provide an international forum for the exchange of the knowledge, research information, experience and results as well as the review of progress and discussion on the state-of-the-art and future trends in engineering for bettering human life. Through the active participation of all delegates in the fruitful discussions in this conference, it is hope that more closely collaborations amongst researchers and research institutions will be developed in the short coming future to achieved a better and higher quality in research nationally as well as internationally.

We would like to express our heartiest thanks to all the authors and participants for their active participations in the 7th International Conference on Quality in Research - QIR 2004, and also to all the paper-reviewers, member of the technical committees, and member of the organizing committees, for their support to the success of this conference. Last but not least, We would also like to invite all participants to the next Conference on Quality in Research -QIR 2005 in August 2005.

Faculty of Engineering  
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Rinaldy Dalimi Ph.D.
FOREWORDS

The 7th Conference on Quality in Research having a theme of “Quality Enhancement in Research toward Global Competitiveness” being the first time to go internationally, has invited limited papers from other countries like Japan, Malaysia, and Singapore. The conference is organized covering a large area of research in Engineering and Management, including Civil Engineering, Mechanical Engineering, Electrical Engineering, Metallurgy and Materials, Industrial Engineering, Project Management, Optoelectronics and Laser Applications. The conference is organized in parallel session focusing on the 6(six) research areas such that many researchers and peer groups may focus their discussions on the relevant topics. All submitted papers had been reviewed by the technical committees appointed and had been arranged into 6(six) sub-theme according to the following fields:

1. In Civil Engineering:
   “Environment Friendly infra-structure Development for Sustainable Future”
2. In Mechanical Engineering:
   “Recent Progress in Energy, Design and Manufacturing Engineering”
3. In Electrical Engineering:
   “Frontiers in Electrical and Electronic Engineering: Toward a Deeper Knowledge”
4. In Metallurgy and Material Engineering:
   “Quality Enhancement in Research on Materials Design and Processing Toward a Sustainable Materials Policy”
5. In Industrial Engineering:
   “Quality and Process Improvement”
6. In Opto-Electro-techniques and Laser Applications:
   “Opto-Electro-techniques and Laser Applications: Support the Future Technologies”

The main purpose of the conference is to provide an international forum for the exchange of the knowledge, research information, research experience and results as well as the review of progress and discussion on the state-of-the-art and future trends in computation methods, research experiments, development of theory, concept of thinking and applications as well as their tools applied to all engineering fields for bettering human life.

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On Simulating Ad Hoc Distance Vector Routing Protocol with NS-2

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Abstract - In this paper, we review the Mobile Ad-hoc network and mobile computing technology. Mobile Ad-Hoc Network is part of the third generation (3G) beyond service infrastructures. Most research on the connectivity or the hybrid network has been performed for small number of mobile nodes and traffic. In this research, we performed the performance evaluation of Ad Hoc on Demand Distance Vector Routing with gateway discovery service (AODV+) on a large network that has more 100 mobile nodes and the connection area is within 1000x800m. We evaluated the characteristics and behavior of AODV in that large network using the ns-2 network simulator with wireless network extension, taking into account the movement and communication patterns. We present and discuss the results of some important performance measures such as packet delivery ratio, routing overhead and end-to-end delay.

Keywords - Ad Hoc Network, AODV protocol, mobile computing, Ns-2 Simulator

1. Introduction

Current research for wireless and mobile devices focuses on MANET (Mobile Ad hoc NETwork). According to IETF and IEEE, approximately 80% of wireless network research on MANET research. The hottest issue in MANET now is the power consumption and the connectivity to Internet. Internet needs a connection system from MANET. In other words, a gateway between wireless and wired network is needed.

In ad hoc network all nodes are wireless and mobile. They behave as router and take a part in discovery and maintenance the routes[10]. MANET working group’s investigation describe that AODV [7] is one of the promising protocols which can be used in a mobile ad hoc network to route packet between mobile nodes. However, it cannot provide Internet access to mobile nodes due to the fact that it does not support routing between fixed network and mobile Ad Hoc network. In order to solution, Alex Hamidin in [1] has modified the source code of AODV in NS 2 and implements the gateway discovery system.

Now, most of the research for the connectivity or the hybrid network has been performed a small number of mobile node and traffic [1,2,6]. In this research, we performed the simulation with the large network, which has more 100 mobile nodes and connection area 1000x800m [9]. We then assessed the behavior of AODV in that large network based on the result presented in [1,2].

2. Ad hoc On Demand Distance Vector (AODV)

AODV shares DSR’s on-demand characteristics in which it also discovers routes on an as needed basis via a similar route discovery process. However, AODV adopts a very different mechanism to maintain routing information. It uses traditional routing tables, one entry per destination. This is in contrast to DSR, which can maintain multiple route cache entries for each destination. Without source routing, AODV relies on routing table entries to propagate a route reply (RREP) back to the source and, subsequently, to route data packets to the destination. AODV uses sequence numbers maintained at each destination to determine freshness of routing information and to prevent routing loops. All routing packets carry these sequence numbers.

An important feature of AODV is the maintenance of timer-based states in each node. The information is on the utilization of individual routing table entries. A routing table entry is expired if not used recently. A set of predecessor.
nodes is maintained for each routing table entry, indicating the set of neighboring nodes which use that entry to route data packets. These nodes are notified with RERR packets when the next-hop link breaks. Each predecessor node, in turn, forwards the RERR to its own set of predecessors, thus effectively erasing all routes using the broken link. In contrast to DSR, RERR packets in AODV are intended to inform all sources using a link when a failure occurs. Route error propagation in AODV can be visualized conceptually as a tree whose root is the node at the point of failure and all sources using the failed link as the leaves.

AODV is a reactive vector routing protocol. The reactive property of routing protocol implies that it only requests a route when it needs one and does not require that the mobile nodes maintain routes to destinations that are not communicating. AODV guarantees loop-free route by using sequence numbers that indicates how new, or fresh, a route is. AODV requires each node to maintain a routing table which contains one route entry for each destination that the node is communicating with. Each route entry keeps track of certain fields. Some of these fields are:

- Destination IP Address: The IP address of the destination for which a route is supplied
- Destination Sequence Number: The destination sequence number associated to the route
- Next Hop: Either the destination itself or an intermediate node designed to forward packets to destination
- Hop Count: The number of hops from the originator IP address to Destination IP address
- Lifetime: The time in milliseconds for which nodes receiving the RREP consider the route to be valid
- Routing Flags: The state of the route; up (valid), down (not valid) or in repair

3. Network Simulator 2 (NS2)

NS2 (in our research we used ns version 2.27) installed from http://www.isi.edu/nsnam/ns/. The installation process was quite lengthy and time-consuming. It involved downloading and setting up a 250 MB package. However, getting the simulator to work was the first step involved in carrying out the simulations. There is a very good tutorial on the web page to understand basic ns2 simulations can be found at http://www.isi.edu/nsnam/ns/tutorial/index.html. Another tutorial written by Jae Chung and Mark Claypool to give new NS users some sample and basic idea of how the simulator works, how to setup NS, where to look further information, etc. can be found at [11]. This tutorial makes new users to use NS and NAM easier.

The Network Simulator 2 (ns2) is an object oriented discrete event driven simulator which developed at UC Berkeley. It is part of the Virtual Internet Network Testbed (VINT) project. The goal of ns2 is to support networking research and education. It is suitable for designing new protocols, comparing different protocols and traffic evaluators. NS2 is developed to support collaborative environment to generate new Internet Protocol. It is distributed freely and open source.

3.1. Structure of ns2

Ns2 is written in C++ language, and with an interpreter, OTcl (Object Tool command language), as a command and configuration interface. In Figure 2, ns2 interprets the simulation script written in OTcl. The user writes the simulation as an OTcl script, plumbs the network component together to the complete simulation. If user needs new network components, user is free to implement them and to set them up in his simulation as well. The C++ objects are controlled by OTcl objects. It is possible to add methods and member variables to a C++ linked OTcl object. A linked class hierarchy in C++ has its corresponding class hierarchy in OTcl (as shown in Figure 3). Results obtained by ns2 (trace files, sector 4.3) have to be processed by other tools, e.g. the Network Animator (NAM), a perl or awk script and gnuplot [4].

3.2. Network Animator (NAM)

Network Animator (NAM) is an animator tool for viewing network simulation traces and real world packet traces. It supports topology layout, packet level animation and various data inspection tools. A trace file is needed to be created, before starting to use NAM. Trace file usually generated by NS.

3.3. Trace Files

There are two trace file formats, old and new [6]. The traces begin with a single character or abbreviation that
indicates the type of trace, followed by a fixed or variable trace format. The tables list differences between fixed and variable trace formats:

- For fixed trace formats, the table lists the event the triggers the trace under the Event heading and the characters that start the trace under the Abbreviation heading. The format is listed across the last two columns, and the type and value for each element of the format are listed beneath the Type and Value headings. Some events have multiple trace formats.
- For variable trace formats, the table lists the event which triggers the trace under the Event heading and the characters that start the trace under the Abbreviation heading. The last three columns list the possible flags, types, and values for the event under the Flag, Type, and Value headings.

### 3.3.1. Old Wireless Trace File Format

This information comes from The ns Manual "Mobile Networking in ns: Trace Support", and the "trace/emu-trace.cc" file. Wireless traces begin with one of four characters followed by one of two different trace formats, depending on whether the trace logs the X and Y coordinates of the mobile node. The old wireless trace format can be found at Table 1.

<table>
<thead>
<tr>
<th>Event</th>
<th>Abbreviation</th>
<th>Flag</th>
<th>Type</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>x:Send</td>
<td>r:Receive</td>
<td>d:Deep</td>
<td>F:Forward</td>
<td></td>
</tr>
<tr>
<td>Double</td>
<td>Int.</td>
<td>Node ID</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Double</td>
<td>X Coordinate</td>
<td>(if Legging Position)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Double</td>
<td>Y Coordinate</td>
<td>(if Legging Position)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>String</td>
<td>Tracer ID</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>String</td>
<td>Reason</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Int.</td>
<td>Event Identifier</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>String</td>
<td>Packet Type</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Int.</td>
<td>Packet Size</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hexadecimal</td>
<td>Time To Send Data</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hexadecimal</td>
<td>Destination MAC Address</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hexadecimal</td>
<td>Source MAC Address</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hexadecimal</td>
<td>Type (ARP, IP)</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Note that the value for the -hd flag may be -1 or 2. -1 means that the packet is a broadcast packet, and -2 means that the destination node has not been set. -2 is typically seen for packets that are passed between the agent (-ni AGT) and routing (-ni KRT) levels.

### 3.3.2. New Wireless Trace File Format

Similar to the old format, in the new format of wireless traces (see Table 2), a file begins with one of four characters. This is followed by a flag/value pairs similar to NAM traces. The first letter of flags with two letters designates the flag type:

- **N**: Node Property

### Table 2. New Wireless Trace File Format

<table>
<thead>
<tr>
<th>Event</th>
<th>Abbreviation</th>
<th>Flag</th>
<th>Type</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>x:Send</td>
<td>r:Receive</td>
<td>d:Deep</td>
<td>F:Forward</td>
<td></td>
</tr>
<tr>
<td>Double</td>
<td>Int.</td>
<td>Node ID</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Double</td>
<td>Node X Coordinate</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Double</td>
<td>Node Y Coordinate</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Double</td>
<td>Node Z Coordinate</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Double</td>
<td>Node Energy Level</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>String</td>
<td>Network trace level (ATM, IP, MAC, etc.)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>String</td>
<td>Deep Reason</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Int.</td>
<td>Hop source node ID</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Int.</td>
<td>Hop destination node ID</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hexadecimal</td>
<td>Destination</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hexadecimal</td>
<td>Source Ethernet Address</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hexadecimal</td>
<td>Destination Ethernet Address</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hexadecimal</td>
<td>Ethernet Type</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>String</td>
<td>Packet Type (arp, enr, impr, etc.)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>String</td>
<td>Packet Type (ewr, eup)</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Note that the value for the -hd flag may be -1 or 2. -1 means that the packet is a broadcast packet, and -2 means that the destination node has not been set. -2 is typically seen for packets that are passed between the agent (-ni AGT) and routing (-ni KRT) levels.

### 3.4. Generating traffic and mobility models

#### 3.4.1. Traffic models

Random traffic connections of TCP and CBR can be set between mobile nodes using a traffic-scenario generator script. This traffic generator script is available under `ns/indep-utils/emu-scen-gen` and is called cbrgen. It can be used to create CBR and TCP traffic connections between wireless mobile nodes. So, the command line looks like the following:

```
ns cbrgen [-type cbr | top] [-m nodes] [-seed seed] [-m connections] [-rate rate]
```

#### 3.4.2. Mobility models

The node-movement generator is available under `ns/indep-utils/emu-scen-gen/setdist` directory and consists
4. Simulation Scenario

We implemented scenario which consist of 100 nodes, 2 gateways, 2 routers and 2 hosts. The topology area with 1000 meter and 800 meters width. A rectangular area was chosen in order to force the use of longer routes between nodes than would occur in a square area with uniform node speed. The gateways are placed on each side with x,y coordinates in (200,300) and (300,300) in Meters. All simulation are run in 900 seconds.

The source of mobile nodes is varied with 4 and 7 nodes with constant bit rate traffic. They distributed randomly in the network. The time when the source start sending packet was distributed uniformly within the first ten second of the simulation. After this time the sources continue sending packet of data until one second before the end of the simulation. The destination of each of the sources was varied between wired host and wireless host.

A screen shot of simulation scenario is shown in Figure 5, with 100 nodes of mobile uniformly distributed random. In this figure packet is sent randomly distributed node.

4.1. Movement

The mobile nodes movement is defined by the random waypoint models [8]. The movement scenario is files generated by the seedest program by CMU’s movement generator. The chosen value for pause time and minimum - maximum speed are shown in Table 3.

The simulation runs for 900 seconds of simulated time with movement pattern for 4 different pause times: 10, 50, 100, and 900 seconds. A pause time has 900 seconds correspondents to a static movement in which no motion happens the nodes at all. Because of the performance of the routing protocols is very dependent on the movements of the nodes [2], different movement pattern for each pause times are generated. The seedest program that we used was version 2, that can generate Vnum and Vmin for each movement pattern.

4.2. Communication Pattern

The simulation in the traffic sources are constant bit rate (CBR) sources. 4 and 7 mobile nodes were communicating with 2 wired hosts and the rest are wireless hosts. Each source mobile node generates packets every 0.2 seconds in this study or 5 packets in one second.

The traffic connection pattern is generated by CMU’s traffic generator (chrgen.tcl). All communications are peer-to-peer in these pattern. The main parameters in chrgen.tcl are “connection” (number of sources) and rate (packet rate), see Table 3.

4.3. Parameters

The parameters that we would use in the simulation are given in Table 3. The transmission range is the maximum possible distance between two communication mobile nodes. If the distance between two mobile nodes is larger than 250 m then they cannot communicate directly with each other [1].

5. Conclusion

There exist some stumbling blocks along the path to valid result of simulation of ns2. First, the compilation of the simulator itself is more difficult then expected. We had difficulties in implementing AODV+ [1] to work in ns 2.27.

By searching the mailing list and discussion we found that some changes must be done for AODV+ to work in ns 2.27. The changes are in AODV.cc and AODV.h files for AODV+, to make it work in ns 2.27 in Linux Red Hat. The most important things was parsing the trace file for both wireless

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to wireless and wireless-to-wired. We found that there are big differences between wireless-to-wired and wireless-to-wireless trace files, especially in received packet in wired network.

The results of the AODV+ simulation are similar to the result in [2]. In [2] report, they compared the AODV DSR with DSDD protocol, especially when they work in Hybrid Network. In this work, we will compare the AODV protocol proposed in [1] with implementation of gateway discovery method, to work under hybrid network. Certain differences exist in the result.

5.1 Packet Delivery Ratio

From Figure 6 shows that the packet delivery ratio with pause time intervals between 0 to 900 s. We measure these graphic with packet delivery.pl runs in perl and plotted it with gnuplot. Packet delivery ratio measured by the percentages of differences between the number of sending packets sent by constant bit rate sources, and the number of receiving packets by the CBR sink at destination. The receiving packet was calculate from the new trace file in ns2.27. The new trace file looks like the following trace:

Here, we see that a packet was sent (s) at time (t) 0.267652078 sec, from source node (Hs) 0 to destination node (Hd) 1. The source node id (Ns) is 0, it's x-co-ordinate (Nx) is 5.00, it's y-co-ordinate (Ny) is 2.00, it's z-co-ordinate (Nz) is 0.00, it's energy level (Ne) is 1.000000, the trace level (Nt) is RTR and the node event (Nw) is blank. The MAC level information is given by duration (Ma) 0, destination Ethernet address (Md) 0, the source Ethernet address (Ms) is 0 and Ethernet type (Mt) is 0. The IP packet level information like packet id (Ip), source address source port number is given by (Is) while the destination address destination port number is (Id).

For the packet delivery we take two models, that is from wireless to wireless and from wireless-to-wired. We take to models because there are some difference format for forwarding and receiving format between those two models.

5.2 Routing Over Head

Routing overhead is shown in Figure 7. We compared the routing overhead in [2] for other protocol. We measure this routing from forwarding packet in RTR trace level. We got that number of routing is larger than in reference [2]. This caused by the large network size and gateway discovery method. We noticed that routing will be updated if they were packet sent. Gateway discovery method would send frequent update of routing path.

Both on Routing Over Head we noticed that curve increased and suddenly breakdown where the pause time approximately at 60 second.

5.3 Average End to End Delay

Figure 8 shows the average end-to-end delay with pause time. We noticed that end-to-end delay is stable in the matter of pause time. However, the reference [1,2], end-to-end delay in AODV+ is bigger than proactive or hybrid protocol. We
6. Further work

In the research limited by time, we know that there still further work that have to be done to get more analysis result. In our research we have built a foundation to implement MANET in a large network especially AODV+ for Internet Connection (wireless-to-wired / hybrid connection). Further investigation can performed to solve the following problems:
- Explanation of the Sudden Break both in pure AODV [2] and AODV+
- Verification of the implementation with other routing protocol with this scenario
- Verification of ns trace level especially in Hybrid network wired-to-wireless.

- Power consumption of the system with the energy models
- Test with IPv6 system especially in integration with the protocol

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REFERENCES