



Mobile Ad Hoc Network: Issues, Research Trend And Challenges

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Abstract— Mobile Ad-hoc Network is an emerging area of research. Most current work is centralized with different issues. MANET is temporarily constructed network with no infrastructure. It is based on self-organizing and rapidly deployed network. The special feature of MANET bring this technology great opportunity together with several challenges This paper describes the fundamental problems of Ad hoc networking by giving its related background including the concept, features, application, issues of MANETs.

Keywords— Mobile Communication, Wireless Network, Ad hoc Network, Research Trend

I. INTRODUCTION

MANET is usually a self-organizing and self-configuring “multi-hop” network which does not require any fixed infrastructure. In such network, all nodes are dynamically and arbitrarily located, and are required to relay packets for other nodes in order to deliver data across the network.

With the success and the growth of wireless and mobile network, a wide range of successful data services in emerging markets has proposed challenging requirements. The mobile user likes to be connected anywhere at any time with the benefit of different services like web browsing, interactive gaming, video streaming or file transfer. To compensate all this, a complete involvement of different network technologies and a successful internetworking between them is required.

Wireless networks have continued to play prominent roles in day to day communication. Military applications, industrial applications and even in personal area networks, wireless networks are everywhere today. The popularity has increased in different applications in view of its different valuable attributes which includes simplicity of installation, reliability, cost, bandwidth, total required power, security and performance of the network. But similar to wired networks, it also makes use of fixed infrastructures [9] such as cordless telephone, cellular networks, Wi-Fi, microwave communication, Wi-MAX, satellite communication and RADAR etc.[2] [1]

Wireless network are classified in two types: - Infrastructure and Infrastructure less networks. Infrastructure network is a network with fixed and wired gateways. A mobile host interacts with a bridge in the network (base station) with fixed and wired gateway. This communication by the mobile host is made within its radius. The mobile unit can move geographically while it is communicating. When it goes out of range of one base station, it connects with the new base station and starts communicating through it. The process is called handoff. In this approach, the base stations are fixed.

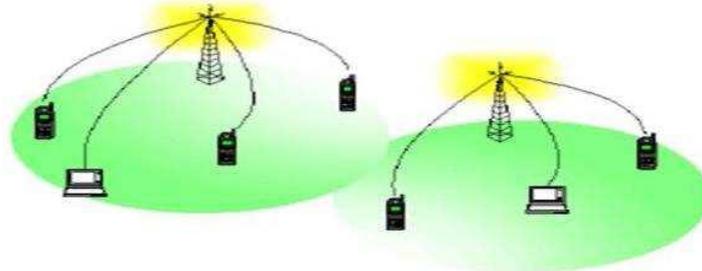


Figure 1.1: Infrastructure-based wireless network [13]

Nowadays, next generation wireless ad-hoc networks are widely in use. All this is because of independent mobile users need for efficient and dynamic communication in emergency/rescue operations, disaster relief efforts and military networks and also for different applications [3] [11]. These networks cover a large geographical area without fixed topology which may change dynamically and unpredictably. These networks improve the scalability of the network compared to the infrastructure-based wireless networks because of its decentralized nature. In any critical scenarios such as natural disasters, military conflicts, an ad-hoc network provides a better performance due to the minimum configuration and quick operations [10] [14].

Recently advancements such as Bluetooth introduced a fresh type of wireless system which is frequently known as mobile ad hoc network. Mobile ad hoc networks or “short live” networks control the non-existence of permanent infrastructure.

Ad Hoc" is a Latin phrase which means "for this purpose". Individual nodes comprising the network are created dynamically and maintained. The network does not depend on a pre-existing infrastructure, e.g. routers in wired networks and therefore it is Ad-hoc.

Ad-hoc networks can be classified into three categories depending on their applications:

Mobile Ad-hoc Networks (MANETs), Wireless Mesh Networks (WMNs) and Wireless Sensor Networks (WSN). A MANET is an autonomous collection of mobile nodes. [4] These nodes are struggling to cope with the normal effect of radio communication channels, multi-user interference, multi-path fading and shadowing etc.

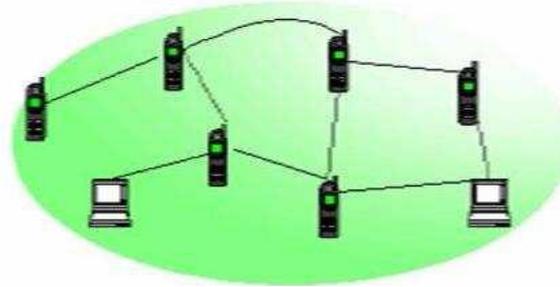


Figure 1.2: Mobile Ad-Hoc Network [32]

II. HISTORY OF MANET

The whole life-cycle of ad-hoc networks could be categorized into the first, second, and the third generation ad-hoc networks systems. Present ad-hoc networks systems are considered the third generation. The first generation goes back to 1972. At that time, they were called PRNET (Packet Radio Networks). The history of ad-hoc networks can be dated back to the DoD1-sponsored Packet Radio Network (PRNET) research for military purpose in 1970s, which evolved into the Survivable Adaptive Radio Networks (SURAN) program in the early 1980s.

In conjunction with ALOHA (Areal Locations of Hazardous Atmosphere) and CSMA (Carrier Sense Medium Access), approaches for medium access control and a kind of distance-vector routing PRNET were used on a trial basis to provide different networking capabilities in a combat environment.

The second generation of ad-hoc networks emerged in 1980s, when the ad-hoc network systems were further enhanced and implemented as a part of the SURAN (Survivable Adaptive Radio Networks) program. This provided a packet-switched network to the mobile battlefield in an environment without infrastructure. This program proved to be beneficial in improving the radios' performance by making them smaller, cheaper, and resilient to electronic attacks. In the 1990s, the concept of commercial ad-hoc networks arrived with note-book computers and other viable communications equipment. At the same time, the idea of a collection of mobile nodes was proposed at several research conferences. Since mid-1990s, a lot of work has been done on the ad hoc standards. Within the IETF, the MANET working group was born, and made effort to standardize routing protocols for ad hoc networks. Meanwhile, the IEEE 802.11 subcommittee standardized a medium access protocol that was based on collision avoidance and tolerated hidden terminals, for building mobile ad hoc network prototypes out of notebooks and 802.11 PCMCIA cards.

There are currently two kinds of mobile wireless networks. The first is known as infrastructure networks with fixed and wired gateways. Typical applications of this type of "one-hop" wireless network include wireless local area networks (WLANs). The second type of mobile wireless network is the infrastructure less mobile network, commonly known as the MANET. [15]

III. MANET CONCEPT

MANETs are a kind of wireless ad hoc networks and it is the one consisting of a set of mobile hosts which can communicate with one another and roam around at their will. [5] Mobile Ad-hoc Networks are one of the fastest emerging network technologies. It is an unstructured network in which nodes are mobile and autonomous. Nodes act as hosts as well as routers. [6] Each device in a MANET is free to move independently in any direction using a wireless physical medium without relying on pre-existence wired infrastructure. That's why the ad hoc network is also known as infrastructure-less network and will, therefore, change its links to the other devices frequently. Each node must forward traffic unrelated to its own use, and, therefore, be a router. Mobile ad hoc network has a fundamental characteristic that they are able to configure themselves on-the-fly without intervention of a centralized administration. This functionality gives another name to ad hoc network as "multi-hop wireless network".

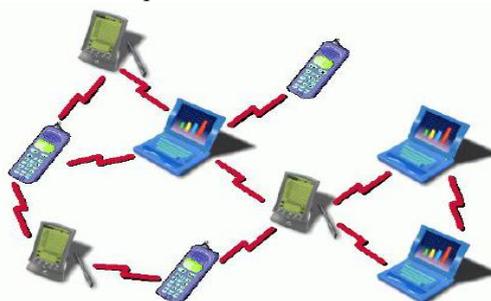


Figure 1.3 Mobile Ad-hoc Network connected by wireless link

Typical MANET nodes are PDAs, Laptops, cellular phones, Pocket PCs, palmtops and Internet Mobile Phones. These devices are lightweight and battery operated. [8]". In a MANET, there is no Base Station i.e. no fixed infrastructure and the nodes are free to move, thus network topology changes dynamically in an unpredictable manner. In this network each node acts both as a router and its job as an ordinary device.

IV. FEATURES OF MANET

Some of the feature of the prominent features of MANET is briefly discussed as under:-

A. Shared Physical Medium

The wireless communication medium is accessible to any entity with the appropriate equipment and adequate resources. Accordingly, access to the channel cannot be restricted. [7]

B. Autonomous Terminal

In MANET, each mobile terminal has an autonomous node which may function both as host or a router i.e. besides the basic processing ability as a host, the mobile node can also perform switching function as a router. [6]

C. Distributed Operation

The load involved in a MANET collaborate among themselves and each node act as a relay as needed to implement functions like security and routing. [6]

D. Multi-hops Routing

Single hop MANET, a simple multi-hop in term of structure and implementation. When delivering data packet from a source to its destination through direct-wireless transmission range. The packet should be forwarded by one or moiré intermediate node. [6]

E. Dynamic Network Topology

A MANET should adapt to the traffic and propagation condition as well as the mobility pattern of the mobile network node. The mobile node in the Network dynamically establish routing among themselves as they move about, formatting their own network on the fly. [6]

F. Fluctuating link capacity

One end to end path can be shared by several sessions in a MANET .the channel cover which terminals communicate is subject to noise fading and interference and has less bandwidth than a wired network. [6]

G. Light weight terminal

In most of the cases, the MANET nodes are mobile devices with less CPU processing capability, small memory size and low power storage, consequently such devices need optimized algorithm, and mechanism that implement the communicating and computing function. [6]

H. Symmetric Environment

All nodes have identical features with similar responsibility and capability and hence it forms a completely symmetric environment. [8]

V. ISSUES AND CHANLLENGES IN MANET

There are certain issues & challenges a MANET has to face. A MANET environment has to overcome these issues and challenges given as under. [6] [5] [12]

A. The wireless link characteristics are time-varying in nature

There are transmission impediments like fading, path loss, blockage and interference that add to the susceptible behaviour of wireless channels. The reliability of wireless transmission is resisted by different factors.

B. Limited range of wireless transmission

The limited radio band results in reduced data rates compared to the wireless networks. Hence optimal usage of bandwidth is necessary by keeping low overhead as possible.

C. Packet losses due to errors in transmission

MANETs experience higher packet loss due to factors such as hidden terminals that results in collisions, wireless channel issues (high bit error rate (BER)), interference, and frequent breakage in paths caused by mobility of nodes, increased collisions due to the presence of hidden terminals and uni-directional links.

D. Route changes due to mobility

The dynamic nature of network topology results in frequent path breaks.

E. Frequent network partitions

The random movement of nodes often leads to partition of the network. This mostly affects the intermediate nodes.

F. Limited bandwidth

Wireless link continue to have significantly lower capacity than infrastructure networks. In addition, the realized throughput of wireless communication after accounting for the effect of multiple access, fading, noise, and interference conditions, etc., is often much less than a radio's maximum transmission rate.

G. Dynamic topology

Dynamic topology membership may disturb the trust relationship among nodes. The trust may also be disturbed if some nodes are detected as compromised.

H. Routing Overhead

In wireless Ad hoc networks, nodes often change their location within network. So, some stale routes are generated in the routing table which leads to unnecessary routing overhead.

I. Hidden terminal problem

The hidden terminal problem refers to the collision of packets at a receiving node due to the simultaneous transmission of those nodes that are not within the direct transmission range of the sender, but are within the transmission range of the receiver.

J. Packet losses due to transmission errors

The Ad hoc wireless networks experiences a much higher packet loss due to factors such as increased collisions due to the presence of hidden terminals, presence of interference, uni-directional links, and frequent path breaks due to mobility of nodes.

K. Mobility-induced route changes

The network topology in an ad hoc wireless network is highly dynamic due to the movement of nodes; hence an on-going session suffers frequent path breaks. This situation often leads to frequent route changes.

L. Battery constraints

Devices used in these networks have restrictions on the power source in order to maintain portability, size and weight of the device.

M. Security threats

The wireless mobile ad hoc nature of MANETs brings new security challenges to the network design. As the wireless medium is vulnerable to eavesdropping and ad hoc network functionality is established through node cooperation, mobile ad hoc networks are intrinsically exposed to numerous security attacks.

N. TCP/ UDP

TCP and UDP are the standard protocols used in the Internet. Data applications running over MANET, such as http and real audio need transport layer protocols like TCP and UDP to send packets over the links. [12]

O. IP Addressing

One of the most important issues is the set of IP addresses that are assigned to the ad-hoc network. IP addressing and address auto configuration have attracted much attention in MANETs.

P. Multiple Accesses

A major issue is to develop efficient medium access protocols that optimize spectral reuse, and hence, maximize aggregate channel utilization in MANETs.

Q. Radio Interface

Mobile nodes rely on the radio interface or antenna to transmit packets. Packet forwarding or receiving via radio interface or antenna techniques in MANETs are useful investigations.

R. Power Management

A power management approach would help reducing power consumption and hence prolonging the battery life of mobile nodes. Because most devices operate on batteries, power management becomes an important issue.

S. Fault Tolerance

This issue involves detecting and correcting faults when network failures occur. Fault-tolerance techniques are brought in for maintenance when a failure occurs during node movement, joining, or leaving the network.

T. QoS/ Multimedia

Quality of Service (QoS) and Multimedia require high bandwidth, low delay, and high reliability.

U. Standards/ Products

The standards and products issues that allow the development of small scale are emerging for this field. For instance, Bluetooth is a low-cost technology for short-range communications techniques. [12]

VI. SECURITY GOALS

In MANET, all networking functions such as routing and packet forwarding, are performed by nodes themselves in a self-organizing manner. For these reasons, securing a mobile ad -hoc network is very challenging.

Security involves a set of investments that are adequately funded. In MANET, all networking functions such as routing and packet forwarding, are performed by nodes themselves in a self-organizing manner. For these reasons, securing a mobile ad -hoc network is very challenging. The goals to evaluate if mobile Ad hoc network is secure or not are as follows:

A. Availability

Availability means the assets are accessible to authorized parties at appropriate times. Availability applies both to data and to services. It ensures the survivability of network service despite denial of service attack.

B. Confidentiality

Confidentiality ensures that computer related assets are accessed only by authorized parties. That is, only those who should have access to something will actually get that access. To maintain confidentiality of some confidential information, we need to keep them secret from all entities that do not have privilege to access them. Confidentiality is sometimes called secrecy or privacy.

C. Integrity

Integrity means that assets can be modified only by authorized parties or only in authorized way. Modification includes writing, changing status, deleting and creating. Integrity assures that a message being transferred is never corrupted.

D. Authentication

Authentication enables a node to ensure the identity of peer node it is communicating with. Authentication is

essentially assurance that participants in communication are authenticated and not impersonators. Authenticity is ensured because only the legitimate sender can produce a message that will decrypt properly with the shared key.

E. Non repudiation

Non repudiation ensures that sender and receiver of a message cannot disavow that they have ever sent or received such a message .This is helpful when we need to discriminate if a node with some undesired function is compromised or not.

F. Anonymity

Anonymity means all information that can be used to identify owner or current user of node should default be kept private and not be distributed by node itself or the system software

G. Authorization

This property assigns different access rights to different types of users. For example a network management can be performed by network administrator only. 8 Resilience to attacks: It is required to sustain the network functionalities when a portion of nodes is compromised or destroyed.

H. Freshness

It ensures that malicious node does not resend previously captured packets. [7]

VII. RESEARCH TREND IN MANET

The research trends from 1998 to 2003 are introduced first .The research trend for different issues are shown via a statistical graph .Mobile Ad Hoc Networks (MANETs) are a fundamental element of pervasive networks, where user can communicate anywhere, any time and on the fly. MANETs introduce a new communication paradigm, which does not require a fixed infrastructure-they rely on wireless terminals for routing and transport services.

A mobile ad-hoc network (MANET) is based on a self-organizing and rapidly deployed network. The ad hoc networking technology has stimulated substantial research activities in the past 14 years. Many scholars were attracted to investigate this domain for further research and learning. Numerous problems and challenges exist in this field because of the frequent and unpredictable MANET topology changes. Recent research areas of MANETs are routing, multicasting, clustering, mobility management etc.

The trends for various issues over the recent six years are shown in Figure 1.4. The stacked bar chart represents the quantity of papers in the period from 1998 to 2003. If we focus on the quantity of papers, the number of papers for routing, power management, and bandwidth management are larger than those on other issues .IP addressing and fault tolerance issues were presented by only a few papers in recent years. If we focus on the growth rate for each issue, we can find that the growth rates of some issues, such as radio interface and security have been greater than other issues. Especially, the total quantity of papers for these issues in 2003 is larger than the total quantity of papers from 1998 to 2002. We found that the growth rates for mobility management and fault tolerance were positive. This result shows that these issues also will have more potential study values in the near future.

The research studies on routing usually focus on three factors scalability, stability, and reliability. The location service studies and power management usually centre on scalability factor issues. The studies on multicasting/ broadcasting usually focus on two factors reliability and scalability. [16]

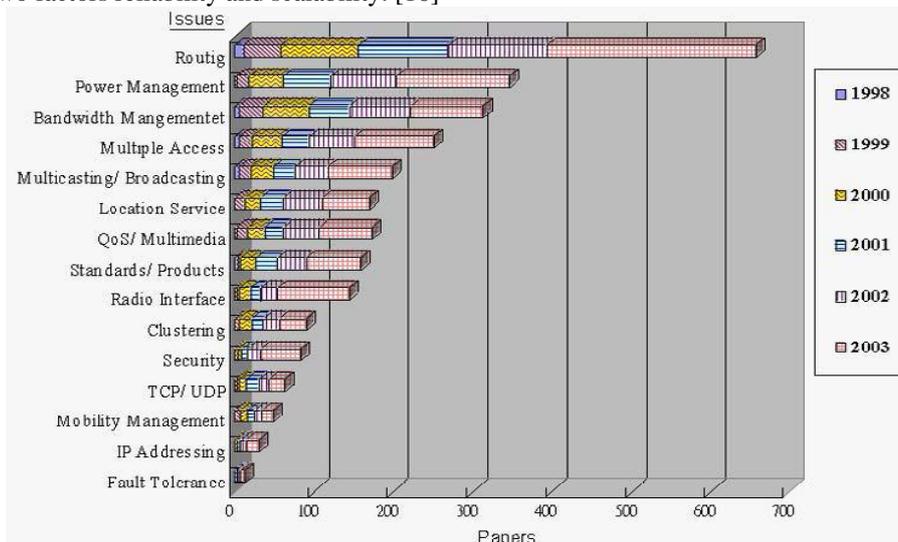


Fig. 1.4 Research Trends in MANETs [16]

VIII. CONCLUSIONS

In the study of many research papers on MANETs, it was found that the routing and power management issues have grown very fast and the most popular in recent years. Ad hoc networking is at the centre of evolution toward the fourth generation wireless technology. There are a lot of issues and challenges like packet losses due to error in transmission, frequent network partition, battery constraints ,security threats particularly energy efficiency in MANET. The future of ad-hoc is really appealing giving the vision of –anytime, anywhere and cheap communication.

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