FUTURE WIRELESS NETWORK ARCHITECTURE

by

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... to my best teacher, Prof Tapio Erke

DECLARATION

I hereby certify that this thesis is submitted in the form of a series of published papers of which I am a joint author. I have included as part of the thesis a written statement from each co-author; and endorsed by the Faculty Assistant Dean (Research Training), attesting to my contribution to the joint publications.

This thesis contains no material which has been accepted for the award of any other degree or diploma in any university or other tertiary institution and, to the best of my knowledge and belief, contains no material previously published or written by another person, except where due reference has been made in the text. I give consent to the final version of my thesis being made available worldwide when deposited in the University's Digital Repository[1], subject to the provisions of the Copyright Act 1968.

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LIST OF PUBLICATIONS BY THE CANDIDATE

1. **A. Asheralieva**, J. Khan, K. Mahata and E.-Hw. Ong, “A Predictive Network Resource Allocation Technique for Cognitive Wireless Networks”, in Proc. ICSPCS, Dec. 2010, pp. 1 – 9.
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9. **A. Asheralieva** and K. Mahata, “Delay Aware Resource Allocation for Secondary Users in Cognitive LTE Network”, to be published in Proc. MASS, Oct. 2014.

LIST OF ABBREVIATIONS AND ACRONYMS

3GPP	- 3d Generation Partnership Project
ACK	- ACKnowledgement
AIC	- Akaike Infromation Criterion
AMC	- Adaptive Modulation and Coding
AP	- Access Point
AR	- Autoregressive
ARIMA	- Autoregressive Integrated Moving Average
ARMA	- Autoregressive Moving Average
ARQ	- Automatic Repeat reQuest
AWGN	- Additive White Gaussian Noise
B3G	- Beyond 3rd Generation
BER	- Bit Error Ratio
BPSK	- Binary Phase Shift Keying
BS	- Base Station
BSR	- Buffer Status Report
CC	- Chase Combining
CCE	- Control Channel Element
CCH	- Control CHannel
CDMA	- Code Division Multiple Access
CR	- Cognitive Radio
CRC	- Cyclic Redundancy Check
CRN	- Cognitive Radio Network
CSMA/CA	- Carrier Sense Multiple Access with Collision Avoidance
DCF	- Distributed Coordination Function
DL	- DownLink
DL-SCH	- Downlink Shared CHannel
DSA	- Dynamic Spectrum Access
eNB	- Evolved Node B
EPC	- Evolved Packet Core
EPC	- Evolved Packet System
E-UTRA	- Evolved Universal Terrestrial Radio Access
E-UTRAN	- Evolved Universal Terrestrial Radio Access Network
FARIMA	- Fractional Autoregressive Integrated Moving Average
FD	- Fully Dynamic

FDD	- Frequency Division Duplex
FEC	- Forward Error Correction
FIFO	- First-In-First-Out
FTP	- File Transfer Protocol
GERAN	- Groupe spécial mobile Enhanced data rates Radio Access Network
GSM	- Groupe Spécial Mobile
GPRS	- General Packet Radio Service
GW	- GateWay
HARQ	- Hybrid Automatic Repeat reQuest
HCF	- Hybrid Coordination Function
HSPA	- High Speed Packet Access
HTTP	- HyperText Transfer Protocol
IEEE	- Institute of Electrical and Electronics Engineers
IR	- Incremental Redundancy
IP	- Internet Protocol
ITU	- International Telecommunication Union
ITU-T	- International Telecommunication Union – Telecommunication Standardization Sector
L1	- Layer 1
L2	- Layer 2
LTE	- Long-Term Evolution
LTE-A	- Long-Term Evolution Advanced
MA	- Moving Average
MAC	- Medium Access Control
MCS	- Modulation and Coding Scheme
MIMO	- Multiple Input Multiple Output
MME	- Mobility Management Entity
NACK	- Negative ACKnowledgement
NMSE	- Normalized Mean Squared Error
OFDM	- Orthogonal Frequency Division Mode
OFDMA	- Orthogonal Frequency Division Multiple Access
PDCCH	- Physical Downlink Control CHannel
PDCP	- Packet Data Convergence Protocol
p.d.f.	- probability density function
PDSCH	- Physical Downlink Shared Channel
PER	- Packet Error Ratio
PER	- Prediction Error Ratio

PF	- Proportional Fair
P-GW	- Packet-data network GateWay
PHY	- PHYsical
PLR	- Pseudo-Linear Regression
PS	- Packet Scheduler
PU	- Primary User
PUCCH	- Physical Uplink Control Channel
QAM	- Quadrature Amplitude Modulation
QoS	- Quality of Service
QPSK	- Quadrature Phase Shift Keying
RA	- Random Access
RACH	- Random Access Channel procedure
RAN	- Radio Access Network
RAT	- Radio Access Technology
RB	- Resource Block
RBP	- Resource Block Pair
RIV	- Recursive Instrumental Variable
RLC	- Radio Link Control
RLS	- Recursive Least Squares
RPEM	- Recursive Prediction Error Method
RR	- Round Robin
RRC	- Radio Resource Control
RTP	- Real-time Transport Protocol
Rx	- Receiver
SAE	- System Architecture Evolution
SC-FDMA	- Single Carrier Frequency Division Multiple Access
SCM	- Spatial Channel Model
SDP	- Session Description Protocol
SDR	- Software Defined Radio
SE	- Spectral Efficiency
S-GW	- Serving GateWay
SINR	- Signal-to-Interference-and-Noise Ratio
SIP	- Session Initiation Protocol
SJF	- Shortest-Job-First
SMP	- SeMi-Persistent
SNR	- Signal-to-Noise Ratio
SP	- Service Provider
st.dev.	- standard deviation

SU	- Secondary User
TCP	- Transmission Control Protocol
TTI	- Transmission Time Interval
Tx	- Transmitter
UDP	- User Datagram Protocol
UE	- User Equipment
UL	- UpLink
UL-SCH	- Uplink Shared CHannel
UMTS	- Universal Mobile Telecommunications System
UTRAN	- Universal Terrestrial Radio Access Network
VoIP	- Voice over Internet Protocol
WiMAX	- Worldwide interoperability for Microwave Access
WLAN	- Wireless Local Area Network
WRAN	- Wireless Regional Area Network

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ABSTRACT

With widespread use of wireless networks and the emergence of multiple Radio Access Technologies (RATs), the present-day network architecture is currently being transformed into the one global infrastructure vision, called Beyond 3rd Generation (B3G) [1]. B3G is a heterogeneous Internet Protocol (IP) based wireless access infrastructure, which aims to provide higher capacity and quality of service (QoS) to the users even considering the limited radio spectrum through support of a cooperative diversity [2] and reconfigurability [3].

In a system with a cooperative diversity each node in the network can act both as an information source and a relay. Such information relay may increase the capacity and diversity gain in wireless networks, leading to the improved performance in terms of both area coverage and QoS [4]. In B3G the cooperative communication assumes that the network infrastructure will rely on more than one RAT: depending on encountered specific conditions (e.g., hot-spot requirements, traffic demands, etc.) at different times in different areas the RATs will cooperate with each other to achieve the maximization of QoS levels offered to users. To support the cooperative communications in B3G, the advanced management functionality is required to deal with the reallocation of traffic to different RATs and sub-networks, as well as the mapping of applications to QoS levels [5-8].

The move towards the reconfigurability concept was initiated by the development of the Cognitive Radio Network (CRN) – the network, where the nodes with fixed licensed spectrum (so-called primary nodes) can share their spectrum resources with nodes without fixed licensed spectrum (secondary nodes) [9]. In B3G the reconfigurability aims to provide essential mechanisms for terminals and sub-networks, to enable them to adapt dynamically and transparently to the most appropriate RAT depending on encountered situation (hot-spot requirements, traffic demands, etc.). The reconfigurability allows for the dynamic allocation of resources (such as bandwidth, service rate, etc.) to RATs, and invokes a variety of new possibilities with respect to the more efficient utilization of available spectrum [1, 9-10].

With regard to the diverse challenges arising upon the development and deployment of B3G, this thesis aims to:

1. explore the potential ways of implementing the future wireless infrastucture based on existing wireless networking standards and co-existance of air such features ;
2. study the main principles of cooperative and cognitive communication which lie in:
   (a) cooperation and information exchange between all member subnetworks;
   (b) support of reconfiguration capabilities of all nodes/user terminals within the network;
   (c) coexistence of the nodes/user terminals belonging to different RATs comprising the network ;
   (d) intelligent resource planning involving cognitive reactive and proactive management of the network resources based on external (environmental) aspects, as well as on goals, capabilities, experience and knowledge.
3. develop the efficient radio resource management platform in order to provide increased spectrum utilization and enhanced end-to-end QoS for users of different RATs with and without fixed spectrum allocation.
4. investigate the problems of co-existance, intra- and cross-layer control between different RATs comprising the network, including:
   (e) PHY layer channel modeling, including noise and interference models, log-distance path loss, shadow and multipath induced fading, physical layer transmission techniques (MCS, AMC);
   (f) MAC/RLC layer design, including traffic generation models, packet scheduling, ARQ/HARQ, DCF/HCF, buffer status reporting, etc.;
   (g) Cross-layer control: necessary parameters (such as packet arrival rate, buffer occupancy, SINR) are observed on MAC and PHY; control of available resources (such as bandwidth, data rate, buffer capacity) on PHY layer;
   (h) Application layer QoS for users as a result of undertaken control on PHY/MAC layer.