MOBILE AD HOC COMMUNICATION – THE ABILITY OF NETWORKING WITHOUT NETWORK

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ABSTRACT

As mobile devices become increasingly pervasive and commonly equipped with new range of radio capabilities it's considerable that the basic paradigm for achieving communication will be extended with completely different level that will certainly include Ad Hoc Communication. Although the new generation of mobile communications already include the existing **infrastructure** wireless network capabilities, the expansion of the new **infrastructureless** mobile ad hoc networks (**MANETs**) it's about to begin. **MANET** stands for "Mobile Ad Hoc Network." and it is a type of ad hoc network that can change locations and configure itself on the fly. Because MANETS are mobile, they use wireless connections to connect to various networks. This can be a standard Wi-Fi connection, or another medium, such as a cellular or satellite transmission. In other words, **MANET** is a collection of wireless nodes that can dynamically form a network to exchange information without using any pre-existing **fixed network infrastructure**.

I. INTRODUCTION

The people's future living environments are emerging, based upon information resource provided by the connections of various communication networks for users. Today, many people carry numerous portable devices, such as laptops, smartphones, tablets etc, for use in their professional and private lives.

There is no doubt that today the whole world is faced with natural disasters like tsunami, volcanic eruptions, earthquakes, floods, landslides and other. All of these catastrophic events can lead to human, financial and environmental losses. During a disaster saving of the human live is priceless, so the time of reaction of the rescue teams in a rescue missions is critical and it depends of time needed to determine the exact location of the survivors in order to give them the necessary assistance. Usually in this cases, the places that are affected from a disaster are destroyed and do not support centralized networking. In this kind of situations Ad Hoc Mobile networking plays key role in the process of enabling communication with the outside world.

Mobile networking is one of the most important technologies supporting pervasive computing. Taking in account that in the past 10 years advances in both hardware and software techniques have resulted in mobile hosts and wireless networking, created the need of distinction between the approaches that are taken in order to consider valuable advantages and disadvantages of the different aspects on the wireless communication.

In General, there are two distinct approaches for enabling wireless mobile devices to communicate with each other:

- *Infrastructured* - Wireless mobile networks have traditionally been based on the cellular concept and relied on good infrastructure support, in which mobile devices communicate with access points like base stations connected to the fixed (centralized) network infrastructure.
- *Infrastructureless* - As to infrastructureless approach, the mobile wireless network is known as a *mobile ad hoc network (MANET)* [1]. **MANET** stands for "Mobile Ad Hoc Network." and it is a type of ad hoc network that can change locations and configure itself on the fly. MANET can be also defined as a collection of wireless nodes that are independent and can dynamically form a network in order to exchange information without using any pre-existing fixed network infrastructure.

The independence of any pre-defined network infrastructure is the one that makes mobile ad-hoc networks (MANETs) suitable for environments and situations where such infrastructure does not exist. The scenario mentioned above, where there is disaster areas in which communication between rescue workers, search teams, and medical personnel needs to be established despite the destruction of network infrastructure is suitable example of the major need of this kind of networking. Instead of relying on existing routing infrastructure with routers or access points, a wireless ad-hoc communication network is decentralized. Here, all network devices have equal status and can connect with any other devices in their wireless link range.

In this paper are described the fundamental problems of Ad hoc networking (See picture 1.1) by giving its related research background including the concept, features, status, and applications of MANETs in different situations. Special attention is paid on network layer routing strategy of MANET and the routing algorithms, security & reliability schemes and QoS model. The research paper covers the main concept of Ad Hoc networking, basic MANET features, current research status and a real (prototype) project called **Splendor** that was developed in order to test the functionality of Ad Hoc networking using both *Infrastructured and Infrastructureless* [2] approach. Finally, the paper is summarized with conclusion that represents the main characteristics and properties of existing Ad Hoc network together with its behavior and applicability in real life.
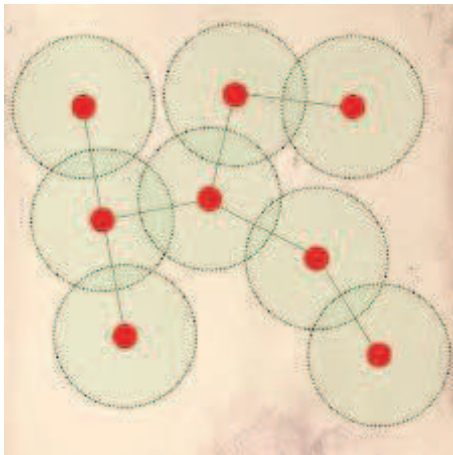
1.1 Ad-hoc networking

II. BACKGROUND

## 2.1. Main concept of Ad Hoc Networking

As mentioned before, *Ad Hoc network* [3] represents an autonomous system in which mobile hosts connected by wireless links are free to move randomly and often act as routers at the same time. The traffic types in ad hoc networks are significantly different from that in infrastructure wireless network. There are three traffic types that can be considered as valid scenarios in MANET's :

- *Peer to Peer* – This represents enabling communication between hosts (nodes) which are in one hope. The traffic of the network is usually consistent because is expected that the nodes are very close to each other and only one hop is required in order to exchange data.

- *Remote to Remote* – This represents communication between two nodes that are (located) beyond a single hope, but still maintain stable route between them. The traffic of the network is similar to standard network traffic.

- *Dynamic Traffic* – This represents a dynamic MANET's where the nodes are not consistent because they are moving around and changing, which means that the routes must be constantly reconstructed which results in poor connectivity, weak network activity and short bursts.

On Picture 2.1 are shown both **Infrastructured and Infrastructureless** networks.

a) **Infrastructure-based wireless network**
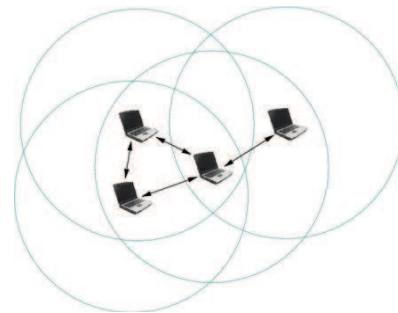
b) **Ad hoc wireless network**

Picture 2.1 (a) Infrastructured and (b) infrastructureless wireless networks

2.2 MANET Features

Ad Hoc Mobile Networks have the following *MANET features* [4]:

1) *Distributed operation* - Since there is no background network for the central control of the network operations, the management of the network is distributed among the nodes involved in a MANET. They should collaborate amongst themselves and each node acts as needed, in order to implement different kinds of functions like routing and security.

2) *Multi-hop routing support* - Different types of ad hoc routing algorithms can be single-hop and multi-hop based. The choice depends of the different link layer attributes and routing protocols that are available. **Single-hop** MANET is simpler than multi-hop in terms of structure and implementation, but also with less functionality and applicability. In **Multi-hop MANET** when packets are delivered from a source to its destination outside of direct wireless transmission range, the packets are forwarded via one or more intermediate nodes.

3) *Dynamic network topology* - Since the nodes (hosts – mobile phones, tablets, PC's with wireless cards) are mobile, the network topology often changes rapidly and unpredictably and the connectivity among the terminals may last much more time. The mobile nodes in the network should dynamically establish routing among themselves as they move about, forming their own network on the fly. Additionally the user in the MANET may not only work on the ad hoc network, but may require (and get) access to a public fixed network (e.g. Internet).

2.3 Current MANET Status

Ad hoc networking has been present for a long while and it's not a new concept. As a technology for dynamic wireless

networks, it has been deployed in military since 1970s. Today every mobile device (host - phone, tablet, lap top) that has wireless can create and share his internet connection with another device by creating his own ad hoc network which will be used to communicate with other devices. However this option is very limited because it depends of the Operating systems that run on different devices, their possibilities and different types of driver support. For example in Windows 7 the user can share his internet connection by creating ad hoc network, and then other device (for example phone) can connect to that network and get access to internet. In this case the scenario is simple, but if we have large number of mobile devices that are in interaction with each other (sending and receiving messages in between, and then sending them to the central network device) then we need a mechanism to handle their interactions in a very efficient way.

The recent *IEEE standard 802.11* [5] has increased the research interest in the field. Many international conferences and workshops have been held by e.g. IEEE in order to encourage the research teams to explore this area more efficient. Research in the area of ad hoc networking is receiving more attention from academia, industry, and government. Since these networks have many complex issues, there are many open problems for research and significant contributions.

2.4. Ad Hoc Networking Challenges

In order to resolve the issue of efficient interaction between nodes in MANET many aspects should be considered in order to enable fast transfer of data from application to application. The features of MANET introduce several challenges that must be studied carefully before a wide commercial deployment can be expected. These challenges are :

- *Routing –* Taking into account that the topology of the network is constantly changing the issue of routing the packets between the mobile devices in the network becomes a challenging task. Most protocols should be based on *reactive routing instead of proactive* [6]. In reactive routing, routes are discovered on-demand when packet must be delivered to an unknown destination. Ad-hoc routing protocols such as AODV (Ad-hoc On-demand Distance Vector) and DSR (Dynamic Source Routing) are examples of this style. Multicast routing is another challenge because the multicast tree is no longer static due to the random movement of nodes within the network. Routes between nodes may potentially contain multiple hops, which is more complex than the single hop communication.

- *Internetworking -* In addition to the communication within an ad hoc network, internetworking between MANET and fixed networks (mainly IP based) is often expected in many cases. This means that the node will be able to access (send) something over an access point device located in centralized network.

The co-elaboration between the routing protocols in such a mobile device is a challenge for the harmonious mobility management.

- *Security and Reliability –* Taking in consideration the fact that all the wireless connections are vulnerable in some way, we need to point out that an ad hoc network has its particular security problems due to ex : nasty neighbor relaying packets. The feature of distributed operation requires different schemes of authentication and key management. Furthermore the link capabilities may have different problems that will hamper the transmission range which will result with mobility-induced packet losses, and data transmission errors.

- *Quality of Service (QoS) –* Enabling different kinds of Quality of Service in a dynamic environment will be challenging. Alternatively, we must be implement adaptive QoS in order to win over the traditional resource reservation to support the multimedia services.

2.5. Basic Barriers and limitations

Today it is recognized that routing strategy is the most important research problem in MANET's. It's considered the most difficult problem to resolve among other problems. The fact that we need to determine viable routing paths and deliver messages in a decentralized environment where network topology fluctuates is far away from a well-defined problem. In order to achieve good protocol design we need to consider various factors like : fading, multiuser interference, power expended, wireless link quality, propagation path loss and topological changes which are relevant issues that are very difficult to study and resolve.

All kinds of routing protocols have been proposed with the form of IETF working documents of both Internet Drafts and Request For Comments (RFC). Numerous projects related to different aspects of MANET are employed by academics and institutes all over the world, with *individual standards* [4,6] being presented occasionally in literatures. These documents serve the purpose of demonstrating the functionality and performance of ad hoc routing with simple protocols, but very few of them can be used in a real application scenario.

III. RESEARCH ISSUES

In this part of the research paper the main focus is given to the MANET network layer routing strategies that are crucial for implementation Ad Hoc networking. This section will analyse the key aspects of MANET like : Z-cast routing, security & reliability, QoS, and interworking with outside IP networks. All of these issues are main challenges of ad hoc wireless networks. The lack of solutions for these problems prevents MANET from wide commercial deployment and implementation.

3.1 Z-cast Routing Algorithms

As in the **infrastructured** wireless networks, all kinds of Z-cast communication schemes should be supported in an ad hoc mobile environment. This includes unicast, any-cast, multicast, and broadcast. MANET is also capable of bringing new Z-cast modes into communications for example*: geo-cast* [7]). The multicast needs to support multiparty wireless communications. Since the multicast tree is not static (the topology is changing during time), the multicast routing protocol must be able to cooperate with mobility, including multicast membership dynamics (leaving and joining from and to the network).In a multi-hop ad hoc context, the routing problem becomes more complex because of the mobility of the hosts and routers. Another issues that need to be taken into account include routing discovery and flooding, caching, location-aided and power-aware, broadcast storm issue, route request and reverse path.

3.2 Internetworking

Enabling intregration of the mobility management schemes in the domains of both traditional infrastructured wireless networks and the new mobile ad hoc networks is an important issue. The mobility capabilities of an ad hoc network is quite different from that of infrastructured networks. In infrastructured networks only the nodes at the very end (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. In an ad hoc network mobility is handled directly by the routing algorithm. In many cases, device accesses both within the ad hoc network and to public networks (e.g. the Internet).

3.3 QoS Model

In order to prioritize data within the ad hoc network, QoS protocols are usually used in order to reserve better connections for high data rate applications while still maintaining enough bandwidth for lower bit rate communication. Special emphasis should be put on achieving a new QoS model for MANETs by taking into consideration the ad hoc features of the target networks: dynamic node roles, data granularity, the traffic and so on.

## 3.4 Security, Availability and Reliability Schemes

This three properties (Security, reliability, and availability) are critical aspect of MANET, especially in security sensitive mobile applications. Taking in account that the Ad Hoc networking is based on wireless communication medium, it is important to deliver a security protocol in order to protect the privacy of the users. The implementation schemes of key management, authentication, and authorization are quite different because there is no aid of a trusted third-party certification authority to create trusted relationships by exchanging private/public keys.

IV. APPLICATION

4.1 Real world scenario that uses Ad Hoc networking – Project Splendor

The commercial application for this research paper is completed by developing a whole project called **Splendor – Global Natural Disaster Center** which is used to share **geolocation** information of the people that are experiencing a **Global** Natural disaster. The purpose of the solution is to solve existing location/navigation issue from the real world in a new way, promoting a brand new concept that will be used for putting all the catastrophic events in a framework that can be tracked and proceed using the latest Microsoft Technologies. The main feature of the solution is to enable to the rescue teams to help victims from a disaster by determining their exact location in a very short time at any spot of our planet.

The solution provides Windows Phone application installed on the mobile phones of the potential victims, that will allow them to send their current geographic position and short SOS message to the rescue crews that are located near the disaster area. When the user starts the Splendor mobile application he gets his current position on map, together with the latitude and longitude. This **Windows Phone Mobile Application** that is able to establish Ad Hoc communication with other Windows Phone mobile devices that has the same app. This app also uses **infrastructureless concept** to send a short SOS message for help over other mobile applications (devices) that are near the disaster area in order to save people that are located nearby. The message can be forwarded to web service and web site over the mobile devices that can access to **infrastructured wireless network (access point).**The data are shown on *website* [8] on map and the rescue teams can react on time in order to save as many human lives as possible.On the picture 4.1 is shown the main concept and functionality between nodes (phones) using *Ad Hoc functionality* [9].
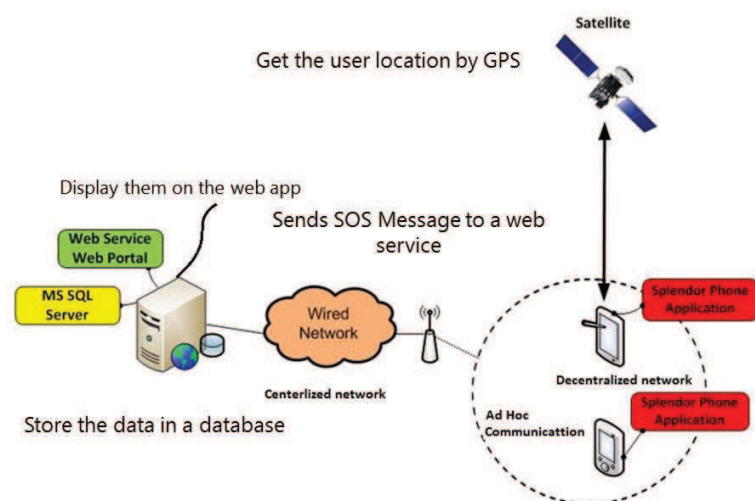
4.1 The main concept of Ad Hoc networking in Splendor

4.2 Commercial Viability

Saving human lives is "priceless", so the commercial aspect of the solution is totally covered in the sense that all the government agencies in the world will be interested to use this kind of software in their disaster handling programs. This information is supported by the fact that many companies in the world want to invest to a solution that will help people hit by different kinds of disasters. The latest article in the Sky News portal [10] with title "New 'App' To Help People Hit By Disasters" where clearly was said that"a natural disaster app could be developed under government plans to exploit new technology to help victims of flood, famines and earthquakes"– was more than enough for me, to decide that the economic and commercial viability of the project is totally justified and make sense.

V. CONCLUSION

In this research paper we tried to give an overview and to analyse the fundamental issues and key problems that affect MANET. In the first chapter MANET was introduced, together with the MANET concept, features, current status, and application areas. Then, in the background information chapter the main challenges of MANET are discussed that lead to the analysis of the difficulties in the routing protocols, various barriers and limitations. The Research issues chapter analyses four key network layer issues of MANET routing strategies which are described in details.Then the real World application that uses Ad Hoc communication was presented together with centralized and decentralized infrastructure that enable to the users to exchange packets (messages) inside and outside of the Ad-Hoc network.

Mobile ad hoc networking is one of the most important and essential technologies that support future pervasive computing scenario. The special characters of MANET bring this technology great opportunities together with severe challenges. Currently MANET is becoming more and more interesting research topic and there are many research projects employed by academic and companies all over the world.

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