

**Online Master of
Computer Science
Proposal**

**Approved by the
Faculty Senate
November 14, 2018**

Overview of the Master of Computer Science Program

The Rice Master of Computer Science (MCS) degree is a Non-thesis Masters degree that is currently offered as an on-campus program. We propose to expand the degree to have two options: on-campus and online. Prospective students must specify one or both of the options on their application and will be admitted to the degree program under that option. If they select both options, they can also specify a first preference. To receive an MCS degree, the student must complete the degree requirements for the option to which they have been admitted. Both options will require a minimum of 30 credit hours of graduate-level coursework.

The online option will expand our existing MCS program by enabling students to complete the degree fully online. The program is designed for both working professionals with a technical background (not necessarily computer science) and students who want to add depth to their existing computer science skills. The online course offerings are specifically designed for technically trained students (with backgrounds in Engineering, Science, or Computer Science) to obtain the depth of practical skills needed for modern computing jobs. The flexibility offered by the fully online option will typically allow students to complete the degree part-time in less than two years. Furthermore, since the online program is more flexible, we expect that the department will be able to recruit students with more diverse backgrounds for the online program than the on-campus program.

Admissions standards for the MCS degree will be the same, regardless of whether the student selects the online or on-campus option. The options simply enable students to trade breadth of course choices vs. flexibility in timing and location. Both options will provide students with a high-quality non-thesis Masters degree. The GRE test is highly recommended for all applicants, however it may be waived, upon discretion of the Admission Committee, if an applicant has a relevant industrial experience. This is in recognition of the fact that the GRE can be a significant obstacle for working professionals to even apply to graduate programs. The current admission standards for our on-campus program is just as high as for our PhD program and we intend to keep it that way. However, in order to ensure that there is no perceived or actual difference in admissions standards or quality of the students in either the online or on-campus program, we will allow the admissions committees to waive the GRE requirements if applicants have relevant work experience for both the online and on-campus options.

Initially, there will be a fixed set of 10 fully-online courses for the online option. Once the online program is successful, more online courses will be created over time, increasing the breadth of electives available for students in the online program. The proposed online program is a tighter and more cohesive program that will also be used to influence and evolve the on-campus program. This will result in improvements in the on-campus program as well as the development of a high quality online program.

The tuition will be similar for either option. However, there will be differences if students choose to be either part time or full time. Students in the on-campus option are expected to be mostly full-time students, whereas students in the online option are expected to be mostly part-time students (although neither option requires a student to be full-time or part-time). Under Rice's current policies, part-time students and full-time students are charged using a different model. Also, as one would expect, the time-to-degree will be longer for part-time students.

The MCS program does not normally lead to further graduate study. No financial aid is available from the university or the department for MCS students. There are a limited number of paid teaching assistantship positions available for interested MCS students.

We intend to launch the program in the Fall of 2019 and are currently on track to do so.

Rationale

The Computer Science department at Rice strives to have an outsized impact through research and education. Most comparable departments are at least double our size, yet we work to maximize our visibility and reputation as a top-tier Computer Science department. One element of our department's strategy to maintain and improve our reputation is to extend the reach of our graduate educational programs. The proposed online program allows us to engage a wider set of students in our world-class graduate program.

Institutions that have introduced such online computer science master's programs have also seen growth and strengthening of their on-campus programs as a result. We therefore view this as an ideal way of strengthening our graduate educational activities both on campus and online to further increase our department's impact.

Our department has six years of experience offering online courses: from MOOCs to fully-online sections of our on-campus courses for Rice students. The department has core competencies in this area and will build upon the successes, lessons learned, and tools built to not only ensure a high quality online program, but also to differentiate ourselves from competing programs. Our program will use an asynchronous delivery model (discussed further in Appendix D) that will provide an interactive educational environment where there will be regular student-faculty and student-student interactions. This environment will enable us to provide a superior experience when compared to existing online programs.

The program has a sustainable financial model that will contribute to the resources available to both the School of Engineering and the Department of Computer Science. Revenue generated by the program will provide increased support for the research and educational mission of both the school and department, enabling us to strengthen our research and existing educational programs.

There is significant demand for such programs, as the demand in general for Computer Science education has seen explosive growth in the past 5 years. The underlying reasons for this growth are sound and there is no reason to believe that it will not continue. Two major drivers of this growth are:

- The availability of good jobs in computer science. Despite over 100% increases in degree production in computer science from 2009 to 2015, the number of available jobs has risen faster. Current predictions show that over 70% of all STEM-related jobs will be computing-based.
- The increasing reliance on computers to collect, analyze, and act upon data across disciplines. Modern companies require computer scientists to aid their existing domain experts in these processes.

The Rice Computer Science department currently receives over 1000 applications per year to its MCS program, but we are able to enroll on the order of 70 in our on-campus program. We are limited far more by available on-campus resources than we are by applicant quality. An online option to the degree is our best mechanism to effectively grow the program, in terms of both the number of students we can educate and the breadth and types of students we can reach.

In particular, we want to expand and scale the size of our MCS program to address the current and future needs of the Houston area, as well as major metropolitan areas of Texas and surrounding states. Current working professionals cannot easily enroll in and attend classes at Rice during the day. Such professionals will find it easier to study part-time in an online program, given the flexibility that online courses provide. Ultimately, an online option will enable the department to actively engage and strengthen ties with local industry, educate their workforce, and grow our brand locally.

Furthermore, an online option for the MCS degree is not limited to local enrollment. It will enable the department to extend Rice's reach in Computer Science and increase our reputation within the US and across the globe.

On-campus option

The on-campus option has a flexible curriculum that allows the student to select advanced courses from a wide range of Computer Science and related areas. The highlights of the curriculum include:

- Composed of on-campus classes from both CS and related Departments offered yearly (in either fall or spring, there are no summer classes),
- Classes that reflect the research expertise of the Rice faculty,
- Requires students to be resident at Rice for one fall or spring semester,
- Designed to be taken by full-time students over the course of 3 (fall/spring) semesters.

More information on the degree requirements for the on-campus option for an MCS degree can be found in Appendix A.

Online option

The online option has a focused curriculum designed to provide advanced training appropriate for modern computing jobs. The highlights of the curriculum include:

- Consists of a small set of fully online classes that are each offered three times per year (fall, spring, and summer).
- Built in consultation with leaders from Houston industry,
- Waives physical residency requirements, such that students never need to be resident on campus,
- Designed to be taken by part-time students over the course of 5-8 (fall/spring/summer) semesters.

While the classes will be offered during the semester and have deadlines for assignments, class material will primarily be delivered asynchronously (more detailed information about what this means in the context of this program can be found in Appendix D). We do not envision any of the classes having regular, required synchronous class periods. However, each class will have opportunities for interaction that are appropriate for the specific class. Such opportunities might include online meetings of small groups of students to work on provided exercises, optional online “lab” sessions where the instructor will be online to help guide students through lab exercises and answer questions, or online office hours where the instructor will be available to answer any questions.

More information on the degree requirements for the online option for an MCS degree can be found in Appendix B. Furthermore, Appendix C summarizes the similarities and differences between the two options.

Online Delivery Method

The Computer Science department has a strong track record in creating and delivering online courses. For example, Scott Rixner and Joe Warren have created 10 highly successful MOOCs on Coursera over the past 6 years. These courses include “An Introduction to Interactive Programming in Python”, which was one of the group of initial MOOCs created at Rice. That course has perpetually received critical acclaim from students since its inception.

The department has leveraged this expertise in online education to improve its on-campus instruction as well. This fall, COMP 140 is one of the first courses to offer a fully-online section during the semester for Rice students.

The department has core competencies in this area and will build upon the successes, lessons learned, and tools built to ensure a high quality online program. The department has worked successfully and synergistically with the Office of Information Technology (OIT) and Rice Online Learning (ROL) to create and deliver these courses in the past and will rely on the expertise of both units in developing and delivering this program.

ROL staff include instructional designers, videographers, online course developers, data analysts, and project managers, and these staff will support the development and maintenance of the Online MCS degree. Over the last four years ROL has successfully developed and delivered numerous Rice online courses for credit during the summer sessions, and this fall is supporting COMP 140, which currently has 84 online students enrolled. ROL is responsible for record keeping and data management as outlined in University Policy 846 and consequently ensures that high-quality learning outcome metrics, faculty and TA training programs, and best pedagogical practices are supported and maintained in all coursework related to the online degree.

The office of the Vice President of Digital and Global Strategy, in coordination with the offices of Finance, OIT, and Public Relations, is concluding a rigorous competitive RFP and review process to retain a best-in-class marketing firm that will publicize the online program and ensure steady yields of well-qualified students. In addition, the office is hiring student success specialists to support student persistence and timely progress through the program.

ROL partners with Rice's Office of Information Technology (OIT) to support all online and web-based course delivery and our course management system, Canvas. Faculty and students have content and platform support through phone, email, and course forums provided by ROL/OIT, who employ course subject matter experts (under faculty guidance) to help students in a course with questions as well as technical staff for platform support help

OIT provides any necessary training or technical support for all online systems or resources. The Rice systems that the OIT team support include student email accounts, online registration, accessing transcripts, cashiers and billing, financial aid, and library resources.

Structure

The online program will operate during three semesters per year: fall, spring, and summer. The fall and spring semester will follow the on-campus academic calendar. The summer semester will be the full length summer semester on the on-campus academic calendar, such that all three semesters are equivalent length.

All core courses will be offered all three semesters in order to provide maximum flexibility to students. Students will be admitted to the program three times per year, and will therefore be able to start the program in any semester.

This structure has been discussed with the Registrar's office and they are highly supportive of it.

Staffing

The program will be overseen by three individuals: the Chair of the Computer Science Department, a program director, and a faculty director. The program director will provide administrative oversight of the program and manage the interactions between the department, Rice Online Learning, external contractors (such as for marketing), the instructors, and the students. The faculty director will provide academic oversight of the program to ensure appropriate academic rigor and that the program is meeting its stated learning outcomes. The faculty director will have a full-time faculty position in the department. Since the faculty director will help evaluate the instructors in the program, the faculty director must also have an appropriate position and rank to do so. The inaugural faculty director will be Scott Rixner, Professor of Computer Science.

Five full-time lecturers or faculty in the teaching professor ranks will be dedicated to teaching the courses in the online option of the MCS degree. These five faculty will be full-time faculty with multi-year contracts in the Computer Science Department. They will be subject to the following conditions:

- They must have a PhD in Computer Science or related discipline,
- They will be paid on an equivalent pay scale to all full-time lecturers or teaching faculty in the department,
- Their performance will be reviewed on a yearly basis using the same process as all lecturers and teaching faculty in the department, and
- They will teach two online courses per semester for three semesters per year.
- They will receive training in online course development and delivery from Rice Online Learning.

There will be no distinction among the instructors in the department, regardless of whether they happen to be teaching online or on-campus courses. The instructors teaching online courses may potentially work remotely, with preference given to qualified candidates who are willing to be local. All instructors in the program will meet with the program director regularly, regardless of whether they have a physical presence on campus or not. If there are instructors working remotely, they will attend in-person meetings at Rice as deemed necessary by the program director and faculty director. Course and instructor evaluations will be reviewed and updates/changes to the courses/program will be discussed during those in-person meetings.

Each course will also be staffed with a teaching assistant. Teaching assistants will be MCS students who have familiarity with the course material. While TAs will initially be drawn from the on-campus program, after the online program ramps up, they could be drawn from either the on-campus or online program.

The oversight of the program by three people — the department chair, faculty director, and program director — provides inherent redundancy in the program's leadership. In addition, the existing on-campus MCS degree has its own parallel leadership, which could be used to provide further redundancy.

Additional staff are included in the budget to provide administrative and advising support for the program. The program director, his/her staff, Rice Online Learning and the Office of Information Technology are responsible for non-academic issues. The program director will ultimately be responsible for routing student issues to the appropriate parties and making sure that students are well aware of all of the support infrastructure that is available to them across these units.

By using the Rice academic calendar, there is inherent redundancy in instructor staffing. The fact that the online program runs on the same semester schedule as our on-campus programs allows faculty resources across the department to backstop the instructors of the online courses on a semester-by-semester basis.

Once the program is successful, we intend to increase the instructor resources dedicated to the program, providing further redundancy. With a larger number of instructors, the overall courses available to the program can be increased, but all electives would not have to be offered every semester. This will enable instructors to cover for each other and fill gaps when instructors leave the program and new instructors get involved with the program.

Technology

The program will be fully supported by Rice Online Learning and Rice OIT. All courses will be delivered using Canvas and other supported academic tools.

As the program develops, we envision building tools to support the courses, including machine grading and plagiarism detection. As these tools mature, the reliance on TAs could decrease over time. Furthermore, we can leverage these tools in our on-campus classes, as well.

Course Development

Courses will be developed specifically for the online MCS program to provide an integrated and cohesive experience to the students. The full-time lecturers associated with the program will be primarily responsible for creating the courses.

Course development will be overseen by the faculty member creating the course, an additional consulting faculty member in the area of the course topic, and the faculty director of the online MCS program. The consulting faculty members will primarily be tenured/tenure-track faculty within the department. (For example, for the initial set of 10 courses, 8 of them will have tenured/tenure-track faculty consultants.) All three faculty members will work to ensure the rigor and quality of the courses as well as ensure that they fit in with the overall program.

The instructor for the course will be in charge of designing and creating the course, including (but not limited to):

- Recording the course videos
- Creating all course activities and assignments
- Designing the interactive components of the class (see Appendix D for elaboration)

The consulting faculty member will be responsible for the following:

- Designing the course syllabus in consultation with the instructor
- Overseeing the coverage of topics by the instructor
- Providing feedback on the assignments created by the instructor

The courses will not all be developed at once. Once a course is launched, it will be offered all three semesters every year (fall/spring/summer). The tentative schedule for launching courses is as follows:

- Semester 1: 3 courses: Algorithms, Programming Languages & Design, and Databases
- Semester 2: 2 courses: Computer Architecture and Data Visualization
- Semester 3: 3 courses: Software Construction Practicum, Software Systems, and Big Data
- Semester 4: 2 courses: Networks & Security and Machine Learning

See Appendix B for further information about these courses. As we anticipate a typical student taking 2 courses per semester, this will likely not slow the initial cohort of students. It will, however, set the minimum time-to-degree of that cohort to 4 semesters (1 $\frac{1}{3}$ calendar year).

Program Learning Outcomes

The addition of an online option for the MCS degree will not change the program learning outcomes (PLOs) for the degree. The learning outcomes will remain as follows:

Upon completing the MCS degree, students will be able to:

- Solve advanced Computer Science problems. Students will acquire and apply a graduate-level understanding of material in sub-areas of Computer Science.
- Design and implement complex software systems. Students will demonstrate skill in their design and implementation and function effectively in teams.
- Communicate effectively to a client and user.

Note that there is a fourth learning objective currently in the General Announcements: “Have improved professional opportunities relative to the time before entering the program.” In the

course of developing the online program, we have decided to eliminate that learning objective from the MCS degree. It is not truly a learning objective, so we have decided that it is not appropriate for either the on-campus or online program. The AVP of Institutional Effectiveness and Institutional Research recommends and supports this change.

Financial Model

The following model was prepared in consultation with the Dean of Engineering's office, Rice Online Learning, the Office of Information Technology, and the VP of Finance. The current model is the result of months of discussions among the relevant parties. So while it may be updated slightly, it should be an accurate reflection of the program budget.

In this budget, the "Provider Expenses" include expenses incurred by outside entities (e.g., for Marketing), Rice Online Learning, and the Office of Information Technology. As the table shows, Central has agreed to pay for the initial startup costs for the program.

The enrollment is calculated as the number of students taking 2 courses per semester throughout the year. For example, a student admitted in the third semester would count as 1/3rd of an enrolled student for the given year in this table. The budget is calculated using the conservative estimate of enrolling 75 students each year (25 per semester).

	Startup	Year 1	Year 2	Year 3	Year 4	Year 5
Enrollment	0	50	116.7	125	125	125
Total Tuition	0	\$2,505,000	\$6,090,000	\$6,787,500	\$7,059,000	\$7,341,600
Central	-\$2,389,412	\$501,000	\$1,218,000	\$1,357,500	\$1,411,800	\$1,468,320
Departmental Expenses	\$1,046,210	\$1,292,620	\$1,249,045	\$1,249,045	\$1,249,046	\$1,249,046
Provider Expenses	\$1,343,202	\$1,557,942	\$1,536,466	\$1,514,740	\$1,514,740	\$1,514,740
Total Expenses	\$2,389,412	\$2,850,562	\$2,785,511	\$2,763,785	\$2,763,786	\$2,763,787
Net Revenue (CS/SoE)	0	-\$846,562	\$2,086,489	\$2,666,215	\$2,883,414	\$3,109,493

Assessment Plan

Both the program learning outcomes and the courses themselves will be assessed by the department using the same procedures that are used for on-campus programs and courses. Consistent with our on-campus programs, the Department Chair will oversee the quality of

course content and delivery and will be supported by the Faculty Directory of the Online MCS program. See Appendix E for further details on Assessment.

For assessment purposes, the Graduate Council will receive from the Department of Computer Science an evaluation of the program after three years of operation, to include information regarding staffing, faculty involvement, student admissions, student retention, quality of instruction, and budget overview.

Appendix A: On-campus MCS Requirements

General Requirements: 30 credit hours are required, of which at least 24 must be completed at Rice. Students cannot use one course to satisfy requirements from multiple categories (e.g., both Breadth and Depth). No more than 3 credit hours total may be counted from 1- and 2-credit-hour courses. All credit hours must be at the 500-level or above.

Breadth (9–12 credit hours): Students must take one course from three of the four following groups. Students demonstrating that they have previously passed one or more courses of comparable depth from a group may petition to be exempted from that group's breadth requirement.

- Languages & Compilers: COMP 506, 511, 512, 515, 535
- Theory: COMP 507, 509, 581, 582
- Systems: COMP 508, 513, 521, 522, 524, 526, 528, 529, 532, 534, 538, 541, 554, 556, ELEC 553
- Applications: COMP 502, 530, 531, 533, 540, 542, 546, 550, 557, 560, 571, 576, 602, ELEC 549

Depth (6–8 credit hours): Students must complete a tightly coupled two-course focus. A list of approved specializations is available (see below), but students may design their own with approval by the MCS advisor. They may include courses outside the Computer Science Department, and they may include one independent study project. The following list of depth specializations is representative, but not comprehensive.

- Parallel computing: two of COMP 515, 522, 534
- PL theory and logic: two of COMP 511, 507, 509
- Compilers: two of COMP 506, 512, 515
- Networking: two of COMP 524, 529, 556
- Systems and security: two of COMP 508, 521, 528, 532, 538, 541, ELEC 553
- AI and robotics: two of COMP 502, 540, 542, 550, 557, 576, 602
- Optimization: two of CAAM 560, 564, 565
- Architecture: two of COMP 526, 535, 554
- Software engineering: two of COMP 501, 504, 505, 539
- Database: COMP 530, 533
- Computer vision: two of COMP 560, 546, ELEC 549
- Data science: two of COMP 502, 530, 533, 540, 542, 576, 602

Design project (4 credit hours): Students must complete a design project: one of COMP 501, 504, 539, or a 590 independent study project of similar depth.

Professional Development: Up to 6 credit hours is encouraged but not required:

- COMP 694 How to be a Chief Technology Officer
- ENGI 510 Technical and Managerial Communications 13

- ENGI 529 Ethics and Engineering Leadership
- ENGI 505 Engineering Project Development and Management
- ENGI 515 Leading Teams and Innovation
- ENGI 528 Engineering Economics
- ENGI 542 Communication for Engineers
- ENGI 545 Strategic Thinking
- ENGI 610 Management for Science and Engineering
- ENGI 614 Learning How to Innovate
- ENGI 615 Leadership Coaching for Engineers

Electives: Any remaining credit hours counting towards the degree must be 500- level or above COMP courses except COMP 590 independent study projects. ENGI 530 Engineering Practicum does not count towards the degree.

Appendix B: Online MCS Requirements

The online program will initially be composed of ten 3-credit courses that all students must take. As the program develops, electives will be added. These targeted courses represent a tighter and more cohesive program that will also be used to influence and evolve the on-campus program. This will result in improvements in the on-campus program as well as the development of a high quality online program.

General Requirements: 30 credit hours are required, all of which must be completed in the program.

Areas (30 credit hours): Courses are divided into three depth areas.

- Principles of Algorithms and Software Area (3 courses)
- Computer Systems Area (3 courses)
- Data Area (4 courses)

Courses

The following table summarizes the initial 10 courses for the program.

Course	Pre-Reqs	Based Upon	Designer	Consultant
Algorithms (ALG)	none	COMP 582	TBA	Luay Nakhleh (Professor)
Programming Languages and Design (PLD)	none	new	TBA	Swarat Chaudhuri (Associate Professor)
Software Construction Practicum (SCP)	PLD	new	TBA	John Greiner (Lecturer)
Computer Architecture (CA)	none	COMP 554	TBA	Scott Rixner (Professor)
Systems Software (SS)	CA and PLD	new	TBA	Alan Cox (Professor)
Networks and Security (NS)	PLD	new	TBA	Ang Chen (Assistant Professor)
Databases (DB)	none	COMP 533	TBA	Risa Myers (Lecturer)
Data Visualization (DV)	ALG	new	Joe Warren (Professor)	Scott Rixner (Professor)
Machine Learning (ML)	ALG	COMP 542	TBA	Anshu Shrivastava (Assistant Professor)
Big Data (BD)	DB	COMP 543	TBA	Chris Jermaine (Professor)

Curriculum Map

The following table shows how the courses in the program map to the program learning outcomes.

Course	PLO1: Solve Complex Problems	PLO2: Design and Implement Complex Software	PLO3: Communicate Effectively
ALG	practice		
PLD		practice	
SCP		master	master
CA	practice		
SS		practice	
NS	practice	practice	
DB	practice		practice
DV	practice		practice
ML	master		
BD	practice	practice	

Example Course Catalog Descriptions

The following are examples of course catalog descriptions for the courses offered in the program. The faculty developing the courses will have the latitude to modify the contents of the courses while maintaining the topic areas, objectives, and learning outcomes. However, we will ensure that at least one of the courses will have a required communication component regardless of the specific technical topic areas covered.

Principles of Algorithms and Software Area

- **Algorithms**

Algorithms are the recipes that underlie all computations executed by a computer. Designing new algorithms, proving their correctness, and analyzing their computational requirements are three foundational tasks in all areas of computer science. This course covers all these three aspects of algorithms. Topics covered include growth of functions,

asymptotic notation and analysis, graphs and their properties, graph exploration, graph algorithms, greedy algorithms, divide-and-conquer algorithms, dynamic programming, NP-Completeness, and heuristic search algorithms.

- **Programming Languages and Design**

This course covers important concepts of programming languages that are critical to understanding and constructing software artifacts. These concepts will be studied in the context of multiple programming paradigms, including functional and object-oriented programming. By using different paradigms, you will learn to think more deeply than in terms of a single approach or the syntax of one language. This course aims to provide a framework for understanding how to use language constructs effectively and how to design correct and elegant programs in any language.

- **Software Construction Practicum**

This course focuses on modern principles for the construction of large-scale programs, with an emphasis on design patterns, modern programming tools, and team management. The material will be applied in a substantial software design/construction project. The course has a significant oral and written communication component where students will be required to document and present their software design.

Computer Systems Area

- **Computer Architecture**

It has become increasingly important to understand the underlying properties of modern computer architectures. System organization, including memory hierarchies, parallel processor organization, and interconnection networks can have a large impact on the performance of software systems. This course aims to provide a foundational understanding of key computer architecture concepts and their impact on performance.

- **Systems Software**

Modern computer systems are designed and implemented in a layered fashion, wherein each layer builds upon those beneath it, providing abstractions for processing, memory, and I/O that are progressively more abstracted from the hardware and easier to use than those of the underlying layers. While this layered architecture has made building systems easier, it has also made understanding their behavior and performance more difficult. Every layer from the managed run-time environments used by modern programming languages to the hypervisor play a role in processor scheduling, memory management, and I/O, making it oftentimes difficult to pinpoint which layer of the system is interacting poorly with a program. This class will teach students about the fundamental characteristics of the abstractions for processing, memory, and I/O at each layer of a modern computer system, so that they might understand the functionality provided by each layer, and instruct them on the use of modern debugging, profiling, and

tracing tools, so that they are equipped to characterize the behavior and performance of their programs.

- **Networks and Security**

Many modern web services, such as Facebook or YouTube, rely on a set of computers that coordinate across a network. A networked system raises unique challenges, not the least of which is security. As applications can send messages to or receive messages from other remote applications, it is important to ensure that such network-facing programs are secure, even if parts of the system may not be trustworthy. This course will teach the concepts, architecture, and implementation of network applications that have high security assurance in the presence of threats. We will cover typical attacks, such as denial-of-service, remote exploits, as well as security practices that developers can adopt to address these challenges.

Data Area

- **Databases**

This course is an introduction to relational and other (NoSQL) database systems, SQL programming, and database design. This course will teach students how to understand trade-offs in database design, to create well-designed databases, and to develop proficiency in effectively managing data in a database. The course is focused on developing skills as a database designer. It also includes discussions of database implementation details to enable students to understand underlying system functionality and how that impacts decisions a database designer makes.

- **Data Visualization**

This course will study methods for creating effective visualizations of a wide range of data (both 2D and 3D). The first part of the course will focus on using Python to organize/process raw data and then apply existing high-level Python packages to generate suitable visualizations. The skills acquired in the first half of this class will allow students to create a wide-range of visualizations using a minimal amount of effort. The second half of course will focus on understanding how these visualizations are generated in terms of algorithms that rely on lower-level graphical primitives used in basic Python graphics packages. The skills acquired in the second half of the class will allow students to create custom visualizations specifically suited to their data.

- **Machine Learning**

Machine learning is the process of automatically improving performance through experience. Learning from large datasets is becoming an increasingly common and valuable technique across a large range of application domains, such as robotics, medicine, speech/facial recognition, and driving autonomous vehicles. This course will focus on providing a foundational understanding of modern algorithms in learning and data mining for practical applications.

- **Big Data**

This course is an introduction to modern data science. Data science is the study of how to extract actionable, non-trivial knowledge from data. The course will focus on software tools used by practitioners of modern data science, the mathematical and statistical models that are employed in conjunction with such software tools and the applications of these tools and systems to different problems and domains. In particular, this class explores the use of these tools and models in the analysis of “big” data, that is datasets that are too large to be analyzed on a typical personal computer.

Appendix C: On-campus vs. Online Similarities and Differences

Program Element	On-campus Program	Online Program
Admissions	Twice per year (fall/spring semesters)	Three times per year (fall/spring/summer semesters)
Admissions Standards	<i>Identical</i>	<i>Identical</i>
Degree requirements	<i>Identical</i> : 30 credit hours/10 courses	<i>Identical</i> : 30 credit hours/10 courses
Learning Outcomes	<i>Identical</i> : 3 PLOs as described above	<i>Identical</i> : 3 PLOs as described above
Minimum time-to-degree	1 ½ years (three fall/spring semesters)	1 year (three fall/spring/summer semesters)
Expected time-to-degree	1 ½ years (three fall/spring semesters)	1 ⅔ to 2 ⅔ years (five to eight fall/spring/summer semesters)
Course delivery method	Face-to-face	Fully online
Course frequency	Most courses offered once per year	Courses offered three times per year

The on-campus program has grown organically in response to rapid increases in enrollment. In contrast, the curriculum for the proposed online option to the degree program has been designed from the ground up in a systematic way. Moving forward, the department intends to use the online curriculum as a model to improve the on-campus curriculum, further unifying the two options.

Appendix D: Asynchronous Classes in the Online MCS Program

A key component of this proposal that differentiates the program from others and maximizes flexibility for students is the asynchronous nature of the classes. This does not mean that the classes will be self-paced or that there will be no student-faculty or student-student interaction.

Classes will have regular, required deadlines, as with conventional synchronous classes. However, students will be able to watch videos, read material, and perform other exercises at a time of their choosing, but during the week in which the materials are supposed to be consumed. For example, in a particular week, students may be assigned multiple videos and readings, be required to take a quiz by Tuesday at Midnight CST, and be required to submit a project by Friday at Midnight CST. The asynchronous nature of the class, however, would allow each student to work on the class at times of their choosing throughout the week, rather than attending a class session at a fixed time.

This asynchronous delivery method will allow for greater flexibility among students who are likely working and who are likely located in different time zones.

In addition to regular deadlines, there will also be regular opportunities for interaction that are appropriate to the specific course. Examples of such opportunities are:

1. Students could be assigned to groups and be required to complete group projects. The students would need to meet with each other in order to accomplish this. The meeting times, however, would be set by the students in the group, not the instructor, allowing them to work these meetings into their respective schedules.
2. The instructor could hold online office hours via video conference or other means. Students would know that the instructor would be online at that time and could meet with him/her if they desired. The instructor likely would not hold such office hours at the same time each week, in order to accommodate different student schedules. That way all students would have opportunities to interact with the instructor, even if not all in the same week.
3. The instructor could hold weekly "lab" sessions where students complete some guided exercises. The instructor and/or TAs would be online during specific times during the week to help students work on these guided exercises. Students, however, could complete the exercises whenever they want and would not be required to work on them during the scheduled times. But, the staff would be known to be available if the students want help and/or student-staff interaction.

These are only a few examples of the possibilities, as different types of interactions will be most appropriate for different types of classes. It is important to understand, though, that all classes will have such opportunities for student-faculty and student-student interaction enabling

students to feel connected with the class, despite not being physically present. This model provides maximum flexibility for students without disconnecting them from the faculty and their peers. Students will strongly be encouraged to take advantage of as many of these engagement opportunities as possible, and the expectations for student engagement will be the same as for on-campus classes. Regardless of the level of engagement, students will still be held to a regular schedule of deadlines and be expected to complete the material at the same pace as everyone else in the class.

Appendix E: Assessment

Rice University's Office of Institutional Effectiveness (OIE) is charged with supporting evaluation and assessment activities within all university units. The Rice Outcomes Assessment Report (ROAR) is the key report that nonacademic and academic units alike complete and submit annually to OIE (during the summer at the end of the academic/fiscal year). ROARs are completed for each program-level student learning outcome (PLOs) based on a schedule contained in the assessment plan that each academic program develops, submits, and reviews annually with OIE. Non-academic units also complete individual ROARs for each of their annual goals. Non-academic units' annual goals are submitted at the beginning of each fiscal year to OIE. All ROARS include a description of the goal or learning outcome, the methodology and standard used to assess its accomplishment, the results of the assessment and conclusion about success, and improvements implemented or planned for the future, if warranted. These reports are shared upward within the organizational structure for review and possible action by upper management (e.g., deans and vice provosts within academic affairs, or associate vice presidents and vice presidents for other divisions of the university). The reports are used to plan and implement improvements, identify new goals, and advise the budgeting process. Reviewed ROARS are submitted to OIE for review and archiving. OIE consults with each academic and non-academic unit annually to support the institutional effectiveness processes within that unit.

The establishment of online degree programs is easily incorporated within the assessment processes that exist currently for all academic programs. New academic programs generally are required to submit a third-year evaluation report on the success and sustainability of the program. The Computer Science Department will submit a report that includes areas identified by the Faculty Senate working group on digital education (approved April 2017, see Appendix A, especially pages 7-8) to ensure quality and consistency with Rice's mission and with principles and standards established by SACSCOC, SARA, and the US Department of Education concerning online education. The third-year report will include the assessments concerning student learning proficiency, enrollment numbers, retention numbers, and post Rice transition. Annual ROARs will be submitted to OIE for review and archiving after being used to document student proficiency both for online students and students in the on-campus program (i.e., demonstrate comparability of quality and proficiency). ROL is responsible for working with the Computer Science Department to establish the methods to accomplish these assessments and to assist in their analysis along with OIE.

Summative assessment of distance learning programs at Rice will follow the assessment system established for all academic programs and are required to engage in assessment of the comparability of online student achievement with on-campus student achievement for the same program or courses. Rice's policy on distance and online education requires that we meet this and other requirements specified by SACSCOC and the US Department of Education and Rice's Faculty Senate. ROL is responsible for ensuring that these assessments and comparisons occur. The procedures establish that the summative assessment built into the

online courses will enable this to occur and that the relevant on-campus courses will also conduct such assessment to determine comparability. In addition, formative assessments are built into the courses to provide feedback to instructors and the course designers on how to improve pedagogically.



Marie Lynn Miranda, Ph.D.
Howard R. Hughes Provost
Professor of Statistics

5 October 2018

April DeConick
Chair, Graduate Council Rice
University

Dear April:

I write in support of the online MS in CS program proposed by the Department of Computer Science. The delivery of a high-quality online degree is innovative and strategically advances both the engineering school and the university by offering a Rice MCS degree to students who may not have the option to be on campus.

I was very impressed with the work that Dean DesRoches and Computer Science Chair Luay Nakhleh undertook to ensure that faculty were actively engaged in the consideration of the idea and in all aspects of the design of the program. The length of engagement and strong support by the faculty will ensure that faculty will fully engage in all aspects of the new degree format and that academic standards and integrity in this new delivery format will meet or exceed the existing excellent programs at the George R. Brown School of Engineering. Most top-20 engineering schools use online delivery in their degree or certificate programs, and all are looking to expand their digital reach. Offering the online MS in CS is one way that the School of Engineering will continue to operate at the forefront of the field.

I am very pleased that the Department of Computer Science has chosen to become a leader in this important growth area for engineering schools and higher education more broadly.

With my very best regards,

A handwritten signature in blue ink, appearing to read 'Marie Lynn Miranda'.

Marie Lynn Miranda, PhD
Professor of Statistics and Provost



REGINALD “REGGIE” DESROCHES
WILLIAM AND STEPHANIE SICK DEAN OF ENGINEERING
PROFESSOR, CIVIL AND ENVIRONMENTAL ENGINEERING
PROFESSOR, MECHANICAL ENGINEERING

7 October 2018

To: Graduate Council
From: Reginald DesRoches, Dean of the George R. Brown School of Engineering
Re: Proposal for an Online MCS Degree Program

As one of my first actions upon arriving at Rice as Dean of the School of Engineering, I asked the Department of Computer Science (CS) to explore offering an Online Master’s of Computer Science (OMCS) program. This request was motivated by several factors. First and foremost, computing education is essential in today’s world. This is why CS has the largest number of declared majors, the largest “Professional Master’s” program (outside the MBA program), and one of the largest PhD programs at Rice. Interdisciplinary fields of study and scholarly research that involve computer science are on the rise, and that is exciting students and, more broadly, the general population. Indeed, stories in the media about the power and promise of computing in areas ranging from medicine to self-driving cars emphasize even to the general public the awesome power of computing. Furthermore, computing jobs account for a great majority of jobs in all STEM fields. According to the Bureau of Labor Statistics, between the years 2014 and 2024, there will be over one million computer occupations and almost 500,000 new jobs in computing. This fact is definitely contributing to the exponential growth that CS has experienced with respect to the number of applicants to the on-campus MCS program. For Fall 2018 alone, CS received upwards of 1,123 applications, which almost equals the number of applicants to all other Professional Master’s programs in Engineering combined. However, due to limited resources and capacity, CS was only able to accept 20% of all these applications, declining many qualified applicants. Offering an OMCS degree program will allow CS to admit more students and, consequently, have much bigger educational impact and visibility.

Potentially more significant for us is that the MCS program can help the School of Engineering and Rice more generally engage with the Houston industry and communities. However, given the lack of flexibility with respect to schedules of employed professionals (e.g., no evening or weekend courses are offered by CS), the on-campus program has failed to attract professionals from the Houston industry to join the program. Deploying an online MCS program will solve this problem, as those interested in the program will be able to attend classes according to their schedules, and have the opportunity to interact with the teaching staff at very flexible times.

Rice CS is one of the top twenty departments in the country (according to US News and World Report ranking of graduate CS programs) and enjoys a very strong reputation among prospective students and employers alike. I have no doubt that the OMCS will be very successful. It will broaden our educational reach, further our impact on computing employment, help us strengthen our engagement with the Houston industry, and will significantly improve the visibility, brand, and reputation of CS, and in turn, the School and University. Therefore, I offer my strongest support to the proposal for creating an Online MCS Degree Program.

Sincerely,

A handwritten signature in cursive script, appearing to read 'Reginald DesRoches'.

Reginald DesRoches
William and Stephanie Sick Dean
Professor, Civil & Environmental and Mechanical Engineering



Department of Computer Science
6100 South Main Street, MS 132
Houston, TX 77005

5 October 2018

FROM: Luay Nakhleh, Chair, Department of Computer Science
TO: Graduate Council
SUBJECT: Proposal for an Online MCS Degree Program

“If I were a senior or first-year graduate student interested in biology, I would migrate as fast as I could into the field of *computational* biology... There are vast quantities of high-quality data accessible to anybody who has the skills to find the nuggets of truth that are hiding in that information.” These are the words of Dr. Francis Collins, Director of the National Institutes of Health, and they reflect the essential role computing plays in the biological and biomedical sciences today. Similarly, computing has penetrated almost all fields of study and all occupations, giving rise to interdisciplinary fields under the umbrella term “X+CS,” where X could be music, economics, physics, historical linguistics, etc. Indeed, it is no exaggeration to say that *computing has become an essential new literacy*. This is precisely why almost one-eighth of all Rice undergraduates have decided to major in computer science, making it by far the largest major on campus (current estimate is that CS has about 525 majors). This is also why in Fall 2008 we had only 2 students in our MCS program (“Professional Master’s”), and 10 years later, we have over 130 students currently enrolled in the program, making it the largest professional Master’s program after the MBA program (not to mention the 1123 MCS applications that our department received for Fall 2018 alone).

We – the faculty in the Department of Computer Science – genuinely believe that computing is indeed a new literacy and that it is incumbent upon us to innovate in education delivery methods to accommodate the larger numbers of students interested in our programs. Indeed, the department was one of the first (if not the first) at Rice to offer successful and highly visible MOOCs (massive open online courses). The department was one of the first to use the flipped-classroom mechanism to accommodate more students and innovate pedagogical practices in CS courses. The department was one of the first to offer a fully online section of one of the most popular courses (COMP 140) in order to scale the delivery of the material to the large numbers of students interested in the course (over 300 students are taking the course in Fall 2018). Along the same lines, an Online MCS program was a natural step for the department.

Upon his arrival at Rice, Dean DesRoches and I met and discussed the opportunity of exploring an Online MCS program precisely for the reasons listed above, but also to increase the reputation and visibility of our department, school, and university. To put things in context, the department’s very successful MOOC “An Introduction to Interaction Programming in Python” (IIPP) has about 800,000 students enrolled in it in

the first five years, with almost 80,000 students having completed it. Rice University has had fewer graduates than that over its entire history! IIPP was recognized on Class Central, one of the main MOOC review sites, as the top rated MOOC of all time in its list of the top 50 online courses. It is this scale of visibility and reputation that an Online MCS program could achieve.

Over the last year and a half, the department has engaged in extensive discussions about the program, the delivery mechanisms, the target audience, etc. Eventually, and despite the stress that the department is under due to the large number of students and increased enrollments in our courses, the faculty voted almost unanimously to create this program, knowing full well that the program would increase the number of students but also recognizing that, in the long run, the benefits of the program far outweigh the cost.

The numbers of applicants to our on-campus MCS program for the Fall semesters between 2013 and 2018 have been about 250, 310, 450, 640, 780, and 1123, respectively. Given resource and capacity constraints, the MCS program has become one of the most competitive programs. For example, in Fall 2018, the department made 223 offers; that is a 20% acceptance rate. Of those 223 accepted applicants, 79 (about 33%) accepted the offer to join our MCS program, which is already a very large number of incoming MCS students. An online component to our MCS degree program will allow us to provide education to the many qualified applicants who seek it but are currently not offered admission due to limited capacity in our on-campus courses. Furthermore, there is much demand from working professionals to pursue an MCS degree either to further their computational skills or to achieve a career change into a computational field. An on-campus program with courses offered only during the weekdays does not provide the flexibility for this demographic. An Online MCS program will provide the necessary flexibility for them to join the program. One important outcome of this would be a much stronger engagement between Rice and the local Houston industry.

As I stated above, the faculty have voted almost unanimously in support of the program, and faculty have volunteered to oversee and be involved in the design and creation of the courses in the program. For effective delivery and to account for the fact that current faculty are already teaching existing (and large) courses, the program will have a dedicated team of well-qualified instructors who will be members of our faculty and will provide the high-quality education that our department has been providing for decades. The program will have a director who oversees the day-to-day operations, as well as a faculty director who is very familiar with the Rice culture and educational standards. Indeed, there could not have been a more appropriate choice for the faculty director position than Professor Scott Rixner, who is one of the foremost innovators in education at Rice and one of the most experienced professors in delivering online education. The choice of Professor Rixner for this role attests to the seriousness that the department gives to the proposed online program.

Launching an Online MCS degree program is a major endeavor. Our department has given serious consideration to the pros and cons of such a program, and has explored in detail its various aspects. Such a program will allow us to deliver “Rice-caliber” computational education to the large number of individuals seeking computational education, computational literacy, opportunities to advance their careers, or opportunities

to switch into a computational career. While computing dominates jobs in the STEM fields, computing education is not only about jobs. As a researcher who has developed computational methods for analyzing data to understand questions ranging from how the Indo-European languages evolved to how intra-tumor heterogeneity arises in cancer, I fully understand the excitement, joy, and power that computational education and skills endow upon those who achieve them. On behalf of the Department of Computer Science, I offer my strongest support and endorsement of this program.

Sincerely,

Luay Nakhleh

Luay Nakhleh

Chair, Department of Computer Science

Master of Computer Science (MCS) Degree, Online Program

Program Learning Outcomes for the MCS Degree

Upon completing the MCS degree, students will be able to:

1. Solve advanced Computer Science problems. Students will acquire and apply a graduate-level understanding of material in sub-areas of Computer Science.
2. Design and implement complex software systems. Students will demonstrate skill in their design and implementation and function effectively in teams.
3. Communicate effectively to a client and user.

Requirements for the MCS Degree, Online Program

The Master of Computer Science, Online degree program is scheduled to start in Fall 2019 (starting in the Academic Year 2019-2020). Online courses are currently under development.

The MCS degree is a non-thesis master's degree. For general university requirements, please see [Non-Thesis Master's Degrees](#). For additional requirements, regulations, and procedures for all graduate programs, please see [All Graduate Students](#). Students pursuing the MCS degree must complete:

- A minimum of 30 credit hours to satisfy degree requirements.
- A minimum of 30 credit hours of graduate-level study (coursework at the 500-level or above).
- A minimum of 24 credit hours must be taken at Rice University.
- A minimum overall GPA of 2.67.
- A minimum GPA of 2.67 in required coursework.

Students in the MCS degree program are expected to pay full tuition and all fees. No financial aid is available from the university or the department for MCS students. The MCS degree is a terminal degree for students intending to pursue a career in the computer industry.

The courses listed below satisfy the requirements for this degree program. In certain instances, courses not on this official list may be substituted upon approval of the program's academic advisor, or where applicable, the department or program's Director of Graduate Studies. (Course substitutions must be formally applied and entered into Degree Works by the department or program's [Official Certifier](#).) Students and their academic advisors should identify and clearly document the courses to be taken.

Summary

Total Credit Hours Required for the MCS Degree, Online Program	30
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Degree Requirements

Core Requirements	
Computer Systems	9
COMP 6XX -- COMPUTER ARCHITECTURE 1	
COMP 6XX -- SYSTEMS SOFTWARE	
COMP 6XX -- NETWORKS AND SECURITY	
Data	12
COMP 6XX -- DATABASES 1	
COMP 6XX -- DATA VISUALIZATION	
COMP 6XX -- MACHINE LEARNING	
COMP 6XX -- BIG DATA	
Principles of Algorithms and Software	9
COMP 6XX -- ALGORITHMS 1	
COMP 6XX -- PROGRAMMING LANGUAGES AND DESIGN 1	
COMP 6XX -- SOFTWARE CONSTRUCTION PRACTICUM	
Total Credit Hours	30

Footnotes and Additional Information

1 Computer Architecture, Databases, Algorithms, and Programming Languages and Design are pre-requisites to other required courses and must be taken first.
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Policies for the MCS Degree, Online Program

Department of Computer Science Graduate Program Handbook

The General Announcements (GA) is the official Rice curriculum. As an additional resource for students, the department of Computer Science publishes a graduate program handbook, which can be found here:

http://gradhandbooks.rice.edu/2018_19/Computer_Science_Graduate_Handbook.pdf.

Admission

The GRE test is highly recommended for all applicants, however it may be waived, upon discretion of the department's Admission Committee, if an applicant has relevant industrial experience.

Financial Aid

No financial aid is available from Rice University or the Computer Science Department for students in the MCS degree program.

Transfer Credit

For Rice University's policy regarding transfer credit, see [Transfer Credit](#). Some departments and programs have additional restrictions on transfer credit. Students are encouraged to meet with their academic program's advisor when considering transfer credit possibilities.

Departmental Transfer Credit Guidelines

Students pursuing the MCS degree should be aware of the following departmental transfer credit guidelines:

- No more than 6 credit hours of credit from another U.S. or international universities of similar standing at Rice may apply towards the degree. Transferred courses must be comparable in content and depth to the corresponding course at Rice, and must not have counted toward another degree.
- Request for transfer credit will be considered by the Computer Science Graduate Committee Chair, and the instructor of the equivalent Rice course.

Additional Information

For additional helpful information, please refer to the *Graduate Study in Computer Science* web page at <https://www.cs.rice.edu/academics/graduate-studies/> or contact the department at gradapp@rice.edu.

Opportunities for the MCS Degree, Online Program

For additional information, please see the Computer Science website: <https://www.cs.rice.edu/>