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Cognitive Resource Management for Heterogeneous Cellular Networks

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Preface

Smartphone fever along with roaring mobile traffic poses great challenges for today's cellular networks. In general, cellular operators and vendors promise to provide seamless mobile access to end users. However, given the temporal and spatial variations of the ever increasing smartphone user demand, they feel obligated to deploy cellular access nodes in a more flexible and intelligent way, e.g., plug-to-play, self-organized, and cost-effective. Therefore, various types of small cells are being adopted indoors and outdoors to complement macrocells in cellular hotspots and blind zones. Designed by different purposes of operations, macrocells and small cells show heterogeneous characteristics, which requires new techniques to solve the challenging coexistence issues including interference management, cell coordination, and interworking.

In this Brief, we exploit cognitive radio techniques to improve spectrum utilization and perform flexible network management in the heterogeneous cellular network (HetNet) formed by macrocells and small cells. Background and literature survey of HetNet and cognitive radio techniques are first presented in Chap. 1. We then introduce an open cell management framework in Chap. 2, namely as *cognitive cellular network management* (CCN), which is mainly aimed to improve spectrum utilization and mitigate co-channel interference in HetNet. In Chap. 3, we investigate in wireless backhaul for flexible deployment of small cells, which requires smooth and reliable communications with the network controller even if wired portal is not available. Instead of static spectrum allocation, overlay spectrum reuse fits such need better, which accommodates the backhaul traffic by fully utilizing the intermittent spare spectrum resources with small spatial prints. An opportunistic routing protocol for wireless backhaul is presented along with the introduction of joint channel and relay selection. In Chap. 4, we further address on the coexistence issue between macrocells and small cells. When small cells are loosely controlled due to limited bandwidth in dense deployment, the effective allocation of radio resources becomes challenging. We propose a distributed QoS-aware cognitive MAC scheme which facilitates users in small cells to find available resources in an opportunistic way so that they can transmit at higher power for better link quality while maintaining tolerable interference to macrocell transmissions.

In addition, a penalty approach is used in backhaul to secure the effectiveness of power allocation in the transmission channels. Finally, we summarize the Brief and provide future research directions in Chap. 5.

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Acronyms

ASP	Arbitrary sensing period
BS	Base station
CBR	Constant bit rate
CCC	Common control channel
CCN	Cognitive cellular network management
CDF	Cumulative distribution function
CoMP	Coordinated multipoint
CRN	Cognitive radio network
CSMA/CA	Carrier sense multiple access with collision avoidance
CTT	Cognitive transport throughput
DSL	Digital subscriber line
FBS	Femtocell base station
FCC	Federal Communications Commission
HDV	High definition video
HetNet	Heterogeneous cellular networks
IEEE	Institute of Electrical and Electronics Engineers
ISM	Industrial, scientific and medical
ITU	International Telecommunication Union
LTE	Long term evolution
LTE-A	LTE advanced
MAC	Media access control
MBS	Macrocell base station
MIMO	Multiple-input multiple-output
NE	Nash equilibrium
OCR	Opportunistic cognitive routing
OFDMA	Orthogonal frequency-division multiple access
PDF	Probability density function
POMDP	Partially observable Markov decision process
POP	Point of presence
PU	Primary user
QoS	Quality of service

RAN	Radio access networks
RF	Radio frequency
RREQ	Routing request
RRSP	Routing response
SCF	Small cell forum
SBS	Small cell base station
SINR	Signal to noise and interference ratio
SNSINV	Sensing invitation
SU	Secondary user
UWB	Ultra-wideband
VBR	Variable bit rate
WiMAX	Worldwide interoperability for microwave access
3GPP	3rd generation partnership program