UNIVERSITY OF TORONTO

Proposal for a Graduate Program

Master of Science
in
Applied Computing Program (MScAC)

In

Department of Computer Science

March 2009

52937

TABLE OF CONTENTS

Page

1 Executive Summary

The Department of Computer Science (DCS) proposes the creation of a new Master of Science in Applied Computing (MScAC) degree program in order to provide an outstanding professional education to train the next generation of technical leaders, innovators, and entrepreneurs. The program is intended for students with a strong undergraduate degree in Computer Science or a related discipline who want to expand their academic competence, but do not intend to pursue careers in research. Its most distinctive features are:

- Through the strong research leadership and mentorship of experienced DCS faculty, it will establish a cadre of highly-qualified personnel able to act as a conduit between researchers and industrial practitioners.
- It will equip graduates with a solid understanding of fundamental concepts in business and technical communication that are relevant to the technical leadership roles they will take on.
- It will also provide a way for highly-qualified personnel outside academia to transfer their expertise to the university through teaching, guest lectures, and co-mentorship of interns.

The program will consist of two terms of course work and an eight-month industrial internship in which students will be required to demonstrate that they are able to translate some novel research idea into practice. There will be no thesis requirement, but students will be expected to present the results of their internship to both the department and its industrial partners upon completion of their degree. Three to four of the seven courses taken by MScAC students will normally be drawn from the foundational courses in the department's existing graduate curriculum. However, MScAC students may, with the approval of the Program Director, substitute relevant courses from other departments, and/or more advanced graduate courses in computer science. Two new courses on technical entrepreneurship and communication skills which will be created specifically for the MScAC, and will be required parts of the program. These courses will initially be taught or co-taught by non CS-faculty with expertise in the relevant domains.

As a unique program in a jurisdiction of high demand and little competition, we expect to initially attract interest primarily from Ontario residents, but also look forward to drawing students from across the country and overseas. Initial student intake will be six students per year, increasing to a maximum of approximately 24 students per year by 2012–2013. A market survey done for DCS by Impact Consulting in January 2007 found that a considerable number of qualified candidates would value a program of this kind highly enough to pay the fees necessary to make it at least self-supporting. The MScAC program will be funded by student fees and BIU funding; no graduate student stipend will be provided by DCS or the University.

The program will draw upon existing DCS faculty who are already associated with graduate programs, or faculty from related departments, and on highly-qualified industrial partners whose skills and experience are relevant to the program. MScAC students will be housed in space belonging to DCS in the Sandford Fleming Building; no other significant impact is expected on physical resources and facilities. Students will have access to all the facilities and services available to DCS graduate students following University of Toronto terms and conditions. They will be governed by the same School of Graduate Studies policies that apply to all SGS students. While students in professional master's programs like the MScAC are generally not eligible for many external and internal awards, it is expected that most students will be paid a substantial portion of a standard industrial salary during their internship, which should be sufficient for most to complete the program without incurring significant debt.

2 Academic

2.1 Description and rationale for the proposal

2.1.1 Description of proposed program

The Department of Computer Science proposes the creation of a new Master of Science in Applied Computing (MScAC) in order to provide an outstanding professional education to train the next generation of technical leaders, innovators, and entrepreneurs.

The MScAC will be a 7.0 FCE, 16-month professional master's program comprising two terms of coursework and a compulsory 8-month term industrial internship. The program is distinctive in several respects:

- Through the strong research leadership and mentorship of experienced DCS faculty, the program will establish a cadre of highly-qualified personnel able to act as a conduit between researchers and industrial practitioners. Both during their internship and afterward, MScAC students will take novel research ideas out of the lab and put them into practice, and bring new techniques and problems from industry back into a university setting to broaden and accelerate faculty members' research programs.

- The program will also equip graduates with a solid understanding of fundamental concepts in business and technical communication that are relevant to the technical leadership roles they will take on. As discussion with current and potential partners has made clear, it is often difficult for personnel with a pure research focus to explain why a new idea is important, or what benefits a new technique might bring, in terms that are relevant to industrial practitioners. One of the central goals of the MScAC is to create people capable of bridging this divide.

- Finally, the MScAC program will provide a natural way for highly-qualified personnel outside academia to transfer their expertise to the university through teaching, guest lectures, and mentorship or co-mentorship of interns.

2.1.2 Rationale for proposal

The applications of computer science continue to revolutionize the way we do business, learn, care for the sick, and entertain ourselves. The past decade alone has seen new ideas move from academia to industry in machine learning (predicting purchase preferences for online retailers), computer graphics (special effects in Hollywood blockbusters), clustered computing (computing-on-demand services for data processing), user interfaces (gesture-based interfaces for handheld devices), program analysis (proving the properties of safety-critical software for power plants and railways), and many other areas. Understanding these ideas and translating them into practical applications requires graduate-level training in the content of relevant research areas, but not necessarily research skills: a solid understanding of business fundamentals and the ability to communicate new ideas clearly and convincingly are equally essential.

The graduate program in the Department of Computer Science (DCS) at the University of Torontois universally recognized as one of the strongest in the world. Its

primary aim is, and will continue to be, to prepare students to conduct novel research. We therefore propose implementing a complementary program that will give future innovators the analytical, critical, scholarly, professional, and communication skills they need to play an active role in ongoing developments. As a unique program in a jurisdiction of high demand and little competition, we expect to initially attract interest primarily from Ontario residents, but also look forward to drawing students from across the country and overseas. Ontario-based companies of all sizes have voiced their desire for a program of this kind, as have hundreds of potential applicants from all across Canada. Meeting this demand by training highly-qualified personnel to turn theory into practice will accelerate economic growth and help Canadian industry remain competitive in an increasingly globalized environment.

The OCGS consultants who reviewed the existing graduate program in 2007 strongly supported the idea of a professional master's program. Creating a professionally-oriented graduate degree will strengthen DCS's ties with industry, which will in turn strengthen the department's research programs. Existing collaborations with IBM, Bell, and other companies have proved extremely beneficial to all involved. However, the department has to date had less contact with the smaller, but equally innovative, companies that have made Toronto the third largest IT hub in North America. Programs like the University's Professional Experience Year (PEY) have demonstrated that companies are eager for such contacts, and peer institutions such as Stanford, Washington, and Waterloo have been able to translate their ties into funding opportunities, graduate student internships, and new research partnerships and directions.

Much has been written on educational preparation of advanced practitioners in computing-oriented disciplines. Generally speaking, graduate level education distinguishes itself as providing "a depth in understanding, knowledge, scholarly competence, inquiry and discovery" that is "distinctly different from that at the undergraduate level". It has been characterized as "advanced, focused and scholarly in nature". Graduate education encourages students not only to critically analyze information presented to them, but also to challenge the underlying tenets of this information, so that they may improve practices as well as apply them. Graduates of such programs are "expected to acquire and apply advanced analytical and interpretative skills" in order to contribute to their disciplines, to educate and transmit knowledge within their domains, to systematically investigate timely questions and produce new knowledge or ways of thinking about their profession, to translate new knowledge to their everyday practice and ultimately extend the services they provide within their discipline and perhaps beyond. It is the enquiry, transformation, and innovation in practice that differentiates recipients of graduate-level education from colleagues with undergraduate-level education.

We believe that the graduates of the program we propose will harness their understanding of fundamental concepts in computer science to act as thought leaders, serving as a conduit to transfer ideas between those most interested in what is new and those most interested in what is useful. There are currently no graduate-level educational opportunities in Ontario of the kind we envision.

Further afield, many American schools complement their Ph.D. programs with terminal master's programs, or offer coursework-only graduate degrees, without explicitly labeling them "professional". The University of Washington's Professional

Master's Program (http://pmp.cs.washington.edu/) is typical: it bills itself as "an evening/distance [program] for fully-employed professionals in Washington State's computing industry". The program takes 50 students a year, most of whom study part-time or attend classes electronically. Students must complete eight courses drawn from a subset of the courses offered to research-oriented students, which includes "Software Entrepreneurship" and "Business Basics for CS Professionals". Students must also earn a few additional credits by taking part in colloquia; the expected time to completion is two and a half years. The program has strengthened ties between the University of Washington and local giants such as Microsoft and Boeing. This in turn led to donations, consulting opportunities, and increased undergraduate hiring by these companies. It also provided additional TA support for graduate students, and a small number of professional masters students became full-time research graduate students.

The University of Chicago's Computer Science Professional Program (http://masters.cs.uchicago.edu/) is similar: courses drawn from the regular curriculum are offered in the evening so that people working full-time in the Greater Chicago area can continue their education at the graduate level. The program was originally designed to create technology managers and strategists, but over the years the scope of the program has expanded to accommodate students interested in pursuing other computing endeavors.

Finally, Stanford University's Master's Degree in Computer Science (http://cs.stanford.edu/degrees/mscs/) is "…meant to show prospective employers that you have a solid, broad understanding of computer science courses." The program structure is rather complicated, but its emphasis on depth distinguishes it from others of its kind: students must complete 21 of 45 units in one of Artificial Intelligence, Biocomputation, Security, HCI, Numerical Analysis, Real-World Computing (which in practice often means computer graphics), Systems, Theoretical Computer Science, or Software Theory (which admits it is a "slightly more applied" version of Theoretical CS). There is good support for distance learning, and some students are able to cover their costs through research assistantships and other on-campus employment.

2.2 Pedagogical and other academic issues, including expected benefits of the proposed program

Through the strong research leadership and mentorship of experienced DCS faculty, the program will establish a cadre of highly-qualified personnel able to act as a conduit between researchers and industrial practitioners. Both during their internship and afterward, MScAC students will take novel research ideas out of the lab and put them into practice, and bring new techniques and problems from industry back into a university setting to broaden and accelerate faculty members' research programs. In the long term, the MScAC program will benefit DCS by creating more receptive partners for joint academic/industrial research projects. As government funding shifts in this direction, it is strategically important for the department, and indeed the university as a whole, to increase the number of potential collaborators who understand what pure research entails, why it is important, and how to reconcile the sometimes divergent aims of various stakeholders. Other leading computer science departments, such as Stanford and MIT, have a long history of "seeding" graduates in this way, with significant long-term payoff.

At the same time, between one third and one half of the department's graduate students leave for careers in industry after completing their M.Sc.. Many of these students never intended to pursue research careers, but undertook graduate study as a way to learn more about advanced topics in computer science. These students are not always well served by a program designed primarily for students who intend to go on to a Ph.D.; as the market survey described in Section 2.3 shows, many would find the MScAC more appealing. The MScAC program will also benefit graduate students in the research stream by creating more opportunities for internships and industrial scholarships. At present, only a minority of companies in Ontario recognize the long-term value of having graduate students pursue their research on site. Exposure to applied research and technology transfer through the hosting of MScAC interns will serve as a step in this direction. Existing faculty will participate in this program, in the roles of teacher, mentor and supervisor. Faculty, as usual, will negotiate teaching commitments each year as part of their overall responsibilities. Comparing anticipated enrolment (a maximum of 24 new students per year) to existing graduate enrolment (approximately 60 new students per year), we expect that the impact of MScAC students on teaching workload and the content of existing graduate courses will be manageable.

2.3 Projected student demand

The impetus to create a program like the MScAC came from discussion among faculty about how well the department's existing graduate programs were meeting students' needs. While the exact numbers vary from year to year, a significant proportion of the department's M.Sc. students choose not to pursue a Ph.D. Many of these students feel that the department's strong focus on original research, with publication as a primary goal, is not appropriate to their needs: while it was important to them to acquire advanced training and exposure to leading-edge concepts in their specialties, many would prefer to allocate the time required to prepare a thesis to a more practical demonstration of their knowledge and capabilities.

At the same time, discussions with existing industrial partners highlighted the fact that the most effective way to transfer technology from academia to industry is to transfer highly-qualified personnel. The possibility of opening up a higher-yield recruiting channel is very attractive to them: many companies already make extensive use of undergraduate interns, and were excited at the prospect of having graduate-level equivalents to choose from people, who could not only push forward the company's existing agenda, but also bring in new ideas and show both how they could be of benefit, and how to implement them in practice. They also saw a professional program as a way to forge new and stronger ties with research faculty, as the program would avoid the tension that sometimes arises between a research graduate student's need to produce publishable results, and industry's desire for solutions to immediate real-world needs.

The OCGS consultants who reviewed our graduate program in 2007 also strongly supported the idea of a professional master's program. DCS therefore commissioned Impact Consulting Group in the fall of 2007 to conduct market research on the feasibility of the MScAC. Impact designed a market survey and distributed it online early in 2008 to undergraduates and alumni from the University of Toronto, Waterloo, McGill, the University of Alberta, the University of Western Ontario, Queen's, York, Ryerson, the University of Calgary, and the University of Saskatchewan. The survey included demographic questions, probes on respondents' interest in the MScAC, and

a conjoint analysis to determine the relative importance of several program elements (see Appendix I for executive summary).

There were a total of 1014 usable responses from Canadians and Landed Immigrants (LIs), and 100 from foreigners. Domestic respondents between the ages of 19 and 30 made up 65% of the sample and 75% of those who expressed an interest in the program. The interested respondents were primarily current undergraduate students or recent graduates now in the workforce. Roughly three-quarters of the sample had computer science backgrounds; over 50% had GPAs above 3.3 and there was no significant variation in interest based on GPA. The program generated stable proportions of interest across respondents of all academic backgrounds except for Business, which had a significantly lower level of interest. As expected, respondents with Master's degrees and Ph.D.'s were not as interested in the program.

There was a negative correlation between income and interest. The lower the current income reported by respondents, the more likely they were to be interested in the program. Interest level did not seem to vary across academic majors. Software Developer was the most common current vocation (43.3% of respondents), and Software Engineering was the preferred area of specialization (17.8%). However, there was a fair amount of response diversity in area of specialization and 12% of the sample was not prepared to choose at the time. There was a varied range of five-year career goals, but the most popular were entrepreneurial, working for a large company, and software development, in that order.

Based on this survey, it is possible to make a rough estimate of the number of qualified applicants the MScAC would attract from a target demographic made up of recent domestic graduates with industry experience and strong academic credentials:

Number of students in Canadian CS undergrad programs 2000-07	7500
Proportion of those who are Canadian or Landed Immigrants	80%
Proportion of those likely to be interested in the program	40%
Proportion of those with GPAs above 3.7	30%
Estimated uptake rate	10%
Estimated number of potential applicants per year	72

Other key conclusions from the market survey are:

1. Since the MScAC is a fairly new professional program, external promotion will be needed to raise awareness, understanding and interest. Marketing materials must emphasize the specific benefits of the program and DCS's ability to deliver them.

2. An internship is a critical factor that will dictate the success of the MScAC. It consistently ranked as more important than skills or timetabling in every demographic, and is the key differentiator between the MScAC and the existing research-oriented M.Sc.. The data suggests that an internship with an open source organization is most preferred, followed by an internship with a large company. We hypothesize that this is because candidates are looking for brand-name internships that will enhance their resumes and increase their earning potential, and does not reflect any intrinsic aversion to working with smaller or younger companies.

3. The MScAC should initially be priced in a lower range than established professional programs such as MBAs: Impact Consulting suggested $8–12,000 for Canadians and $10–13,000 for international students. The price can and should be raised when there is an established value proposition that is corroborated by both alumni and employers.

4. There was no definitive preference for scheduling. Canadian respondents generally preferred evening and weekend courses, but the target demographic and foreign respondents preferred full-time scheduling. We believe the latter is the best option for three reasons:
   a) The majority of those interested in the program were completing their undergraduate studies and were not yet employed.
   (b) A full-time program would disrupt course scheduling and faculty research time much less than evening/weekend scheduling.
   (c) Full-time students' completion rates are significantly higher than those of part-time students.

5. Canadians in all categories want business skills to be included in the MScAC. The MScAC addresses this by requiring students to take two business-oriented courses as part of their program *Communication for Computer Scientists* and *Technical Entrepreneurship* (CSC2701 and CSC2702 respectively):

To complement this survey, twelve software companies in the Greater Toronto Area were contacted by phone in the spring of 2008 in order to determine industrial interest in the internship component of the proposed program. Ten of these companies were very enthusiastic, and would be: most interested in genuinely novel or exploratory projects; be flexible on intellectual property issues; pay a salary equivalent to or higher than what they pay undergraduate interns. Some stated that they would primarily be interested in using the program for recruiting purposes (i.e., as an extended job interview); several also stated that communication skills would be as valuable as business skills, if not more so, as interns would have to promote their work. Only two of the companies were equivocal: one is technologically very conservative, and felt there would not be a role internally for graduate-level interns, while the other company (one of the largest IT companies in the world) was concerned that the bureaucratic overhead of setting up something of this kind would outweigh the benefits.

TABLE 1[1]

PROJECTED INTAKE AND ENROLMENTS Masters (M) Program			
YEAR	**FULL-TIME**		**TOTAL ENROLMENT**
	Intake	**Enrolments**	**Masters**
	M	**M**	
2010-11	6	6	6
2011-12	12	18	18
2012-13	24	29	36
2013-14	24	48	48
2014-15	24	48	48
2015-16	24	48	48

[1] *Table1 shows annual enrolments. Cohorts only overlap for one term, during which the senior cohort is off campus.*

2.4 Impact on the Department's and Division's program of study, including impact on other divisions

This program fits well within the mission of the Department. DCS has a long history of interdisciplinary research with departments from several faculties and local hospitals, and will be receptive to new ideas brought in from industry by MScAC students. This program will positively impact the work of the department's academically-focused graduate students and their faculty supervisors.

2.5 Evidence of consultation with other affected divisions

During the past two years, DCS has discussed this proposal at several levels with faculty from related academic units, such as Electrical & Computer Engineering, Business, Information Studies, and Mathematics. The response was uniformly positive. The proposal has been discussed with the administrators of the Professional Experience Year program, who are enthusiastic about prospects for collaboration.

2.6 Appropriateness of the name and designation of the new program

The MScAC program is intended to produce graduate-level computer science practitioners, rather than researchers. The use of this degree name, MScAC, signifies the course- and internship-based nature of the program and distinguishes it from the existing research-based M.Sc. provided by DCS.

2.7 Program description and requirements, course titles/numbers, and faculty members

2.7.1 Program description and requirements

Admission requirements: The general regulations of the School of Graduate Studies will govern the admissions process for the MScAC. Applicants to this program must have completed a recognized 4-year BSc in Computer Science or its equivalent (e.g., an undergraduate degree in Electrical Engineering or Software Engineering); have obtained a minimum GPA of B+ (77–79%) over their final two years of (full-time) undergraduate studies; arrange for three letters of support from faculty and/or employers familiar with their work; and provide a statement of purpose.

Program requirements: The Master of Science in Applied Computing is a 7.0 FCE program composed of 3.5 FCE of required courses including 2.5 FCE of general DCS graduate courses, 1.0 FCE of program-specific graduate courses described in Section 6, and successful completion of a two-term (eight-month) full-time industrial internship worth 3.5 FCE. To ensure cohesion within each cohort, and to facilitate informal ongoing progress monitoring, one of the two new courses created specifically for this program will be put on as an evening course during the eight-month internship. To meet the needs of both the MScAC and research programs, the department is in the process of defining foundational courses that will provide a broad overview of the core areas of computer science. Students may include up to 1.0 FCE of elective courses from related departments with the prior approval of the Program Director. There is no thesis requirement.

The MScAC will not initially have an explicit breadth requirement. Rather, the

department will identify a range of “foundational courses” which will provide the necessary background for a subject area and then proceed to bring students to the current state of knowledge and practice in the area. Foundational courses will also identify the state of some current research so that students will then be prepared for more advanced courses and related internships. While we envision a range of backgrounds and undergraduate preparation, normally we would expect MACS students to take between 2 and 4 foundational courses and at least one advanced course. Course selection for each individual student will be approved by the Program Director.

The MScAC industrial internship distinguishes this program from other graduate-level programs in Canada. Students spend the second eight months of the program in a full-time internship sited at a local company, non-profit, or open source organization. The focus is technology transfer: students must take a novel idea from computer science research and translate those ideas into insightful models and analysis and/or commercial-quality software in order to demonstrate mastery of both the intellectual domain and professional practices.

DCS will facilitate matching MScAC students with host companies, and students will negotiate salaries with those companies on a case-by-case basis. All of the companies contacted in the spring and summer of 2008 stated that they would expect to pay MScAC interns at the same rate as, or higher than, undergraduate PEY and co-op students (currently $36-$45K, or roughly two thirds to three quarters of a junior developer’s salary). Discussions with Mathematics and Information Technology and Complex Systems (MITACS) indicate that many internships should qualify for partial funding under the MITACS ACCELERATE CANADA program, which would offset half of the employers’ costs, and thereby make interns even more attractive. Should a suitable paid placement not be found the department will arrange an equivalent unpaid placement with an open source organization or non-profit organization.

Intellectual property rights will also be negotiated on a case-by-case basis with the involvement of the MScAC Program Director or an appointed alternate. The university will provide a small number of templates to use as starting points for these discussions; these will be reviewed and updated on an annual basis. As with internships, DCS will take the lead in coordinating these arrangements. All of the companies contacted in the spring and summer of 2008 understood that interns would need to be able to discuss their work publicly in order to be evaluated, and believed that equitable arrangements could easily be reached.

The program’s support for establishing and maintaining industrial partners for internships is key to attracting students. Students will not only gain practical experience in technology transfer, but will also have access to well-trained professional support staff in their host company to help realize their vision and make further connections in industry. Our market survey and other research have demonstrated that potential applicants and company partners will value this opportunity highly.

The Program Director will play an active role in coordinating internships. Each project will be monitored by a faculty sponsor, a representative from the host company, and the MScAC Program Director or an appointed alternate. Students will be required to report progress three times during their internship (mid-summer,

September, and late October), and to present the final results of their work at the end of the internship. Internships will be evaluated on a CR/NCR basis.

2.7.2 Course titles/numbers

CSC2104H: Formal Methods of Program Design
CSC2107H: Compilers and Interpreters
CSC2108H: Automated Verification
CSC2130H: Empirical Research Methods in Software Engineering
CSC2203H: Packet Switch and Network Architectures
CSC2204H: Operating Systems
CSC2206H: System Modeling and Analysis
CSC2209H: Computer Networks
CSC2221H: Introduction to Distributed Computing
CSC2227H: Topics in the Design and Implementation of Operating Systems
CSC2228H: Topics in Mobile and Pervasive Computing
CSC2231H: Special Topics in Computer Systems
CSC2302H: Numerical Solution of Initial Value Problems for Ordinary Differential Equations
CSC2305H: Numerical Methods for Optimization Problems
CSC2306H: High-Performance Scientific Computing
CSC2307H: Numerical Software
CSC2310H: Computational Methods for Partial Differential Equations
CSC2321H: Matrix Calculations
CSC2322H: Boundary Problems for Ordinary Differential Equations
CSC2401H: Introduction to Computational Complexity
CSC2404H: Computability and Logic
CSC2405H: Automata Theory
CSC2426H: Fundamentals of Cryptography
CSC2410H: Introduction to Graph Theory
CSC2411H: Linear Programming and Combinatorial Optimization
CSC2413H: Combinatorial Methods
CSC2414H: Topics in Applied Discrete Mathematics
CSC2415H: Advanced Topics in Distributed Computing
CSC2417H: Algorithms for Genome Analysis
CSC2418H: Computational Structure Biology
CSC2427H: Topics in Graph Theory
CSC2429H: Topics in Computational Complexity
CSC2431H: Topics in Computational Molecular Biology
CSC2501H: Computational Linguistics
CSC2502H: Knowledge Representation and Reasoning
CSC2503H: Foundations of Computer Vision
CSC2504H: Computer Graphics
CSC2507: Conceptual Modelling
CSC2508: Advanced Database Management Systems
CSC2511H: Natural Language Computing
CSC2512H: Constraint Satisfaction Problems
CSC2515H: Introduction to Machine Learning
CSC2518H: Spoken Language Processing
CSC2519H: Natural Language Semantics
CSC2521H: Topics in Computer Graphics: Physics-Based Character Animation
CSC2522H: Advanced Image Synthesis
CSC2523H: Object Modeling and Recognition
CSC2525H: Research Topics in Data Management
CSC2528H: Advanced Computational Linguistics
CSC2529H: Computer Animation
CSC2530H: Computer Vision for Advanced Digital Photography
CSC2531: Advanced Topics in Data Management Systems
CSC2535H: Learning Algorithms for Neural Networks

CSC2539H: Topics in Computer Vision
CSC2540H: Special Topics in Computational Linguistics
CSC2541H: Topics in Machine Learning
CSC2600H: Convex Optimization
CSC2701: Communication for Computer Scientists*
CSC2702: Technical Entrepreneurship*

* *New courses to be developed specifically for this program.*

2.7.3 Faculty members

The MScAC program will draw on the established strength in computer science among graduate faculty members at the University. Leaders in all areas of computer science, ranging from algorithm theory (where the university boasts Canada's only Turing Award winner) and machine learning to computer graphics, software engineering, and more will all teach in the core of the program. The faculty list will be broadened as the program evolves during its three-year ramp up phase to ensure quality and choice to participants.

As of November 2008, the Department of Computer Science has 51 full-time faculty members and 11 full-time lecturers across three campuses. 41 full-time faculty are cross-appointed to DCS from other departments, while another 13 hold adjunct appointments or have some other standing with SGS through their relationship with DCS. Should cross-appointed faculty wish to participate in this program, approval will be requested from the head of their home department.

All of these appointments have associated expectations related to teaching, mentoring and supervision. Specific teaching and administrative assignments are negotiated and agreed to each year as part of the overall department planning.

The faculty listed in Table 2 have all committed in principle to being actively involved with the program. All are first-rate teachers and researchers in their specialties, and have extensive experience in graduate mentoring through existing M.Sc./Ph.D. programs. Most are known internationally for the strength of their research, and many also have prior experience with technology transfer and joint industrial projects. Their high qualifications and wide range of knowledge and expertise will ensure an intellectually challenging learning environment.

TABLE 2

Faculty Members by Field													
				Fields[2]									
Faculty Name	**M/F**	**Home Unit**	**Supervisory Privileges[1]**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
Bacchus, Fahiem	M	CSC	F				X						
Baecker, Ron	M	CSC	F						X				
Balakrishnan, Ravin	M	CSC	F						X				
Borodin, Allan	M	CSC	F	X	X			X					
Boutilier, Craig	M	CSC	F				X						
Brudno, Michael	M	CSC	A							X			X
Christara, Christina	F	CSC	F			X							
de Lara, Eyal	M	CSC	F							X			
Demke-Brown, Angela	F	CSC	F							X	X		
Dickinson, Sven	M	CSC	F				X						
Easterbrook, Steve	M	CSC	F					X				X	
Enright, Wayne	M	UTSC	F			X							
Fiume, Eugene	M	CSC	F			X			X	X	X	X	
Fleet, David	M	UTSC	F				X						
Hadzilacos, Vassos	M	UTSC	F	X	X					X			
Hertzmann, Aaron	M	CSC	F			X	X		X				
Hirst, Graeme	M	UTSC	F				X						
Jackson, Ken	M	CSC	F			X							X
Levesque, Hector	M	CSC	F				X						
Lilien, Ryan	M	CSC	A										X
Magen, Avner	M	UTM	A	X	X								
Marbach, Peter	M	CSC	F							X			
Penn, Gerald	M	CSC	F				X						
Roweis, Sam	M	CSC	F				X						
Truong, Khai	M	CSC	A						X	X			
Wilson, Greg	M	CSC	A									X	

Supervisory Privileges[1] F= Full Member A = Associate Member

Fields[2]

Field 1 Computational Complexity
Field 2 Applied Discrete Mathematics
Field 3 Scientific and Numerical Computation
Field 4 Artificial Intelligence
Field 5 Database and Information Systems
Field 6 Computer Graphics & Human-Computer Interaction
Field 7 Computer systems: Hardware and Software
Field 8 Programming Languages and Methodology
Field 9 Software Engineering
Field 10 Bioinformatics

3 Students

3.1 Student affairs and services

Like students in our other graduate programs, MScAC students will be challenged by courses which will provide the motivation, scientific basis, and state of current knowledge in a wide variety of subject areas. These foundations will be complemented by research ideas that will move the field significantly beyond its current state. All of our courses require rigorous analysis; many also require students to demonstrate the ability to undertake successful implementations where appropriate through significant projects. Instructors make themselves available as much as possible for individual meetings; other than small seminar courses, most also have Ph.D. students assigned as teaching assistants who make themselves available for further discussion.

The graduate environment, however, is much more than course work. All graduate students are expected to attend seminars relevant to their interests as well as more general colloquia featuring distinguished international scholars. The department supports weekly seminars in all research areas featuring visiting scholars as well as seminars based on faculty research and student research. In particular, every research M.Sc. student continuing on to the Ph.D. program presents a seminar based on their research. Beyond these departmentally-organized seminars and colloquia, graduate students often run more informal seminars at which they present recent conference papers as well as give preliminary reports on their own work.

In order to ensure that MScAC students are fully engaged in these activities, they will be required to give a presentation near the end of their internship summarizing their experiences and the contributions they have made. Also, as discussed elsewhere, MScAC students will be enrolled in one of the two special business-oriented courses during their internship. Scheduling the course this way will facilitate discussions as to the progress of the internship and any issues that may arise. While we expect and will promote complete integration of all graduate students, it is expected that these two special courses and the commonality of an internship will foster additional cohesiveness amongst MScAC students.

Beyond the activities within the department, the University sponsors a wide variety of seminars and colloquia for all members of the University community as well as the general public. We frequently enjoy thought provoking presentations by Nobel Prize winners, internationally acclaimed artists and authors, and major political leaders.

3.2 Student conduct and discipline

Standard university guidelines and policies for student conduct will govern in the MScAC program. All University policies and procedures governing professional students will be followed both while they are on campus full time and during their internships.

3.3 Financial Support

The MScAC program will be entirely self-funded: students will not generally be eligible for NSERC grants, Ontario Graduate Scholarships, or other research-

oriented support. DCS may allow them access to departmental scholarships and similar funds administered at the department's discretion, provided they meet the criteria. See Section 2.7.1 for a discussion of salaries that MScAC students could reasonably expect during their internships.

As the MScAC program is a professional master's degree program, students are not part of the University's funded graduate cohort. Funding may be available for scholarships and awards and to assist students with incidental fees. We do not anticipate any significant number of students receiving direct financial support from their employers. Any agreements students reach with previous employers regarding internship projects must be approved by the Program Director. See section 5.3 for further details.

3.4 Computing facilities

All MScAC students will be provided with a standard University of Toronto account that will give them access to electronic mail facilities, the Internet, and a wide variety of tools and services. The University of Toronto Information Commons, Computer and Networking Services, Software Distribution Service, and Resource Centre on Academic Technology provide extensive computer support to students. All students in the MScAC are expected to have access to a home/office PC or laptop with internet access, electronic mail, and general office software. MScAC students will also be provided with accounts giving them access to shared DCS teaching computing facilities, which include compute and database servers, and workstations that provide access to a wide array of software packages (such as Matlab), laser printers, and DCS wired and wireless networks.

In particular, MScAC students will have access to the department's collection of more than half a dozen shared teaching laboratories, each containing twelve to twenty-four workstations (approximately 150 in total). As this is only a moderate increase over current numbers, we expect no significant impact on our current programs. Further access to specialized facilities belonging to particular research groups (e.g. innovative user interface devices or high-performance computing clusters) will be determined on a course-by-course or project-by-project basis, taking into account the student's need and the likely impact of their work on both the department's and the research group's interests.

In general, industrial project partners will be expected to provide facilities for internship students. However, industrial partners may be given some level of access to departmental or research group facilities on either a free or paid basis. Decisions regarding this will be made case-by-case by the Program Director in consultation with academic members of any affected research groups.

Appendix I – Impact Consulting Group Market Survey

Executive Summary

The purpose of this study is to investigate the potential market demand for the University of Toronto Department of Computer Science's (DCS) proposed offering of a Professional Master's Program (PM). The DCS commissioned Impact Consulting Group (Impact) to conduct market research on the feasibility of this program and to analyze the results for insights that may prove to be helpful in the program's marketing. The study began with a facilitation session where Impact outlined a value proposition for the PM based on the input received from various DCS stakeholders. The market research survey was then designed and distributed online to over 1114 undergraduates and alumni from 10 Canadian post-secondary institutions. The survey included demographic questions, probes on respondents' interest in the PM and a conjoint analysis to determine the relative importance of several program elements. The key findings from this study are the following:

- There is a sufficient level of interest in the market to conclude that the PM is feasible
- The most interested demographic is undergraduates and recent graduates of computer science (CS) programs, between the ages of 19-30.
- The internship is critical to the successful marketing and implementation of the PM. After price, it is the most important program element. It is the key value driver for the program.
- The DCS should use the internship and business skills to differentiate the PM from the Research Masters (RM) and to alleviate the concern of program dilution
- The DCS should not put a large price premium on the PM. Potential candidates are not willing to pay high tuition for an unproven value proposition.

The report has six sections. The first section is an introduction which outlines the core objectives and provides a frame of reference for the motivation behind initiating the study. The second section presents the value proposition created by Impact for the DCS. The next section describes the survey design process. The results then follow. The final two sections are a discussion of the survey results and Impact's recommendations to the DCS for the PM.

Appendix II – Chief Librarian's Report

REPORT ON LIBRARY RESOURCES FOR THE GRADUATE PROGRAM MASTER OF SCIENCE IN APPLIED COMPUTING (M.Sc.A.C.)

REPORT ON LIBRARY RESOURCES FOR THE GRADUATE PROGRAM MASTER OF SCIENCE IN APPLIED COMPUTING (MSAC)

The documentation for this program states "This new proposal for a Master of Science in Applied Computing is vital to accelerating the uptake of leading-edge research ideas in computing and related disciplines in Toronto and across Canada. The past decade has seen new ideas move from academia to industry in fields as diverse as machine learning, computer graphics, clustered computing, user interfaces, and program analysis".[1] The University of Toronto Libraries is comprised of collections that will help support the goals and objectives of this program, and will provide the resources necessary for successful candidates to engage in course work and an industrial internship in which students will be required to demonstrate that they are able to translate some novel research idea into practice.

A brief history of resources in computer science follows. On September 26, 1962 the Institute of Computer Science Library initiated a request to become a departmental library of the central University Library beginning in 1963. The central Library was to provide acquisition and cataloguing services, provide transferred material, but was not to administer the library.[2] Between 1963 and April 1998, the Computer Science Departmental Library acquired a total of 14,613 books, 314 microforms, 20 CD-ROMs, 28 computer files, 6 metres of manuscripts, and 193 Serial subscriptions.[3] On June 25, 1998 a "Memorandum" of principles was signed to define the merger of the Computer Science Departmental Library collections into the newly designated **Engineering and Computer Science Library**, administered by the Central Library System.[4]

The University of Toronto's holdings in computer science are extensive, as described below. The Library through its collections and ongoing acquisition policy supports research and teaching in all areas of computer science. The holdings have been built up in a systematic way since 1966. The Dealer Selection Order system, along with a book selector in the Collection Development Department, ensures that almost all commercially produced current imprints of books are received automatically. Access to the collections is provided by an online catalogue of University of Toronto records which are searched by author, title, or keyword.

DESCRIPTION OF THE COLLECTION

1. Serials

Computer science literature is comparable to the literature of the sciences in general, and periodical publications assume a major part in which information is made known to scientists. Dramatic increases in journal prices and high exchange rates have made the maintenance of existing subscriptions and the acquisition of new titles difficult. Despite this, the physical and applied science libraries, including engineering and mathematics, altogether subscribe to 4,743 print titles[5] – a level of holdings that are second to none in Canada.

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[1] Proposal for a Graduate Program Master of Science in Applied Computing (MSAC) in the Faculty of Arts & Science November 2008 by Greg Wilson, Ravin Balakrishnan, Allan Borodin, and Derek Corneil, October 20, 2008

[2] Library Council Executive Council Minutes, September 26, 1962, and Library Council Minutes November 29, 1962

[3] University of Toronto Library Annual Statistics, May 1, 1997-April 30, 1998

[4] "Memorandum" To Ms. Carole Moore, Chief Librarian From Wayne Enright, Chair. June 25, 1998

[5] University of Toronto Library Annual Statistics, May 1, 2006 - April 30, 2007

2. Monographs

It is the policy of the Library to acquire a single copy of all science books published in English that are considered to be of research value. In computer science this includes proceedings of conference and symposia, professional society publications, review literature, technical handbooks and reference books in addition to research monographs. The Library has resources in the forms of handbooks, encyclopedias, dictionaries and biographies. We have the 25 volume **Encyclopedia of Computer Science and Technology**, and an institutional membership in the Association for Computing Machinery (ACM) and the Institute of Electrical and Electronics Engineers (IEEE). The Springer series of **Lecture Notes on Computer Science** is held from its first volume in online format and the Library subscribes to the **IEEE Explore** (IEEE/IEL Electronic Library Online) and **ACM Digital Library**. The Library subscribes to the online full text edition of **Computing Reviews**.

The Library collects Masters and PhD computer science theses by University of Toronto Students and has 1,152 volumes.

In addition to the Engineering & Computer Science Library (211,913 volumes), other relevant libraries include the Gerstein Science Information Centre which holds physical and applied science and biological and medical science material (1,096,133 volumes), and the Mathematical Sciences Library (45,234 volumes).[6] The Association of Research Libraries (ARL Statistics) ranks the University of Toronto Libraries third in volumes held, and fourth in volumes added gross.[7]

Currency is of utmost importance in computer science. There have been continuous improvements in the Library's processing of new books. The use of online cataloguing source files and the restructuring of departments have made major improvements in materials processing. There are currently no backlogs in computer science and the majority of items are catalogued and on the shelf within days of having been received by the Library.

ELECTRONIC RESOURCES

The electronic information services at the University of Toronto Library have been evolving since 1987, when the first online catalogue was established. Within a year the online catalogue was available in all the campus libraries, and dial-in access was introduced with a small number of lines. Abstracts and indexes had been computerized since the early 1970's and through the 1980's, searched by trained intermediaries. Beginning in the late 1980's CD-ROMs and networked databases widened the access of electronic databases to the end-user to perform his or her own searches. In 1991 the Library added seven H.W. Wilson periodical index databases to its electronic network. Today the Library is experiencing a revolution in electronic publishing and access to information. The Library is a world leader in the field, and is serving the University of Toronto community through a variety of information systems through its terminals. It provides access to 1,546 electronic reference sources, 551,890 electronic books, 3,542 electronic newspapers and news services, 1.011 electronic indexes and abstracts, and 39,681 electronic full-text journals.[8]

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[6] University of Toronto Library Annual Statistics, May 1, 2006 - April 30, 2007
[7] http://fisher.lib.virginia.edu/cgi-local/arlbin/arl.cgi?task=setuprank
[8] http://main.library.utoronto.ca/eir/E-Resources, October 21, 2008

STAFF and SERVICES

Currently the Engineering and Computer Science Library staff consists of 2 librarians, 1 professional manager, 5 library technicians, 1 part time library technician and approximately 160 hours of student assistance per week.

The Library is open 78.5 hours per week from September to May (including Saturdays and Sundays) and 59.50 hours per week from May to August. There are 211 seats (106 open carrels) and 42 public computer terminals in the Library. Wireless access to the internet is available in all campus libraries.

Given the quantity and complexity of computer science literature, the growing role of electronic databases, and the size of the University of Toronto collection, reference services in the Engineering and Computer Science Library play a key part in making the collections accessible. Access to the national and international scientific information networks is facilitated. Reference services offered include the verification of citations, training in the use of networked databases, training on Internet use, the searching of online and print union list files to locate materials not available on campus. Reference service is available except after 7:00 p.m. in the evening. Interlibrary loan and computer literature searching are available to all faculty, students and staff. The Library provides free current awareness and bibliographic management services to staff, student and faculty. Now a few databases provide free current awareness services under *my.alerts*. In-person and online orientation services to the Library's collections and system is available all year round. Course- or assignment specific instruction seminars and workshops are available on request.

SUPPORTING COLLECTIONS

The most important supporting collection in computer science is CISTI (Canada Institute for Scientific and Technical Information), Canada's national science library in Ottawa.
It is now possible to handle transactions electronically from CISTI, thereby decreasing the time required to fill requests.

BUDGET and LONG-TERM COMMITMENTS

The strength of the Library's financial commitment over the next seven years depends upon University policy. Up to now, it has been the University of Toronto's stated policy to protect, as far as possible, the Library's acquisition budget from rising costs. It is hoped that this protected status will be maintained.

Prepared by: J S Wang

Jiabin Wang, Head, Engineering and Computer Science Library

Submitted by: Carole Moore

Carole Moore, Chief Librarian, University of Toronto Libraries

October 23, 2008