

MOBILE AD HOC NETWORKING FOR PERVASIVE COMPUTING

Sangeeta Mishra

Assistant Professor, Department of Computer Science and Engineering,
BBD, UPTU, Lucknow, UP

ABSTRACT: In the current scenario where we are using 3G and 4G technologies for communication purposes the Mobile Ad Hoc Networks (MANETs) are generating a lot of interests. The next generation of mobile communications will include both prominent infrastructure wireless networks (3G, 4G) and novel mobile ad hoc networks. It is a collection of portable wireless nodes that can dynamically form a network to exchange information without using any pre-existing fixed network infrastructure. This allows portable mobile devices to establish a communication path without having any central infrastructure. Since there is no centralized infrastructure in the MANET and the mobile devices are moving randomly, they may give rise to various kinds of problems, such as energy efficient and multicast congestion control. This paper describes the primary problems of ad hoc networking by giving its related research background. Some of the technical challenges it poses are also presented, based on which the paper points out some of the key research issues for ad hoc networking technology that are expected to promote the development and accelerate the commercial applications of the MANET technology. Special attention is paid on network layer routing strategy and key research issues include new X-cast routing algorithms, security & reliability schemes, QoS model, and mechanisms for interworking with outside IP networks.

KEYWORDS: Mobile Communications, Wireless Networks, QoS, Ad-hoc Networking, Pervasive Computing, Routing Algorithm, Multicast, Unicast, congestion.

INTRODUCTION: A mobile ad-hoc network (MANET) is composed of portable or mobile nodes without any infrastructure. Mobile nodes are self-organized to form a network over radio links. The goal of MANETs is to extend mobility into the realm of autonomous, mobile and wireless domains, where a set of nodes from the network by using some kind of the routing infrastructure in an ad-hoc fashion. The majority of applications of MANETs are in areas where fast and dynamic reconfiguration is necessary and wired network is not available. The mobile ad-hoc network is such a network which does not require any infrastructure like traditional wireless network. Initially, it can be useful for the smaller areas like with the computer lab, homes (For communicating with digital cameras, cooking ovens, washing machines, refrigerators, vacuum cleaners and thermostats), the classrooms, etc. But later on after it was successfully implemented and used in these small areas then there is tremendous scope of ad-hoc network. It can be used in military battlefields, emergency search, rescue sites, where participants share information dynamically using their mobile devices. These applications lend themselves well to multicast operations

In the last decade, advancement in both hardware and software techniques have resulted in mobile hosts and wireless networking. We can categories mobile wireless communication in two distinct approaches:

1. With Infrastructure. The current or traditional wireless mobile network requires good infrastructure support on the cellular concept in which mobile devices communicate with other mobile devices with base stations connected to the fixed network infrastructure. Typical examples of this kind of wireless networks are GSM, UMTS, WLL, WLAN, etc.

2. Without Infrastructure. In this approach, the mobile wireless network is commonly known as a mobile ad-hoc network (MANET).[1,2] In MANETs (Mobile Ad Hoc Networks) communication with the mobile nodes can be achieved by using multihop wireless links. The architecture of such network is based not on a centralized base station, but on each node which acts as a router and forwards data packets to other nodes in the network. The aim of each such protocol, in an ad-hoc network, is to find valid routes between two communicating nodes. These protocols must be able to handle high mobility of the nodes which often cause changes in the network topology. Wireless ad hoc networks themselves are an independent, wide area of research and applications, instead of being only just a complement of the cellular system.

In this paper, we express the basic problems of the ad hoc networking and we shall focus on its research background. Some of the key research issues for ad hoc networking technology are discussed in detail that are expected to promote the development and can assist in the development of the commercial applications of the MANET technology.

The paper is structured as follows. In Section II, the small description of the ad-hoc network is introduced, including its past research progress, its applications and current research scenario. The technical challenges of MANET are presented in Section III. Section IV mainly discusses the key research issues of MANET with the emphasis on network layer routing strategies. Finally, we summarize the paper by conclusions in Section V.

MANET BACKGROUND:

Manet Concept: MANETs inherits common characteristics found in wireless networks in general, and add characteristics specific to ad-hoc networking. In general, mobile ad hoc networks are formed dynamically by an autonomous system of mobile nodes that are connected via wireless links without using an existing network infrastructure or centralized administration. The nodes are free to move randomly and organize themselves arbitrarily; thus, the network's wireless topology may change rapidly and unpredictably. Such a network may operate in a standalone fashion, or may be connected to the larger Internet. Mobile ad hoc networks are infrastructure-less networks since they do not require any fixed infrastructure such as a base station for their operation.[3]

Fig. 1.1:Shows an example mobile ad hoc network (Infrastructure less) and its communication:



Fig. 1.1

Infrastructure-less wireless networks[4]

Fig. 1.2: Shows the examples of infrastructure-less wireless networks.

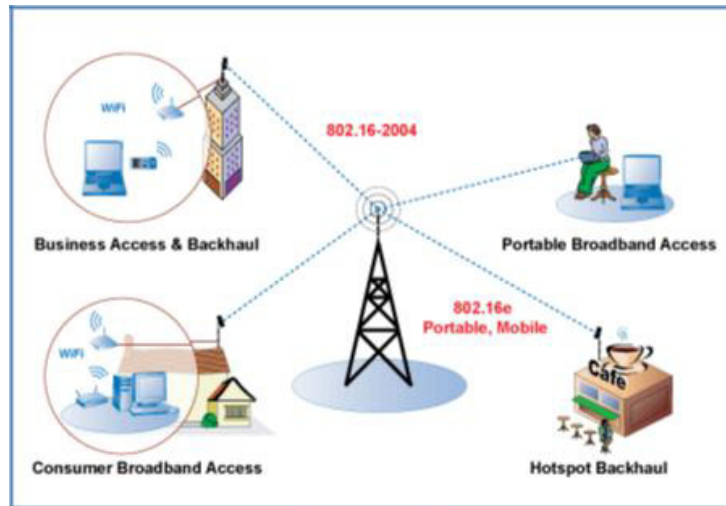


Fig. 1.2

Infrastructure-based wireless network[5]

MANET CHARACTERISTICS:

Manet has the following Characteristics:

1. In a MANET, each node acts as both host and router. That is, it is autonomous in behavior.
2. Multi-hop radio relaying - When a source node and destination node for a message is out of the radio range, the MANETs is capable of multi-hop routing.
3. Distributed nature of operation of security, routing and host configuration. A centralized firewall is absent here.
4. The nodes can join or leave the network anytime, making the network topology dynamic in nature.
5. Mobile nodes are characterized with less memory, power and light weight features.
6. The reliability, efficiency, stability and capacity of wireless links are often inferior when compared with wired links. This shows the fluctuating link bandwidth of wireless links.
7. Mobile and spontaneous behavior which demands minimum human intervention to configure the network.
8. All nodes have identical features with similar responsibilities and capabilities and hence it forms a completely symmetric environment.
9. High user density and large level of user mobility.
10. Nodal connectivity is intermittent.

Manet Status: The ad-hoc network is in existence since 1970s, when it was deployed in military operations. There is a wide scope of research on the ad-hoc network of military operations, disaster management and in the area where there is no supporting infrastructure for cellular communication because it does not require any infrastructure. The vision of mobile ad hoc networking is to support robust and efficient operation in mobile wireless networks by incorporating routing functionality into

mobile nodes much of which will involve the use of the Internet Protocol (IP) suite.[6] A new working group for MANET has been formed within the Internet Engineering Task Force (IETF). The aim of this task force is to investigate and develop standard Internet routing support for mobile communication and develops a framework for running IP based protocols in ad hoc networks.

Manet Applications: With the increase of the portable devices and the growing need of communication, ad hoc networking is gaining importance with the increasing number of widespread applications. It can be applied anywhere where there is little or no communication infrastructure or the existing infrastructure is expensive or inconvenient to use. Ad hoc networking allows the devices to maintain connections to the network as well as easily adding and removing devices to and from the network. Moreover the legacy applications that move from traditional infrastructure environment in the ad-hoc context, a great deal of new services can and will be generated for the new environment. Typical applications include:

Some of the Typical Applications Include:

1. **Military battlefield:** Advancement in the wireless technology has enabled military forces to use the state-of-art mobile technology, but if the ad-hoc network is adopted by the military forces it would allow them to take advantage of commonplace network technology to maintain an information network between the soldiers, vehicles, and military information head quarter.
2. **Collaborative work:** In some business environments, the need for collaborative computing might be more important outside office environments than inside and where people do need to have outside meetings to cooperate and exchange information on a given project.
3. **Local level:** Ad-hoc networks can autonomously link an instant and temporary multimedia network using notebook computers to spread and share information among participants at a conference or classroom. Another appropriate local level application might be in home networks where devices can communicate directly to exchange information.
4. **Personal area network (PAN) and Bluetooth:** A personal area network is a short range, localized network where nodes are usually associated with a given person.[7] Short-range MANET such as Bluetooth can simplify the intercommunication between various mobile devices such as a laptop, and a mobile phone.
5. **Commercial Sector:** Ad-hoc can be used in emergency/rescue operations for disaster relief efforts, e.g. in fire, flood, or earthquake. Emergency rescue operations must take place where non-existing or damaged communications infrastructure and rapid deployment of a communication network is needed.

MANET TECHNICAL CHALLENGES:

Manet Challenges: A MANET environment has to overcome certain issues of limitation and inefficiency. It includes:

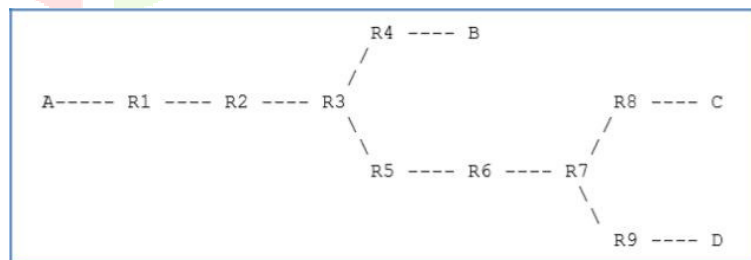
1. The wireless link characteristics are time-varying in nature: There are transmission impediments like fading, path loss, blockage and interference[8] that add to the susceptible behavior of wireless channels. The reliability of wireless transmission is resisted by different factors.
2. A limited range of wireless transmission: The limited radio band results in reduced data rates compared to the wireless networks. Hence the optimal usage of bandwidth is necessary by keeping low overhead as possible.

3. 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.
4. Route changes due to mobility: The dynamic nature of network topology results in frequent path breaks. So, some stale routes are generated in routing table which leads to unnecessary routing overhead.
5. Frequent network partitions: The random movement of nodes often leads to the partition of the network. This mostly affects the intermediate nodes.
6. 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.
7. Quality of Service (QoS). Providing different quality of service levels in a constantly changing environment will be a challenge. The inherent stochastic feature of communications quality in a MANET makes it difficult to offer fixed guarantees on the services offered to a device. An adaptive QoS must be implemented over the traditional resource reservation to support the multimedia services.

Key Research Issues: This section is divided into four points. The first point describes the X-cast routing algorithm that delivers packets to the destination node where each packet is equipped with an X-cast header. The point two discusses the internet working mechanism for the different nodes of the MANET. The third point discusses the quality of services for communicating nodes. This issue is the main challenge for MANET. The last point describes security, reliability and availability of the MANET.

X-cast Routing Algorithms: In the Host Group Model, the packet carries a multicast address as a logical identifier of all group members. In Xcast, the source node keeps track of the destinations in the multicast channel that it wants to send packets to.[9] The source encodes the list of destinations in the Xcast header, and then sends the packet to a router. Each router along the way parses the header; partitions the destinations based on each destination's next hop, and forward a packet with an appropriate Xcast header for each of the next hops. When there is only one destination left,[10] the Xcast packet can be converted into a normal encrusted packet, which can be encrusted along the remainder of the route. This is called X2U (Xcast to Unicast).

For example, suppose that A is trying to get packets distributed to B, C, and D in Figure 4.1 below:



This is accomplished as follows: A sends an Xcast packet to the list of destinations in its Xcast header to the first router, R1. Since the Xcast header will be slightly different for IPv4 and IPv6, the packet that A sends to R1 looks like this: [src = A, dest = B C D payload] When R1 receives this packet, it needs to properly process the Xcast header.[11] The processing that a router does on receiving one of these X cast packets is as follows:

1. Perform a route table lookup to determine the next hop for each of the destinations listed in the packet.
2. Partition the set of destinations based on their next hops.
3. Replicate the packet so that there's one copy of the packet for each of the next hops found in the previous steps.
4. Modify the list of destinations in each of the copies so that the list in the copy for a given next hop includes just the destinations that ought to be routed through that next hop.
5. Send the modified copies of the packet on to the next hops.
6. Optimization: If there is only one destination for a particular next hop, the packet can be sent as a standard unicast packet to the destination (X2U). So, in the example above, R1 will send a single packet on to R2 with a destination list of < B C D >, and R2 will send a single packet to R3 with the same destination list.

Internet Working Mechanisms: The mobility mode of an ad-hoc network is quite different from that of infrastructure networks. In infrastructure networks only the nodes (Terminals) at the very edges (The last hop) of fixed networks are moving, whereas an ad-hoc network can be completely mobile, since a device can serve both as router and host at the same time. Consequently, in an ad hoc network mobility is handled directly by the routing algorithm.

The ad-hoc network should be facilitated to access both the networks which are within the ad-hoc network and to the public networks (e.g. The Internet). The mobile ad-hoc network is required to not only communicate with the individual mobile node, but it is to be required to communicate with the outside network so that huge amount of data can be accessed and decisions can be made. Therefore the internet working between the fixed network and the mobile nodes is necessary. To establish this internet working Internetwork Protocol (IP) need to be studied in depth to explore the possibility if internet working. The coexistence and cooperation with the public IP based wireless networks is necessary to many contexts.

QoS Supporting Model: For obtaining QoS (Quality of Service) on a MANET, it is not sufficient to provide a basic routing functionality. Other aspects should also be taken into consideration such as bandwidth constraints due generally to a shared media, dynamic topology since MNs are mobile and the topology may change and power consumption due to limited batteries.

QoS need to support multimedia like audio, video, voice, web and data stream services which will most likely be required within and throughout the MANET.,

In such a stochastic changing environment involving dynamic nodes, hidden terminals, and fluctuating link characteristics, supporting end-to-end QoS at different levels will be a great challenge that requires in-depth investigation.[12] An adaptive QoS must be implemented over the traditional plain resource reservation to support the multimedia services. Special emphasis should be put on achieving a new QoS model for MANETs by taking into account the ad-hoc features of the target networks: dynamic node roles, data flow granularity, traffic profile, etc.

Availability, Reliability and Security Schemes: Availability, Reliability, and Security are three crucial aspects of MANET, especially in security-sensitive applications. During the development and designing of MANET protocol the availability, reliability and security issues must be taken into consideration. Since it is a wireless network and wireless network is susceptible to security threats.[13] As we have earlier discussed that MANET topology changes very fast and frequently, the undergoing protocol stack must ensure availability of the node involving in the communication process. Some authentication procedure among the communicating node can be introduced for secure communication, within the internetwork group of nodes and for the nodes outside the MANET. Various types of threats and attacks against routing in MANET should be analyzed leading to the requirement of ad-hoc network routing, security and higher solutions need for the secure routing of the MANET.

Security is another major deployment concern; due to the mobility and wireless nature of the network malicious nodes can enter the network at any time, the security of the nodes and the data transmitted needs to be considered.[14] Due to these issues ad-hoc networks are not appropriate for most general usage of mobile devices, where internet access is the key requirement; in these situations wireless devices typically connect into the wired infrastructures through access points (AP) to reduce the unreliability of the wireless domain.[15] However Ad-Hoc networks show great potential in situations where internet access is not a key requirement or infrastructure is not available; including disaster or military scenarios or in low power wireless sensor networks or vehicles which only need to communicate with each other.

CONCLUSIONS: This article describes the primary issues of ad-hoc network and analyzes key research problems of the MANET. In the beginning of the paper we have discussed some of the background information of MANET like its concepts, areas of application, features and current status. The four key issues concerning the network layer of MANET have been discussed in detail and MANET routing strategies has been discussed. MANET, one of the most dominant feature technologically, support pervasive computing scenario.

There is a wide scope of research and development of new protocols in mobile ad-hoc network, as drafted by IETF. Mobile ad hoc network best suits to the areas where there is no infrastructure. The mobile devices themselves are cable of working as router and as well as communicating devices. This leads to various concerning research issues around the MANET like its safety, security, internet working and different new type's protocol stack.

REFERENCES:

1. T.W. F. Wang, D. Zeng, and L.Yang, "Smart ars on Smart Roads: An IEEE Intelligent transportation Systems Society Update,"IEEE Pervasive Computing, vol. 5, no. 4, pp.68-69, Oct.-Dec.2006.
2. Ad Hoc Networking Extended Research Project. Online Project.
3. <http://triton.cc.gatech.edu/ubicomp/505>.
4. Royer and C.K. Toh, "A review of current routing protocols for ad-hoc mobile wireless networks," IEEE Personal Communications, vol. 6, no.2, pp. 46-55, 1999.
5. https://www.google.co.in/search?q=images+of+ad+hoc+network&num=20&source=lnms&tbm=isch&sa=X&ved=0CAcQ_AUoAWoVChMImuucrJ7zXgIVQn6ICh2sAgIH

6. https://www.google.co.in/search?biw=1280&bih=667&tbm=isch&sa=1&q=infrastructure+based+MANET+&oq=infrastructure+based+MANET+&gs_l=img.3...19799.25115.0.25883.20.20.0.0.5.285.2399.0j9j3.12.0....0...1c.1.64.img..19.1.185._AFzDHrspro
7. J. Hubaux, S. Capkun, and J. Luo, "The Security and Privacy of Smart Vehicles," *IEEE Security and Privacy Magazine*, vol. 2, no.3, pp.49–55, May/June 2004. <http://eprints.usm.my/16280/1/effect.pdf>.
8. M. Gerla, C.-C. Chiang, and L. Zhang, "Tree multicast strategies in mobile, multihop wireless networks," *ACM/Baltzer Mobile Networks and Applications*, special issue on Mobile Ad Hoc Networking, 4 (3), pp.193-207, 1999.
9. R. Akbani, T. Korkmaz, and G.V. S. Raju, "HEAP: A packet authentication scheme for mobile ad hoc networks," *Ad Hoc Networks*, vol. 6, no. 7, pp. 1134–1150, 2008.
10. Boukerche et al., "Routing protocols in ad hoc networks: A survey," *Computer Networks: The International Journal of Computer and Telecommunications Networking*, vol. 55, no. 13. pp. 3032–3080, May 2011.
11. K. Sampigethaya, M. Li, L. Huang, and R. Poovendran, AMOEBA: Robust Location Privacy Scheme for VANET," *IEEE J. Selected Areas in Comm.*, vol. 25, no. 8, pp. 1569-1589, Oct. 2007.
12. S. Sesay, Z Yang and Jianhua He, "A survey on Mobile Ad Hoc Network", *Information Technology Journal* 3 (2), pp.168-175, 2004.
13. Javed Alam and M. K. Pandey "Development of Intelligent Traffic Light System Based On Congestion Estimation Using Fuzzy Logic" in International Organization of Scientific Research, *Journal of Computer Engineering (IOSR-JCE)*, Vol. 16, Issue 3, PP 36-44, June 2014.
14. F. Delli Priscoli, et al., "Application of dynamic channel allocation strategies to the GSM cellular network," *Selected Areas in Communications, IEEE Journal on*, vol. 15, pp. 1558-1567, 1997.
15. Rakesh Kumar and Mayank Dave, "A Comparative Study of Various Routing Protocols in VANET," *International Journal of Computer Science Issues (IJCSI)*, vol. 8, Issue 4, no. 1, July 2011.

RESEARCH ARTICLE

AUTHORS:

1. Sangeeta Mishra

PARTICULARS OF CONTRIBUTORS:

1. Assistant Professor, Department of Computer Science and Engineering, BBD, UPTU, Lucknow, UP.

Date of Submission: 26/03/2018.

Date of Peer Review:

Date of Acceptance:

Date of Publishing: