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Enhanced Channel Assignment Scheme for Cognitive Radio Network

A Thesis

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Abstract

With the recent growth in the usage of wireless communication devices, it is being predicted that there will be a serious shortage of bandwidth in the near future. Considering the frequency bands already assigned for various applications (e.g. television transmission, cellular communication, etc.) it may appear that such a shortage could occur.

However, if we closely examine the usage of the frequency spectrum, a significant portion of the spectrum is under-utilized. For example, in several small cities many television channels in the VHF and UHF bands are unassigned.

Cognitive Radio Network (CRN) allows the Secondary Users (SUs) or the unlicensed users to share the licensed bands with the Primary Users (PUs) or the licensed users under some constraints such as limitation in the transmitted power.

CRNs need a Medium Access Control (MAC) protocol to control channel assignment process. Common Medium MAC protocols for a single channel do not provide, in general, mechanisms for channel switching and working with less performance in multiple channels environments. An enhanced Multi-channel MAC protocols is needed when having multiple independent channels to be used simultaneously.

Thus, several desired features are required for CR MAC protocol. First, it should be able to predict future spectrum usage based on statistics of local spectrum utilization up to the current time instance. To implement this feature, a CR device should monitor the spectrum usage continually to maintain an accurate view of spectrum utilization or depends on a statistical distribution for the current channel or have a database for certain band such as TV band. Second, it should avoid the harmful interference with licensed users. Third, it is preferred to have cooperation between the CR users to circumvent the collision between SUs.

This thesis discusses the problem of frequency band scarcity and clarifying the importance of cognitive radio to solve this issue. It shows cognitive radio's transmission techniques, characteristics and its applications. The thesis also introduces different types of MAC protocols for cognitive radio networks and compares between them; states the advantages and disadvantages of each one.

Also, a predictive model is suggested to estimate PU's behavior; in order to exploit the channel's vacancies to transmit SUs data. This predictive model is Exponential Smoothing Model (ESM). MATLAB program was written to approve the validation of this model to be used by SUs.

A new MAC protocol is proposed to be applied in CRNs. This protocol is called a Predictive MAC (P-MAC). It uses Exponential Smoothing Model to access the licensed channel in the absence of PU. In addition, an enhanced version from P-MAC is suggested called Enhanced Predictive MAC (EP-MAC). Ns-2 program was used with modified code to evaluate the performance of P-MAC and EP-MAC protocols, whose simulation results give better results compared with another MAC protocol.

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List of Abbreviations

ACK	ACKnowledgment
AN	Ad hoc network Node
AP	Access Point
AS-MAC	Ad hoc Secondary system Medium Access Control
ASN	Ad hoc Secondary Network
ATIM	Ad hoc Traffic Indication Messages
BCCH	Broadcast Control CHannel
BS	Base Station
CA	Collision Avoidance
CC	Control Channel
CCCH	Common Control CHannel
CCD	Cell Channel Description
CDT	Channel Detection Time
CI	Cell Identity
CMAC	Control Media Access Control
CPE	Customer Premises Equipment
CR	Cognitive Radio
CRAHN	Cognitive Radio Ad Hoc Network
CRN	Cognitive Radio Network
CRS	Cognitive Radio System
CSMA/CA	Carrier Sense Multiple Accesses/Collision Avoidance
CTS	Clear To Send
CVS	Contact Verification Signal
CW	Contention Window
DC	Data Channel
DCF	Distributed Coordination Function
DIFS	Data Inter Frame Space
DSA	Dynamic spectrum access
DVB-T2	Digital Video Broadcasting – second generation Terrestrial
ECMA	European Computer Manufacturers Association

ECR-MAC	Energy Efficient Multichannel Medium Access Control
EMI	Electro Magnetic Interference
EMC	Electro Magnetic Compatibility
EP-MAC	Enhanced Predicted – MAC
ESM	Exponential Smoothing Model
FCC	Federal Communications Commission
FCCH	Frequency Correction CHannel
FDD	Frequency Division Duplex
FDMA	Frequency Division Multiple Access
GSM	Global System for Mobile communication
ISM Band	Industrial, Scientific and Medical Band
KNOWS	Kognitiv Networking Over White Spaces
LAI	Location Area Identity
LAN	Local Area Network
MAC	Media Access Control
MCHTP	Multi Channel Hidden Terminal Problem
MHCRN	Multi-Hop Cognitive Radio Network
MMAC	Multichannel Medium Access Control
MS	Mobile Station
NAV	Network Allocation Vector
NRA	Not Random Access
ns2	Network Simulator 2
OFDM	Orthogonal Frequency Division Multiplixing
OFDMA	Orthogonal Frequency Division Multiple Access
OP-MAC	Opportunistic Periodic - MAC
PHY	Physical
P-MAC	Predicted - MAC
PU	Primary User
QAM	Quadrature Amplitude Modulation
QOS	Quality Of Service
QPSK	Quadrature Phase Shift Key
RA	Random Access

RAM	Resource Allocation Matrix
RES	REServation message
RF	Radio Frequency
RTS	Request To Send
RX	Receiver
SCA-MAC	Statistical Channel Allocation Medium Access Control
SCH	Synchronization CHannel
SIFS	Short Inter Frame Space
SM	Spectrum Manager
SU	Secondary User
SYN-MAC	Synchronized Medium Access Control
TDD	Time Division Duplex
TDMA	Time Division Multiple Access
TRX	Transceiver
TS	Time Slot
TV	Tele-Vision
TVWS	TV White Space
TX	Transmitter
UWB	Ultra Wide Band
WLAN	Wild Local Area Network
WRAN	Wireless Regional Area Network