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# **REVIEW ARTICLE**

# Applications, Advantages and Challenges of Ad Hoc Networks

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#### **Abstract**

Recent trends in compact computing and wireless technologies are expansion of ad hoc network. Ad hoc network consists of versatile flat forms which are free to move expeditiously. Ad hoc networks are multi-hop network that use wireless communication for transmission without any fixed infrastructure. The networks are form and deform on-the-fly without the need for any system. Ad hoc structure does not require an access point, it is easy to setup, especially in a small or temporary network. Each node in the network forwards the packet without the need of central administration. In ad hoc network, node acts as a router to send and receive the data. An advantage of the system is robustness, flexibility and mobility. Ad hoc network are capable for analyzing radio propagation environment to optimize the performance. This typically requires that the network node have positioning capability as well as memory to recall geographical local condition. An ad hoc network typically refers to any set of network where all devices have equal status on a network and are free to associate with any other ad hoc network device in link range. Ad hoc network often refers to a mode of operation of IEEE802.11 wireless networks. This review is focused on the applications, advantages and challenges of ad hoc networks.

Keywords: Wireless technologies, ad hoc network, robustness, network node, radio propagation.

#### Introduction

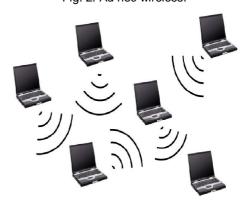
Adhoc network is an autonomous system node connected with wireless link (Corson et al., 1996). The node in the ad hoc network communicates with other node without any physical representation. The nodes in the ad hoc organization instantly form the network whenever the communication is established. Each node in the network communicates with other node using radio waves. The entire network is distributed and nodes are collaborated with each other without fixed station access point (AP) or base station. An ad hoc network is local area network that builds an automatic connection to the nodes in the network (Frodigh et al., 2000).

The wireless network architecture is be classified in two ways, first one is infrastructure where the node are connected with the fixed physical representation. Thus, the nodes are communicated through AP (Fig. 1). Examples for these kinds of wireless networks are GSM, UMTS and WLAN etc. Second is infrastructureless where the node is communicated without any fixed physical representation (Frodigh et al., 2000). The ad hoc networks are formed by connecting the terminals in the multi-hop distributed architecture (Stojmenovic and Lin, 2000). Due to the absence of centralized structure, the nodes in the ad hoc network acts as router to send and receive the data (Fig. 2). Due to the non-static nature, ad hoc network avoid the single point of failure and make the network more robustness.

Fig. 1. Infrastructure based wireless networks.



Fig. 2. Ad hoc wireless.



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In ad hoc network, the transmission occurs between the source and destination via intermediate nodes e.g. conference applications, intelligent devices or sensor.

#### Applications of ad hoc networks

With the increased number of lightweight devices as well as evolution in wireless communication, the ad hoc networking technology is gaining effort with the increasing number of widespread applications. Ad hoc networking can be used anytime, anywhere with limited or no communication infrastructure. The preceding infrastructure is fancy or annoying to use. The ad hoc network architecture can be used in real time business applications, corporate companies to increase the productivity and profit. The ad hoc networks can be classified according to their application as Mobile Ad hoc NETwork (MANET) which is a self-arranging infrastructureless network of mobile devices communicated through wireless link. Vehicular Ad hoc NETwork (VANET) uses travelling cars as nodes in a network to create a mobile network. Wireless Sensor Network (WSN) consists of autonomous sensors to control the environmental actions. The importance of ad hoc network has been highlighted in many fields which are described below:

Military arena: An ad hoc networking will allow the military battleground to maintain an information network among the soldiers, vehicles and headquarters (Bangnan et al., 2003).

Provincial level: Ad hoc networks can build instant link between multimedia network using notebook computers or palmtop computers to spread and share information among participants (e.g. Conferences).

Personal area network: A personal area network is a short range, localized network where nodes are usually associated with a given range.

Industry sector: Ad hoc network is widely used for commercial applications. Ad hoc network can also be used in emergency situation such as disaster relief. The rapid development of non-existing infrastructure makes the ad hoc network easily to be used in emergency situation.

provide Bluetooth: Bluetooth can short range communication between the nodes such as a laptop and mobile phone.

### Advantages of ad hoc networks

The rapid development in ad hoc technology is widely used in portable computing such as laptop, mobile phone used to access the web services, telephone calls when the user are in travelling. Development of self-organizing network decrease the communication cost.

The growth of 4G technology enhances anytime, anywhere, anyhow communication in ad hoc network. Ad hoc network is simple to design and install. The advantages of an ad hoc network include:

- Separation from central network administration.
- Self-configuring nodes are also routers.
- Self-healing through continuous re-configuration.
- Scalability incorporates the addition of more nodes.
- Mobility allows ad hoc networks created on the fly in any situation where there are multiple wireless devices.
- Flexible ad hoc can be temporarily setup at anytime, in any place.
- Lower getting-started costs due to decentralized administration.
- The nodes in ad hoc network need not rely on any hardware and software. So, it can be connected and communicated quickly.

#### Challenges in ad hoc networking

The ad hoc networks are self-forming, self-maintaining, self-healing architecture. The challenges are, no fixed access point, dynamic network topology, contrary environment and irregular connectivity. Ad hoc network immediately forms and accommodate the modification and limited power. Finally, ad hoc have no trusted centralized authority. Due to the dynamic changing property, the ad hoc faces some challenges which are listed in the below sections.

#### Quality of Service (QoS)

The ad hoc network is dynamically creating the organization whenever the node wants to communicate with their neighbor node. Due the dynamic changing topology in ad hoc network, providing QoS is a tedious task (Chakrabarti and Mishra, 2001). QoS are essential because of rapid development in mobile technology and real time applications like multimedia, voice. Providing QoS in ad hoc network is necessary to maintain best-effort-of service. The QoS metric are bandwidth, latency, jitter and delivery guarantee. The bandwidth is used to denote the data rate carried in the network. Latency ensures the delay occur from origin to target. Jitter denotes the variation of delay. Reliability demonstrate the percentage of deny to access the network service. Wireless channels are varying rapidly and it severely affects the multi-hop flows. In ad hoc networks, the peer-to-peer channel quality may alter rapidly. So, the link quality may affect the peer-to-peer QoS metrics in the multi-hop path (Wattenhofer et al., 2001). The factors of QoS are described below:

Packets are tangle for the shared media on adjacent links of a flow: Tangle between the packets in the same stream at various nodes. Such tangleness occurs in the wireless channel which is shared by nodes in the neighbor.

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Interference between the nodes affects the transmission quality: In ad hoc network, QoS is affected by radio interference. Interference strongly arises in ad hoc because nodes are beyond the transmission range. While the nodes are in the transmission, the remaining power is enough to interfere with transmission interference in non-neighboring nodes may drop the packet.

Limited resources: Due to the dynamic changing of link flow, ad hoc network provide varying resources.

Sufficient admission control: The admission control take decision about whether the available bandwidth is enough for link flow in available resources. Ad hoc networks providing finite bandwidth capacity may affect the end quality of service.

Highly dynamic: Ad hoc network characteristics are dynamic changing topology and this dynamic changing occurs due to radio transmission and mobility.

#### Components of QoS

QoS model: The QoS model specifies the entire architecture of ad hoc network and also maintains the services provided to the network. It does not specify any protocols or implementation. Two types of QoS model are available. One is Integrated Service (Intserv) which must maintain the virtual circuit connection oriented state information in every flow. Second, is Differentiated Service (Diffserv) which does not specify any state information.

QoS signaling: QoS signaling is used to allocate and reallocate the resources during the network flow. The signaling process is based on two categories. First, QoS signaling is used between the routers. Second, the signaling can be rightly identified and used by the corresponding resources. The QoS signal can be classified into in-band and out-band. In in-band signaling, signal information is carried along with its packet. In out-bound signaling, explicit packet is needed to handle the signaling.

QoS routing: QoS routing is designed to provide the optimal path between end-to-end resources that meet QoS requirements such as bandwidth, delay etc. The QoS can maintain ad hoc network by using the admission control to check whether the local available bandwidth is greater than the needed bandwidth. Thus, the process may leads to maintain the quality of service in ad hoc network.

#### Scalability

The scalability problem occurs in ad hoc networks due to the nature of the multi-hop (Wattenhofer *et al.*, 2001). The scalability in ad hoc network depends on the network size and forwarded packet capacity in the network.

Recently, lot of problems address in large-scaled ad hoc networks. The scalability depends on the following factors:

Equal node priority: All the nodes in the network have same priority to share the physical resources. So, all nodes have same data rate.

*Uniform distribution of destination:* The packets are distributed equally from source to N-1 nodes (Chiasserini and Rao, 2000).

Spreading the node reliably: The transmission capacity of the node should be large enough than their neighbor nodes to avoid interference.

Shortest path: The packets transmitted from source destination depend on the shortest path.

The scalability can preserve by dividing the network area according to their geographical location. The whole network area can be divided into small virtual grid cells such that every node in each virtual grid cell can communicate with other nodes in the same cell.

#### Security

Security is a major concern in the ad hoc networking standards (Gagandeep et al., 2012). Data transformation in ad hoc network must be done in a secured way. The security issue in ad hoc network is dynamic topology, bandwidth, small device size and limited battery life. Due to the dynamic nature, it is difficult to maintain secured transmission in the (Papadimitratos and Haas, 2002). The ad hoc network does not depend on any pre-existing infrastructure so that the node can leave and join the network in such a situation where security may fall down. Two types of attack occur in ad hoc network, first is passive attack, this attack does not change the transmitted data in the network. But, it can allow unauthorized user to discover the message. Second, is active attack, it is a severe attack and prevents the message flow between the node in the network. It may allow the unauthorized user to modify the message. The malicious node can be identified by dropped packet, battery drained, bandwidth consumption, unreliable packets, delay, connection break and false routing.

## Security approach

Scope: It describes whether the node is available to provide the services. It also provides facility to access the authorized user in a desired time.

Confidentiality: It ensures only authorized user can access the information. It should be protected against unauthorized user and snooping.

*Incorruptibility:* It must provide the assurance that the transformation of message without any corruption.

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Authorized user only has the privilege to access and modify the data. It also certifies when and where the message was delivered.

Verification: It describes participant nodes which are authenticated in the communication network. The resources in the network must communicate through authenticated nodes.

Approval: The authorization assigns different access rights to different types of users. For example, a network management can be performed by network administrator only.

Aggression: It can preserve the network functionality when the parts of nodes are fragmented.

*Uniqueness:* It ensures that malicious node does not resend previously captured packets.

#### Power control

Power control is one of the main components in ad hoc network as battery provides limited capacity to the nodes. If the power failure occurs in the node, it may affect itself and the entire network architecture gets fragmented. The reason for power control is limited capacity of nodes, non-static infrastructure, constraints on the battery sources, selection of excellent transmission power and channel utilization (Lorch and Smith, 1998). Ad hoc power maintenance is based on:

Low capacity condition: The low power mode enables the node to be active during transmission of packet and it makes the node inactive when they are waiting to receive the packet (Singh and Raghavendra, 1998).

Transmission power control: The transmission power control must be based on transmission range, error rate and interference. Thus, the strong transmission power increases the transmission range and reduces the hop count to the destination (Ramanathan and Rosales-Hain, 2000).

Power aware routing: The routing protocols are designed to find the shortest hop between source and destination. Thus, the routing protocol allows increasing the network life time by reducing the usage of nodes battery life time (Wattenhofer *et al.*, 2001).

In order to maintain power control by minimizing the active energy, the power down mode is used to minimize energy during inactive. The load balancing technique allows the network maximizing by reducing over usage of the node (Petrioli *et al.*, 2001).

#### Cooperation between nodes

Cooperation between the nodes is essential in the ad hoc network. Each node in the network cooperates with other node for packet forwarding and routing.

Due to dynamic changing topology, the nodes in the network do not rely on other node. In ad hoc network, source node transmits the data to destination via intermediate node. Without cooperation between the neighboring nodes source, node cannot transfer the data successfully. Therefore, frequent modification in link may lead for uncertain topology changes and network disconnections. The non-cooperative nodes may be described in two ways, first one is the malicious nodes refer that the set of the node attack the network or break the link. The selfish nodes use the network for their purpose without pay back for the usage of network. Both nodes are considered as misbehaving nodes (Buttyan and Hubaux, 2003). In ad hoc high level cooperation between the neighbor nodes make the network more flexible. Low level cooperation among the node makes the network vulnerable. Strategies for node cooperation are:

Concentrating acquaintance: The node, forward or drop the packet based on the neighbor node behavior. This requires the node to listen in abandoned mode to capture the actions of its neighbor node.

Conversation of node: Nodes are always communicated with one of nearest neighbor node in the entire network. It must identify the misbehavior node and isolate the corresponding node.

To manage the cooperation between nodes, it is needed to optimize the trade-off of forwarding packets for others vis-a-vis conserving their energy resources.

#### Performance measurement of ad hoc network

Internet Engineering Task Force (IETF) identified the performance metrics of the ad hoc network based on their behavior. The performance of ad hoc networks based on network capacity, network connectivity, topological change rate, link speed and mobility. The ad hoc network performance measurement is based on the following metrics (Singh *et al.*, 1998):

Packet transmission ratio: The ratio is measured by number of packets transmitted by source and number of packets received by destination. The measurement is based on Constant Bit Rate (CBR) in order to find out packet loss, throughput of the data in the network.

Route procurement time: It mentions the time required to inaugurate the routes. The measurement is based on end system performance.

Routing overhead: The routing overhead describes the number of routing packets needed for route discovery and route maintenance phase. It also determines whether the protocol is well situated in low-bandwidth situation and able to work with low power consumption. The causes of routing overhead are network congestion and route error in large network.

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End-to-End delay: The packet transfer in the network based on mean time. This property ensures the analyzing the routing efficiency.

Hop count: Determine the number of hops needed to reach from source to destination.

#### Conclusion

The rapid developments in the field of ad hoc networking allows the nodes to form a self-creating, self-organizing and self-administering wireless network. Its intrinsic flexibility, lack of infrastructure, ease of deployment, auto configuration, low cost and potential applications makes it an essential part of future pervasive computing environments. This review aims to discover ad hoc network architecture, application, features and also mentions about various challenging issues and provides the feasible solution based on new technology.

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