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 16, 2016

1. **Name of the student:** TANVIR AHMED KHAN
   Roll No.: 1014052013
   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 [2]. A CRN generally comprises of two types of users - Primary Users (PUs), i.e., the users who are licensed to operate over a spectrum band, and Secondary Users (SUs), i.e., the unlicensed users employing cognitive radios to discover and opportunistically access temporal free spectrums [3, 4].

   On the other hand, classical wireless networks frequently adopt the notion of deploying users with multiple radios [5, 6] to improve performance of the networks [5, 7, 8, 9] through increased spectrum utilization. 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 literature. Such multi-radio deployment on CRNs improves end-to-end delay up to a certain point, however, throughput degrades with an increase in the number of radios per secondary user [10].

   Therefore, the main motivation behind our study is to investigate 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 attempting to increase the network throughput.
9. **Objectives with specific aims and possible outcome:**
   The main objectives of our study are as follows:

   i. The first objective of our study is to propose a new approach for multi-radio CRNs that can improve network throughput through exploitation of the multiple radios. Here, we want to make sure that no other metric such as end-to-end delay gets degraded through our approach.
   ii. The second objective is to evaluate performance of our proposed approach through experimentation.
   iii. The third objective is to compare performance of our proposed approach with that of other contemporary approaches.

   The possible outcomes of our study are as follows:

   i. The first outcome will be a feedback-based multi-radio exploitation approach for CRNs. We want to incorporate information on performances obtained from lower layers (Physical layer and Data Link layer) in the process of decision making in an upper layer (Application layer).

ii. The second outcome will be an evaluation of the performance of the proposed approach. Here, we will perform simulation using a discrete event simulator named CRE-NS3 [11]. We will implement the proposed feedback-based approach in the simulator and measure various performance metrics in response to an increase in the number of radios per SU.

iii. The final outcome will be a comparison of 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 CRN model along with a new approach of dynamic channel access where SUs opportunistically access PUs' licensed spectrum bands. In our approach, first, we will dynamically distribute available wireless channels among available multiple radios of an SU. Second, we will measure packet delivery ratio for each radio to evaluate their individual performance as per the dynamic distribution. Third, we will calculate channel utilization ratio for each channel to assess their conditions. Finally, we will predict the overall network throughput from these measurements and set the data rate for each radio to maximize the throughput ensuring no degradation of other metric such as end-to-end delay.
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 simulate multi-radio CRNs using our developed module and investigate the performance of the network. Here, we will vary operational parameters of our proposed approach and evaluate sensitivity of changing the parameters' values over performance of the network.
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 end-to-end 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] K. Pelechrinis, P. Krishnamurthy, M. Weiss, and T. Znati, "Cognitive radio networks: realistic or not?" *ACM SIGCOMM Computer Communication Review*, vol. 43, no. 2, pp. 44–51, 2013.

[4] Y. Zhang, J. Zheng, and H.-H. Chen, *Cognitive radio networks: architectures, protocols, and standards*. CRC press, 2016.

[5] 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.

[6] 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.

[7] 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.

[8] 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.

[9] 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.

[10] 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.

[11] 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 Materials:
   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.	
4.	
5.	
6.	
7.	
8.	

_____
Signature of the Student

_____
Signature of the Supervisor

_____
Signature of the Head/Director