

# Chapter 46

## Spectrum Sensing in Emergency Cognitive Radio Ad Hoc Networks

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### ABSTRACT

*Ad hoc networks are infrastructure less networks which are self organizing and adaptive. Such networks can be used in emergency situations like disaster management and military applications. Usage of cognitive radios as the wireless terminals in ad hoc networks in emergency situations has distinct advantages. Better bandwidth, interoperability, avoidance of interference, and ant-jamming capabilities are a few such advantages. Ad hoc networks with cognitive radios are wireless terminals used in emergency situations and can be referred to as Emergency Cognitive Radio Ad Hoc Networks (Emergency CRAHNs). In this chapter, the authors discuss emergency CRAHNs and the specific requirements that must be met by the spectrum sensing mechanism used by them. In particular, the authors discuss collaborative spectrum sensing methodology; where in multiple cognitive radios operate together such that reliability of spectrum sensing is improved. This collaborative sensing in ad hoc networks can be either of centralized or distributed architectures, both of which are discussed in this chapter.*

### INTRODUCTION

Ad hoc networks are infrastructure less networks that are formed or de-formed on the fly without any need of system administration. That is, they are self-organizing and adaptive (Toh, 2007).

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Ad hoc networks find application in emergency scenarios like disaster management and military. In emergency situations, it is required for a mobile group to communicate with each other on peer to peer basis. These communication links must be reliable and provide redundant paths to cater for operations under communication link failures. For example, in S.E. Fireworks disaster in Enschede,

the Netherlands (May 2000), a fireworks depot exploded and destroyed a large part of the city, 23 people were killed and more than a thousand were injured. Fire brigade, police and relief workers in the medical chain experienced severe communication problems, both internally and with each other, because transmission equipment appeared not to be working, or was functioning inadequately. Similarly, disasters such as the Hurricane Katrina, 9/11 attack on the world trade center (Johnson, 2005) Minnesota bridge collapse or the collapse of terminal 2E at Paris Charles de Gaulle Airport (Shamik, 2010) emphasize the importance of wireless communication. Such situations demand reliable, interoperable and quick connectivity between relief groups. Data, audio, video information and pictures need to be communicated periodically. This information is used to access the co-ordinates, health status of workers and also provide surveillance information. These multimedia applications have different Quality of Service requirements. For example, real-time voice and video are sensitive to delay and jitter. Streaming voice and video are bursty and are bandwidth crunching in nature. The network must be able to handle a wide variety of multimedia signals and deal with large, possibly unpredictable amounts of data. The large amount of data obviously requires equally large bandwidth requirements. Any protocol used in such a network must be robust and capable of supporting heavy traffic during peaks of the activity. Network protocols must be energy efficient since most of the devices are battery powered. It is also necessary that packets carrying critical information are transported through the network with minimum latency (Przemysław, 2010).

In disaster management situations, the networks usually depend on public networks such as GSM & GPRS. These public networks are likely to get overloaded resulting spectral bandwidth limitations to the multimedia applications and also in worst cases cause denial of service. Usage of cognitive radios in emergency situations has

the potential of alleviating the spectrum shortage problem by dynamically accessing free spectrum resources. Such CRAHNs provide flexibility in terms of frequency of operation of the ad hoc network. Cognitive Radios (CRs) based on Software Defined Radios (SDR) by definition are able to work in different frequency bands and support multimedia services such as voice, data, and video.

In military networks, peer to peer communication between soldiers or tanks is considered to play an important role in the success of mission operations. For such environments, wireless mobile ad hoc networks play an important role since they are self-organizing wireless networks composed of sets of cooperative mobile participants with redundant routes between them. Radio communications in tactical wireless mobile ad hoc networks are susceptible to external jamming by enemies and internal interference (e.g., radio channel congestion due to scalability problems). Spectrum diversity is a good countermeasure against jamming and congestion, since it exploits multiple radios or channels to increase capacity and scalability. Upon detecting jamming or channel congestion, a CRAHN can switch to other empty channels/frequencies on the basis of monitored channel information. Other advantages of usage of cognitive radios in military networks include interoperability among different services and legacy equipment. The use of dynamic spectrum management in future military CRAHNs is expected to improve service and increase the combat capability during the exercise and operation (Joshua, 2011).

CRAHNs used in emergency situations such as disaster management and military applications are called Emergency CRAHNs. In this chapter we consider an emergency CRAHN with a collaborative spectrum sensing mechanism. The network size could be varying from a small values to medium sized one (*i.e.* less than 100). The Primary Users (PUs) are the licensed users operating in a subset of these frequencies. Each cognitive radio

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