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An Overview of MANET: Generations, Characteristics & Applications

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ABSTRACT: A network refers to a group or system of interconnected objects, devices, or people that are linked together to share information, resources, or services. In computing, a network is typically made up of computer systems, servers, routers, switches, and other hardware and software components that allow them to communicate with each other. A MANET is an ad-hoc network that connects a group of mobile devices together into a decentralized wireless mesh network. A MANET can move around, add and remove mobile devices, and reconfigure itself on the fly. These networks often use standard wireless technologies like Wi-Fi, cellular, and Bluetooth, although some specialized equipment uses UHF and VHF radio frequencies. This paper covers introduction to networks, its classification into wired and wireless networks, evolution of mobile adhoc networks, its characteristics & applications.

KEYWORDS: Adhoc, Applications, Characteristics, History, MANET, Network, Wireless

I. INTRODUCTION

Computer network is required to share resources via interconnected nodes that can transmit audio, video & text messages. The nodes in the network comprise of dissimilar gadgets such as personal computers, laptop, mobile phones or any other such devices. The interconnections can be categorized as connection oriented or connection less and the nodes are interconnected with each other by means of various network topologies. The network addresses help in locating the nodes to establish route path. Many factors are considered while creating computer networks such as transmission medium, bandwidth, communications protocols, network size, topology, traffic control mechanism, networking load, energy efficiency. Broadly, Computer networks is categorized into two parts, wireless networks and wired networks. Wired Networks [1,2] imply connections through any physical medium via cables such as copper wire cable, twisted pair cables, fiber optic cables etc. All the gadgets such as laptops or desktop are connected to internet through cables only. In wired networks, routers are required to establish connections via Ethernet ports. The cable is connected to Ethernet port from one end and connected to node from another end on network router. With invent of wireless communication, world has become global village. Wireless network [1,2] allows the devices to stay connected but not through cables. Generally radio waves are used for wireless data communication between two devices. It makes the devices to be connected to the network while roaming from one place to other place as shown in figure 1. This type of network allows device to stay connected but in untethered ways and allows flow of communication freely via electronic media where distances are not a bar. In present scenario, whole world is relishing high speed internet access in affordable manner that is helpful in promoting communication and hence business worldwide. The Wireless network types are as follows:-

- Infrastructure Wireless Network
- Infrastructure-less Wireless Network

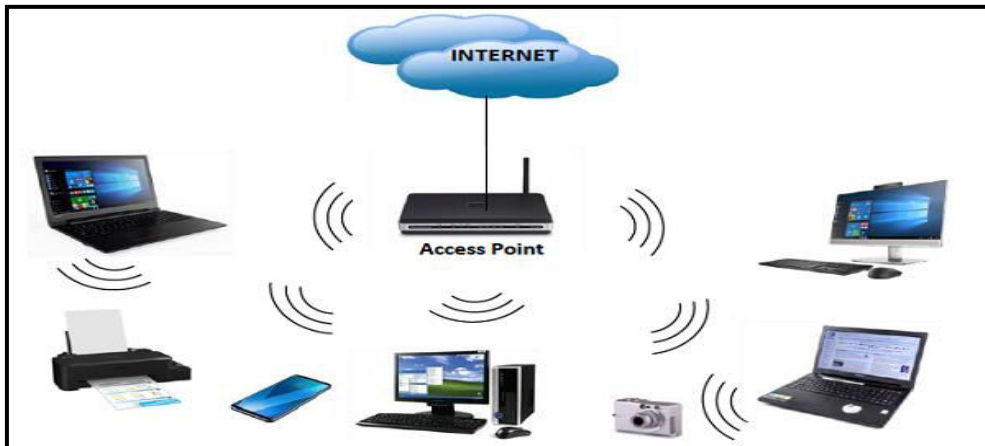


Figure 1: Wireless Networks

In case of Infrastructure wireless networks [3,4], medium is required to create and supports infrastructure to establish networks as shown in figure 2.

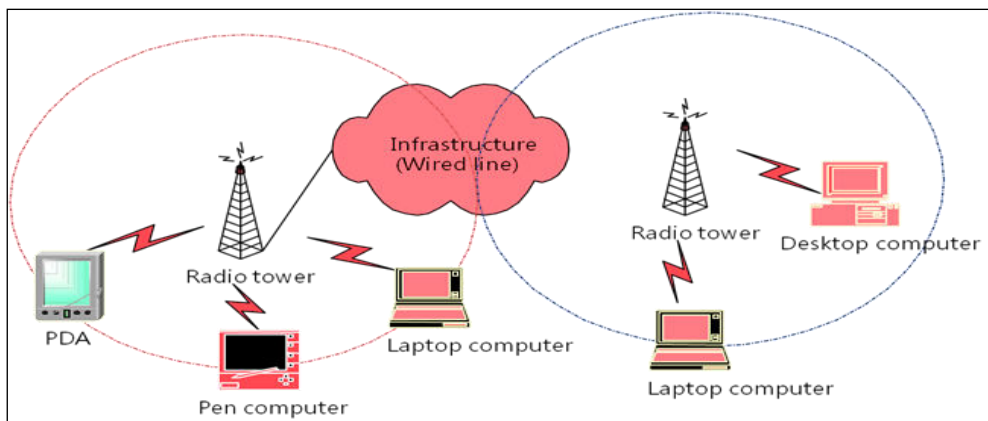


Figure 2: Infrastructure Wireless Network

In these networks, the communication takes place between wireless nodes through base station that is fixed. Cellular phone can be considered as an example to understand the concept of infrastructure network that needs towers for its functionality. In this type of network, access points can be added easily to enhance the range. This network is suitable for permanent network and also used to connect with other types of network such as wired network. There is no fixed base station in this type of network [3,4], mobile nodes are free to move while establishing communication path as shown in figure 3. Here, all nodes can participate to become a router. Routes are established dynamically and network is formed as and when required.

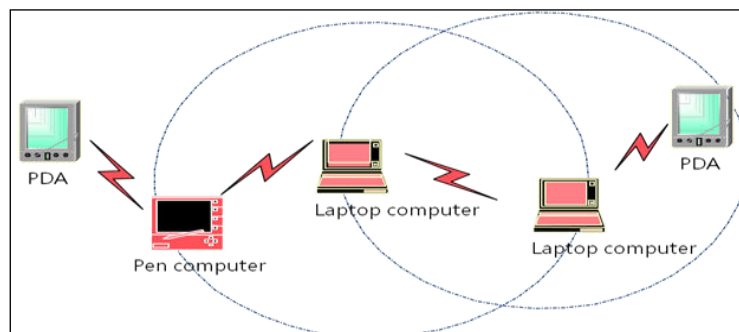


Figure 3: Infrastructure-less Wireless Network

Devi, M. and Gill, N. S. [5] in their paper entitled Novel Algorithm for Enhancing Bitrate in MANET for Topology Based Routing Protocol displays Infrastructure & Infrastructure-less wireless networks as given in figure 4.

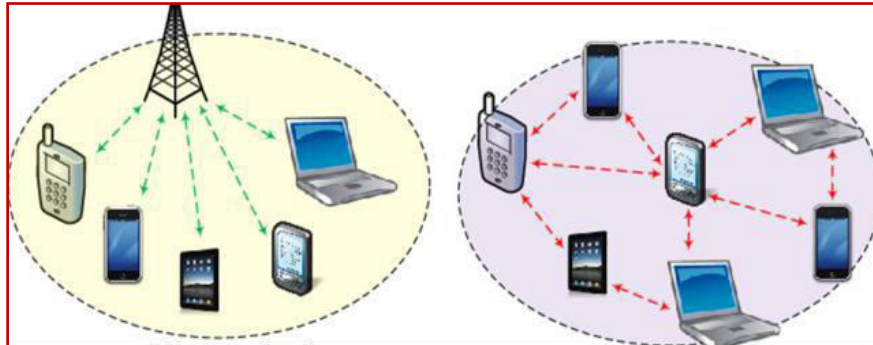


Figure 4: Infrastructure & Infrastructure-less Wireless Networks

II. MOBILE ADHOC NETWORK (MANET)

MANET [6] is among the attention seeking topic of research which is of utmost importance and gave rise to numerous other applications such as Tactical Networks [7], Wireless Sensor Networks (WSN), Data and Device Networks. Infrastructure-less devices are capable of configuring themselves wirelessly which makes up Mobile Adhoc Network [8,9]. With this functionality, gadgets such as mobile phones, laptops, sensors, palmtop etc. can change their location and re-arrange themselves as depicted in figure 5. Prerequisite for establishing mobile adhoc network is its ability to track existence of other devices so that appropriate set up can be done to smooth the process and expedite communication for sharing of data and services. Adding and removing nodes is also major task to be performed by mobile adhoc network for its maintenance.

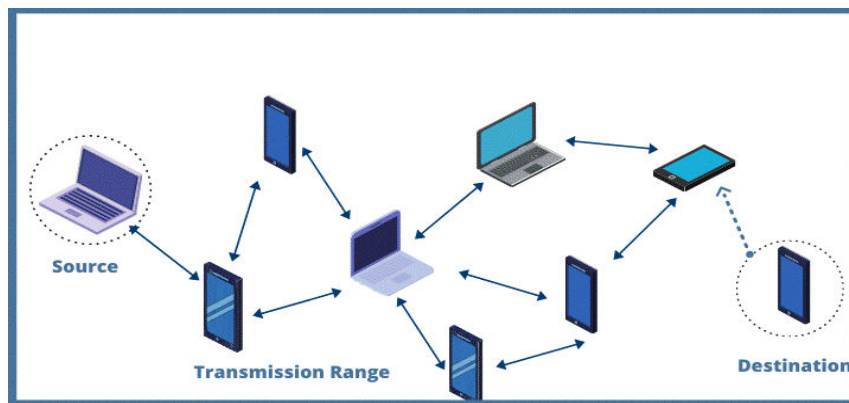


Figure 5: MANET

III. GENERATIONS OF MANET

Adhoc network life cycle is divided into three generation networks system. Current Adhoc networks system is taken as the third generation. Adhoc networks were called as Packet Radio Networks (PRNET) when the first generation began in 1973. To begin with, the Defense Advanced Research Projects Agency (DARPA) put efforts to ensure reliable computer communications. This project DARPA PRNET included Network equipments, routing protocols and protocols for automated network management. In connection with Areal Locations of Hazardous Atmospheres (ALOHA) and Carrier Sense Multiple Access (CSMA) techniques for Medium Access Control (MAC) and distance-vector routing, PRNET were meant to test network potential in a challenging situation. In 1980s, as part of the Survivable Adaptive Radio Networks (SURAN) programme, the adhoc network technologies were evolved to mark the second generation adhoc networks. Packet switched network is being provided to the mobile area in a surroundings with no infrastructure. This initiative succeeded in making the radios more effective by making them more compact, affordable, and resistant to electronic attacks. The idea of commercial adhoc networks came into view in 1990s along with computer systems and other useful communications tools.



Since middle of 1990, numerous efforts have been put on the adhoc standards. The IETF's MANET group was formed with the objective of standardized routing protocols for networks that are adhoc in nature. The IEEE 802.11 subcommittee defined a MAC protocol for creating mobile adhoc network prototypes using laptops and PCMCIA/PC cards. These protocols supported veiled terminals and shun collisions. Some of the standards such as High Performance Radio LAN (Hiper LAN) and Bluetooth benefited adhoc networking. The most recent advancement of 3rd generation is adhoc sensor network. Mobile Adhoc Networks and mobile adhoc sensors networks are two categories of adhoc networks. Mobile adhoc sensor network follow a wide sequence of functional scenarios, hence demand a minute intricate setup system. A mobile adhoc sensor or hybrid adhoc network comprises of many sensor distributes throughout a broad spectrum. Every single sensor has mobile communication capabilities and possesses intelligence to some extent and analyzes signals to communicate data. Routing protocols [10] determine node connectivity and routes packets to facilitate routing communication effectively. This formulates a robust and highly adaptable mobile adhoc sensor network that can be set up in varied situations. Mobile adhoc sensor networks have proven useful in a various instances. These networks improve the functionality in various sectors such as several civil works as in a military operation to learn more about where and how the rival is moving. Adhoc sensor networks can be employed in the networks to study automobile congestions on highway. In case of mobile surveillance sensor network, security can be provided in very sensitive places like malls, hotels, offices and other important areas. There are many other application areas of mobile adhoc sensor networks such as in parking area to trace free and unavailable spots, to observe ecological change in areas such as forests, oceans, forest fires, weather patterns, examination of endangered species, global warming etc. The mobile adhoc sensor network is a revolution with a broad scope and it affects our living. Each node or host in mobile adhoc sensor networks may be provided with different sensors to detect various events. In adhoc sensor networks, incurrence of costs such as running costs or installation cost is less. It has wider scope of implementation for the upcoming generations. The main concern of proposed research is to streamline various schemes existing at present into a single framework. The main objective is to formulate a standard for all the potential applications that will utilize adhoc networks for implementations. Wireless devices are getting smaller, cheaper and more sophisticated. Table 1 depicts generations of MANET.

Table 1: Generations of MANET

<i>Generations of MANET</i>	<i>Rationale</i>
<i>The first generation</i> PRNET (1973 to mid-1980s)	In order to provide reliable computer communications, DARPA began investigating the viability of employing packet-switched radio communications. This led to development of packet radio networks. Packet radio network components includes firmware, communication, measuring, cyclic redundancy checksum, chip modulation, radio frequency capabilities, routing and network management.
<i>The 2nd generation</i> SURAN, GloMo and NTDR (1980s to mid 1990s)	Second generation innovations concentrated on the further expansion of the already developed network structure. Some important progress includes SURAN Programme, Global Mobile Information (GloMo) Systems and Near Term Digital Radio (NTDR) Systems .
<i>The 3rd generation</i> Adhoc Networks, Bluetooth, Adhoc Sensor Networks (1990s to till dated)	Third generation adhoc network systems are also known as commercial adhoc network systems. During this generation, the significant commercial applications of mobile adhoc networks emerged as Bluetooth & Adhoc Sensor Networks. In order to transfer wireless data across small distances, Bluetooth uses radio waves, which was initially launched in 1998. A mobile adhoc sensor network is made up of various sensors distributed over a region. Each sensor has some level of intelligence to analyze signals and communicate data. These networks are effective in particular applications, such as parking places, businesses and the military. Recently, new technologies that enable long-range communications [11] have emerged viz. Long Term Evolution for Machines (LTE-M), Narrowband-Internet of Things (NB-IoT), 5G, Long Range (LoRa) and Sigfox .

IV. CHARACTERISTICS OF MANET

This network has the potential to open new possibilities and captivating opportunities for users. Since these nodes are autonomous, they can move anywhere and still has connection with each other. The Significant characteristics [12] of MANET are:-

- a) **Dynamic Topology:** Network topology varies quickly at unpredictable periods and may include both bi-directional and uni-directional links. This is because mobile nodes in this network are free to move arbitrarily. Mobile nodes forming adhoc network join and leave the network randomly without any prior information that causes regular transformations in network topologies. The temporal nature of MANET topology and network traffic patterns pose serious threat to efficient computing in such hostile environment. Computing efficiency is seriously threatened by the temporal characteristic of MANET architecture and network traffic patterns in this environment.
- b) **Autonomous Terminal:** Each mobile terminal in MANET is a unique node with the ability to serve as host & router. Nodes are able to do switching task as router in addition to their basic computational power as hosts. Hence, endpoints and switches in MANET are sometimes indistinguishable.
- c) **Multi-hop Communication:** A lot of pairs of mobile nodes are not able to interact directly as each radio connection has an inadequate communication range; instead, they must transfer data to each other through one or more cooperative intermediary mobile nodes. A multi-hop network comprises of computers and nodes those are mobile in nature and are linked by wireless communication channels mainly implemented with digital packet a radio that is one of the techniques of packet switching. Each link through which packet is delivered is referred as a hop. Route or path refers to the set of connections that a packet uses to travel from one way to another. In Figure 6, the shaded circle signifies the local adhoc network created for transferring data from source mobile node to destination mobile node. The dotted circle signifies the transmission range of the mobile node positioned at the centre of each such circle.

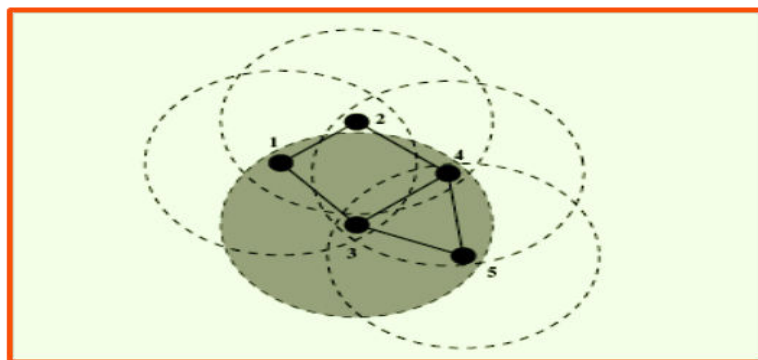


Figure 6: Multi-hop Data Transfer

Mobile node 1 transmits packet via neighboring mobile node for direct communication. Until the packet is transferred to the target mobile node, the surrounding mobile node keeps transferring it to one of its neighbors. Basic illustration of such a network may be shown in Figure 7, where multi-hop routing is displayed by five wireless mobile nodes. When a node uses multi-hopping, it means that it transmits data to its neighbor and the process recurs till the destination node is reached. As MANET is a multi-hop network, each node assists the other node to create routes and forward data to the appropriate source and destination in which nodes act as routers. Presume there are five nodes in MANET viz. A,B,C,D,E. Here, A serves as the source node and “D” serves as the destination node. Without any support from intermediary nodes, Node A cannot interact with Node D since their radio ranges rarely overlap. Interaction between nodes A and D is possible through nodes B and C, which act as routers.

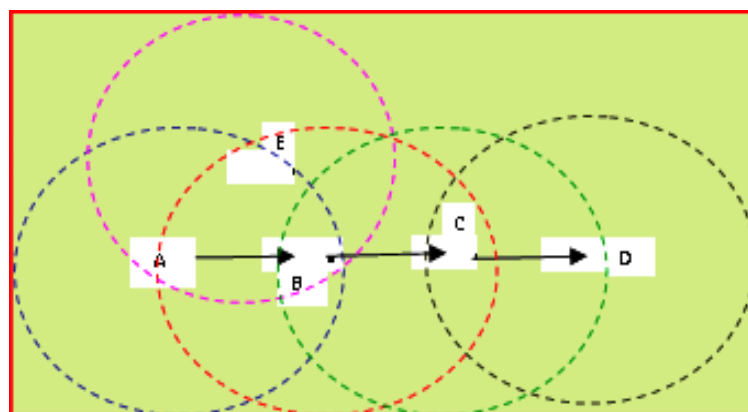


Figure 7: Example of Multi-hop Data Transfer



- d) **Variable Capacity Links:** In MANET, a variable capacity link refers to a wireless communication link that can change its data transfer rate dynamically based on the network conditions. This can be contrasted with fixed capacity links, which have a set data transfer rate that does not change. In comparison to a wired network, wireless networks typically have lesser levels of capacity, reliability, efficiency and stability. In addition, the real throughput is substantially lower than the stated transmission rate because of the impacts of multiple access, fading, noise and interferences. Variable capacity links are important in MANETs because the network topology and the available bandwidth can change rapidly as nodes move around and join or leave the network. In order to maintain efficient communication, nodes must be able to adjust their data transfer rates to match the available capacity of the links between them. There are various methods that can be used to implement variable capacity links in a MANET, including adaptive modulation and coding schemes, dynamic rate control, and link quality estimation. These methods can aid in maximizing the network throughput while curtailing the effects of interference and congestion.
- e) **Decentralized Control & Distributed Operation:** MANET has a decentralized structure with no administration point contrary to a network based on client/server mode. Due to decentralized feature, MANET is free from troubles caused by failures of central server that makes this network robust to an extent. As there is lack of central administration, therefore network control and management is dispersed among the terminals. The mobile nodes have the ability to communicate among themselves and have the potential to create routing.
- f) **Scarcity of Resources:** The nodes in MANET are mobile devices with a lesser amount of CPU processing power, limited memory storage and less power backups. Strong algorithms are required by such devices for optimization for robust communication and computational functions.
- g) **Diversity:** Devices in MANET must be designed in a way to consider all types of interfaces for inputs such as touch screens, laptops, PDA and must be able to respond in unreceptive environment. Devices must have capabilities to cope up with interoperability characteristic.
- h) **Limited Physical Security:** MANET has limited physical security in comparison to fixed-cable networks and is more vulnerable. Attention should be given to the high risk of eavesdropping, Denial of Service (DoS) attacks and spoofing. To lower security risks, wireless networks often implement link security measures. Decentralized network control in MANET handles even a single failure with robustness as compared to centralized networks.
- i) **Energy Restriction:** MANET nodes typically have limited battery life and processing power which can make it challenging to support complex applications. The most challenging task in MANET is to handle batteries which are exhaustible in nature. Most desired and required design is the system equipped with energy conservation and its optimization. MANET has these capabilities to few extents.

V. APPLICATIONS OF MANET

An Adhoc network has plenteous possible applications [12] which have its worldwide implementation and usage. MANET has proven its benefits in diverse fields ranging from battleground, in calamities such as flood, fire and earthquake, emergency operations, personal usage, confidential meetings to share and discuss sensitive information. Some of the important developments of MANET in military communications are GLoMO programme and NTDR programme. MANET allows users for barrier free communication in secure manner in their time zone. This concept was initiated and designed with consideration of adverse situation that gradually focus on routine needs too such as e classrooms, military operations, acquisitions of data repository in adverse situations, virtual meetings, to coordinate defense or attack in battle field among soldiers etc. Various MANET applications have been summarized in Table 2.

Table 2: MANET Applications

<i>Area</i>	<i>Possible scenarios/services</i>
Strategic networks	<ul style="list-style-type: none"> - Military operations in battlegrounds - Autonomous management of vehicles and robots with no human intervention
Emergency assistance	<ul style="list-style-type: none"> - Navigate and rescue operations - Establishing networks in natural calamity situation - Assistance to police - Providing assistance to doctors and nurses in medical fields.



Commercial & civilian assistance	<ul style="list-style-type: none"> - Supports hassle free electronic payments - Supports in working of e offices - Assists Vehicular services in road safety or accident information, conveying road and climatic conditions, cab networks etc. - Helpful in Sports, fairs, shopping areas - Helpful in establishing networks at airports
Home and enterprise networking	<ul style="list-style-type: none"> - Wireless networking at home or offices - Air pollution monitoring - Conferences, meeting rooms - Establish networking on construction sites
Education	<ul style="list-style-type: none"> - E-learning platform at University campus - Mobile Virtual classrooms - Adhoc setup of networks for lectures
Entertainment	<ul style="list-style-type: none"> - Game playing in team virtually - Internet access in remote locations - Biomimetic artificially designed pets
Sensor networks	<ul style="list-style-type: none"> - Underwater adhoc networks - Sensors embedded in consumer electronics - Body area networks for healthcare - Sensor networks in space exploration - Sensor in data mining
Contextual aware services	<ul style="list-style-type: none"> - Automatic data collection and response generation - Information gathering at particular time - Applications in marketing for product analysis

Adhoc wireless networks are quick to implement and put less burden economically that makes it suitable for many applications. To understand the concept, an example of military can be taken. Enemy tank movement can be traced when it comes under the geographical coverage area by the network. Supervisors can use adhoc networks to spot traffic passing through crossroads, and check its speed and direction. Usage of MANET can also be seen in establishing network that can help in analysis of environment to know atmospheric temperature & pressure, intensity of sunlight, humidity at various locations and forecasting like tsunami and cyclones.

VI. CONCLUSION

This paper presents a comprehensive survey and an overview of MANET. A detailed discussion has been carried out on networks, its classification into wired and wireless networks, evolution of mobile adhoc networks, characteristics & applications of MANET. In MANET, mobile nodes are moving without restrictions while establishing communication path and there is no fixed base station. Here, all nodes can participate to become a router. Routes are established dynamically and network is formed as and when required. Adhoc network life cycle is divided into three generation networks system. These networks contributes in various sectors such as military operations, to study automobile congestions, security in sensitive areas, parking areas, ecological change assessment, endangered species examination, global warming etc. MANET characteristics open new avenues and fascinating research opportunities for researchers in the fields of mobility, link path breakage, reliability, scalability, congestion control, security, energy management and QoS. Also this review paper provides the recent direction of research works related to MANET that will help to invent and produce new products of applications that has an impact in different areas such as military, education, video streaming, real-time video games, health care and monitoring and IoT applications.

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