Technical Introduction of Wireless Mesh Network

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***Abstract*—In the process of evolution to the next generation network, wireless is an indispensable technology. Because of its Multi-Hop characteristics, the application value of Wireless Mesh Network in the next generation Internet has been proved. Because of Mesh peer-to-peer network topology, if a node fails, it will not affect the operation of the whole network, and can effectively avoid single point of failure. As a solution to provide high-speed internet services, Wireless Mesh Network can provide network access for mobile users in its coverage area, and it has evolved into an effective solution for broadband home networks, community networks, enterprise networks and other wireless access networks.**

Keyword-Wireless Mesh Network; Network Architecture; Networking; Channel

I. INTRODUCTION

As a wireless access network that can be deployed quickly and does not need expensive network wiring infrastructure, its application value in the next generation Internet has been proved. In the process of evolution to the next generation network, wireless is an indispensable technology. Wireless Mesh can cooperate with other networks and is dynamic and calculable network architecture.

Traditional wireless networks are mainly point-to-point or point-to-multipurpose star structures, and their topological structure is shown in Figure 1, while Wireless Mesh Networks use peer-to-peer network topology, in which each node communicates with its neighboring nodes and has the function of data forwarding, and its topological structure is shown in Figure 2. Mesh peer-to-peer network topology also has high reliability. If a node fails, it will not affect the operation of the whole network, and it can effectively avoid single point of failure. With multi-word interconnection and Mesh topology, Wireless Mesh Network has evolved into an effective solution for broadband home networks, community networks, enterprise networks and other wireless access networks [1].

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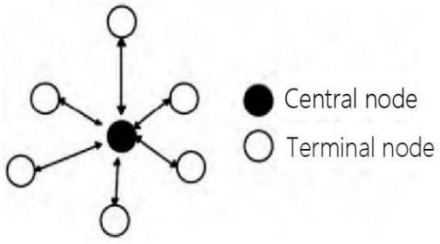

Figure 1. Traditional network topology

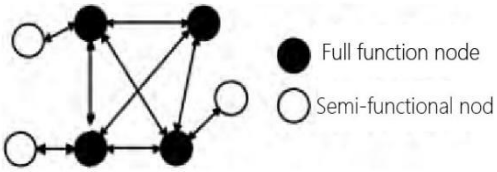

Figure 2. Mesh network topology

II. Architecture of Wireless Mesh Network

Wireless Mesh routers form self-organizing networks through Multi-Hop interconnection, which provides higher reliability, wider service coverage and lower upfront investment cost for WMN (Wireless Mesh Network) networking. The general architecture of WMN consists of three different types of wireless network elements: gateway router (router with gateway/bridge function), Mesh router (access point) and Mesh client (mobile or other), as shown in Figure 3. The Mesh client accesses the wireless Mesh router through wireless connection, and the wireless Mesh router forms a relatively stable forwarding network in the form of multi-word interconnection [2].

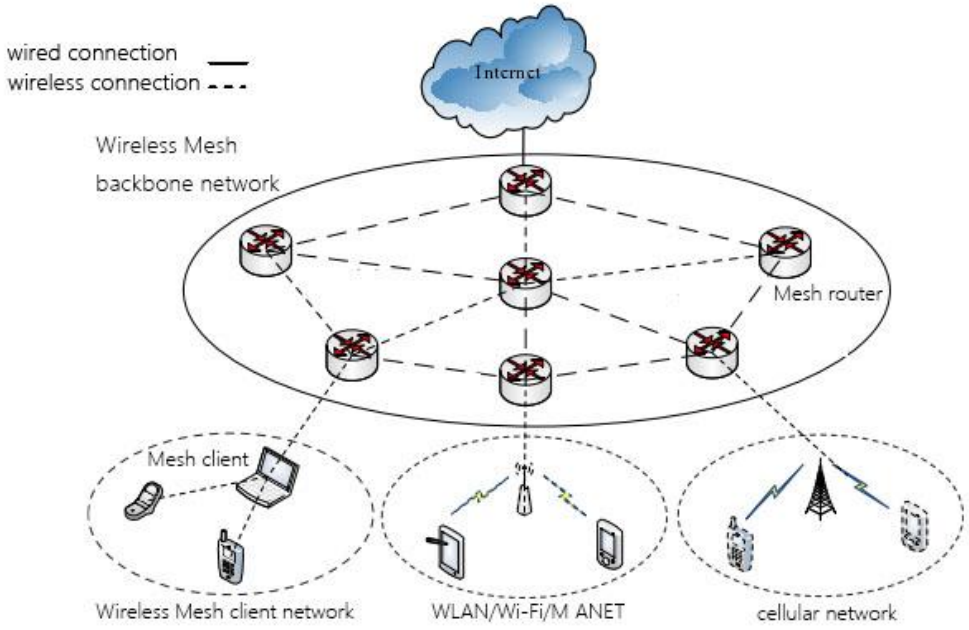

Figure 3. Wireless Mesh Network Architecture

In the general network architecture of WMN, any Mesh router can be used as the data forwarding relay of other Mesh routers, and some Mesh routers also have the additional capability of Internet gateway. The gateway Mesh router forwards the traffic between WMN and the internet through a high-speed wired link. The general network architecture of WMN can be regarded as consisting of two planes, in which the access plane provides network connection to

Mesh clients, while the forwarding plane forwards relay traffic between Mesh routers. With the increasing use of virtual wireless interface technology in WMN, the network architecture of WMN is becoming more and more popular.

III. The organization scheme of Wireless Mesh Network

A. *Single frequency of Wireless Mesh Network organization*

Single frequency of Wireless Mesh Network organization are mainly used in areas with limited equipment and frequency resources, and are divided into single-frequency single-hop and single-frequency Multi-Hop. In the single frequency of Wireless Mesh Network organization, the access and return of all wireless access points Mesh AP and wired access point Root AP work in the same frequency band. According to the different product implementation methods and channel interference environments during networking, the channels adopted between hops may be completely independent channels without interference, or channels with certain interference. At this time, due to the interference between adjacent nodes, all nodes cannot receive or send at the same time, so it is necessary to negotiate with the MAC mechanism of CSMA/CA in the Multi-Hop range. With the increase of hop count, the bandwidth allocated by each Mesh AP will drop sharply, and the actual single-frequency networking performance will also be greatly limited [3].

B. *Dual Frequency of Wireless Mesh Network Organization*

Two different frequency bands are used for back haul and access of each node in the Dual Frequency of Wireless Mesh Network Organization, such as 2.4 GHz 802.1l b/g channel for local access service, and 5.8 GHz 802.11a channel for backbone Mesh back haul network, which do not interfere with each other. In this way, each Mesh AP can perform the back haul forwarding function while serving local access users. Dual Frequency of Wireless Mesh Network Organization solves the channel interference problem of back haul and access, and greatly improves the network performance. However, in the actual environment and large-scale networking, because the back haul links use the same frequency band, there is still no interference between the channels. Therefore, with the increase of hop count, the bandwidth allocated by each Mesh AP still has a downward trend, and the Mesh AP far away from the Root AP will be in a channel access disadvantage, so the hop count of Dual Frequency of Wireless Mesh Network Organization should also be carefully set.

IV. Key technologies

A. *The negotiation of muti-channel*

When Wireless Mesh Networks access multiple channels, MP nodes in the network can only keep watch to one channel at a time. In order to use multiple channels, nodes have to dynamically switch between available channels, which requires a coordination mechanism to ensure that both nodes in communication work on the same channel. One solution is to divide the time axis into beacon intervals, establish a time window called ATIM at the beginning of each beacon interval, and require all nodes in the network to be forcibly switched to the same channel at the beginning of the ATIM time window. In the ATIM window, nodes with data to be sent use control messages to negotiate channels with the receiver [4].

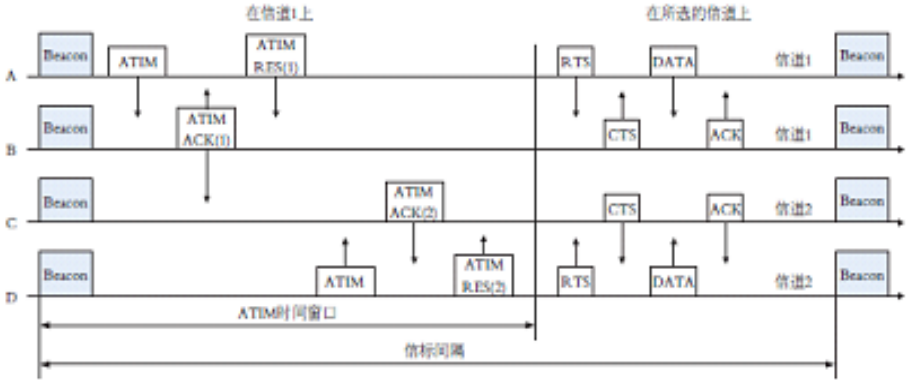

Figure 4. Muti-channel negotiation process based on ATM time window

The channel negotiation process is shown in fig. 4. Four nodes form a chain topology and are arranged in the order of a-b-c-d. Node a has packets to send to node b and node d has packets to send to node c. When a new beacon interval starts, all nodes switch to channel 1 and enter the ATIM window. After A waits for a random delay (avoiding collision), it sends an ATIM packet to B. The ATIM packet contains A's PCL (Preferable Channel List), which records the channel usage in the neighborhood of the node. After receiving ATIM packet, Node B selects channels according to PCL of A and its own PCL. In the communication range between sender and receiver, the channels used by fewer nodes will be preferentially selected. Assume that Node B selects Channel 1, and then Node B replies to Node A with ACK-ACK packet containing the selected channel, and Node A sends AIM-RES to Node B to confirm this negotiation. According to ACK-ACK and ATIMRES grouping, the neighbors of node a and node b know that node a and node b will use channel 1 to communicate, and update their PCL, which is convenient for selecting channels for themselves according to these information in the future. When the ATIM window ends, each node switches to the selected channel and communicates in the remaining time of the beacon interval.

In addition, MMAC can broadcast messages during ATIM window, supporting local broadcast function. PCL divides the channel into the following three states. High priority means that this channel has been selected by the node in the current beacon interval, and only one channel of a node can be in high priority state at most in each beacon interval. Medium priority indicates that this channel has not been selected by nodes within the transmission range. Low priority indicates that this channel has been selected by at least one neighbor node. At the beginning of each beacon interval, the channel in PCL is reset to the medium priority state. If the sending node and the receiving node negotiate a certain channel, then the two nodes set the channel to a high priority state; If a node finds ATIM packets, and the channel specified in the packet is in medium priority, the channel is set to low priority and its associated counter is set to 1; If the channel specified in the packet is at high priority, the state is not changed; If the channel specified in the packet is already at low priority, the counter associated with it is incremented by 1. The purpose of this Muti-channel negotiation method is to select the channel with small traffic load, balance the channel load as much as possible, and

reduce the bandwidth wasted by competition and back off.

B. Channel organization

Channel allocation technology is mainly used for the use and management of multiple channels in Muti-channel Wireless Mesh Networks, which can ensure good network connectivity and reduce the probability of channel conflicts in Mesh networks to improve network efficiency [5]. Different from Muti-channel negotiation technology, channel allocation technology allocates the use of multiple channels in Mesh network from the perspective of channel frequency resource division. Group division is a commonly used channel allocation scheme for Wireless Mesh Networks, which divides all neighboring nodes of each MP node into groups, and then assigns channels uniformly to each group; The channel allocated by each group selects the channel with the least number of times in the neighborhood of node conflict to designate and ensure the interconnection between groups[6].

C. Discovery of the Network

Discovery of the Network technology is mainly used to discover new nodes and neighboring nodes in Mesh networks and establish corresponding information lists. Discovery of the Network is mainly carried out by means of network scanning and list maintenance, in which network scanning means that MP nodes in Wireless Mesh Network actively send or monitor Beacon signals to monitor neighboring nodes around them, while list maintenance means adding the information of neighboring nodes belonging to the same Mesh network discovered by network scanning to the list. If the discovered neighbor node is a new node, it can be discovered by the whole network through the routing table.

D. Routing forwarding

Many technical characteristics and advantages of Wireless Mesh Network come from its Mesh connection and routing, while the design of routing forwarding directly determines the utilization efficiency of Mesh connection and affects the network performance. When designing the routing protocol of Wireless Mesh Network, we should pay attention to: firstly, we should not only select the route according to the "minimum hop count", but also comprehensively consider various performance metrics and conduct the route selection after comprehensive evaluation; Secondly, to provide network fault tolerance and robustness support, when the wireless link fails, it can quickly select an alternative link to avoid interruption of service provision; Third, we must be able to use traffic engineering technology in load balancing among multiple paths to maximize the use of system resources; Fourth, it is required to support MP and Mesh STA simultaneously.

E. Security of Wireless Mesh Network

The unique Multi-Hop self-organization characteristics of Mesh network lead to its unique security goals, such as two-way authentication between Mesh nodes; Confidentiality and integrity protection of end-to-end link data traffic of each hop; Access control and management of Mesh nodes. In order to solve these security problems, Mesh security technology is proposed. Mesh Security Association (MSA) is a commonly used Mesh security architecture. In MSA security architecture, key system is its core, and an MP is allowed to initiate communication in the network only after establishing a set of key system after passing identity authentication. The MSA architecture divides MP nodes participating in security interaction into three roles: Candidate MP, MA, and MKD. Candidate MP refers to nodes wishing to join Mesh network, and MA is a node

qualified to provide authentication service for Candidate nodes. It can establish and Maintain a secure link to MKD to ensure the security of Candidate MP certificate information forwarded by MKD. There is a secure physical link between MKD and external authentication server AS, which is mainly responsible for the generation and distribution of master keys and the qualification of ma. Initial MSA authentication is used to securely establish the link between MP pairs. Every Candidate MP can transmit data in the network after at least one successful initial MSA authentication.

V. CONCLUSIONS

Wireless Mesh Network is composed of Mesh terminal nodes, Mesh routing nodes and gateways. the backbone network is formed by interconnection between Mesh routing nodes, and finally connected with gateway nodes, providing access services for Mesh terminal nodes in a wireless Multi-Hop manner. It combines the advantages of WLAN and Ad Ho c networks, and is a distributed wireless network with high speed and high capacity. At the same time, Wireless Mesh Network provides users with flexible wireless broadband access services on the basis of self-organization and self-management. Wireless Mesh Network has the advantages of flexible deployment, good stability and wide coverage, and has become one of the key technologies of wireless access network, which is bound to affect the development of the next generation wireless network technology [7].

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