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MANETs: Overview, Tools, Security and Applications in Health Care

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ABSTRACT

Background: The rapid advancements in the wireless technologies aim at pervasive computing that maintains communication between mobile nodes without any geographical and time constraints. The self-organized, self-administered, self-created and temporarily made wireless networks are called as Mobile Adhoc Networks (MANETs). Such networks can exist at anytime and anywhere and provide facilities where possibility of infrastructure networks looks hard. These networks prove people friendly irrespective of their geographical location. This is because infrastructure may not be required for short range communication. In Mobile adhoc networks, no central controlling unit is present which makes it different from cellular networks. This special feature has attracted its use in the areas of defense, emergency, health care, combined or collective networks, fire predictions, education etc. **Objective:** This paper gives an introduction to the mobile adhoc networks and also discusses various simulation tools available today for MANETs. Since nodes which are also called as mobile routers in Mobile adhoc networks involve unpredicted topology hence for such networks security of nodes, routing is a major challenging task. This paper also highlights various security issues faced by such networks. This paper also discusses applications of MANETs in healthcare and also presents other possible areas in which such networks can be applied in real world. This paper also discusses various cold and emerging research areas which can be further explored for future work. **Result:** The traditional health care system can be improved and made more user friendly by efficient use of MANETs technology. **Conclusion:** It is concluded that resources consumption can be minimized and facilities for health care can be made available at doorsteps by the use of MANETs. The increase in MANETs usage technology has also proved beneficial to elders, handicapped, pregnant women as this technology minimizes transportation, saves time, avoids long queues in hospitals.

INTRODUCTION

The origin of Mobile Adhoc Networks (MANETs) lies back in 1970s when Defense Advanced Research Projects Agency (DARPA) initiated packet radio networks for communication. The first packet radio network was ALOHA (Bang, A.O. and P.L. Ramteke, 2013) which provided reliable communication between nodes. These were the 1st Generation adhoc network systems having characteristics like half duplex transmission and reception, chip modulation, spread spectrum, network management techniques, radio frequencies capabilities. The second generation adhoc network systems – Global Mobile Information System, Near Term Digital Radio came in 1980s with improvements in applications, radio performance, scalability and security. The third generation adhoc networks came in 1990s with applications like Bluetooth and adhoc sensors (Bang, A.O. and P.L. Ramteke, 2013).

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MANET Internet Engineering Task Force (IETF) working group formed in 1998 (https://datatracker.ietf.org/wg/manet/charter/) not only gives the current status of working of MANETS but also tells the technical issues in its implementation. The purpose of this working group is ``*to standardize IP routing protocol functionality suitable for wireless routing application within both static and dynamic topologies. The fundamental design issues are that the wireless link interfaces have some unique routing interface characteristics and that node topologies within a wireless routing region may experience increased dynamics, due to motion or other factors".* Such networks have no central node or access point for central administration and control. The network topology and network address assignment gets changed as the mobile routers move from one network to another. General mobile adhoc network has been shown in Fig.1.

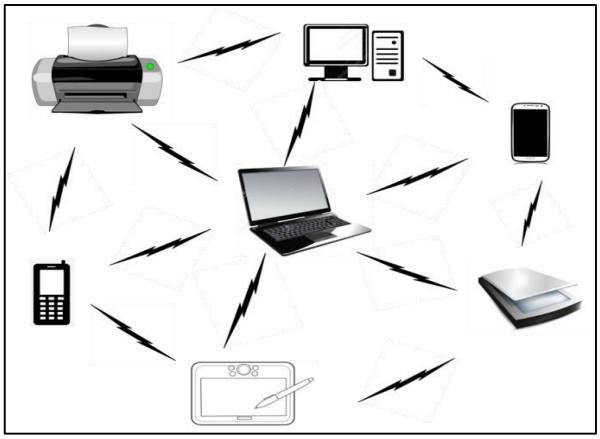

Fig. 1: General mobile adhoc network

Since simultaneous transmission by all nodes is not possible, therefore protocols are needed for selecting nodes, called relays, for cooperative transmission. In order to increase the transmission coverage and save power, cooperative adhoc networks are also possible. Such networks allow different nodes which are ready to transmit to help collectively in transmission to other nodes. The authors in (Biswas, M., *et al*., 2014) have proposed cooperative MANET system on the basis of energy proficient topology control and optimum relay node selection. The nodes in the network are not secure as there are threats from inside as well as outside nodes. A MANET is an adhoc network but an adhoc network is not necessarily a MANET as represented in Fig. 2. Communication at airports (Frodigh, M., *et al*., 2002) is an example of mobile adhoc network. Whenever a new trust group is to be created as the nodes move randomly in the network, security is always an issue which occurs at different layers of MANETs. The current paper starts with an introduction to mobile adhoc networks in Section I. Section II discusses the need of such networks. Section III discusses various simulation tools used for MANETs. Section IV gives an insight into the security issues faced by such networks and future research directions. Section V discusses applications of MANETs in health care. This has been found that MANET paradigm is rapidly decreasing in terms of MANET protocols.

II. Why we go for adhoc?:

MANETs prove practical for short range communication as well as for real world applications in disaster management, crisis situations or emergencies where temporary communication network is the requirement. The features like scalability, flexibility, mobility, easy installation, no initial cost for setting base stations, temporary network management has added new directions in the wireless technologies applications. Routing protocols developed for MANETs are either specifically for MANETs or are derived from protocols for infrastructure networks. Not only this, research is also going on hybrid networks employing both infrastructure less networks as well as some central controlling unit. Adhoc and infrastructure based networks e.g. hybrid cellular opportunistic networks (ONs) as presented in (Conti, M., *et al*., 2015) in which nodes are mobile or fixed and communication are possible among nodes using dynamic routes. ONs are a special case of Disruption Tolerant Networks (DTNs). MANETs can also be extended to vehicle movements. The issues that are critical in Vehicular Adhoc Networks (VANETs) are spectrum usage, data centric design and Information centric networking.

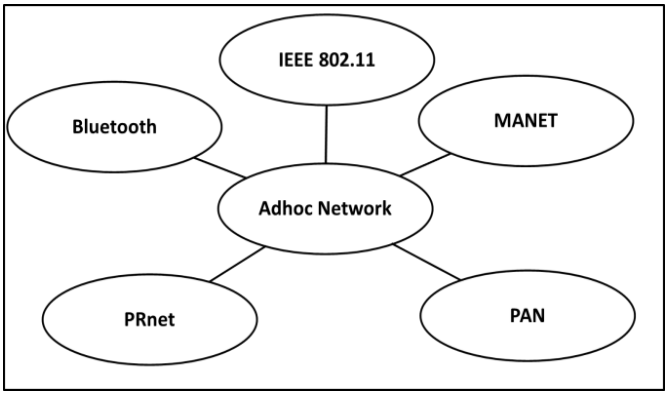

Fig. 2: Classification of Adhoc Networks

The main aspect in implementing a mobile adhoc application is its security. Design based and game theoretical model can be implemented using directional antenna for security purpose. The authors in (Rachedi, A., *et al*., 2009) have proposed Dynamic Demilitarized Zone as a solution for protecting certificate authority node against probable attacks. Also use of Intrusion Detection Systems in MANETs security has also been proposed in (Rachedi, A., *et al*., 2009). They have defined clustering algorithm for authentication and integrity of data in MANETs.

III. Simulation Tools Description:

Simulation tools are universally accepted software for studying and implementing adhoc networks. MANETs can be developed and their protocols can be tested using following tools- NS2, SWANS, OPNET, GloMoSim, SUMO, TraNS.

NS2 is Unix based Network Simulator which can be used by researchers and teaching professionals. It was invented in 1996-97.This can be used for wired and wireless network simulation. It uses the network structure used for TCP, UDP, etc. i.e. simulates variety of IP packets.NS2 programming is written in C++ and Tool Command script language. For the first time user the installation is quite complicated as there are very few user friendly links or videos available (Fall, K. and K. Varadhan, 2011).

SWANS (Barr, R., 2004) is Scalable Wireless Adhoc Network Simulator which is a virtual machine based simulator that works on Java script and is specifically designed to cover the research needs in the field of wireless and adhoc networks. The performance of SWANS is no doubt more appropriate than NS2 performance and that too in shorter times.

GloMoSim (Dehghan, M. and A. Darehshoorzadeh) is Global Mobile Information Simulator which is again a protocol simulator based on Parsec C language. But this simulator is not used nowadays. It now supports protocols that are purely for wireless networks but earlier it was developed for both wired and wireless networks. It is commercially available software with less memory consumption and more code complexity.

OPNET (Jarmo, P., 2006) is commercially available software used for network simulation and analysis, developed by OPNET Technologies. It is very expensive software but free version is also available for educational purposes. It can be utilized for different heterogeneous networks simulation using wide variety of protocols. Existing protocols and models can be utilized and new ones can be proposed. It was earlier developed for military applications but later it proved to be powerful tool for all networks simulations. It is a high level user interface based on C and C++ source code and various OPNET library functions.

SUMO is Simulation of Urban Mobility tool that is specifically used for vehicular communications and traffic management (Krajzewicz, D., *et al*., 2012). It is high performance, microscopic traffic road simulation package that was started in 2001 with first open source release in 2002.It was mainly developed by Institute of Transportation Systems at German Aerospace Centre.

Another Traffic simulation tool is TraNS (Piorkowski, M.,). TraNS is open source simulation tool which can be used for both Traffic and Network simulations. This tool combines the network simulator NS2 and traffic simulator SUMO features. This tool can be used for exhaustive calculation of vehicle movements at network centric and application centric levels.

IV. Security Challenges And Research Directions:

Since MANETs adopt dynamic topology and there is no central controlling unit to supervise the network, hence security of nodes, routing techniques used is the major challenging issue in such networks. In MANETs, due to absence of controlling or base station unit, there is lack of authenticity in the network. These are called the threats due to which any system or network can be weakened and the ability of a network can be exploited by means of intelligent sources. Not only this, MANETS are also prone to External & Internal attacks. External

attacks arise by the nodes, which are out of the boundary of the network and can lead to false data, disruption of network, etc. While internal attacks arise by the nodes which are within the network itself. Any faulty or malicious nodes appear as a true node and participate in various activities of the network. MANETs must be made secure in terms of availability of resources, Privacy, Integrity, and Authenticity, authority, anonymity and non-repudiation of information (Goyal, P *et al*., 2011).

To avoid any selfish node and for trust establishment between nodes, cooperative enforcement schemes are implemented. As distance from nodes increases, trust among nodes decreases in the network. Credit based and reputation based cooperation enforcement schemes are used for providing short routes and increasing the probability of successful transmission. This will also help in minimizing attacks and threats on network layer of MANETs (Maris, G.F., *et al*., 2006).

Another problem encountered in MANETs is the address conflict which arises as the nodes moves from one network to another. Different techniques and protocols are available that do address assignment automatically. Dynamic Host Configuration Protocol (DHCP) used for wired networks is not applicable for MANETs. Three address assignment techniques have been described by authors in (Gammar, S.M., *et al.*, 2010). These are – Stateless, Stateful and Hybrid. In Stateless address assignment, each node assigns address on its own and no address information is maintained by nodes. In stateful approach, each node has a record of already used addresses and address assignment for new nodes is done by neighbor nodes. In hybrid approach, each node is capable of configuring its address which can be combined with stateful approach (Gammar, S.M., *et al*., 2010). Adhoc Networks are standalone self-ruling, self-governing and self-determining network. Statistics of study shows that majority of work has been done in developing new routing protocols or modifying existing ones and this has been a cold area of research in MANETS. In (Penttinen, A. 2002), authors have highlighted future directions of research in different areas of MANETs. Research in the implementation of energy saving protocols with characteristics like maximizing both network and single battery lifetime by taking into considerations concept of sleepy nodes is also popular. Energy efficiency can be improved by sensing inactivity on application layer by using different algorithms, routing techniques, etc. By combining preferable properties of different routing protocols a Cooperative MANET can also be proposed. Various major projects in this field which have been done and are in progress. The Terminodes project aims to produce large scale adhoc network with features like security, position determination, mobility administration. Another project Smart dust aims at designing, building, testing network consisting of small nodes. The project can be used in military, traffic management, sensing during earthquakes.

Not only this, integration of WSN-MANET will enable cross network communication with low latency in different domains of IoT. Integrated models can be developed which will support heterogeneous networks and will improve the coverage and capacity of future wireless networks (Bellavista, P., *et al*., 2013). As represented in (Singh, S., *et al*., 2012), MANETs research has declined in the field of routing protocols. The major thrust areas are location determination, security, power management, QoS, Mobility management, multiple access.

V. Applications In Health Care:

No doubt, MANETs have found applications in fields of smart cities, industrial internet, fire predictions, heterogeneous networks, vehicular networking, environmental monitoring and virtual classrooms in addition to personal health care. This section is specifically dedicated to applications in the medical field. MANETs are a solution for communication during earthquakes, hurricanes, destroyed networks, rescue and search operations.

In (Li, Z., *et al*., 2005), the authors have utilized bandwidth resources and storage capabilities of grid computing to add more properties to adhoc networks. Application in e-healthcare is possible by combining these technologies which provides pre- hospital treatment to the patient. A lightweight architecture has been presented which supports anywhere anytime feature of mobile adhoc networks. The factors like Job Scheduling, QoS provisioning in the design of architecture has been taken into considerations. But the challenges faced by such networks are- on request access of distributed data, suitable job concerns, simultaneous data streams transmissions and fault resistant infrastructure.

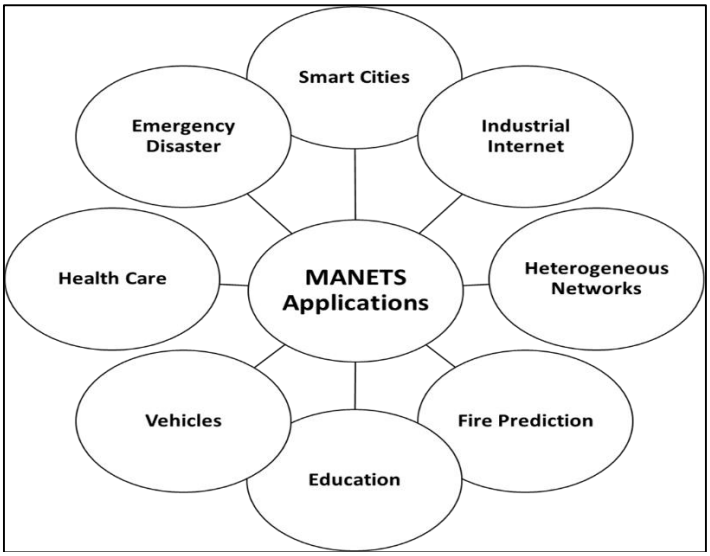

Fig. 3: Applications of MANETs

A mobile device application for smart phones has been developed by authors in (Paschou, M., *et al*., 2015) which not only provides personal satisfaction to the hospital staff but also decreases the time overheads for both patients as well as medical staff. A personal rostering solution has been proposed and implemented. A hospital management system has been implemented which supports features like automatic shift updates, recordings and emergency management. This has been implemented using XML architecture and effective security solutions for this system have been defined for future study. This is being a ubiquitous information system which will prove helpful for managing day to day activities of hospital staff.

Participatory sensing campaigns have been proposed by authors in (Burke, Jeffrey, A., *et al*., 2006) and can be done in public health sector- e.g. health care identities and government bodies can initiate activities to collect data and analyze it for preventive care regimes. This will help in timely care, patient alertness and quality feedback of information. It will also help in utilizing the resources for both professional and public interest.

In healthcare applications, energy efficient routing protocols are desired. One such solution is Dynamic Energy Efficient Routing Protocol (DEERP) that was selected from proactive and reactive routing protocols by authors in (Abid, S., *et al*., 2014). They have concluded that this protocol gives better performance in terms of energy consumed in idle mode, transmitter mode, receiver mode and maximum remaining energy as compared to other protocols.

In (Kumar, S., A. Soni and R. Kumar, 2015), authors have proposed microcontroller based remote patient monitoring system using MANETs. A flexible, low cost, auto configurable, easy to deploy solution for remote monitoring of patients has been developed. The system architecture consists of acquisition of data, processing and then communication with remote doctors.

Today's smart phones have made many facilities mobile like emergency alert messages, breathing rate, blood pressure, glucose level, temperature and other vital signs of patients can be checked. For elders and handicapped people, long queues can be avoided as home care patient monitoring systems are a boon to the society. The conventional way of visiting hospitals has become smart and intelligent.

Conclusion:

Latest technological advancements have found greater impact on our daily life and are becoming primary part of our living. MANETs have been a practical solution for disaster management, crisis situations, and emergencies during military operations, traffic management and networking, rescue operations. This paper presented a brief history and introduction to mobile adhoc networks technology. Important features of various simulation tools available today for implementing adhoc networks have also been discussed. The security issues, supported projects and applications of adhoc networks especially in the area of advanced health care have also been highlighted. It is concluded that resources consumption can be minimized and facilities for health care can be made available at doorsteps by the use of MANETs. The increase in MANETs usage technology has also proved beneficial to elders, handicapped, pregnant women as this technology minimizes transportation ,saves time, avoids long queues in hospitals.

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