



UNIVERSITI PUTRA MALAYSIA

***ENHANCED DISTRIBUTED COOPERATIVE SPECTRUM SENSING
FOR COGNITIVE RADIO NETWORKS***

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**ENHANCED DISTRIBUTED COOPERATIVE SPECTRUM SENSING
FOR COGNITIVE RADIO NETWORKS**

By

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**Thesis Submitted to the School of Graduate Studies, Universiti Putra
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Philosophy**

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DEDICATION



To my Beloved Family

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Abstract of thesis present to the Senate of Universiti Putra Malaysia in fulfillment of the requirement for the degree of Doctor of Philosophy

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COGNITIVE RADIO NETWORKS**

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July 2011

Chairman: Prof. Borhanuddin Mohd Ali, PhD

Faculty: Engineering

Cognitive radio will gain acceptance only when the primary detection model is accurate to insure no interference to primary system. Cooperative sensing for primary detection is degraded by the reliability of local node sensing in high fading environments. Further, managing the control channel and fusion node is problematic aspect. For instance, to ensure the local sensing is reported correctly to fusion centre requires very low bit error rate (BER) channel. Another issue, that reporting channel needs large bandwidth to carry the reporting traffics. In order to improve the sensing performance and reduce the reporting error, a distributed architecture for processing and fusion of sensing information is considered. This thesis proposes an adaptive and distributed detection threshold based on maintained probability of false alarm to increase reliability of sensing under Rayleigh fading channel. The link quality status of the sensing channel of the candidate nodes is used to determine the detection threshold dynamically and the reporting link status is used for dynamic selection of fusion node for the distributed

cooperative sensing. Furthermore a dynamic TDMA MAC is proposed for media access and information exchange where the noise estimation is also used for the nodes reporting scheduling; this method increases the sensing time for the later scheduled cognitive radios. The proposed distributed scheme shows a significant improvement in the overall detection readability. The probability of detection, and bit error rate (BER) were used as performance metrics in the analytical and simulation results to validate the proposed method over the direct cooperation and non-cooperative sensing. Also analytical formulation with possible candidate selection criteria is used to investigate and optimize the distributed cooperation gain. The results show that by employing such distribution and selection technique, the reporting error due to the fading channel is reduced up to 42% based on number of candidate nodes. Results also shown that the method significantly improved the sensing performance by increase the probability of detection up to 0.9 at <0.1 probability of false alarm. Sensitivity requirement is reduced dramatically by more than 95% with varying number of nodes and probability of detection. Receiver operation characteristic (ROC) curve with the parameters and performance achieved verified that the probability of detection P_d can be improved significantly while maintaining probability of false alarm <0.1 .

Abstrak tesis yang dikemukakan kepada Senat Universiti Putra Malaysia sebagai memenuhi keperluan untuk ijazah Doktor Falsafah

**DIPERTINGKATKAN PENGESANAN SPEKTRUM BEKERJASAMA
TERABUR DALAM RANGKAIAN RADIO KOGNITIF**

Oleh

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Kognitif radio akan diterima hanya apabila model pengesanan sistem utama adalah tepat untuk menginsuranskan tiada gangguan kepada sistem utama. Penderiaan Koperasi untuk mengesan sistem utama adalah dihina oleh kebolehpercayaan nod tempatan sensing dalam persekitaran yang tinggi pudar. Selain itu, aspek yang bermasalah adalah pengurusan saluran kawalan dan titik penggabungan. Sebagai contoh, untuk memastikan pengesanan dilakukan dengan betul ke titik penggabungan ia memerlukan saluran BER (Bit Error Ratio) yang rendah. Selain itu, laporan ini memerlukan jalur lebar yang besar untuk membawa laporan kawalan. Supaya meningkatkan prestasi penderiaan dan mengurangkan kesilapan pelaporan, satu seni bina teragih untuk pemprosesan telah dipertimbangkan. Di sini, kami mencadangkan satu adaptif dan mengedarkan ambang pengesanan berdasarkan selenggara kebarangkalian panggilan palsu untuk meningkatkan kebolehpercayaan penderiaan di bawah kaedah Rayleigh saluran pemudaran. Status kualiti hubungan saluran penderiaan nodus calon digunakan bagi menentukan ambang

pengesanan dinamik dan melaporkan status pautan yang digunakan untuk pemilihan dinamik lakuran untuk penderiaan bekerjasama teragih. Tambahan pula TDMA MAC yang dinamik adalah dicadangkan untuk akses media dan pertukaran maklumat di mana anggaran bunyi bising juga digunakan untuk nodus penjadualan; kaedah ini meningkatkan masa penderiaan untuk dijadualkan kepada radio-radio kognitif. Skim teragih dicadangkan menunjukkan satu kemajuan yang ketara dalam kebolehbacaan pengesanan menyeluruh. Kebarangkalian pengesanan, dan kadar ralat bit (BER) telah digunakan sebagai prestasi metrik dalam keputusan simulasi dan analisis. Juga perumusan analisis dengan kriteria pemilihan calon munasabah digunakan untuk menyiasat dan mengoptimumkan keuntungan kerjasama teragih. Keputusan menunjukkan itu dengan mengambil taburan sedemikian dan teknik pemilihan, kesilapan pelaporan disebabkan saluran pemudaran dikurangkan sehingga 42% berdasarkan nombor nodus calon. Keputusan juga menunjukkan cara yang disarankan nyata sekali meningkatkan prestasi penderiaan dengan peningkatan kebarangkalian pengesanan sehingga 0.9 pada <0.1 kebarangkalian panggilan palsu. Keperluan kepekaan dikurangkan secara mendadak oleh lebih daripada 95% dengan jumlah kebarangkalian pengesanan yang berbeza-beza. Operasi penerima biasa (ROC) lengkung dengan parameter dan prestasi di sahkan dengan kebarangkalian pengesanan, P_d dan ia boleh dibaiki dengan memelihara kebarangkalian panggilan palsu <0.1 .

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I certify that a Thesis Examination Committee has met on July 18, 2011 to conduct the final examination of Rania Abdelhameed Mokhtar on her thesis entitled "Distributed Cooperative Spectrum Sensing for Cognitive Radio Networks" in accordance with the Universities and University Colleges Act 1971 and the Constitution of the Universiti Putra Malaysia [P.U.(A) 106] 15 March 1998. The Committee recommends that the student be awarded the Doctor of Philosophy.

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