EXECUTIVE SUMMARY
COMPUTER NETWORKS PERIODIC PROGRAM REVIEW REPORT
Submitted April 2015 with Computer Networks Self Study Report

The Computer Networks program is geared towards both networking professionals who wish to increase the depth and breadth of their knowledge in the field and those less familiar with the area who wish to enter the high-demand field of computer networks. It fills the gap between regular MASc and MEng programs and professional certificate programs. There are only two other Master's programs in networking in Canada. Unlike the other two programs, which only offer MEng-like options, the Computer Networks program offers both MEng and MASc options. The MEng option equally emphasizes the theoretical and practical aspects of Computer Networks; the MASc option, on the other hand, provides opportunities for students to undertake in-depth research on specific topics in Computer Networks. The majority of the students in the program are in the MEng option.

Ryerson University is located in downtown Toronto, and is one of the critical factors for the success of the program. Nearly all of our domestic applications come from the Greater Toronto Area. The program also attracts over 150 international applications each year and 25-30 of them are admitted and enrolled to the program.

The program has a strong practical component in the curriculum. Every course in the program has a number of labs from which students can develop valuable practical skills. The computer networks lab has been continuously updated and upgraded with major equipment acquisitions. The most recent acquisitions are Cisco Nexus 7000 and 5000 switches, Cisco UCSs and Huawei LTE 4G wireless system. The switches and UCSs are used for the Cloud Computing labs, the LTE system for the wireless labs. These labs make our facility and curriculum unique even among the similar Master's programs in networking.

Based on the employment records of 235 alumni, our graduates have a high successful rate of finding technical positions in the industry. They are working for the large Internet Service Providers (ISPs) such as Rogers, Bell and Telus, banks such as TD and RBC, public institutions such as universities and colleges, and variety of companies. Also, by tracking some of the graduates' career paths, we can see that a significant percentage of graduates have developed very successful careers. Their careers range from network consultants, network architects, senior network engineers, senior IT managers. Even though the program does not have many MASc graduates (around 20 since 2005), 8 of them went on to the PhD studies. As of this year, two graduates have become tenured university professors, another two are working as university lecturers while the rest are still in the PhD program.

The program has several intrinsic weaknesses. Firstly, its research output from its students is not strong. It is understandable, since the program is mainly a professional MEng program and it does not have a PhD option. Secondly, full-time faculty teaching participation rate is not high.

Since the teaching for the Computer Networks program is counted as overload, not a regular teaching load, the faculty members has less motivation to teach more than one course in the program. The full-time faculty members are still actively involved in the curriculum development, MASc thesis supervision and MEng project supervision. Thirdly, the tuition fees

of the program are among the highest in Ryerson University. This may deter some well-qualified potential applicants to apply. We addressed this problem by providing various program scholarships, awards and teaching assistantships. But clearly, more is needed to be done.

The program five-year development plan focuses on the following areas:

Enable Greater Student Engagement and Success through Exceptional Experiences
The program will encourage student interactions among themselves and with their professors and alumni. It will organize more student events, as well as more industrial and research seminars.

The program will also continue to improve and upgrade the existing lab facilities to keep pace/ahead of current technologies. Faculty and staff will work collaboratively to foster teaching excellence, provide students with strong intellectual foundations as well as transferable skills, who will become responsible global citizens and enable positive change.

Increase SRC Excellence, Intensity and Impact
The program will strive to increase more contacts and co-operations with the industry.
The program envisions a major shift of technology from the traditional networking to software defined networking (SDN) and Network Functions Virtualization (NFV) in the next few years. Building on the current existing lab facility and expertise, the program will shift its resources in the same direction to support SRC activities in this area. This will help maintain the effort in keeping the program's academic curriculum up-to-date and relevant.

Foster Greater Interdisciplinary SRC Activity, Curriculum and Programs
By nature, the Computer Networks program is an interdisciplinary program, a combination of Computer Engineering and Computer Science. The recent development in SDN and NFV has pushed the two disciplines ever closer. The program will co-operate with the Department of Electrical and Computer Engineering and Department of Computer Science to develop the interdisciplinary curriculum and research activities.

RYERSON UNIVERSITY

Yeates School of Graduate Studies

Final Assessment Report (FAR) and Implementation Plan for the Periodic Program Review of the Graduate Program in Computer Networks

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In accordance with the University Institutional Quality Assurance Process (IQAP), a final assessment report (FAR) is required to provide an institutional synthesis of the external evaluation and internal responses and assessments of the Periodic Program Review of the graduate program in Computer Networks (CN). This report identifies significant strengths of the program and opportunities for program improvement and enhancement. It also sets out and prioritizes recommendations selected for implementation.

This report includes an Implementation Plan that identifies:
- Who will be responsible for approving the recommendations outlined in the final assessment report; who will be responsible for providing any resources made necessary by the recommendations; who will be responsible for acting on the recommendations;
- Timelines for acting on and monitoring the implementation of the recommendations.

Summary of the Periodic Program Review of the Graduate Program in Computer Networks

The graduate program in Computer Networks submitted a self-study report to the Yeates School of Graduate Studies in April, 2015. The report outlined the program descriptions and learning outcomes, an analytical assessment for the program, and program data including data and the standard data packages. Course outlines and CVs for full-time faculty members were appended.

Three reviewers were selected:
- Dr. Hassan Naser, Associate Professor and Chair, Lakehead University
- Dr. Kui Wu, Professor, Department of Computer Science, University of Victoria
- Dr. Jelena Mišić, Department of Computer Science, Ryerson University

Upon review of the Computer Networks self-study documentation they conducted a site visit to Ryerson on June 15-16, 2015. The Peer Review Team (PRT) interviewed a cross-section of individuals and groups, including the Provost; Faculty Deans and Associate Deans including the Dean and Associate Dean of the Yeates School of Graduate Studies (YSGS); Dean of Faculty of Engineering and Architectural Science (FEAS); Associate Dean of FEAS; and meetings with faculty members; students; support staff; alumni; and graduates.

The PRT report was submitted to YSGS on June 29, 2015. The PRT cited several strengths of the program in their report, ranging from the program having a strong practical curriculum component, unique and appropriate lab facilities, and strong industrial relationships.

PRT Identified Strengths of the Graduate Program in Computer Networks
- **Curriculum:** The program has a strong practical component in the curriculum. Every course includes both lectures and labs, enabling students to develop practical skills. Several lecturers

have abundant industrial experience. The case studies offer a unique opportunity for students to apply their knowledge to solving industrial problems.

- **Facilities**: The computer networks lab houses routers, switches, network equipment, Cloud Computing facility, and a LTE wireless testbed. The facilities are unique among similar programs in Canada and provide students with excellent hands-on learning opportunities less available elsewhere.

- **Industrial Relationship**: The program is geared towards industries and has been successfully educating graduates for the computer networks industry. Many alumni are working for big international network companies (such as Cisco) and ISPs (such as Bell, Rogers and Telus). The alumni are invaluable for maintaining and broadening the strong industrial relationships.

- **Library:** Ryerson University has a modern and unique library that offers special learning and an interactive environment. Together, with the support that enables students to remotely access to resources housed in the program's computer networks lab, the library effectively expands the studying space for the program.

PRT Identified Weaknesses of the Graduate Program in Computer Networks

Given such a range of responsibilities it is not surprising that there are also some weaknesses in the existing program. Those weaknesses could be summarized as challenges:
- While it is evident that the program has been supported by full-time faculty members from the departments of Electrical and Computer Engineering and Computer Science, the involvement of regular faculty members to this program is not high. This is mainly due to the fact that teaching in this program is considered as overload to regular faculty members.
- Tuition fee for international students may be too high ($41,000 for MASc. students, and $31,000 for MEng. students). This fee level may deter excellent students from entering this program.

- The percentage of MASc. students is low. The small number of MASc. students negatively impact the research output of the program.

- The MEng case studies/ projects are typically short and their technical depth requires further improvement.

PRT Identified Opportunities of the Graduate Program in Computer Networks

- The hands-on experiment-oriented teaching, learning, and research environment offers a unique opportunity not only for increasing the enrolment of graduate students, but also for enhancing system-oriented research. The excellent experimental platform is ideal to support top-notch research in computer systems and networks. Very few universities worldwide have the lab facilities like this for teaching and research. Permanent faculty members are recommended to leverage the unique opportunity that the program offers and work more with contract lecturers and students to broaden the scope of research areas.

- The industrial trend towards Cloud Computing presents new opportunities for stronger industrial needs. Cloud Computing brings new teaching and research topics, and, with computing resource virtualization, lab management should be more flexible and easier.

Summary of the Reviewers' Recommendations with Responses from Computer Networks and Yeates School of Graduate Studies (YSGS)

As mandated by Ryerson Senate Policy 126, what follows is the YSGS-level response to both the PRT report, and the response to the report of Computer Networks. We summarize below the recommendations and responses. We divide recommendations into two broad categories: academic and administrative. The role of YSGS is to provide direct commentary on academic matters, while making suggestions for administrative matters. Each section begins with an overview of the major PRT recommendations. Note: the recommendations are numbered in the order that they appeared in the PRT report (in order as bullet items), and do not reflect a priority rank in ordering.

Academic Recommendations

Recommendation 1
Devise and keep course outlines consistent with the official calendar entries. To accommodate the flexibility in the fast-changing network area, the program could make the calendar entries more general and give enough flexibility for individual instructors to add/revise most recent materials.

The program will update the YSGS calendar entries to reflect changes of the course curriculum. The GPC curriculum committee will address curriculum updates and changes in a yearly basis. YSGS supports the program level response. We encourage an ongoing curriculum review to ensure the relevance and accuracy of the advertised course offerings.

Recommendation 2
Include student learner outcomes in the course outlines in order to demonstrate level of learning and to provide support for the program objectives and degree level expectations.

The program supports the introduction of the Student Learning Outcomes in the course outline. The GPC will convene to discuss this issue further in the next meeting. YSGS supports this suggestion. Learning outcomes should be articulated in the course management materials.

Recommendation 3
Develop a long-term curriculum planning. Curriculum changes should go through an official procedure. Keep track record of curriculum changes.

The GPC and its curriculum committee will be responsible to the long-term curriculum planning and curriculum changes. All the changes will be documented. YSGS will provide support to the CN GPC for curricular planning and updates.
Please note that there is a process, governed by Senate policy, for enacting curriculum changes.

Recommendation 4
Reduce the number of required courses for MASc. students so that they have more time for doing research.

The program will introduce a Directed Studies elective for the MASc option. This elective will provide an opportunity for the MASc students to start their research under the supervision of their respective thesis supervisors at the earlier stage of their studies. In effect, the introduction of the Direct Studies will somehow reduce the MASc course workload. The program does not want to reduce the number of required courses, recognizing that the practical component offered in our courses is what makes the program unique and attractive to our students. YSGS supports the program level response. However, it would be a valuable exercise for the CN GPC to review their current course offerings, to determine the relevancy of courses, and topics to either drop or add.

Recommendation 11

MEng case studies/ projects are short, and in general their technical depth requires further improvement. The majority of case studies have been supervised by Drs Ma and Jaseemuddin, staff, and non-permanent members. To remedy, introduce more research ingredients into projects to motivate engagement of permanent faculty members and in the meantime potentially increase research output from the program.

The case studies course is designed for MEng students. Most of them are only interested in acquiring practical knowledge to prepare/enhance their careers in the industry. It is difficult to design case studies that have enough practical contents with research components and can be completed in an 8-week period.

We may of course lengthen the case study duration. Since the workload of the program is already very high, lengthening the case studies duration requires the reduction of the number of required courses. These are major curriculum changes whose impacts on the program are unknown. Further analysis is required.

YSGS is in favour of balancing the length of the program and its SRC related outcomes. We will work with the program and FEAS in ways of engaging of increasing the pool of faculty who supervise the case studies. Note that student interests and needs should be weighed carefully on this point, as the majority of CN students are MEng, rather than MASc.

Recommendation 12

The background of students varies. The intensive course schedule does not work well for all students based on the students' feedback.

The program realizes that students have various networking backgrounds and that is why a large number of GAs (5 GAs for 70 plus students) are provided in the first introductory course. GAs are used in other courses with enrollment of 20 or more. The students can complete the course load at a slower pace, if legitimate reasons could be provided.

YSGS supports the program level response. To clarify the program response, the GAs serve to support incoming students with weaker backgrounds in the introductory course.

Administrative Recommendations

Recommendation 5

Tuition fee for international students may be too high ($41,000 for MASc. students, and $31,000 for MEng. students). This fee level may deter excellent students from entering this program.

The tuition fees are not set by the program. Fees are uniform across the board for fully funded programs such as Computer Networks. Exceptions are possible if the program moves to a deregulated tuition model. Note that the Board of Governors sets fees for the Computer Networks program. The program may consider requesting a reduction in tuition, but this needs to be balanced with the high cost of maintaining equipment used in the program.

Furthermore, other MASc programs at Ryerson University have the same tuition fees – roughly around $21,000 per year or $41,000 for two years. Despite of the high tuition fees, the program still has many qualified international applications every year. In fact, our program has the largest number of international students in YSGS.

Recommendation 6

While the program has been supported by full-time faculty members from the departments of Electrical and Computer Engineering and Computer Science, the involvement of these faculty members to this program is not high. This is mainly due to the fact that teaching in this program is considered as overload to regular faculty members.

To engage the full-time faculty, the program provides:
  - a) *Full funding to the MASc students supervised by the faculty,*
  - b) *Higher compensation for the overload teaching ($8800/$8000 vs. $6300), and*
  - c) *Technical support for developing and upgrading the lab contents of their courses.*

All the full-time faculty members are also GPC members. They are heavily involved in drafting and implementing the program's policy.

YSGS also encourages that the program look at ways courses to be offered with fewer paid overloads.

Recommendation 7

The program director has a heavy duty of teaching, supervision of a large number of case studies, and administration of the program. Reduce the teaching/supervising workload of the program director to focus more on the coordination and interaction with faculty members and industrial partners.

This issue needs to be discussed with the Deans of FEAS and YSGS. As of the 15/16 academic year, the GPDs report directly to the local Dean and/or Associate Dean of their home faculty (in this case, FEAS). A discussion of workload and additional teaching release for the Computer Networks GPD should be directed towards the Dean of FEAS.

Recommendation 8

The workload of technical staff is heavy, including lab maintenance, device update/installation, data center management, licences issues, security patching, server migration, vendor contact, supervising case studies, and so on. Manpower requirement and responsibility of facility management are high to make the program successful.

To alleviate the workload of our technical staff in certain occasions, the program hires a technical support from the Department of Computer Science on hourly basis. We also hire some of our students. This arrangement is mutually beneficial. The program can find good technical help quickly, and the students can gain further practical experience. YSGS supports this program level response.

Recommendation 9

The program administrator has an unduly high administrative load.

Occasionally, the program administrator may have high workload in a short period of time (e.g. at the beginning of the term). If it is really necessary, we will hire extra part-

time help for the high-workload periods.

Recommendation 10
Space is limited for the infrastructure. We recommend allocating space for staging/equipment testing for smooth running of the data center.

More than two third of EPH404 is temporarily used as a research lab by an ELCE professor. We will reclaim the space when needed.

Recommendation 13
Attention should be given to the sustainability and risk management of developing course materials (lectures, laboratory exercises, etc.) specific to a given equipment vendor.

Our labs use the equipment mostly from Cisco because Cisco's networking and data center products are the most popular in North America. In the foreseeable future, Cisco will remain to be the top player in the networking industry. Because of this reason, acquiring knowledge of using Cisco products helps the careers of our students tremendously. Our labs also use devices from other big vendors such as Juniper and Huawei.

Implementation Plan

Recommendation	Proposed Follow-up	Responsibility for Leading Follow- up	Timeline for Addressing Recommendation
Academic			
Recommendation 1 Devise and keep course outlines consistent with the official	The program will update the YSGS calendar entries to reflect changes of the course curriculum. The GPC	Graduate Program	Winter 2016 to Fall 2017 with Review in Oct
calendar entries. To accommodate the flexibility in the fast-changing network area, the program could make the calendar entries more general and give enough flexibility for individual instructors to add/revise most recent materials.	curriculum committee will address curriculum updates and changes in a yearly basis.	Director, CN	2016.

Recommendation 2 Include student learner outcomes in the course outlines in order to demonstrate level of learning and to provide support for the program objectives and degree level expectations.	The program supports the introduction of the Student Learning Outcomes in the course outline. The GPC will convene to discuss this issue further in the next meeting.	Graduate Program Director, CN	Winter 2016 to Fall 2017 with Review in August 2016.
Recommendation 3 Develop a long-term curriculum planning. Curriculum changes should go through an official procedure. Keep track record of curriculum changes.	The GPC and its curriculum committee will be responsible to the long-term curriculum planning and curriculum changes. All the changes will be documented.	Graduate Program Director, CN and CN Curriculum Committee.	Winter 2016 to Winter 2018 with Review in August 2017.
Recommendation 4 Reduce the number of required courses for MASc. students so that they have more time for doing research.	The program will introduce a Directed Studies elective for the MASc option. This elective will provide an opportunity for the MASc students to start their research under the supervision of their respective thesis supervisors at the earlier stage of their studies. In effect, the introduction of the Direct Studies will somehow reduce the MASc course workload. The program does not want to reduce the number of required courses, recognizing that the practical component offered in our courses is what makes the program unique and attractive to our students.	Graduate Program Director, CN	The course proposal of the Directed Studies elective has been submitted to YSGS. We expect that the course will be in place in Winter 2016.
Recommendation 11 MEng case studies/ projects are	The case studies course is designed for MEng students. Most of them are only interested in acquiring practical	Graduate Program	This issue has been discussed during the GPC

		Director, CN	meeting in the Summer of 2015. The general consensus among the GPC members was that the current structure of the case studies is best- suited for the characteristics of our program.
short, and in general their technical depth requires further improvement. The majority of case studies have been supervised by Drs Ma and Jaseemuddin, staff, and non-permanent members. To remedy, introduce more research ingredients into projects to motivate engagement of permanent faculty members and in the meantime potentially increase research output from the program.	knowledge to prepare/enhance their careers in the industry. It is difficult to design case studies that have enough practical contents with research components and can be completed in an 8-week period. We may lengthen the case study duration. However, since the workload of the program is already very high, lengthening the case studies duration requires the reduction of the number of required courses. These are major curriculum changes whose impacts on the program are unknown. Further analysis is required.		
Recommendation 12 The background of students varies. The intensive course schedule does not work well for all students based on the students' feedback.	The program realizes that students have various networking backgrounds and that is why a large number of GAs (5 GAs for 70 plus students) are provided in the first introductory course. GAs are used in other courses with enrollment of 20 or more. The students can complete the course load at a slower pace, if legitimate reasons could be provided.	Graduate Program Director, CN	Currently in place.
Administrative			
Recommendation 5 Tuition fee for international students may be too high ($41,000 for MASc. students, and $31,000 for MEng. students). This fee level may deter excellent students from entering this program.	Tuition fees are not set by the program and these fees are uniform across the board for fully funded programs such as CN. Despite of the high tuition fees, the program still has many qualified international applications every year. And in fact has the largest number of international students in YSGS.	Graduate Program Director, CN	*n/a*
Recommendation 6 While the program has been supported by full-time faculty	To engage the full-time faculty, the program provides: a) Full funding to the MASc students supervised by the	Graduate Program Director, CN	Currently in place.

members from the departments of Electrical and Computer Engineering and Computer Science, the involvement of these faculty members to this program is not high. This is mainly due to the fact that teaching in this program is considered as overload to regular faculty members.	faculty, b) Higher compensation for the overload teaching ($8800/$8000 vs. $6300), and c) Technical support for developing and upgrading the lab contents of their courses. All the full-time faculty members are also GPC members. They are heavily involved in drafting and		
Recommendation 7 The program director has a heavy duty of teaching, supervision of a large number of case studies, and administration of the program. Reduce the teaching/supervising workload of the program director to focus more on the coordination and interaction with faculty members and industrial partners.	This issue needs to be discussed with the Deans of FEAS and YSGS. As of the 2015/16 academic year, the GPDs report directly to the local Dean and/or Associate Dean of their home faculty (in this case, FEAS). A discussion of workload and additional teaching release for the CN GPD should be directed towards the Dean of FEAS.	Graduate Program Director, CN	The role and duties of a program director (or associate chair) is the same for every department. This item will not be discussed.
Recommendation 8 The workload of technical staff is heavy, including lab maintenance, device update/installation, data center management, licences issues, security patching, server migration, vendor contact, supervising case studies, and so on. Manpower requirement and responsibility of facility management are high to make the program successful.	To alleviate the workload of our technical staff in certain occasions, the program hires a technical support from the Department of Computer Science on hourly basis. We also hire some of our students. This arrangement is mutually beneficial. The program can find good technical help quickly, and the students can gain further practical experience.	Graduate Program Director, CN	Currently in place.
Recommendation 9 The program administrator has an unduly high administrative load.	Occasionally, the program administrator may have high workload in a short period of time (e.g. at the beginning of the term). If it is really necessary, we will hire extra part-time help for the high-workload periods.	Graduate Program Director, CN	Currently in place.
Recommendation 10 Space is limited for the	More than two third of EPH404 is temporarily used as a research lab by an ELCE professor. We will reclaim	Graduate Program	Currently in place.

infrastructure. We recommend allocating space for staging/equipment testing for smooth running of the data center.	the space when needed.	Director, CN	
Recommendation 13 Attention should be given to the sustainability and risk management of developing course materials (lectures, laboratory exercises, etc) specific to a given equipment vendor.	Our labs use the equipment mostly from Cisco because Cisco's networking and data center products are the most popular in North America. In the foreseeable future, Cisco will remain to be the top player in the networking industry. Because of this reason, acquiring knowledge of using Cisco products helps the careers of our students tremendously. Our labs also use devices from other big vendors such as Juniper and Huawei.	Graduate Program Director, CN	Currently in place.