

# CHAPTER 3

## Adhoc NETWORKS

### CHAPTER OUTLINE

- Mobile Ad Hoc Networks (MANETS)
- Features of Ad Hoc Networks
- Goal of Using Ad Hoc / Mobile Ad Hoc Networks
- Advantages of AD Hoc Networks
- Disadvantages of Ad Hoc Networks
- Application of Adhoc Networks
- Ad Hoc Versus cellular Networks
- Network Architecture of Ad Hoc Networks
- Adhoc Network Protocols: MAC Protocols
- Ad hoc Routing Protocols
- Challenges and Issues in MANETS
- Ad Hoc Networks Technologies

### 3.1. MOBILE AD HOC NETWORKS (MANETS)

As a matter of fact, wirelessly connected devices have created a revolution in the way networked resources can interact with each other. The concept of *Ad hoc* networking is one of the advanced mechanisms that is used for wireless networking. Basically, *Ad hoc* networks consist of a collection of wireless nodes. These nodes are connected with each other to dynamically establish an *Ad hoc* or on-the-fly network without any kind of support of any centralized infrastructure. Infact, such a network supports anytime and anywhere mobile computing and thus, allowing the spontaneous formation of mobile networks for a period of usage. In this kind of a network, each mobile host works as a router which enables peer-to-peer as well as peer-to-remote wireless communications.

The field of wireless and mobile communications has experienced an unprecedented growth during the past decade. Current second-generation (2G) cellular systems have reached a high penetration rate, enabling worldwide mobile connectivity. Mobile users can use their cellular phone to check their email and browse the Internet. Recently, an increasing number of wireless local area network (LAN) hot spots is emerging; allowing travellers with portable computers to surf the Internet from airports, railways, hotels and other public locations. Broadband Internet access is driving wireless LAN solutions in the home for sharing access between computers. In the meantime, 2G cellular networks are evolving to 3G, offering higher data rates, infotainment and location-based or personalised services.



However, all these networks are conventional wireless networks, conventional in the sense that as prerequisites, a fixed network infrastructure with centralised administration is required for their operation, potentially consuming a lot of time and money for set-up and maintenance. Furthermore, an increasing number of devices such as laptops, personal digital assistants (PDAs), pocket PCs, tablet PCs, smart phones, MP3 players, digital cameras etc. are provided with short-range wireless interfaces. In addition, these devices are getting smaller, cheaper, more user friendly and more powerful. This evolution is driving a new alternative way for mobile communication, in which mobile devices form a self-creating, self-organising and self-administering wireless network, called a *mobile ad hoc network*.

### 3.2. FEATURES OF ADHOC NETWORKS

1. Autonomous and infrastructureless
2. Multi-hop routing
3. Dynamic network topology
4. Device heterogeneity
5. Energy constrained operation
6. Bandwidth constrained variable capacity links
7. Limited physical security
8. Network scalability
9. Self-creation self-organization and self-administration

### 3.3. GOAL OF USING AD HOC / MOBILE AD HOC NETWORKS

One of the original motivations for MANET is found in the military need for battlefield survivability. In the battlefield, the soldiers (with or without their warfare) have to move freely without any of the restrictions imposed by wired communications devices. They still need communication device, so they can report their position, gathered information, and communicate with other soldiers. For this purpose, they can't rely on an infrastructure. In some regions, such as the desert, the jungle, or mountain there is no torrential communications infrastructure. Therefore they can not to establish networks without infrastructure and ad hoc networks specially MANETs support this case.

The interest of MANETs increases rapidly in recent year. because ad hoc supports mobility and higher self organizing in the networks. The commercial applications have already implement MANETs' concept to some device, such as PDA, mobile phone, laptop, etc. Another application is to help improving education in developing countries. The children's machine "one laptop per child" program. The laptops use the standard IEEE 802.11 to establish their own communications network.

### 3.4. ADVANTAGES OF AD HOC NETWORKS

There are many reasons better to use ad hoc than infrastructure. The biggest ad hoc's strength is its independency from any infrastructure. Therefore, it is possible to establish an ad hoc network in any difficult situations. The following are the advantages of ad hoc networks.

- (a) **No Infrastructure and Lower Cost:** There are situations with which a user of a communication system cannot rely on an infrastructure. Using a service from a infrastructure can be expensive for specific applications.



In an area with very low density, like desert, mountain, or isolated area it is not impossible to establish an Infrastructure. But, if we compare how often the people there are using service of infrastructure and how many data per day transmitted with cost of installation, maintenance, and repair, it may be too expensive.

Almost the same problem with military network. It is obviously very useless to build an infrastructure in a battlefield. Aside from cost of installation, the enemy can destroy the infrastructure in short time. A independent from infrastructure network is needed for both cases.

**(b) Mobility (MANET Only):** In the next generation of wireless communication systems, there will be a need for the rapid deployment of independent mobile users. The most popular examples include military networks, emergency/rescue operations, disaster effort. In these scenarios, we can not rely on centralized connectivity. MANETs support nodes' mobility. We can still communicate with our mobile devices as long as the destination is reachable.

**(c) Decentralized and Robust:** Another advantage of ad hoc networks is that they are inherently very robust. Imagine that for some reason one of the base stations is not working. In this case, all users of that base station will lose connectivity to other networks.

In the ad hoc networks you can avoid such problem. If one node leaves the network or is not working, you can still have connectivity to other nodes and maybe you can use these nodes to multi-hop your message to the destination nodes, as long as there is at least one way to desired node.

**(d) Easy to Build and Spontaneous Infrastructure:** Malfunction of a network infrastructure is sometimes not avoidable. It is obviously difficult to repair or replace the malfunction infrastructure in short time, while the network's existence must be maintained all-time. Establishing an ad hoc is a good deal in such situation. The network participants can act as ad hoc nodes and hop the messages.

### 3.5. DISADVANTAGES OF AD HOC NETWORKS

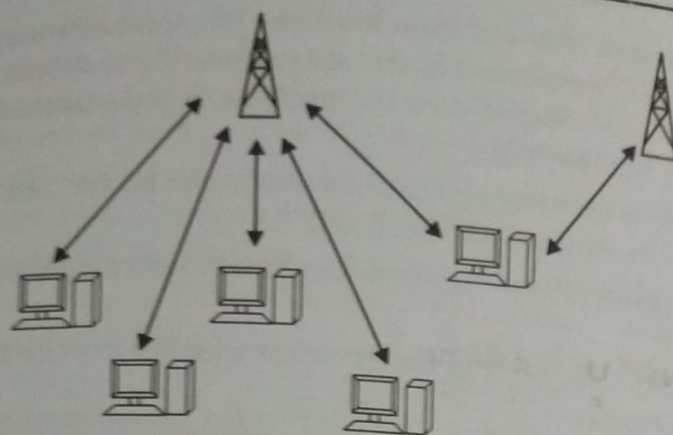
The wireless communication is very famous nowadays, using wireless can make rooms look better, because fewer cables are used. The weakness of wireless link impact ad hoc. Lower data rate, security, and medium access control are common problems in the wireless communications. Ad hocs strengths cause also some problems. The following are the disadvantages of ad hoc networks.

**(a) Higher Error Rate:** Unlike wired transmission, the wireless transmission may deal with problem the characteristic of the electronic wave. In a free room without obstacle, the electronic wave propagate linear indepentry from its frequency. There is seldom such a situation. The obstacle causes shadowing, reflection, scattering, fading, refraction, diffraction of the wave. These propagation may lead to transmitted packets being garbled and thus received in error.

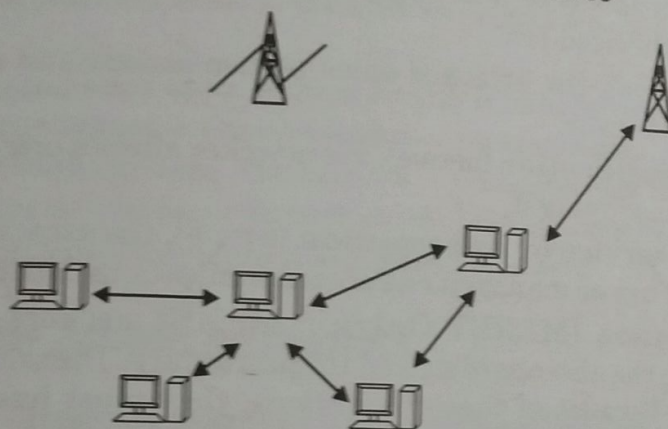
**(b) Lower Data Rate:** One of biggest problem of ad hoc networks is reduced data rates. The characteristic of wave, which is used for wireless communication, prevents wireless communication to transmit data better than wired communication. A higher frequency can transmit more data, but then it is more vulnerable to interference and performs well in short range.

**(c) Dynamic Topology and Scalability:** Because ad hoc networks do not allow the same kinds of aggregation techniques that are available to standard Internet routing protocols, they are vulnerable to scalability problem.





(a) Network before malfunction occurs



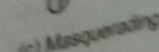
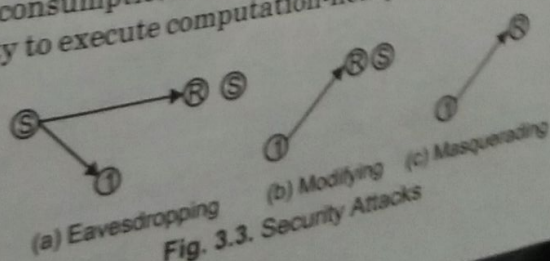
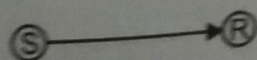
(b) Using ad hoc after a malfunction occurred

**Fig. 3.1.** Scenario in which ad hoc network can replace infrastructure

Since the MANET's nodes are mobile, the routing changes as the nodes move. Current connectivity Information must be propagated to all network's participant. Control messages have to be sent around the network frequently. The increased number of control messages burdens the available bandwidth. Therefore, the ad hoc protocols are typically designed to reduce the number of control messages, such as by keeping the current information.

A good algorithm for ad hoc networks must be able to evaluate and compare networks' relative scalability in the face of increased number of nodes and nodes mobility. It is very important to know how many control message is required. So we can control bandwidth's usage.

- (d) **Security:** Due to dynamic distributed infrastructure-less nature and lack of centralized monitoring points, the ad hoc networks are vulnerable to various kinds of attacks. Unlike wired channel, the wireless channel is accessible to both legitimate network users and malicious attacker. Therefore, the ad hoc networks are susceptible to attacks ranging from passive attacks such as eavesdropping to active attack such as interfering. Especially for MANET, limited power consumption and computation capabilities, due to energy limitation, causes incapability to execute computation-heavy algorithms like public key algorithms.

**Fig. 3.3.** Security Attacks**Fig. 3.2.** Normal Data Flow



listens the channel, therefore, the active attacks modifies, deletes the packets, injects packets and dissemination. Active attack can be detected.

There are numerous security problem issues in the ad hoc networks. The following are some of the security problem of IEEE 802.11.

1. **Eavesdropping (passive)**, a non-legitimate listening into a transmission between two nodes.
2. **Traffic analysis (passive)**, the attacker monitoring the transmission for pattern of communication.
3. **Masquerading (active)**, the attacker pretends to authorized user of a system in order to gain access to it or to gain greater privileges than they are authorized for.
4. **Replay (active)**, the attacker spies transmissions and retransmits message as the legitimate user.
5. **Message modification (active)**, the attacker alters a original message by deleting, adding to, modifying it.
6. **Denial-of-service or interruption (active)**, the attacker prevents or prohibits the normal use or management of communications facilities.

(e) **Energy Limitation (MANET Only)**: A MANET network allows mobile nodes to communicate in the absence of a fixed infrastructure. Therefore, they operate with battery power. Because of these limitations, they must have algorithms which are energy-efficient as well as operating with limited processing and memory resources. The usage of available bandwidth will be limited because nodes may not be able to sacrifice the energy consumed by operating at full link speed.

It is also very annoying, while receiving data from someone with PDA, the battery is almost depleted. Repeating the transfer process after recharging is necessary. Therefore, a MANET is not suitable for a permanent network.

Table 3.1. Advantages and disadvantages of ad hoc network



Scalability		Depend on routing algorithm, how the ad hoc networks can perform well. In a network with a large number of nodes and high mobility, a table driven algorithm would not perform well, because there will be big overhead. Generally, the infrastructure networks perform better in this situation. The infrastructure networks have only specify tasks, so they can handle more nodes.
Routing	In the infrastructure networks, if the access point is defected, there will be no more communication in the affected cell.	Mobility and increased or decreased number of nodes can force some routing algorithms to alter their routing table.
Security	Some attacks can cause malfunction. If one of participant is attacked and it doesn't work anymore. The network can relay the messages through other route (if alternative route is available).	Internal attacks may be possible via ad hoc transmissions. It means, the attacker can disguise itself as a ad hoc participant. It can spy, modify, or delete the hopped messages.

### 3.6. APPLICATIONS OF ADHOC NETWORKS

Table 3.2. Mobile ad hoc network applications

Application	Possible Scenarios/Services
Tactical networks	<ul style="list-style-type: none"> <li>• Military communication and operations</li> <li>• Automated battlefields</li> </ul>
Emergency services	<ul style="list-style-type: none"> <li>• Search and rescue operations</li> <li>• Disaster recovery</li> <li>• Replacement of fixed infrastructure in case of environmental disasters</li> <li>• Policing and fire fighting</li> <li>• Supporting doctors and nurses in hospitals</li> </ul>
Commercial and civilian environments	<ul style="list-style-type: none"> <li>• <b>E-commerce:</b> Electronic payments anytime and anywhere</li> <li>• Business dynamic database access, mobile offices</li> <li>• <b>Vehicular Services:</b> Road or accident guidance, transmission of road and weather conditions, taxi cab network, inter-vehicle networks</li> <li>• Sports stadiums, trade fairs, shopping malls</li> <li>• Networks of visitors at airports</li> </ul>
Home and enterprise networking	<ul style="list-style-type: none"> <li>• Home/office wireless networking</li> <li>• Conferences, meeting rooms</li> <li>• Personal area networks (PAN), personal networks (PN)</li> <li>• Networks at construction sites</li> </ul>