Comparison and Performance Analysis of AntNet and Distance Vector Routing Protocol in Telecommunication Networks

Case Study : XYZ Company

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Abstract—**In this paper, we learn and adapt ant colony algorithm to know about the quality of services of routing protocol in broadband backbone infrastructure of XYZ Company. The objective of this research is XYZ Company need a basic research reference to realize broadband services such as Internet Protocol Television (IPTV) and digital television with the existing network infrastructure. In other words, company should not buy and build a new infrastructure to apply a new service. In that way the budget to buy new expensive devices could be allocated to another aspect. We perform our work by using simulation NS-2. In our method, we assume that all nodes are a router. We show through our deep experiments based on real network topology and also we compare AntNet routing protocol with distance vector routing protocol to learn their behavior and performance. The simulation result shows that AntNet routing protocol is better than distance vector in term of packet delivery ratio for larger packet size. However, in term of routing overhead and delay, AntNet produces higher header packet than distance vector routing protocol.**

Keywords—AntNet; Distance Vector; Routing Protocol; Performance;

I. INTRODUCTION

Since announced officially the digital television in a few years ago, it should brought big steps forward for television broadcaster, especially Internet Service Providers (ISPs) to give a better public services. This technology utilizes existing telephone wiring network that has been installed at consumer's house. Thus, operators no longer need to create a new network infrastructure. One cable could be used for various transmission services i.e packet data transmission (e-mail, internet, etc), voice and video. To access all those services, we only need one infrastructure and no longer subscribed to cable or satellite TV since houses have been connected into an infrastructure service. In addition, offering a service such as IPTV to broadband access subscribers is a key challenge as well as prospective revenue for ISPs.

There are two main problems that ISPs will found while we apply this technology. First problem is the cost to access the services and second problem is the Quality of Services (QOS) of IPTV services. Currently, the prices should be paid by a consumer to enjoy IPTV services is still quite expensive. It means only rich people who could access all features of IPTV. This is due to the large investment costs taken by providers to upgrade their infrastructure and devices. As compensation they would charge for every service to user subscriber. In addition to second problem, IPTV application needs high speed communication, high quality and minimum packet lost during broadcasting packet data to obtain good services.

XYZ Company is one of ISP that provide broadband backbone infrastructure. At this moment all routers use distance vector routing protocol. As we know that increasing demand for connection is proportional to increasing bandwidth requirement. Network connectivity becomes a major issue as users or clients want to access to network. Gateways such as bridges and routers could help solve this problem. Some optimized methods have already proposed, such as signal compressions, multiplexing algorithms, and routing protocols.

In this paper, we propose an alternative solution to address those problems. With an existing infrastructure, we could optimize protocol communications by porting ant colony algorithm to support IPTV services. The basic idea in this research is how we can optimize the existing infrastructure network with low cost. Currently, routing protocol algorithm that widely used in existing infrastructure is distance vector algorithm. Distance vector algorithm uses a distance calculation plus a vector to choose the best path to a destination. The network protocol will forward data using the best paths selected. Distance vector is a term to describe a routing protocol which is used by routers to forward packet data. Distance is the cost of reaching a destination, usually based on the number of nodes or hops the path passes through. Vector is the interface traffic that will be forwarded out in order to reach destination along the best path selected.

We proposed to use optimize algorithm inspired from nature, because nature gives many ideas for us, one of them is ant. Ant Colony Optimization (ACO) called ant system which inspired by studies of the behavior of ants. Ant colony algorithm is an algorithm using a probabilistic technique for solving computational problem that can reduce to finding good paths or routes through graphs. What can we learn from ant colony to address the problem, especially in data transmission for IPTV services from source (provider) to destinations (costumers). Ant colony algorithm is one of algorithm that implemented in routing protocol to achieve an optimal performance.

The research method we used in this work is simulation using network simulation. This simulation is used to describe a method for evaluation of scientific work. The steps to performing simulation are defining experimental objectives, define simulation models and environment, define performance metrics, simulation phase, post simulation process, result analysis, data interpretation and presentation of results.

The rest of the paper is organized as follows. Section II reviews related work. Section III presents our simulation environment. We present simulation results and analysis in Section IV and conclude the paper in Section V.

II. Related Work

Dhilon et.al [3] has compared the performance of AntNet, an ant-routing algorithm, with Dijkstra's shortest path algorithm. The result shows that the performance of AntNet is comparable to Dijkstra's shortest path algorithm. Moreover, under varying traffic loads, AntNet adapts to the changing traffic and outperform shortest path routing.

Baran et.al [4] analyzed AntNet algorithm and proposed an improvement, then comparing their performance with respect to the original AntNet and other commercial algorithms like Routing Information Protocol (RIP) and Open Shortest Path First (OSPF). Simulation results indicate a better throughput (number of packets successfully routed per unit time) for the improved proposals. As for packet delay, the improved proposals bettered the original AntNet, although RIP and OSPF were unbeatable in this measure of performance. Due to the increase in the number of users in networks like the Internet, it may be expected that network service administrators will prioritize throughput to maximize services to a growing number of users. So, AntNet and its variant here proposed are promising options for routing in large public networks such as the Internet.

A. *AntNet*

AntNet is is a proactive routing algorithm proposed for wired datagram network based on the principle of ant colony optimization (ACO) [8]. ACO features a multi-agent organization, stigmergic communication among the agents, distributed operations, use of a stochastic decision policy to construct solutions, stigmergic learning of the parameters of the decision policy. It has been applied with success to a large variety of combinatorial problems. AntNet has been the first ACO algorithm for routing in packet-switched networks. AntNet, as well as most of the other ACO routing algorithms designed after AntNet, displays a number of interesting properties: it works in a fully distributed way, is highly adaptive to network and traffic changes, uses lightweight mobile agents (called ants) for active path sampling, is robust to agent failures, provides multipath routing, and automatically takes care of data load spreading.

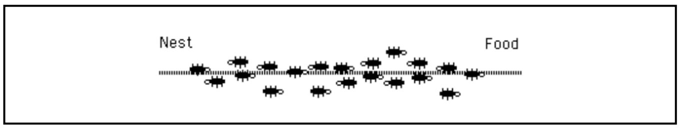

Figure 1. Ants trail from nest to food [10]

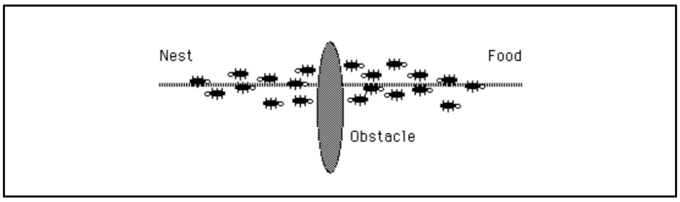

Figure 2. Ants facing an obstacle [10]

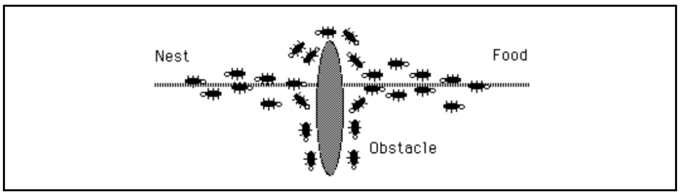

Figure 3. Ants try to found alternative routes [10]

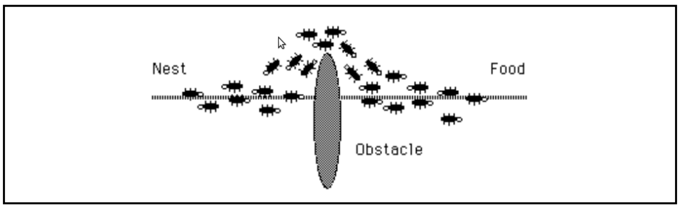

Figure 4. Ants go through the shortest route [10].

Figure 1, 2, 3, and 4 show a scenario with a route from the nest (source) to the food place (destination) in which all ants follow the pheromone pathway. Quickly, an obstacle gets in their way so the first ants randomly select the next branch between the two branches: the upper and lower branches. Since the upper route is shorter than the lower one, the ants which take this shorter path will reach the food place first. On their way back to the nest, the ants again have to select a path. After a short time the pheromone concentration on the shorter path will be higher than on the longer path, because the ants using the shorter path will increase the pheromone concentration faster. The shortest path will thus be identified and eventually all ants will only use this one. This behavior of the ants can be used to find the shortest path in networks [10].

In AntNet each node maintains its routing table and has an additional task of maintaining the node movement statistics based on the traffic distribution over the network. The routing table contains the destination node, next hop node and a measure of the goodness of using the next hop to forward data packet to the destination. The goodness measure is based on Pheromone values that are normalized to one. Ant net uses two sets of homogeneous mobile agents called forward ants and backward ants to update the routing tables. These mobile agents are small and light packets containing source IP address, destination IP address, packet ID and a dynamically growing stack consisting of Node ID and Node Traversal Time. A node which receives a forward ant for the first time creates a record in its routing table [9].

An entry in the routing table is having triple values. They are destination address, next hop and pheromone value. During the route finding process ants deposit pheromone on the edges.

AntNet's performance has been widely proven in simulation, considering divergent networks and traffic patterns, and compared to certain state-of-the-art routing algorithms. In the enormous majority of the considered situations, AntNet has extensively outperformed all its competitors, showing excellent adaptively and robustness.

B. *Distance Vector*

Distance vector protocol is also known as Distributed Bellman-Ford or Routing Information Protocol (RIP). Every node maintains a routing table and it contains all available destinations details, the next node to reach to destination, the number of hops to reach the destination. To maintain topology in a network nodes periodically send table to all neighbors. By using the distance vector protocols, each router over the internetwork send the neighboring routers, the information about destination that it knows how to reach. Moreover to say the routers sends two pieces of information first, the router tells, how far it thinks the destination is and secondly, it tells in what direction (vector) to use to get to the destination. When the router receives the information from the others, it could then develop a table of destination addresses, distances and associated neighboring routers, and from this table then select the shortest route to the destination. Using a distance vector protocol, the router simply forwards the packet to the neighboring host (or destination) with the available shortest path in the routing table and assumes that the receiving router will know how to forward the packet beyond that point. The best example for this is the routing information protocol (RIP)[11].

To maintain the routing tables, each node periodically transmits a routing update to each of its neighbor routers, containing the information from its own routing table. Each node uses this information advertised by its neighbors to update its own table, so that its route for each destination uses as a next hop the neighbor that advertised the smallest metric in its update for that destination; the node sets the metric in its table entry for that destination to 1 (hop) more than the metric in that neighbor's update. A common optimization to this basic procedure to spread changed routing information through the network more quickly is the use of triggered updates, in which a node transmits a new update about some destination as soon as the metric in its table entry for that destination changes, rather than waiting for its next scheduled periodic update to be sent. Distance vector routing protocols are simple, but they cannot guarantee not to produce routing loops between different nodes for some destination. There are a number of advantages to the distance vector approach, the primary being that it is a relatively simple approach. In the computer world, simple things are usually easy to implement, and they place fairly low demands on the system's processing power. This tends to be true of distance vector routing protocols. Distance vector routing protocols tend to suffer from a number of significant shortcomings. The disadvantages tend to magnify significantly as the internetwork grows. First, routing tables in a large internetwork can be correspondingly large, and they can consume significant bandwidth in the exchange process. Given that most distance vector routing protocols generate periodic updates at intervals of 10 to 90 seconds, this can result in the routing protocol consuming a significant amount of bandwidth [12].

In large internetworks, distance vector routing protocols may take some time to converge because changes in the network topology take time to propagate across the entire internetwork. Each router has to receive an update and recalculate its routing table before it can generate an update to its neighbors. Although most distance vector routing protocols support event-driven updates, most also impose the concept of hold downs to avoid transient loops. The result is that loss of routes (bad news) travels fast, but alternative routes (good news) take longer to follow.

III. SIMULATION

A. *Scenarios and Parameters*

This section provides an overview of our simulation and scenario. Simulation has been conducted using NS-2 version 2.34. Table I illustrates our simulation parameters. In this simulation, we run simulation for 500 seconds. As we mention before, we used AntNet and distance vector routing protocol to compare. We choose data type constant bit rate (cbr) with vary packet size. And in addition, we vary the scenario simulation with 3 different scenarios i.e.: scenario I is no link broken, scenario II is only 1 link drop and up again at particular time, and scenario III is 1 link broken. The aim of these scenarios is to achieve data from network simulation close to real-world.

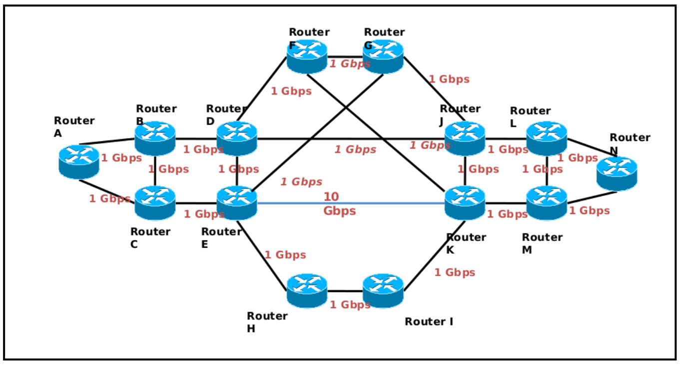

Figure 5. Network Topology

Figure 5 depicts the network topology from the ISP's company and we applied in the simulation scenario. We have bandwidth connection between all routers is 1 Gbps and only from router E to router K has 10 Gbps respectively.

The scenario we designed with adjustable bandwidth and packet size of data. We will observe the performance of AntNet and distance vector routing protocol with this network topology. Router A establishes communication to router N. We run this simulation with 69 experiments.

TABLE I. SIMULATION PARAMETERS

Parameter	***Value***
Simulation time	500 s
Routing Protocol	AntNet, DV
Data type	cbr
Packet size	256 B – 1792 KB
Bandwidth	128-1024 Mbps

B. *Performance Parameter*

- Throughput is comparison between successfully received packets and the simulation time.

$$T = \frac{\sum Numbers\ of\ bit\ successfully}{\sum time\ duration} \quad \dots (1)$$

Users of telecommunication networks, systems designers, and researchers are often interested in knowing the expected performance of a system.

Packet Delivery Ratio (PDR) is the ratio of the number of delivered data packet to the destination. PDR reflects the network processing ability and data transferring ability, and as the main symbols of reliability, integrity, effectiveness and correctness of the protocol. The formula to calculate packet delivery ratio shows as follows:

$$PDR = \frac{\sum Numbersofpacketreceive}{\sum Numbersofpacketsend} * 100\ \% \quad \dots (2)$$

The greater value of packet delivery ratio means the better performance of the protocol.

- Delay is the average time taken by a data packet to arrive in the destination. It also includes the delay caused by route discovery process and the queue in data packet transmission. Only the data packets that successfully delivered to destinations that counted.

$$Delay = \frac{\sum(arrivetime - sendtime)}{\sum Numberoflinkorconnection} \quad \dots (3)$$

The lower value of end to end delay means the better performance of the protocol.

- Routing overhead is equals to the ratio between the number of routing control packets transferred during the whole simulation process and the number of data packets. It is refer to how many routing control packets are needed for one data packet transmission. It is an important index that compares the performance among different routing protocols; moreover it can evaluate the scalability of routing protocol and the network performance under lower bandwidth availability.

$$Routingoverhead = \frac{\sum routingpacket}{\sum packetreceived} \quad \dots (4)$$

IV. RESULT AND ANALYSIS

In this section, we present several key performance metrics of AntNet and distance vector routing over telecommunication networks. We simulate our work on the dedicated links as seen in Figure 1.

A. *Throughput*

Figure 6 shows the throughput performance. As we can see that the increase of throughput is proportional to packet size. The highest throughput is achieved by distance vector routing protocol, 270226.49 Kbps. Followed by AntNet in the second highest throughput, 259222.4 Kbps, while there is no broken link at network. The different throughput performance between AntNet and distance vector is quite significant. For example when see the throughput performance at no link drop scenario, AntNet can achieve throughput up to 259214.89 Kbps, and distance vector can reach until 257973.83 Kbps. It means the difference only 1241.06 Kbps.

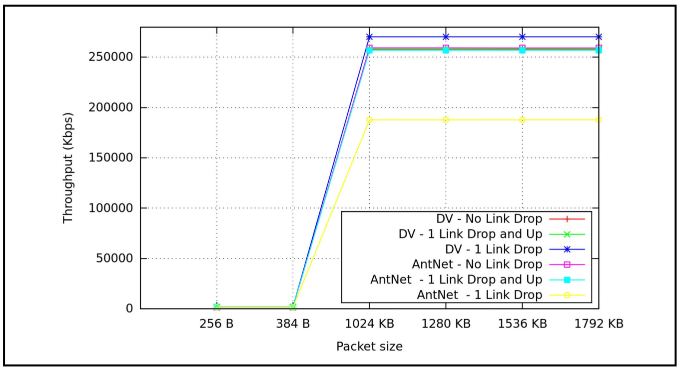

Figure 6. Throughput vs Packet size

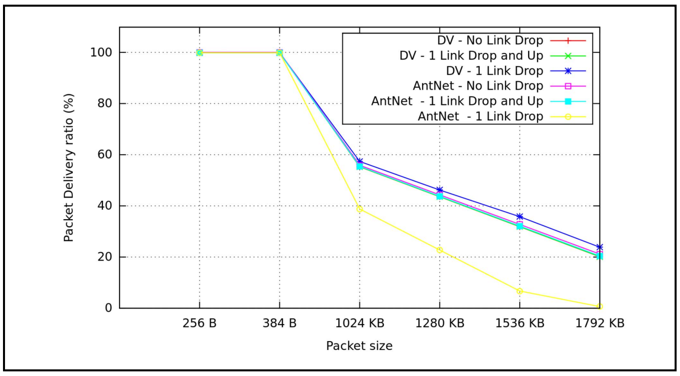

Figure 7. Packet delivery ratio vs Packet size

B. *Packet delivery ratio*

As seen at Figure 7, packet delivery ratio for both routing protocols is decline, especially while packet size request at 1024 KB. In addition, the ability to transfer packet data from source to destination with different available bandwidth become decrease while suffer of available bandwidth. Simulation shows that more than 99% packet data can be successfully transferred and received at destination when the packet size is 256 bytes and 384 bytes in all scenarios. Nevertheless, since packet size greatly increase to 1024 KB, the performance of both routing protocol decrease. In this situation, network start losing and dropping packet. The highest ratio packet loss occurred is 57.41056 % respectively, when we used distance vector as routing protocol under scenario III. And the lowest ratio is 0.6608% performed by AntNet routing protocol under scenario II.

C. Delay

Figure 8 shows the average delay under all scenarios, no broken link, 1 link drop and up again, 1 broken link. Here, the delay measures the interval from the time when a packet data arrives to the destination from source node to the time when the packet reaches the intended node. We further show the average delay of packet size 256 Bytes and 384 Bytes. As can be seen, more than 578.196 ms of delay for distance vector and 878.755 ms of delay for AntNet for scenario I (no broken link condition). However, the delays for AntNet decrease while the condition of topology is under scenario III (1 broken link) exist and also the delay reaches more than 614.303 ms and 607.783 ms respectively. In condition while the packet size less than 384 bytes and bandwidth 1024 Kbps, distance vector outperform AntNet in any scenario. However, in other condition, when the packet size is very high increase more than 1024 KB, the delay performance is getting better for both routing protocol, AntNet and distance vector.

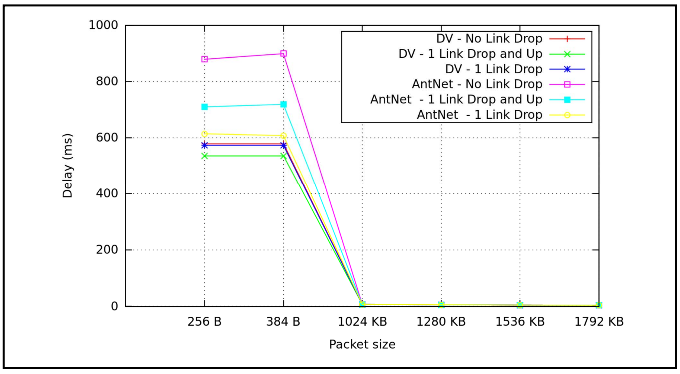

Figure 8. Delay vs Packet size

V. CONCLUSION

In this paper, we studied the performance of AntNet and distance vector routing protocol over telecommunication networks. We make some scenarios to investigate the system capacity. Additionally, we also perform our simulation using constant bit rate (cbr) data type with various packet size, from 266 Bytes until 1024 Kilo Bytes (1 Giga Byte). The bandwidths we used are also varied from 128 Mbps until 1024 Mbps. We use these parameters to achieve result closely do the real world application in network infrastructure. From the result, we can say that AntNet is better than distance vector algorithm in term of throughput, and packet delay for larger packet size. However, in term of routing protocol, AntNet routing protocol is bigger than distance vector routing protocol. For all experiments, the performance of AntNet and distance vector has been excellent. AntNet has always provided comparable performance than distance vector. The overall result can be seen as statistically significant. Concerning scalability and future impact to the network, we can define that increasing packet size is proportional to reducing performance of network. Antnet routing protocol showed better performance. In addition, regarding AntNet and distance vector, to which the majority of results refer to, in order to provide understanding to our study, we have to consider some different traffic patterns and level of workload for some different types of networks. In future, we will consider works as follows; security and scalability aspects in telecommunication networks, change the priority of ants as the propagate through the system, deeper study of negative reinforcement of connection, and to add flow error control.

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