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Enhancing the Efficient Packet Routing in Wireless Mesh Networks using ANT-MESH

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ABSTRACT*:* In wireless mesh network the nodes are dynamically self-organized and self-configured networks create a changing topology and keep a mesh connectivity to offer Internet access to the users. The shortest path problem is one of the most fundamental problems in networking. This problem can be solved by many techniques and algorithm. In this paper we find the shortest path by using the fittest nodes in the network. By using the fittest node we can send the packets to the destination without packet loss, delay in packets. Routing in wireless mesh networks (WMNs) has been an active area of research for the last several years. In this paper, we address the problem of packet routing for efficient data forwarding in wireless mesh networks (WMNs) with the help of smart ants acting as intelligent agents. The aim of this paper is to study the use of such biologically inspired agents to effectively route the packets in WMNs. In particular, we propose AntMesh, a distributed interference-aware data forwarding algorithm which enables the use of smart ants to probabilistically and concurrently perform the routing and data forwarding in order to stochastically solve a dynamic network routing problem. AntMesh belongs to the class of routing algorithms inspired by the behaviour of real ants which are known to find a shortest path between their nest and a food source. In addition, AntMesh has the capability to effectively utilize the space/channel diversity typically common in multi radio WMNs and to discover high throughput paths with less interflow and intra-flow interference while conventional wireless network routing protocols fail to do so. We implement our smart ant-based routing algorithm in ns-2 and carry out extensive evaluation. We demonstrate the stability of AntMesh in terms of how quickly it adapts itself to the changing dynamics or load on the network. We tune the parameters of AntMesh algorithm to study the effect on its performance in terms of the routing load and end-to-end delay and have tested its performance under various network scenarios particularly fixed nodes mesh networks and also on mobile WMN scenarios. The results obtained show AntMesh's advantages that make it a valuable candidate to operate in mesh networks

KEYWORDS*:* Wireless mesh networks, shortest path, packet loss, delay in packets, average end to end delay, link interference, ant colony optimization, routing, meta-heuristic ANT-MESH

I. INTRODUCTION

A wireless mesh network (WMN) is a mesh network created through the connection of wireless access points installed at each network user's locale. Each network user is also a provider, forwarding data to the next node

The networking infrastructure is decentralized and simplified because each node need only transmit as far as the next node. Wireless mesh networking could allow people living in remote areas and small businesses operating in rural neighborhoods to connect their networks together for affordable Internet connections.In a full mesh topology, every node communicates with every other node, not just back and forth to a central router. In another variation, called a partial mesh network, nodes communicate with all nearby nodes, but not distant nodes. All communications are between the clients and the access point servers. The client/server relationship is the basis for this technology [9].

A wireless mesh network (WMN) is a communications network made up of radio nodes organized in a mesh topology. Wireless mesh networks often consist of mesh clients, mesh routers and gateways. The mesh clients are often laptops, cell phones and other wireless devices while the mesh routers forward traffic to and from the gateways which may, but

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need not, connect to the Internet. The coverage area of the radio nodes working as a single network is sometimes called a mesh cloud. Access to this mesh cloud is dependent on the radio nodes working in harmony with each other to create a radio network. A mesh network is reliable and offers redundancy. When one node can no longer operate, the rest of the nodes can still communicate with each other, directly or through one or more intermediate nodes. Wireless mesh networks can self form and self heal. Wireless mesh networks can be implemented with various wireless technology including 802.11, 802.15, 802.16, cellular technologies or combinations of more than one type.

The principle is similar to the way packets travel around the wired Internet— data will hop from one device to another until it reaches its destination. Dynamic routing algorithms implemented in each device allow this to happen. To implement such dynamic routing protocols, each device needs to communicate routing information to other devices in the network. Each device then determines what to do with the data it receives — either pass it on to the next device or keep it, depending on the protocol. The routing algorithm used should attempt to always ensure that the data takes the most appropriate (fastest) route to its destination [10].

II. PROPOSED SYSTEM

A cross-layer metric that selects the path with the highest packet delivery rate considering both the quality of wireless links and the reliability of network nodes. Expected Forwarding Counter (EFW), a new reliability metric that combines information across the routing and MAC layers to cope with the problem of selfish behavior (i.e., packet dropping) of mesh routers in a WMN. EFW combines direct observation of routing-layer forwarding behavior of neighbors with the MAC-layer quality of wireless links in order to select the most reliable and high-performance path. MEFW and JEFW are the two variants of EFW which capture the worst and joint dropping behavior of the nodes that have established the wireless link.

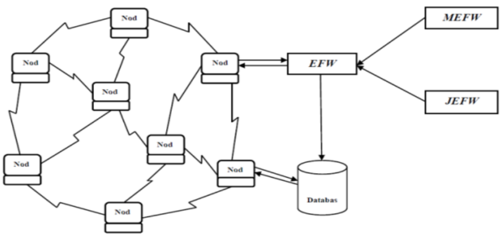
Let (i, j) be the wireless link established between nodes i and j: pij and p*ji* denote the packet loss probability of wireless link (i, j) in reverse and forward respectively.

$$EFW_{ij} = \frac{1}{p_{fwd,\, ij}} = \frac{1}{(1-p_{ij}).\,(1-p_{ji})} \cdot \frac{1}{(1-p_{d,\, ij})}$$

$$ETX = \frac{1}{p_{s,\, ij}} = \frac{1}{(1-p_{ij}).\,(1-p_{ji})}$$

Where $p_{fwd,\, ij} = p_{s,\, ij}.\,(1-p_{d,\, ij})$ the probability that a packet sent through a node *j* will be successfully forwarded can be computed, The probability of a successful transmission on the wireless link *(i,j)* can be 1.

III. SYSTEM MODEL



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However, it has no assurance of optimality; hence it definitely differs from more recent algorithms despite it likely being the most popular method in modern car navigation systems
Suppose that an edge e is included in the shortest path from v to u, and an endpoint of e is the kvth closest vertex to v , and the other endpoint is the kuth closest vertex to u. If both kv and ku are larger than a threshold value h, we call e a highway. . The highway hierarchy method [6,7] constructs a highway network composed of highway edges. We start by executing Dijkstra's algorithm on the original network, then go to the highway network after h steps. The highway network is usually sparser than the original network; thus the computational time is shortened. Moreover, by constructing highway network upon highway network recursively, the computational time becomes much shorter. In contrast to the layer method, the highway hierarchy method does not lose optimality. Short preprocessing time is also an advantage of this method.

The highway hierarchy method finds the edges common to the middle of the shortest paths. In contrast to this, bit vector finds a common structure to the shortest paths between a vertex and a region. When the source vertex is close to the region including the target vertex, the edges to be examined become many, and hence computational time increases. By increasing the number of the regions q , the bit vector can increase the efficiency instead of increasing memory usage. Moreover, the preprocessing of the bit vector needs to solve the all pairs shortest paths problem, and thereby it takes a long time.

IV.ROUTING ALGORITHMS

However, formalizing routing as such optimization problem requires complete knowledge of traffic flows between each node in the network; this is prohibitively difficult to model in the presence of rapidly changing network dynamics (found in typical WMNs). Therefore, heuristic policies are often used to create quasi-optimal routing in WMNs. There has been a significant body of research in designing efficient heuristic based routing protocols and metrics for WMNs (for a quick overview see [2 - 5]). In the wired networking domains, a new family of routing algorithms has been proposed based on swarm intelligence by Dorigo et al. called Ant Colony Optimization (ACO) framework [6, 7], which is a meta-heuristic approach for solving hard optimization problems.
ACO algorithms draw their inspiration from the behaviour of real ants, which are known to find the shortest path between their nest and a food source by a process where they deposit pheromones along trails (acting like a local message exchange in a communication network). Ants generally start out moving at random, however, when they encounter a previously laid trail, they can decide to follow it, thus reinforcing the trail with their own pheromone substance.
This process is thus characterized as a positive feedback loop, where the probability with which an ant chooses a path increases with the number of ants that previously chose the same path [7]. Hence, In ACO framework, *artificial ants* probabilistically and iteratively converge to a solution by taking into account pheromone trails deposited by other ants and other local heuristics. Artificial ants move stochastically (instead of deterministically) in the solution space, therefore they can explore a wider variety of possible solutions of a problem independently and in parallel. A more detailed explanation of the ACO framework can be found in [6].

***AntNet**: O*ne of the first applications of ant colony optimization framework (ACO) for wired network routing is AntNet [8]. In AntNet, routing is achieved by generating forward ants at regular intervals from a source node to a destination node to discover a low cost path and by backward ants that travel from destination to source to update pheromone table at each intermediate node. Forward ants keep track of trip times from source to destination node using the data traffic queues in order to experience the same delay that data packets experience. Forward ants select the next hop by a probabilistic decision rule which takes into consideration the pheromone intensity which is reinforced by other backward ants and heuristic information which is based on the queue length of the intermediate node. Once, a forward ant reaches the destination node, a backward ant is generated that tracks back to the source using high priority queues (for timely delivery) reinforcing the selection probability of intermediate nodes according to the fitness of the trip times of forward ants. However, the fact that AntNet was proposed for wired networks makes it unsuitable for WMNs because of their unique characteristics i.e. wireless interference and load balancing etc. etc. There are variations and extensions, e.g., [13, 14], of the original AntNet algorithm which targeted wired networks and thus are outside the scope of our research.

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AntHocNet : is a hybrid, multi-path, ant based algorithm. It consists of both a reactive and a proactive component. The reactive part is used for route establishment whereas the proactive component is used for route maintenance. The reactive component is used at the start of a data session where a *reactive forward ant* is broadcast to find multiple paths to the destination and upon reaching the destination; a *reactive backward ant* sets up the multiple paths to the destination using local heuristic information. While data packets are being routed, proactive forward ants are also generated. This helps in exploring new paths and getting up-to-date link quality information. One of the drawbacks of AntHocNet is the number of ants that need to be sent over the network for establishing routes to destinations as they are broadcast during a route discovery phase. Also, each ant stores list of visited nodes from source to current node and depending upon the distance to the destination, this list (and thus the ant's size) can grow long, increasing routing overhead.

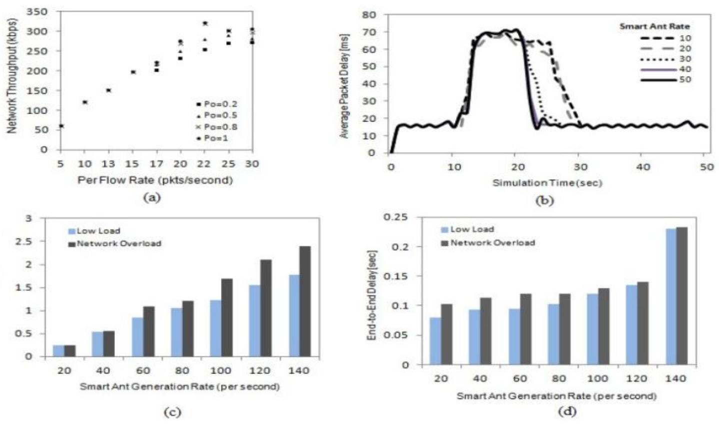
V.THE ANTMESH ALGORITHM

In this section, we describe the details of AntMesh; a distributed routing algorithm which incorporates smart ants to find high throughput paths with less interference and improved load balancing specifically designed for WMNs. The basic operation of Ant Mesh follows the routing protocol described. Smart ants in the form of control packets are generated at regular intervals from each node towards destinations in the network. Indeed, three types of ants are generated: forward smart ants (FSA) which travel from source to destination to discover paths, backward smart ants (BSA) travelling from the destination to the source to update the routing tables and hello smart ants (HSA) which collect the local link quality information to populate link estimation table. In AntMesh, both the FSA and BSA use high priority queues so that the FSA do not need to carry their per hop experienced trip times, rather BSA will estimate their trip time.

VI. SHORTEST PATH EXPLORATION

The idea behind the shortest path exploration is the optimum route (OR) is that route between a source node and a destination, providing the following specifications:

- We create multi-hop neighbor from source to destination
- The fittest node is found using the higher energy in the network.
- The node which has more energy will be found and those nodes are used to find the shortest path from source to destination.
- It is the shortest route between the source and destination.
- The same destination, unless the joint node is one of the Destination's neighbors. (No joint node (JN) or joint link (JK)).



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VII . CONCLUSION

This paper studied the problem of packet routing in wireless mesh networks with a specific emphasis on a framework using small antsinterference-aware data forwarding scheme called AntMesh which provides a distributed, stochastic heuristic to solve a dynamic network routing problem. In addition, we also emphasized on the importance of having certain desirable properties that smart ants should possess in order to effectively utilize the space/channel diversity typically common in such networks. We demonstrated the stability of AntMesh through simulations that it quickly converges to the best path under situations when traffic characteristics change (among others when load on the network is increased). We have shown that with an appropriate tuning of the parameters, AntMesh behaves better when compared to other competing approaches in mesh networks.

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