BANGLADESH UNIVERSITY OF ENGINEERING AND TECHNOLOGY, DHAKA
OFFICE OF THE MEMBER SECRETARY OF THE COMMITTEE FOR ADVANCED STUDIES & RESEARCH, BUET, DHAKA

(Thesis Proposal)

Date: July 13, 2016

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   Status: Part-time
   Session: October, 2014
2. **Present Address:** Room No. 420, Dept. of CSE, BUET, DHAKA.
3. **Name of the Department:** Computer Science and Engineering
   Programme: M.Sc. Engineering
4. **Name of the Supervisor:** Dr. A. B. M. Alim Al Islam
   Designation: Assistant Professor, Dept. of CSE, BUET.
5. **Name of the Co- Supervisor:** Not Applicable
   Designation: Not Applicable
6. **Date of First Enrolment in the Programme:** Novermber 1, 2014
7. **Tentative Title:** OVERCOMING THROUGHPUT DEGRADATION IN MULTI-RADIO COGNITIVE RADIO NETWORKS.
8. **Background and present state of the problem:**
   The famous spectrum scarcity problem along with significant spectrum under-utilization in traditional spectrum management has lead towards the notion of dynamic spectrum access [1] through cognitive radios. A cognitive radio monitors its operational electromagnetic environment to dynamically adjust its operating parameters [2]. Thus, a cognitive radio is capable of accessing temporal free spectrum. Cognitive radio networks (CRNs) exploit this capability of cognitive radios to form a network. A CRN generally comprises of two types of users- primary users (PUs), i.e., the users who are licensed to operate in the spectrum bands, and secondary users (SUs), i.e., the unlicensed users employing cognitive radios to discover and opportunistically access instantaneous spectrum holes.

   On the other hand, classical wireless networks frequently adopt the notion of deploying users with multiple radios [3, 4] to improve performance of the network [5, 3, 6, 7]. Now, as the primary motive of deploying cognitive radio networks is also to improve the performance of secondary users (through dynamic spectrum utilization), it is intuitive that simultaneous utilization of both these techniques, i.e., multi-radio CRNs, will result in significantly improved network performance. Therefore, the concept of exploiting multiple radios in CRNs to supplement the dynamic spectrum access has been proposed in the contemporary literature. Such multi-radio deployment on CRNs improves delay up to a certain point, however, throughput always degrades with an increase in the number of radios per secondary user as per the existing studies in the literature [8].

   Therefore, the main motivation behind our study is to examine how to overcome the already-known phenomena of getting degraded network throughput while equipping secondary users with multiple radios. At the same time, we also want to make sure that the delay metric does not get worse while trying to increase the network throughput.

9. **Objectives with specific aims and possible outcome:**
   In this study, we have proposed a feedback based multi-radio exploitation approach for CRNs to improve network throughput. Our proposed approach consists of three steps. First, we dynamically distribute available wireless channels among available multiple radios equipped by a secondary user. Second, we measure packet delivery ratio for each radio, to evaluate their individual performance. Third, we calculate channel utilization ratio for each channel to assess channel condition. Subsequently, our proposed approach predicts the overall network throughput from these measurements and set the data rate for each radio accordingly to maximize the throughput.

   The main objectives of our study are as follows:

   i. We will propose a feedback-based multi-radio exploitation approach for CRNs. The motivation behind this design is to incorporate information on performances of lower (Physical and Medium Access Control) layers to decision making in upper (Application) layer.

ii. To evaluate the performance of the proposed approach, we will perform simulation using CRE-NS3 [9]. We will implement the proposed feedback-based approach in the simulator and measure various performance metrics with an increase in the number of radios per SU.

iii. We will compare the performance of our proposed approach against that of the existing approaches available in the literatures for multi-radio CRNs.

10. Outline of Methodology/ Experimental Design:

Outline of our proposed methodology and experimentation can be summarized in the following steps:

1. At first, we will propose a multi-radio CRNs model where SUs opportunistically access PUs' licensed spectrum bands.
2. Then, we will perform modifications in CRE-NS3 simulator required for implementation of our proposed approach. The existing simulator does not offer any module to implement a feedback-based approach. Therefore, we will develop such a module at our own and integrate it in the simulator.
3. Next, we will implement our proposed approach in our modeled multi-radio cognitive radio network and investigate the network performance. Here, we will vary parameters of our proposed approach and evaluate sensitivity of the parameters.
4. Then, we will compare the following network performance metrics obtained through our proposed approach against that of the existing approaches.
   i. Average network throughput,
   ii. Per packet average delay,
   iii. Per node average throughput,
   iv. Average packet loss.
5. Finally, we will investigate various properties of our proposed approach, discuss findings of our study, and highlight open issues of the study as future directions.

11. References:

[1] I. F. Akyildiz, W.-Y. Lee, M. C. Vuran, and S. Mohanty, "Next generation/dynamic spectrum access/cognitive radio wireless networks: a survey," *Computer Networks*, vol. 50, no. 13, pp. 2127–2159, 2006.

[2] J. Mitola and J. Maguire, G.Q., "Cognitive radio: making software radios more personal," *Personal Communications, IEEE*, vol. 6, no. 4, pp. 13–18, 1999.

[3] P. Bahl, A. Adya, J. Padhye, and A. Walman, "Reconsidering wireless systems with multiple radios," *ACM SIGCOMM Computer Communication Review*, vol. 34, no. 5, pp. 39–46, 2004.

[4] A. Adya, P. Bahl, J. Padhye, A. Wolman, and L. Zhou, "A multi-radio unification protocol for ieee 802.11 wireless networks," in *Broadband Networks, 2004. BroadNets 2004. Proceedings. First International Conference on*. IEEE, 2004, pp. 344–354.

[5] R. Draves, J. Padhye, and B. Zill, "Routing in multi-radio, multi-hop wireless mesh networks," in *Proceedings of the 10th annual international conference on Mobile computing and networking*. ACM, 2004, pp. 114–128.

[6] A. Miu, H. Balakrishnan, and C. E. Koksal, "Improving loss resilience with multi-radio diversity in wireless networks," in *Proceedings of the 11th annual international conference on Mobile computing and networking*. ACM, 2005, pp. 16–30.

[7] W. Song and W. Zhuang, "Performance analysis of probabilistic multipath transmission of video streaming traffic over multi-radio wireless devices," *Wireless Communications, IEEE Transactions on*, vol. 11, no. 4, pp. 1554–1564, 2012.

[8] T. A. Khan, C. S. Hyder, and A. Islam, "Towards exploiting a synergy between cognitive and multi-radio networking," in *Wireless and Mobile Computing, Networking and Communications (WiMob), 2015 IEEE 11th International Conference on*. IEEE, 2015, pp. 370–377.

[9] A. Al-Ali and K. Chowdhury, "Simulating dynamic spectrum access using ns-3 for wireless networks in smart environments," in *Sensing, Communication, and Networking Workshops (SECON Workshops), 2014 Eleventh Annual IEEE International Conference on*. IEEE, 2014, pp. 28–33.

12. List of courses taken:

Course No	Course Name	Credit	Grade	Grade Point	G.P.A
CSE 6806	Wireless and Mobile Communication Networks	3.0	A+	4.0	3.75
CSE 6813	Network Security	3.0	A+	4.0	
CSE 6402	Graph Theory	3.0	B	2.5	
CSE 6602	High Dimensional Data Management	3.0	A+	4.0	
CSE 6506	Data Mining	3.0	A+	4.0	
CSE 6811	Wireless Ad Hoc Networks	3.0	A+	4.0	
CSE 6000	Thesis	18.0	–	–	

Signature of the Tabulator: _____

13. Cost Estimate:

(a) Cost of Material:

a. Ink Cartridge: Tk.: 4000/=

Total: Tk.: 4000/=

(b) Field works: Not applicable.

(c) Conveyance/Data Collection: Not applicable.

(d) Typing, Drafting, Binding, & Paper etc.:

a. Drafting: Tk.: 1250/=

b. Binding: Tk.: 1250/=

c. Paper: Tk.: 1500/=

Total: Tk.: 4000/=

Grand Total: Tk.: 8000/=

14. Approximate time (in hour) for BUET workshop facilities (if required): Not applicable

15. Justification of having Co-Supervisor: Not applicable

16. Doctoral Committee/BPGS/RAC reference:
Meeting No.: **Resolution No.:** **Date:**

17. Time Extension(if any) up to: Not applicable
Approved by the CASR **Resolution No.:** Not applicable **Date:** Not applicable
Meeting No.: Not applicable

18. Appointment of Supervisor & Co-Supervisor Approved by the CASR Meeting No. (For Ph. D): Not applicable
Resolution No.: Not applicable **Date:** Not applicable

19. Appointment of Doctoral Committee Approved by the CASR Meeting No. (For Ph. D): Not applicable
Resolution No.: Not applicable **Date:** Not applicable

20. Result of the comprehensive examination for Ph. D.: Not applicable

21. Number of Post-Graduate Student(s) working with the Supervisor at Present:

Names and signatures of the members of the Doctoral Committee (if applicable)

1.	
2.	
3.	
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5.	
6.	
7.	
8.	

_____
Signature of the Student

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Signature of the Supervisor

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Signature of the Head/Director