Thesis projects in Wireless Systems 2012

Master Thesis Projects @ Communication Systems (COS)

Here you find some suggested Thesis projects ("Exjobb") suitable for students specializing in Wireless Systems. The collection is not to be seen as complete in any way. The proposals may not all be available at the time you read this, but they still fulfil the function of "place-holders" and examples of what kind of thesis projects can be conducted at the company in question. The contact person listed in the proposals below may in this case have another project available or guide you to some colleague that has. Several of the proposals are about projects that are, or may be, run in cooperation with Wireless@KTH industry partners. Some of the projects or part thereof could also be suitable for Bachelor Theses. Contact the contact person to find out more about the projects.

Most projects are scheduled to start in January 2012

The collection of project proposals is constantly updated at
http://www.kth.se/ict/om/organisation/forskningsenheter/cos/2.18460/master/proposals

Capacity of 'Femtocell-like' Secondary System in TV White Space

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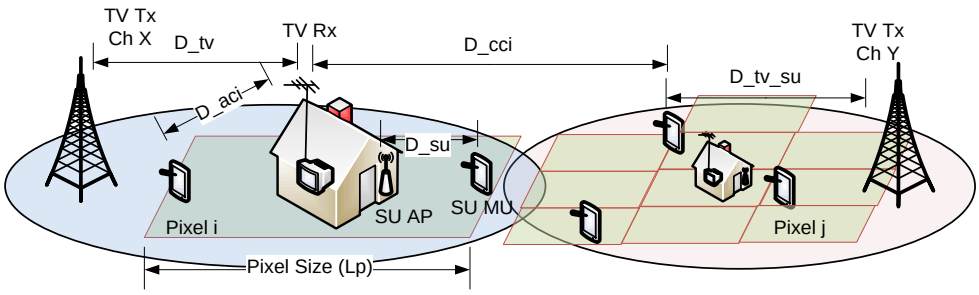
Background

With the rapid growth of wireless data traffic, the spectrum has become a bottleneck for the development of wireless services. Secondary access in the VHF/UHF TV band, often referred to as TV white space (TVWS), is considered as one promising solution to this 'spectrum scarcity'. It allows secondary users (SU) to access the TV spectrum, as long as SU(s) can control its transmit power to limit the aggregate interference inflicted to TV receiver [1]. A geo-location database, that contains information about TV coverage and terrain data, enables SU to determine its permitted Tx power based on the estimated median path loss of the co-channel interfering link to the TV coverage boundary [2,3,4]. However, SU transmitting on adjacent channels inside the TV coverage cannot estimate the path loss of its adjacent channel interfering link, as the victim TV receiver could be located anywhere close by and the database has limited resolution [5]. Current study has focused on either single secondary user [6] or multiple users in hypothetical environment with macro cellular deployment [7].



Problem Formulation

Estimate the capacity of a 'Femtocell-like' secondary system in TV white space in a realistic environment. Conduct case study for regions from the real world. Control interference received by TV from secondary system by utilizing information that is available in the geo-location database, such as population density, terrain and TV coverage.

References

[1] M. Nekovee, "Cognitive radio access to tv white spaces: Spectrum opportunities, commercial applications and remaining technology challenges," in New Frontiers in Dynamic Spectrum, 2010 IEEE Symposium on, april 2010, pp. 1 –10.

[2] "Technical and operational requirements for the possible operation of cognitive radio systems in the white spaces of the frequency band 470-790MHz". ECC Report 159. http://www.ero.dk

[3] H. Karimi, "Geolocation database for white space devices in the uhf tv bands: specification of maximum permitted emission levels," in 2011 IEEE International Symposium on Dynamic Spectrum Access Networks (DySPAN), 2011.

[4] E., Obergon; L. Shi; J., Ferrer and J., Zander; A Model for Aggregate Adjacent Channel Interference in TV White Space; VTC 2011.

[5] L. Shi; K.W., Sung and and J., Zander; On the Permissible Transmit Power for Secondary User in TV White Spaces; Submitted to IEEE Electronics Letters.

[6] M. Nekovee, "UHF white space in Europe – quantitative study into the potential of the 470–790 MHz band" in IEEE Symposium on New Frontiers in Dynamic Spectrum, april 2011, pp. 1 –10.

[7] K. Ruttik, K. Koufos, and R. Jäntti, "Modeling of the secondary system's generated interference and studying of its impact on the secondary system design," Radio Engineering, December, 2010.

Spatial and Fading Models for Evaluation of Wireless Systems

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Background

Modeling of base station locations and fading environment play important roles in performance evaluation of cellular wireless systems. Traditionally, base stations (BSs) are assumed to have a hexagonal grid of locations for simplicity. However, it is reported that a recently developed mathematical model provides better description of real-life BS deployment [1-2]. As for fading, uncorrelated shadow fading is often used for tractability [3]. However, there exists a correlation in spatial shadowing distribution. In spite of its importance, the impact of simplified models on the accuracy of performance evaluation has not been investigated well.

Problem Formulation

This project will examine different models for BS locations and fading in order to identify the relationship between the complexity of models and accuracy of performance evaluation. There are various levels of simplification in the modeling from hexagonal cells without fading to BS locations by stochastic geometry and correlated shadowing map. The aim of the project is to find out critical factors that can make significant impact on the performance evaluation.

This work involves mathematical analysis and simulation. A student with good knowledge of probability models and random variables will be considered with priority.

References

[1] R. K. Ganti, F. Bacelli, and J. G. Andrews, “A New Way of Computing Rate in Cellular Networks,” in Proc. IEEE ICC, June 2011.

[2] J. G. Andrews et al, “A Primer on Spatial Modeling and Analysis in Wireless Networks,” IEEE Communications Magazine, Nov. 2010.

[3] K. W. Sung, H. Haas, and S. McLaughlin, “A Semianalytical PDF of Downlink SINR for Femtocell Networks,” EURASIP Journal on Wireless Communications and Networking, vol. 2010, Article ID 256370, doi:10.1155/2010/256370, 2010.

Performance Comparison of Secondary Sharing via Geo-location or Spectrum Sensing

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Background

The great demand for new and existing wireless services with higher data rates has led to an apparent shortage of the available spectrum. However, studies have shown that the spectrum is mostly underutilized in space and time due to the regulatory policies that allows only static spectrum allocation. Dynamic Spectrum Access (DSA) paradigm was proposed as a solution to this inefficient use of the available spectrum. DSA allows secondary users to dynamically access the white spaces or unused portions of spectrum licensed to a primary system. Previous studies have mainly focused on the protection of the primary system while performance of multiple secondary users under practical assumptions has not been fully addressed.

Problem Formulation

We consider secondary system with low-power devices that gather information about the primary system either via geo-location database or spectrum sensing. Secondary users have a limited knowledge about the propagation-loss or the location of the primary victim. Therefore, conservative decisions must be taken by the secondary users to avoid harmful interference to the primary victim. The performance of secondary users is evaluated in terms of their transmission probability at given location.

This thesis aims at providing insights in the following research questions:

- Which spectrum sharing scheme gives the highest performance of secondary user?
- Implementing both sharing schemes gives a considerable improvement on the performance of secondary user or gains are not significant?

References

[1] Ghosh, C.; Roy, S.; Cavalcanti, D.; , "Coexistence challenges for heterogeneous cognitive wireless networks in TV white spaces," Wireless Communications, IEEE , vol.18, no.4, pp.22-31, August 2011

[2] Goncalves, V.; Pollin, S.; , "The value of sensing for TV White Spaces," New Frontiers in Dynamic Spectrum Access Networks (DySPAN), 2011 IEEE Symposium on , vol., no., pp.231-241, 3-6 May 2011

[3] Gurney, D.; Buchwald, G.; Ecklund, L.; Kuffner, S.L.; Grosspietsch, J.; , "Geo-Location Database Techniques for Incumbent Protection in the TV White Space," New Frontiers in Dynamic Spectrum Access Networks, 2008. DySPAN 2008. 3rd IEEE Symposium on , vol., no., pp.1-9, 14-17 Oct. 2008

[4] Ki Won Sung; Obregon, E.; Zander, J.; , "On the requirements of secondary access to 960–1215 MHz aeronautical spectrum," New Frontiers in Dynamic Spectrum Access Networks (DySPAN), 2011 IEEE Symposium on , vol., no., pp.371-379, 3-6 May 2011

Energy Efficiency Improvements Through Two-tier Cellular Networks

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Background

Energy Efficiency in cellular mobile radio networks is impacted by the power consumption and has recently gained momentum. One of the recent developments in mobile networks is the introduction of femto base stations. Femto base stations are low-power, low-cost, user-deployed devices, designed for use in residential or enterprise environments [1].

The performance of femtocell networks is commonly investigated with respect to its spectral efficiency, however recently possible energy consumption reductions via femtocells are started to be discussed. When we consider that about %60 of voice and % 90 of data traffic is expected to be originated from indoors, we can guess that usage of femto base stations will be more energy efficient than blasting the signals through the walls [2],[3].

Problem Formulation

This thesis project investigates the energy efficiency of joint deployment of macrocells for area coverage and open& closed access femtocells. Co-channel deployment between macro and femto networks will be assumed. First, load-independent power consumption model will be considered and possible energy efficiency improvements will be shown for different femtocell penetration rate by considering the performance degradation because of interference between Macro and Femto networks. Then, the results will be compared for load dependent power consumption scenario. The study aims at finding the energy efficiency improvements via indoor femtocell deployment compared to traditional homogenous network deployment.

Type of Project: Simulation, and analysis.

Required background: Wireless networks or equivalent, good background in system level simulation is preferred.

References

[1] Hoydis, M. Kobayashi, and M. Debbah, “Green small-cell networks”, in Vehicular Technology Magazine, IEEE, vol. 6, march 2011.
[2] K. Dufkova, et al., “Energy Consumption Comparison Between Macro-Micro and Public Femto Deployment in a Plausible LTE Network”, in e-Energy 2011: 2nd International Conference on Energy-Effcient Computing and Networking 2011.
[3] L. M. Apio, et al., “Energy Efficiency and Performance in Mobile Networks Deployments with Femtocells”, in Personal Indoor Mobile Radio Communications, IEEE, vol. 6, September 2011.

Delay distribution in selfish multichannel random access networks

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Background

Efficient management of the limited spectrum resources is an important prerequisite for wireless systems to perform well. However, the most efficient solutions which squeeze most number of bits for a given amount of bandwidth and transmit power are typically the most complex solutions as well, e.g. centralized systems which exchange lots of control information. Therefore in certain scenarios, efficiency requirements may be relaxed in favor of reduced system complexity, e.g. as in distributed systems. However, in distributed systems, users may try to maximize their own performance and disregard how their behavior may adversely affect other users, so analysis of selfish behavior in such distributed systems becomes an interesting issue. Voice services are still a strong contributor to operator revenues, and constitute a significant portion of user demand. Therefore it is interesting to consider how delay-sensitive services like voice services can be provided in future wireless networks in which users access the spectrum resources in a distributed manner .Distributed multichannel systems with delay-sensitive applications are considered in [1-2]. In [1] channel selection problem for delay-sensitive applications in a distributed multichannel system is considered. A learning strategy for distributed users is analyzed in [2]. A multichannel random access system with selfish users which have incomplete channel state information are considered in [3], however, this work considers user performance in terms of throughput rather than delay.

Problem definition

The objective of this thesis is to obtain the delay distribution of packet traffic generated by selfish users in a multichannel random access (MRA) system in which there is no central entity to control or coordinate the users. In order to perform this analysis, the behavior of selfish users is to be modeled with a suitable utility function which takes into account users' delay and energy expenditure considerations. Following this, the behavior of selfish users in this MRA system will be analyzed using a learning model, for example fictitious play [4]. Delay distribution of the traffic under various system sizes and loads will be obtained by means of simulations. This thesis involves some analytical work as well as numerical simulations. Therefore, strong mathematical skills will be helpful. It is also a plus if the student has completed some coursework on random access networks and game theory, however, these are not mandatory.

References

[1] [1] Hsien-Po Shiang; van der Schaar, M.; "Conjecture-based channel selection game for delay-sensitive users inmulti-channel wireless networks," Game Theory for Networks, 2009. GameNets '09. International Conference on ,vol., no., pp.241-250, 13-15 May 2009

[2] [2]Fangwen Fu; van der Schaar, M.; , "Learning to Compete for Resources in Wireless Stochastic Games,"Vehicular Technology, IEEE Transactions on , vol.58, no.4, pp.1904-1919, May 2009

[3] Ozyagci, Ali; Zander, Jens; "Distributed Dynamic Spectrum Access in Multichannel Random Access Networkswith Selfish Users," Wireless Communications and Networking Conference (WCNC), 2010 IEEE , vol., no., pp.1-6,18-21 April 2010

[4] Berger, U.; "Brown's "Brown's original fictitious play," Journal of Economic Theory, Volume 135, Issue 1, July 2007, Pages 572-578

Spectrum Sharing between Indoor Operators in Asymmetry Environments

Contact Person: Du Ho Kang (dhkang@kth.se) and Jens Zander

Starting Time: Immediately

Background

In mobile broadband era, ever-increasing data traffic will be mostly generated from indoor or hotspot places. To manage the capacity shortage problem in a cost-effective manner, many traditional operators consider to deploy local indoor networks in their selective areas, e.g., shopping malls or offices. However, limited availability or access to spectrum may hinder parallel deployment of local wireless networks in dedicated spectrum. Instead, they may agree to share their licensed spectrum or deploy their networks in a common spectrum, e.g., WiFi deployments in unlicensed band [1].

Without any regulations or fine agreements between indoor operators, each network may selfishly utilize the spectrum while harming severe interference to neighboring operators, e.g., adjacent office buildings. Also, they naturally prefer network independence for business flexibility. In the literature, most of scenarios regarding interference management among operators assume the same environmental conditions, e.g., user statistics or channel model [2]. However, the symmetry conditions may not be true in practice due to the different network deployment and indoor structures [3]. In this project, we will study how such various asymmetric environments affect the operator competition in shared spectrum.

Problem Statement

This task will be to investigate the performance of indoor operators according to various network asymmetry when they interfere each other at the close vicinity. Also, which environment asymmetry is negligible or dominant to affect the operator competition need to be further explored. As a good start, students can consider two simplified neighboring office networks which was modeled in [2]. The operator competition in shared spectrum can be also modeled as a strategic game.

Type of work: Modeling, Simulation

References

[1] D. H. Kang, K. W. Sung, and J. Zander, “Cooperation and Competition in Cost-efficient Indoor & Hotspot Mobile Broadband Systems”, submitted to IEEE Wireless Magazine.

[2] D. H. Kang, K. W. Sung, and J. Zander, “Cooperation and Competition between Wireless Networks in Shared Spectrum”, IEEE PIMRC, Toronto, Canada, Sep. 2011.

[3] D. H. Kang, K. W. Sung, and J. Zander, “Operator Competition with Asymmetric Strategies in Shared Spectrum”, submitted to IEEE WCNC 2012.

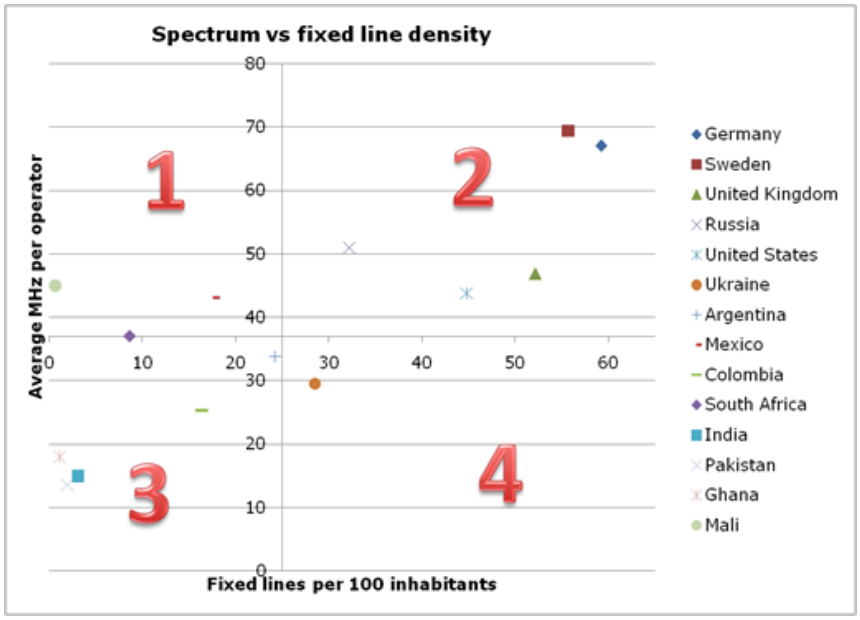
Alternative mobile broadband deployment

Advisors: Jan Markendahl (janmar@kth.se), Bengt G. Mölleryd (bengt.molleryd@pts.se)

Background and scope

The numbers of users and usage of mobile data service are increasing dramatically due to the introduction of smartphones and mobile broadband dongles. For the next decade the mobile broadband market is expected to grow and reach a level where the average data consumption per user is orders of magnitude greater than today. For the telecom industry it is a magnificent challenge to design and deploy these high-capacity wireless networks taking into account limitations in cost, energy and radio spectrum. The R&D has for many years been targeting high peak data rates enabled by improved spectral efficiency, adding more spectrum bands, aggregation of frequency bands and offloading to local wireless networks connected via public fixed phones or broadband.

However, many of these features driving the technology development are representative for the conditions in US and Western Europe where the amount of spectrum allocated to operators is high and where there is a lot fixed line networks, see quadrant 4 in the figure. The wireless networks also need to be designed assuming deployment in regions in the world where both the availability of spectrum as well as the penetration of fixed phones and broadband are limited. ***Hence, we will run a set of 1-2 student thesis projects focused on the conditions for countries in the other quadrants.***



Objective

The first objective for the projects is to investigate the specific conditions and requirements for network deployment in countries with low fixed line penetration and/or low amounts of spectrum. Secondly, possible network deployment strategies should be identified and assessed at a high level.

Reference

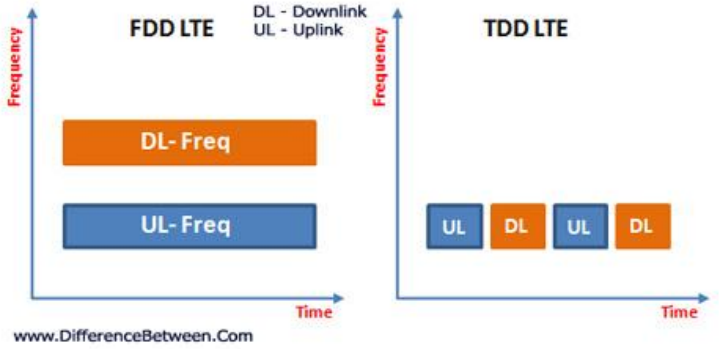
Jan Markendahl, Bengt G Mölleryd, Claes Beckman, Östen Mäkitalo, " Scenario driven requirement engineering for design and deployment of mobile communication networks ", 22nd European Regional ITS Conference Budapest, 18-21 September, 2011.

Analysis of impact of TD-LTE for mobile broadband

Advisors: Jan Markendahl (janmar@kth.se), Bengt G. Mölleryd (bengt.molleryd@pts.se)

Background

Spectrum for mobile services is allocated to both Frequency Division (FDD) and Time Division (TDD) type of systems. However, most mobile systems today are of the FDD type and hence there is a lot of unused TDD spectrum. There are a lot of TDD initiatives and commercial launches around the world.



Statement by Goldmann Sachs ***TD-LTE adoption is gaining momentum among global carriers:***
"In our view, TD-LTE is becoming the global solution for unpaired spectrum due to its 3G interoperability, large data capacity, and leverage of the FDD-LTE ecosystem. Verizon's successful launch of FDD-LTE in the US should further accelerate the conversion of WiMAX to TD-LTE. In June, two more carriers have joined the TD-LTE camp, which now totals 12 carriers. China Mobile, Bharti, and Softbank, three major carriers covering 39% of the global population, look on track to roll out some TD-LTE services in late 2012 or early 2013, and the significant potential of these markets should attract increasing R&D investment into TD-TLE technology, in our view".

Two types of projects and tasks

Technology and network oriented task:

Make a high level analysis of benefits and problems for LTE-TD from a network deployment perspective. Then select two deployment cases, e.g. countries and operators with different spectrum allocation, and compare benefits and challenges (e.g. capacity, cost, interference, FDD co-existence).

Market impact and competition oriented task:

First, make a high level compilation of the market situation and operator situations in countries where TD-LTE are considered in order to identify key issues regarding competition. Then, select two countries and make a detailed analysis if and how use of TD-LTE may have an impact on the market, e.g. market structure, operator position, end-user prices, new services, level of competition.

Some reading

[1] Goldmann Sachs, "TD-LTE: gearing up to cover 2.7bn people in Asia by 2013", June 30, 2011 http://www.gsmamobilebroadband.com/upload/resources/files/GS-TDLTE.pdf

[2] Global TD-LTE Initiative (GTI) web page: http://www.lte-tdd.org/

[3] "Softbank Mobile Goes TD-LTE", http://www.dailywireless.org/2011/09/29/softband-mobile-goes-td-lte/

[4] "Indian 3g/4g Auction: Qualcomm Bidding TD-LTE" http://www.dailywireless.org/2010/03/19/indian-3g4g-auction-qualcom-bidding-td-lte/

Femtocell-based business models using TV white spaces

Advisor: Jan Markendahl (janmar@kth.se)

Background

LTE-femtocells are small coverage area cells which are expected to be widely deployed in future wireless networks to enhance indoor radio coverage and system capacity in enterprises and hotspots. Such microcell technologies should not just deliver fixed access over a wireless environment but need to interwork with the large scale network. Extensive research has been done in order to show that femtocells could provide promising indoor coverage solutions, i.e., high capacity, compact system which reduces device count and lower environmental costs, improves service profitability with lower data delivery costs, support network migration plans (4G) without forklift upgrades, it also has the potential to reduce operational costs by enabling backhaul over public broadband network, etc. [1].

Most literature on LTE-femtocell for indoor wireless systems contains well investigated contributions which describe the benefits on the technical design, interference analysis and radio wave propagation models. Analysis of operational costs reduction benefits through femtocells that cognitively access the white spaces in TV bands is still to be developed. Business models for LTE-femtocell--operating in TV white spaces--for cost reduction deployment must be proposed.

Problem formulation and main tasks

There are three main problem areas that need to be addressed:

1. In order to assure profitability and provide ubiquitous broadband wireless access, femtocell services must be provided with favourable cost options. The capital and operational expenditures should be kept at a reasonable level in order to justify a femtocell solution.

    a. Does LTE-femtocell operating in TV white space provide any cost reduction gain when providing broadband access in an indoor scenario? If so, under which conditions is this possible?

    b. The idea is to analyse the cost structure of providing broadband services in indoor environments with macro cell solution only then analyse the joint macro-femtocell deployment cost to meet the demand and finally compare the cost saving when deploying cognitive femtocell systems which operate in the white spaces of the TV bands.

2. Business models for open and dynamic access: The cost reductions when offloading the macro network by femtocell operation and discovering the vacant resources by cognitive capabilities provide a strong motivation for operators to introduce cognitive

femtocell-based services. These cost savings can be exploited to provide low-cost voice and data services to customers. The economic benefits of data offloading from a mactocell to a local LTE femtocell can be analysed. The system model presented in [2] can be reused and additionally, devise the economic model.

3. Assuming a network where indoor users own their femtocell equipment, some more practical and streamlined business models could to be developed to improve operators' profitability. This could be done by encouraging the femtocell owners to be willing to **share their resources with secondary users**. Moreover, charging models and service agreements for cognitive femtocell users are to be defined.

This work could be done by three master students.

References

[1] Solution Briefs & Overviews, "Scalable Security Gateway Functions for Commercial Femtocell Deployments and Beyond", STOKE report August **2011**, Available at: http://www.stoke.com/Document_Library.asp,

[2] Peng Lin, Jin Zhang, Yanjiao Chen, and Qian Zhang, *"Macro-Femto Heterogeneous Network Deployment and Management: From Business Models to Technical Solutions",* IEEE Wireless Communications, June **2011**. Available at: http://ieeexplore.ieee.org/stamp/stamp.jsp?tp=&arnumber=5876502

[3] Doru Clain, Holger Claussen and Huseyin Uzunalioglu, *"On Femto Deployment Architectures and Macrocell Offloading Benefits in Joint Macro-Femto Deployments",* IEEE Communication Magazine, January **2010**. Available at: http://ieeexplore.ieee.org/stamp/stamp.jsp?tp=&arnumber=5394026

[4] Milind M. Buddhikot, Irwin Kennedy, Frank Mullany, and Harish Viswanathan, *"Ultra-Broadband Femtocells via Opportunistic Reuse of Multi-Operator and Multi-Service Spectrum",* Bell Labs Technical Journal **2009**, Available at: http://www.bell-labs.com/user/mbuddhikot/psdocs/cogfemto/BLTJ134_08_129-144-photoready.pdf

[5] Gürkan Gür, Suzan Bayhan, and Fatih Alagöz, *"Cognitive Femtocell Networks: An overlay Architecture for Localized Dynamic Spectrum Access",* IEEE Wireless Communications, August **2010**, Available at: http://ieeexplore.ieee.org/stamp/stamp.jsp?tp=&arnumber=5547923

[6] William Gerhardt and Richard Medcalf, *"In Femtocells: Implementing a Better Business Model To Increase SP Profitability",* Cisco Internet Business Solutions Group (IBSG), March **2010**, Available at http://www.cisco.com/en/US/solutions/ns341/ns973/ns941/femtocell_point_of_view.pdf