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Layered Issues in Wireless Mesh Networks

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Abstract—With the use of wireless sensor networks in industrial settings, a new type of network topology, mesh networks, has emerged in today's market. Wireless mesh network is a promising technology is providing the last mile broadband access. Wireless mesh networks has the potential to deliver Internet broadband access, wireless local area network coverage and network connectivity for stationary or mobile hosts at low costs both for network operators and customers. A mesh network is reliable and offers redundancy. Various features of wireless mesh networkshave attracted the research community, which led to the rapid growth of this technology. This paper presents technical overview on wireless mesh networks and emphasize the less obvious issues at each layer related to WMNs.

Keywords: WMNs, PTP, PTM, MTM, CDMA.

I. INTRODUCTION

Wireless communication is without a doubt a very desirable service as emphasized by the growth in both cellular and wireless local area networks. Most of the traditional wireless systems, such as cellular telephone networks and wireless local area networks, use either point -to-point or point-to-multipoint network topologies. Wireless mesh network is an upcoming technology that has the potential to deliver Internet broadband access, wireless local area network coverage, and network connectivity for network operators and customers at low costs. Internet Service Providers (ISPs) increasingly attracted towards this communication network coverage. WMNs greatly help the users to be always-an-line anywhere anytime by connecting to wireless mesh routers. It provides unprecedented freedom and mobility for a growing number of users who no longer need wires to stay connected with their workplace and the Internet. The cellular networks offer wide area coverage, but the service is relatively expensive and offers low data rates. On the other hand, the WLANs have rather limited coverage. In order to increase the coverage of WLANs, a wired backbone connecting multiple access points is required. WMANspartially bridges this gap, offeringhigh data rates with guaranteed quality of service to a potentially large customer base.

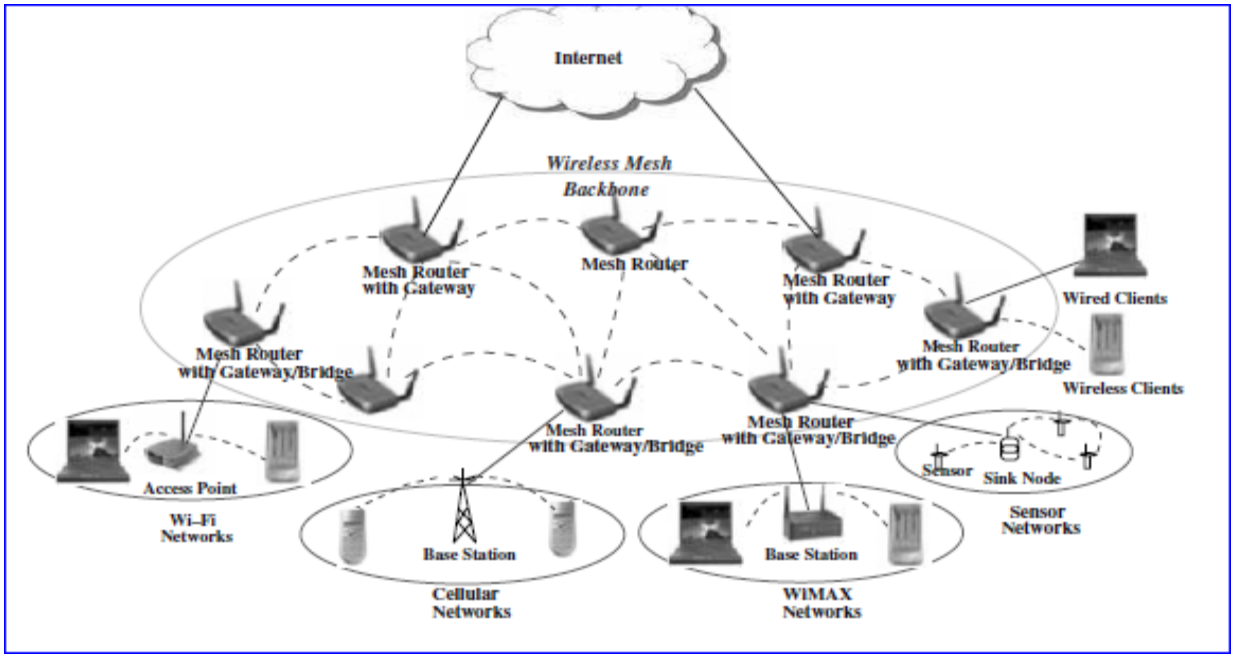

Fig. 1 Wireless Mesh Network

II. CLASSIFICATION OF WMNs

WMNs are emerging as a promising technology with a rich set of applications, e.g. wireless community networks, wireless enterprise networks, transportation systems, home networking and last-mile wireless Internet access. Wireless

networks can be classified based on the connectivity types of the various network elements, which are either Point to Point (PTP), Point to Multi-Point (PTM) or Multi-Point to Multi-Point (MPM) networks.

A. Point-to-Point Networks

PTP networks are reliable and simplest form of wireless network. PTP is composed of two radio and two high gain antennas in direct communication with each other. PTP links are often used to provide high-performance, dedicated connections or high-speed interconnect links. However, they are not scalable and their level of adaptability is low.

B. Point-to-Multipoint Networks

Point-to-Multipoint Networks have a star topology that can provide either one-way or two-way communications. PTM nodes share link between an uplink node with Omni directional antenna and repeater nodes or downlink nodes with high gain directional antennas. A PTM networks is suited for either backhaul operations or customers that need high-speed connections, but are not willing to pay for dedicated capacity that may go unused. PTM networks are moderately scalable, but they have low adaptability and reliability.

C. Multi-point to Multi-point Networks

In order to overcome PTM limitations, MTM networks are offering features that provides high reliability, adaptability and scalability to accommodate a large number of users. MTM is one of the key network architectures in which devices are connected with many redundant interconnections between network nodes such as routers and switches. As the number of nodes in the network increase the transmission power needed for each node will be reduced. But, MTM wireless networks use multiple hopes to increasing the transmission power.

III. CHALLENGES

A. Physical Layer

The challenges of the physical layer of WMNs are not fundamentally different from other wireless technologies. At the physical layer, the main issue is the choice of an appropriate radio technology. As a minimum, the physical layer of a WMN should be reliable. The choice of a radio technology can be based on technological and economic considerations. The main technological considerations include data rule and the ability to operate in the presence of interference. The choice of technologies such as code division multiple access (CDMA), ultra wide band (UWB), and multiple input multiple output (MIMO) are more suitable for WMN physical layer than the most popular physical layer technology, orthogonal frequency division multiplexing (OFDM) used in today's WMNs. Most important requirement social or economical where the simplicity of the physical layer technology will lead to less expensive devices and hence better social affordability of WMNs.

WMNs capable of supporting user mobility, it is necessary for the physical layer to support the shift in frequency and adapt to the fast fading conditions commonly associated with mobile users. The availability of link quality feedback can significantly improve the efficiency of the upper layer. It is currently well recognized that, for wireless networks, link quality information can be effectively used in the higher layers for detecting handover imminence, routing decisions, capacity optimization, etc. When transmission conditions are less than ideal, a more robust modulation or error-correcting codes should be employed to restore the reliability of a link.

Finally, the transceivers should be able to switch quickly between the available channels, between transmitter and receiver mode and be able to quickly acquire synchronization. The efficiency of the transmission can be significantly lowered if preambles and inter-frame spacing is long, especially for short packets.

B. Data Link Layer

In WMNs, improvements to the traditional contention based are usually not sufficient to improve allocation efficiently and fairness. Traditional MAC protocols are limited. Multiple radios and multiple channels bring new problems of channel assignment and medium access for instance.

1) Channel Assignment

An interesting problem in WMNs is how to efficiently utilize multiple physical channels. For example, two possible channels for a WMN with three channels, three gateways, twenty routers and one transceivers in each router which of the two channels maximizes the capacity of the network depends on the offered load at each node in the network. Potentially, there can be a very large difference in network capacity between the two channels. The problem is further complicated by an increase in the number of transceivers or/and the flexibility offered by some technologies in choosing a channel capacity: in CDMA and UWB by choosing different code lengths, different rates can be assigned to different transmitters.

2) Smart Antennas

Smart antennas are part of the 3G standards. Their advantages are very similar to those of traditional directional antennas with the added advantage that they can change the direction of the antenna and thus switch between different neighbours and track mobile users. Designing efficient MAC protocols for smart antennas is for from trivial, requiring good coordination between the antennas of the transmitter and receiver as well as provisions for new nodes to join.

C. Network Layer

At the network layer distinct characteristics and traffic flow direction, is highly skewed between the client and the gateway. In order to take the advantage of this, WMNs need the new and improved protocols. WMNs are radically

different from 3G systems, WLANs and WMANs. All these technologies use a single wireless link, and hence have no need for a network layer. In contract, for WMNs and MANETs the source and destination can be several wireless hops away from each other. The main issues faced by routing protocol in WMN are:

1) Design of routing metric

The routing metric design plays a critical role in archiving good performance. The best routing metric may also differ in its performance.

2) Quality of Service

In addition to support from the MAC layer or/and the forwarding engine, selecting the best routes for different traffic classes is an essential ingredient for QoS support.

3) Route robustness

Use of wireless mediumdemands quick path reconfiguration capability in order to maintain the robustness of the path.

4) Efficiency

If the routing protocol has a high overhead and requires global information, it will be impossible to scale it to a large number of nodes.

5) Reliability

The routing protocol should be able to reroute fact around failed nodes, broken links, and upon the failure of a gateways it should be able to redistribute the orphaned clients among neighbouring gateways.

D. Transport Layer

WMNs have some challenges at the transport layer. The transport protocols should efficiently utilize available network resources and allocate them fairly. However, fairness problem is wireless networks are inherently due to the interdependencies among neighbouring wireless links.

Another challenge is the performance of transport of transport protocols over the WMN. A WMN has large round-trip time (RTT) variations are dependent on the number of hops in the path, the end-to-end TCP throughput. Packet loss, collision, network asymmetry, and link failures can also contribute to the degradation in transport layer protocol performance.

TCP is currently the most widely used transport protocol on the Internet. Unfortunately, TCP was designed for wired networks where most packet losses are due to buffer overflows in the routers. This assumption is simply not true in WMNs where most losses are due to poor wireless links, user mobility and medium access contention.

IV. OTHER ISSUES

This section will present several other issues that span multiple layers of the OSI stack.

A. Security

Security is one of the first problems to be solved. For WMNs, Authentication is the issue to be considered. Before allowing a user to join the network, each stationary or mobile should be authenticated. This can prevent access by unauthorized users or those that simply are not willing to pay for the service.

It is imperative to protect the control data of users. If it is unprotected, it will be relatively easy for an attacker to disable a WMN.

Privacy is another issue in WMNs, where user data travels through multiple wireless hops; the clients will be concerned with the privacy of their information. User data should be secured from being read by other network users at intermediate hops.

B. Topological and deployment issues

The fundamental issue of a WMN is to provide the Internet access with high speed and for this, thedesign of the network architecture should be addressed carefully. Also Quality of Service for end users and determining the network performance is important for a WMN.

Structured and Organic deployments are two types of deployment. Service will be provided in a new area in structured deployment. Hence, it provides flexibility may translate into improved network performance by capturing the regularity of the deployed mesh network. Mesh network will be deployed organically over existing infrastructure in organic deployment. Thus, there are limited options of topology are limited options of the network architect to choose.

C. Provisioning

The main provisioning problem is to determine how much bandwidth each subscriber can receive, given a WMN topology and the offered loads. The capacity of a WMN is decreasing with the number of clients connected to each gateway. At some point, the operator should upgrade the infrastructure by adding one or more gateways. Here, the problem is to determine the location of the additional gateways that maximizes the networks capacity. Another problem is to determining where to install gateways or repeaters in neighbourhood.

V. CONCLUSION

WMNs have become an important focus area of research in the recent years owing to their great potentials in realizing numerous next-generation wireless services with stringent QoS guarantees and with high mobility support for the users. WMN Technology is facing many issues while it has some great advantages which make it a technology of today. There are challenges like: fairness, energy management, mobility management, capacity management, addressing and routing, integration with the Internet, service levels, etc., at different layers such as: physical, MAC, transport, and network. The

main drawback of the technology is its complexity. The main source of this complexity is a combination between wireless technology and the unusual role of each wireless node. The challenges are in large part unique to WMNs and considerable research has yet to be completed before WMNs can reach their full potential.

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