The Mobile Multi-hop Solution in Ad hoc Networks

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Abstract-Wireless communication has been the main network research recently whereas still lots of problems and great improvement to deal. In this paper we broadly discuss the recently research of the mobile Ad hoc networks (MANET) and give a main relation among the infrastructure wireless network (802.11 family) and the infrastructure-free wireless network (802.15). One fair media access control scheme is introduced to prevent the difference service of near-far problem and the indirect flow problem. The proactive and reactive networkings are then pointing out which are the latest research by the mobile Ad hoc networks (MANET) working group. Since this research area is still not well-done on the procedure of lots performance modelings, basically the discussions in this paper are in the ideal synthesis.

I. INTRODUCTION

An ad hoc network is a self-configuring network of mobile routers (and associated hosts) connected by wireless links – the union of which form an arbitrary topology. The routers are free to move randomly and organize themselves arbitrarily; thus, the network's wireless topology may change rapidly and unpredictably. It is used may in the last end of internet to communicate among laptops, vehicles and so on.

Many of the academic papers evaluate protocols and abilities assuming varying degrees of mobility within a bounded space, usually with all nodes within a few hops of each other, and usually with nodes sending data at a constant rate. Different protocols are then evaluated based on the packet drop rate, the overhead introduced by the routing protocols, and other measures. A Mesh network [1] can be seen as one special type of ad hoc network that the component parts can all connect to each other via multiple hops but they generally are not mobile.

Basically we can classify the entire wireless networks, are drawing as Figure 1, into two parts according to the physical architectures: 1. infrastructure wireless network, 2.

infrastructure-free wireless network. Two parts according to their deployment ranges: 1. wireless local area network (WLAN), 2. personal area network (PAN) [2].

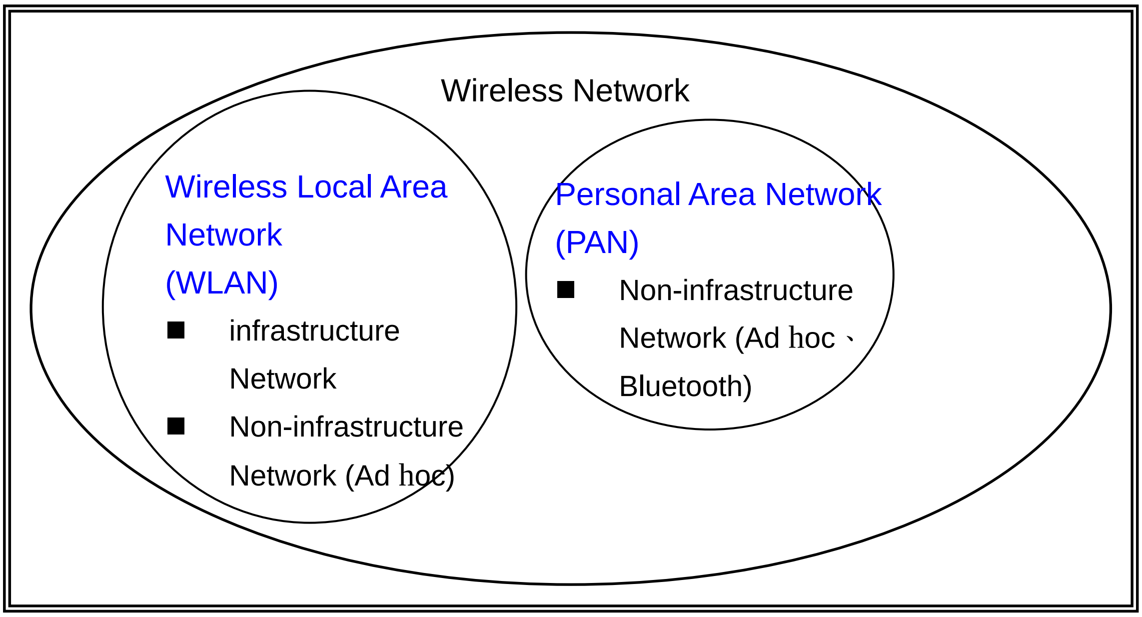

Figure 1. Categories in the Wireless Network

Table 1 gives a comparison for the examples of WLAN and PAN. Typically the most popular 802.11b standard and the Bluetooth standard are given recently.

Here is a confused concept about the “ad hoc network”. The ad hoc network is not a protocol but a network structure that the recently research [3] contains the network layer and the media access control (MAC) layer. Both 802.11 and 802.15 are standards that offer the definitions of the MAC layers and the physical layers. But notice that some how there are always some cross-layer controls in those standards.

We offer the Table 2 a full 802.x family standards as the final review works, including the wire and the wireless networks. In Table 2 we have to notice that some standards are not for working any more but they still stand in those comments.

Table 1

Comparison with the Bluetooth to 802.11b

	Bluetooth	**802.11b**
Bandwidth	724 kbps	11 Mbps
Transmission Range	10 meters	100 meters
Current Consumption	60 mA	300 mA
Networking	Multi-hop	Single-hop
Using Frequency Band	2.45G Hz	2.4GHz
Multiplexing	FH-SS	CDMA

Table 2

IEEE 802 Standards

Number	Topic
802.1	Overview and architecture of LANs
802.2 ↓	Logical link control
802.3 *	Ethernet
802.4 ↓	Token bus (was briefly used in manufacturing plants)
802.5	Token ring (IBM's entry into the LAN world)
802.6 ↓	Dual queue dual bus (early metropolitan area network)
802.7 ↓	Technical advisory group on broadband technologies
802.8 †	Technical advisory group on fiber optic technologies
802.9 ↓	Isochronous LANs (for real-time applications)
802.10 ↓	Virtual LANs and security
802.11 *	Wireless LANs
802.12 ↓	Demand priority (Hewlett-Packard's AnyLAN)
802.13	Unlucky number. Nobody wanted it
802.14 ↓	Cable modems (defunct: an industry consortium got there first)
802.15 *	Personal area networks (Bluetooth)
802.16 *	Broadband wireless
802.17	Resilient packet ring

II. SEVERAL CHARACTERISICS AMONG AD HOC NETWORKS

From the present review and introduction in section I., we have organize some characteristics that may quite different from the typical wireless networks in ad hoc networks. The reason for those features always come from nature needs of rapid mobility and multi-hop topology.

1. **Dynamic topologies** – Nodes are free to move arbitrarily. Thus, the network topology, which is typically multi-hop, may change randomly and rapidly at unpredictable times, and may consist of both bidirectional and unidirectional links.
2. **Bandwidth-constrained, variable capacity links** – Wireless links will continue to have significantly lower capacity than their hardwired counterparts. In addition, the realized throughput of wireless communications after accounting for the effects of multiple access, fading, noise, and interference conditions and so on., is often much less than a radio's maximum transmission rate.
3. **Energy-constrained operation** – Some or all of the nodes in a MANET may rely

on batteries or other exhaustible means for their energy. For these nodes, the most important system design criteria for optimization may be energy conservation.

4. **Limited physical security** – Mobile wireless networks are generally more prone to physical security threats than are fixed-cable networks. The increased possibility of eavesdropping, spoofing, and attacks should be carefully considered. Existing link security techniques are often applied within wireless networks to reduce security threats. As a benefit, the decentralized nature of network control in MANET provides additional robustness against the single points of failure of more centralized approaches.

III. THE UNFAIRNESS FUNCTIOIN

While in the wireless network scheme, there always exists a near-far problem. That is, the far sending node will have degrade itself throughput and cause an unfair service. As the Figure 2, once the mobile node **A** and the mobile node **B** are sending data streams to the same mobile node **C** at equal powers, then due to the inverse square law the receiver will receive more power from the nearer transmitter.

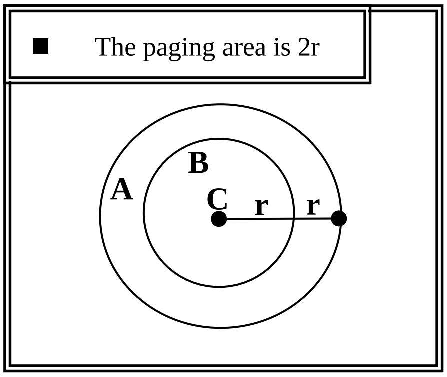

Figure 2

Average Paging Area for Near Node (Node **B**) and Far Node (Node **A**) to the Corresponding Node **C**

This problem will be eased by adaptively adjust the mobiles' powers or adaptively configure their contention window in the MAC layer and so on. While in the mobile ad hoc network the power control is already a very important part due to its infrastructure-free architecture, we will focus on an efficiency solution called a topology-aware fair access [4]. A Further problem [4], [5] is that with the different length of flows or the unbalanced interferences there will cause unmeaningful deferring slot times in the carrier sensing multiple access (CSMA) protocol. In CSMA, the reciprocal flow transmissions are implemented whether a flow is from the same transmitter or not. There are four main parts [4] for the fairness framework :

1. Exchange of flow information among nodes.
2. Adaptive backoff algorithm.
3. Switching sender-initiated and receiver-initiated scheme as appropriate.
4. Dealing with two-way (ex: TCP connection) flows from that is one-way flows.

IV. TOPOLOGY-AWARE FAIR ACCESS IN AD HOC NETWORK

1. **Exchange and Maintenance of Flow Information.**

   The flow table should have three special columns :

   - The service tag

     Denotes the measurement how much channel resource the flow has got. Which is updated by the sender after its ACK and is propagated to other nodes through subsequent packet transmissions.

   - The direct flag

     As in Figure 3, indicate the flow comes directly from listening to the channel or indirectly from flow advertisement of other nodes. And node d will not advertise the indirect flow to other nodes.

   - The position flag

     Denotes whether the flow is original (data) or derivative (ACK). The reason for this flag needed is that the traffic between two flows is quite different and we have the variable service tags to denote them.

2. **Flow Aware Backoff Algorithm.**

   The basic idea is that adaptive adjust mobile nodes' contention windows to treat on the original flows or the derivative flows. And this will be a few difference in two different service tag situations [4].

3. **Topology-Aware Hybrid Collision Avoidance Handshake.**

   Implementing the hybrid scheme alternate in two modes: Sender-initiated (SI) and Receiver-initiated (RI). In the SI mode, typically four-way handshake is used (RTS-CTS-data-ACK). While in the RI mode, the three-way handshake is used to invite the receiver to start the scheme and also reduce the resource for the channel (CTS-data-ACK) [4], [7]. In other words, when the receiver is expecting a message and has not received after a certain time, it sends a request for retransmission. Once the sender node has sent the same RTS packet for more than one half of the tine allowed in the IEEE 802.11 MAC protocol.

4. **Dealing with Two-Way Flows.**

   On the two-way flows, data packets and the ACKs are dependent to each other. There are two keys below:

- Let f_d be the derivative flow, f_o be the original flow:

$$f_d(sender) = f_d + f_o \tag{1}$$

is the flow that the sender receives a derivative flow

- Let f_{nd} be the new service flag of derivative flow of a receiver, f_{no} be the new service flag of original flow of a receiver:

$$f_{nd} = f_o \text{ and } f_{no} = f_o + f_d \tag{2}$$

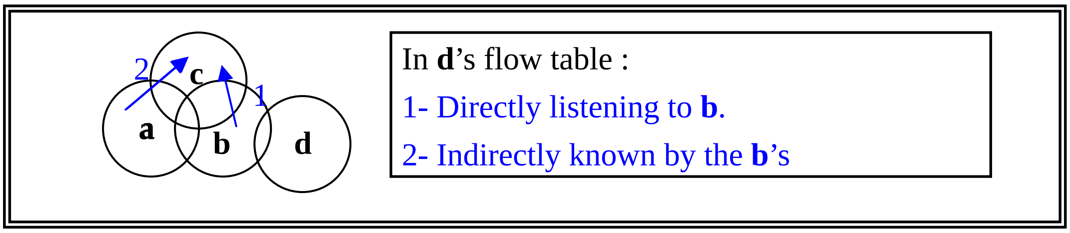

Figure 3. A Direct Flow and An Indirect Flow

V. MULTI-HOP BROADCAST IN WIRELESS NETWORK

Within the Internet community, routing support for mobile hosts is presently being formulated as "mobile IP" technology. The core network functions such as hop-by-hop routing still presently rely upon pre-existing routing protocols operating within the fixed network. In contrast, the goal of mobile ad hoc networking is to extend mobility into the area of autonomous, mobile, wireless domains, where a set of nodes which may be combined routers and hosts to be a mesh. And themselves form the network routing infrastructure in an ad hoc fashion.

One basically simplest routing ability is broadcast that can be supported with or without neighborhood information or related discovery of relay nodes. The main idea for broadcast is flooding packets. Whereas the amount of the flooding information have to be concerned with the network loading. We need more efficient flooding techniques will typically be preferred due to expected gains in network efficiency and reductions in wireless congestion and contention. Assume a probability ***P*** is used to denote the chance of each node rebroadcast the information after it receives the broadcasting information and the ***P*** must be small number but not close to zero. We have two solutions below for an efficient flooding:

1. **Distributed heuristic** – Seeking to find a small subset as a forwarding relay set which is called dominating set (DS), each node in the DS or connects to the DS, and that every nodes in the network receives the broadcasting packets.
2. **Multipoint Relaying** – As in Figure 4, nodes broadcast the packets but only the Multipoint Relays (MPRs), which are decided by the 1-hop neighbors, rebroadcast

them. The MPRs cover all the 2-hop neighbors, which are the neighbor of the neighbor, can cover the most nodes.

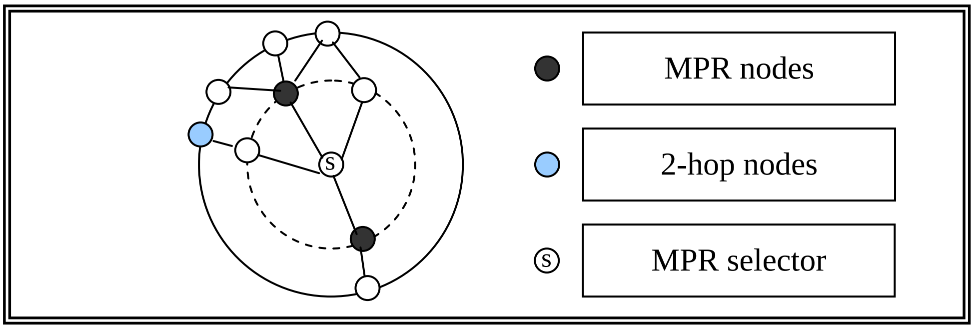

Figure 4. Multipoint Relaying

VI. UNICAST ROUTING PROTOCOL

Routing is the one of the main problems of ad hoc network due to its complexity to deal with the mobility among routes and performance. In the latest years, the proactive and reactive routing are performed sequentially and many novel solutions are presented in papers. Essentially the “Proactive” means that nodes maintain the routing table and have the topology information before transmitting. “Reactive” means to discover the present route by transmitter querying instead maintain the huge information.

1. Proactive Routing.

- Distance Vector Protocols **(**Local Algorithm**).**
  1. Destination-Sequenced Distance-Vector (DSDV)

     As in Figure 5, using the destination sequence numbers to calculate the shortest path to route. Each node maintains the distance table and updates frequently.
  2. Wireless Routing Protocol (WRP)

     Maintain only the next hop and second-to-last hop sequence information to locally determine the path (path finding).
- Link State Protocols **(**Global Algorithm**).**
  1. Optimized Link State Routing (OLSR)

     Using the concept of the Multipoint Relays to disseminate the link state to every nodes. The routing table only contains the links between MPRs and their MPR-selectors. This technique substantially reduces the message overhead as compared to a classical flooding mechanism and is suitable for large and dense networks.

Destination nodes \ Passing nodes	A	B	D
A	1	14	5
B	7	8	5
C	6	9	4
D	4	11	2

Figure 5. An Example of Distance Vector Table

2. Topology Broadcast Based on Reverse-Path Forwarding (TBRPF)
   As in Figure 6, using the Reverse Path Forwarding concept. That is, the routing table now contains the self node X and its shortest neighbor Y (if X has one or more than one). Finally we have the shortest path from the original source node called Reported Tree (RT).

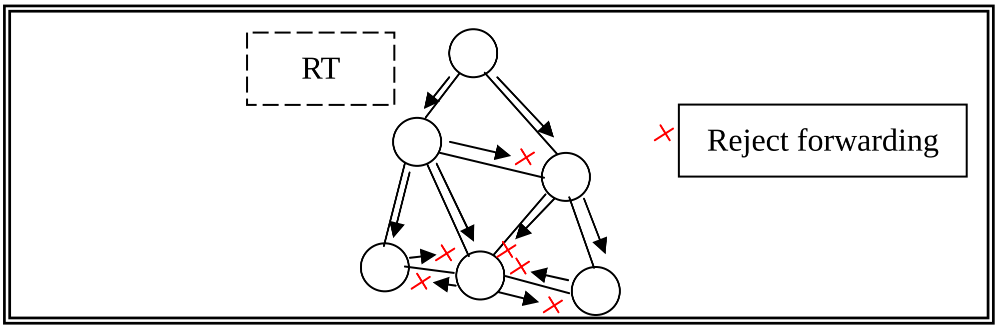

Figure 6. The Reported Tree

Instead of assuming an uniform traffic distribution within the network (and maintaining routing between all nodes at all times), let the routing algorithm adapt to the traffic pattern on a demand or need basis. If this is done intelligently, it can utilize network energy and bandwidth resources more efficiently, only need the cost of increasing route discovery delay.

Reactive (On-Demand) Routing.

- Dynamic Source Routing (DSR)
  Flooding the hole network and get a dynamical route by a route request packet. Route reply get back along a traversing path made by the route request. The route information will be cached at the source for future use. Finally the sender knows the complete hop-by-hop route to the destination, and this information is stored in route cache.

- Ad hoc On-demand Distance Vector (AODV)
  1. Using traditional routing table (one entry per destination) but still discover routes as needed.
  2. Using sequence numbers as in DSDV to prevent routing loops.
  3. Nodes only need to maintain the route to the destination corresponding to the latest sequence number.
  4. Ad hoc On-demand Multipath Distance Vector (AOMDV) discover multipath to a destination to solve the frequently topology problem.
- Temporally Ordered Routing Algorithm (TORA)
  1. Discover multiple routes to a destination like in AOMDV and constitute a destination-oriented directed acyclic graph (DAG).
  2. When a link is in failure to connect at a node (and thus no longer in destination-oriented state), link reversals will help the node to get back the destination-oriented state.

VII. CONCLUSIONS AND FUTURE WORKS

A mesh network may be a solution to continue to the end nodes communication that combines the architecture of infrastructure and infrastructure-free to accommodate the popular facilitation. In this paper, we give a broadly review and some problems in the fairness works and proactive or demand-based routings. In the routing schemes, few algorithms are utilized according to the contexts of the wireless networks and not means to suit all.

Demand-based routing offers quick adaptation to dynamic link conditions, low processing and memory overhead, low network utilization, and determines unicast routes to destinations within the ad hoc network. Whereas the proactive routing is desirable in a few of situations that the additional latency on-demand operation are unacceptable. That also means only the bandwidth and the energy resources permission, the proactive routing is suitable.

It seams that the bounded improvement are in the result without the physical handling. Consequently we have some interesting subjects in wireless network are mentioned recently that whether the spatial diversity for smart antenna can offer a preferring throughput performance. Future work about antenna diversity is put in the next discussion.

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