Chapter 5
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 in 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). 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.
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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
terminal 2E at Paris Charles de Gaulle Airport
(Shamik, 2010) emphasize the importance of wire-
less communication. Such situations demand reli-
able, 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 surveil-
lance 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 pro-
tocols 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 net-
works usually depend on public networks such as
GSM & GPRS. These public networks are likely
to get overloaded resulting spectral bandwidth
limitations to the multi media 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 net-
work. 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 communi-
cation 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 partici-
pants 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 ex-
pected to improve service and increase the com-
bat 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 collabora-
tive spectrum sensing mechanism. The network
size could be varying from a small values to me-
dium 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
makes independent measurement of the spectral
information and the individual local decisions are
fused together to form the global decision. The
following assumptions are made with respect to
the system model.

Common Control Channel (CCC): A common
error-free control channel is used to communicate