



PCC Proposal to Establish a Post-Baccalaureate Certificate in Networking Software Development (PCC ID #16054)

PRESENTED BY Dylan Roby, Chair

REVIEW DATES SEC – August 29, 2017 | SENATE – September 6, 2017

VOTING METHOD In a single vote

RELEVANT POLICY/DOCUMENT N/A

NECESSARY APPROVALS Senate, President, Chancellor, Maryland Higher Education Commission (MHEC)

ISSUE

The A. James Clark School of Engineering and Department of Electrical and Computer Engineering propose to establish a 12-credit Post-Baccalaureate Certificate in Networking Software Development. This certificate program will be for students who are enrolled in the Master of Science in Telecommunications program. As computer networks become more sophisticated there is a growing need for software designed specifically for computer networks. Examples of emerging networking software technologies are Software Defined Networking and Network Function Virtualization. As these technologies increase in use, there is an emerging need for telecommunications professionals who are skilled in networking software development.

Course requirements for the certificate program include four courses.

At least two courses must be taken from the following set:

- ENTS689A Special Topics: Algorithms and Data Structures
- ENTS669X Special Topics in Computing Systems series

Also, at least two courses must be taken from the following set:

- ENTS689G Special Topics: Design and Analysis of Communication Networks
- ENTS649X Special Topics in Networking series
- ENTS749X Advanced Topics in Networking series

This proposal was approved by the Graduate School Programs, Curricula, and Courses committee on March 17, 2017, and was approved by the Senate Programs, Curricula, and Courses committee on May 5, 2017.

RECOMMENDATION(S)

The Senate Committee on Programs, Curricula, and Courses recommends that the Senate approve this new certificate program.

COMMITTEE WORK

The committee first considered this proposal at its meeting on April 7, 2017. The committee recommended changes to the proposal. The revised proposal was presented to the committee on May 5, 2017. Zoltan Safar, director of the Master of Science in Telecommunications program, presented the proposal. The revised proposal was unanimously approved by the committee.

ALTERNATIVES

The Senate could decline to approve this new certificate program. If the Senate declines to approve this certificate program, students in the Master of Science in Telecommunications program will lose an opportunity to have their focus in networking software development formally recognized.

RISKS

There are no risks to the University.

FINANCIAL IMPLICATIONS

There are no significant financial implications with this proposal.

**THE UNIVERSITY OF MARYLAND, COLLEGE PARK
PROGRAM/CURRICULUM/UNIT PROPOSAL**

- Please email the rest of the proposal as an MSWord attachment to pcc-submissions@umd.edu.

PCC LOG NO.

16054

- Please submit the signed form to the Office of the Associate Provost for Academic Planning and Programs, 1119 Main Administration Building, Campus.

College/School: A. James Clark School of Engineering

Please also add College/School Unit Code-First 8 digits:

Unit Codes can be found at: https://hypprod.umd.edu/Html_Reports/units.htm

Department/Program: Department of Electrical and Computer Engineering/Master's in Telecommunications program

Please also add Department/Program Unit Code-Last 7 digits:

Type of Action (choose one):

- | | |
|---|--|
| <input type="checkbox"/> Curriculum change (including informal specializations) | <input checked="" type="checkbox"/> <i>New academic degree/award program</i> |
| <input type="checkbox"/> <i>Renaming of program or formal Area of Concentration</i> | <input type="checkbox"/> New Professional Studies award iteration |
| <input type="checkbox"/> <i>Addition/deletion of formal Area of Concentration</i> | <input type="checkbox"/> New Minor |
| <input type="checkbox"/> <i>Suspend/delete program</i> | <input type="checkbox"/> Other |

Italics indicate that the proposed program action must be presented to the full University Senate for consideration.

Summary of Proposed Action: The Master's in Telecommunications program is proposing a new Graduate Certificate Program in Networking Software Development

APPROVAL SIGNATURES - Please print name, sign, and date. Use additional lines for multi-unit programs.

1. Department Committee Chair Dr. Zoltan Safar Zoltan Safar 07.16.17.
2. Department Chair Dr. Rama Chellappa Rama Chellappa
3. College/School PCC Chair Jenna Bucci Jenna E. Bucci 3/7/17
4. Dean Dr. Peter Konfinas Peter Konfinas 3/6/17
5. Dean of the Graduate School (if required) Jeff Franke, Jeff Fuke 4/17/2017
6. Chair, Senate PCC Andrew Harris 4/7/17
7. University Senate Chair (if required) _____
8. Senior Vice President and Provost _____

Proposal to Establish a Graduate Certificate in Networking Software Development

I. OVERVIEW

A. Overview and Rationale

Established in 1992, the Master of Science in Telecommunications (ENTS) program provides a unique cross-disciplinary industry-oriented graduate education in telecommunications. It is run jointly by the Department of Electrical and Computer Engineering in the A. James Clark School of Engineering and the Robert H. Smith School of Business. Combining rigorous technical education with invaluable business insight and entrepreneurial skills, the ENTS program offers students a unique perspective on the telecommunications industry and profession. The ENTS program caters to both full-time students and working professionals. Most ENTS courses are offered once a week and are scheduled in the afternoon or evening to suit working professionals, while some courses additionally offer daytime sections. All ENTS courses are “traditional” (residential) courses; the program does not offer off-campus locations or online options. ENTS students are responsible for a differential tuition rate and the program is considered a self-support unit within the University of Maryland. Currently, approximately 240 students are enrolled and approximately 110-120 MS degrees are awarded each year.

To be considered for admission, applicants to the ENTS program must have earned a bachelor’s degree, typically in a technical field (engineering, computer science, etc.) and have an undergraduate GPA of 3.0. Applicants must also submit a personal statement and three letters of recommendation. To earn the MS in Telecommunications degree, students must successfully complete 30 credits of course work (10 three-credit courses) with a GPA of 3.0 or more and a scholarly paper. A typical ENTS student takes 6-8 core courses (up to 2 of the 8 core courses may be waived if justified) and 2-4 elective courses.

The ENTS program is taught by full-time and part-time instructors employed by the Electrical and Computer Engineering Department and the Robert H. Smith School of Business. They all hold PhDs in their respective fields (engineering/computer science or business), and they all have worked in the industry for several years and have considerable industrial experience.

As our communications technology and infrastructure evolves, recent development trends point toward heavy softwarization and virtualization. The telecommunications industry has been moving towards Software Defined Networking (SDN) and Network Function Virtualization (NFV) as next-generation telecommunication technologies. Thus, there is an emerging need for telecommunications professionals who are not only well versed in computer networking, but also skilled in software development. This skill set the boundary of computer networking and software development has been largely overlooked by most graduate degree and certificate programs. This certificate proposal aims to address this need.

We propose the creation of a Graduate Certificate Program in Networking Software Development embedded in the ENTS program. The Certificate Program will be offered to current ENTS students, and its aim is to provide official recognition for acquiring focused knowledge in a particular subfield of telecommunications. Over the past years, many of our students opted to take additional electives (i.e. electives in addition to meeting the minimum degree requirements) to improve their skill sets and their marketability to employers after graduation. This trend is beneficial to both students and the program as it results in better prepared and more marketable graduates with stronger, focused technical background, thus improving the quality of our graduates. This enhances their transcripts, resumes, and chances of finding employment or promotion in their current employment, further improving the reputation of the ENTS program and its alumni base. We would like to encourage, organize and recognize such efforts by offering the Graduate Certificate in Networking Software Development, a well-defined, focused areas within telecommunications. The certificate will be comprised of existing ENTS elective courses, which include special topics and advanced topics courses in computer networking, computer programming, algorithms and data structures and software development. Within the telecommunications industry, certificates are widely accepted proof of expertise in a given technical subfield such as routing, computer security, etc. A Graduate Certificate is an appropriate recognition for the additional coursework, time and effort the student needs to invest to obtain the knowledge/expertise. The Graduate Certificate in Networking Software Development will be one of several proposed certificates designed to strengthen the ENTS program.

The aim of the Graduate Certificate in Networking Software Development is to encourage the students to acquire specialized knowledge and skills in the technical areas of networking and software development. We have positioned this Certificate to expose the students to both computer networking and software development, which will allow them to go through a well-balanced course work in excess of the Master's degree requirements. While completing the certificate program, students will also acquire/develop additional practical problem-solving, programming and analytical skills. Typical industry positions our students take after graduation that would benefit from this Certificate include: software engineer or software quality engineer (for a networking device vendor such as Cisco or a cloud service provider such as Amazon), system engineer, or cloud engineer.

The Master's in Telecommunications program is unique to the University System of Maryland, and thus adding certificate programs for current ENTS students would not replicate or detract from any existing programs. Since the ENTS program specializes in Telecommunications, we offer a wide range of special-topics and advanced-topics courses that no other units offer. The ENTS electives will serve as the basis for the proposed Graduate Certificate Program. This proposal differs from the ENTS Graduate Certificate in Computer Networking in that the latter focuses on computer networking technologies and protocols, preparing students to become network engineers, and being able to deploy, configure and troubleshoot vendor-supplied networking equipment. This proposal focuses on the skills and knowledge needed for the

development of the software components of future networking equipment and network-related information technology services, such as cloud services. Thus, having different focuses, these two certificates will prepare our students for different industrial career paths.

The University of Colorado Boulder offers the “Interdisciplinary Telecom Program” (ITP). UCB has marketed ITP as “a highly-integrated and comprehensive program combining technology, policy, and business with hands-on experience.” As a peer program to the ENTS, ITP offers a Master of Science in Telecom. MS students have the option to pursue “tracks” in network engineering, wireless engineering, network security and telecom policy. These tracks enable students to tailor the technical content of their degree to prepare themselves for careers in industry. Embedded with the tracks is the opportunity for students, who complete the requirements, to earn the corresponding 12-credit Graduate Certificate. Students may be awarded the certificate while completing the MS degree. ITP also offers the Graduate Certificates to non-degree seeking students. The Graduate Certificates include: Computer and Network Security; Network Architecture; Telecom Policy and Strategy; and Wireless Networks and Technologies.

The Graduate Certificate in Computer Networking allows ENTS students to have the option of enhancing their MS degree with specific technical knowledge and also enable them to remain competitive in the marketplace with graduates from similar degree programs at peer institutions.

Additional information:

<http://www.colorado.edu/itp/>

<http://www.colorado.edu/itp/masters-degree>

<http://www.colorado.edu/itp/prospective-students/graduate-certificates>

B. Student Audience

The Certificate in networking software development will only be available to current ENTS students. For a typical ENTS student, this will mean taking 1-2 extra electives in addition to the courses taken to satisfy the MS degree requirements.

Based on the results of a survey we have recently conducted among current ENTS students, there is a significant interest in obtaining Graduate Certificates. Out of 58 responses, 46.6% found a Graduate Certificate very valuable to their portfolios, and 36.2% found it somewhat valuable. Demonstrating their interest, 58.6% responded that they would most definitely obtain a Graduate Certificate if offered, and 32.8% responded that they would most likely obtain one. Finally, 72.4% of the responding students showed interest in obtaining a Graduate Certificate in networking software development.

We also reached out to 39 ENTS alumni to poll their opinions on the value a Graduate Certificate program. Out of 24 responses, 54.2% found it very valuable, and 37.5% found it somewhat valuable to their portfolios. We also asked if they would encourage current ENTS students to

obtain a Graduate Certificate if it was offered, and 45.8% responded “yes, most definitely”, and 41.7% responded “yes, most likely”. Out of the responding alumni, 87.5% responded that they found a Graduate Certificate in the area of networking software development valuable.

C. Eligibility

Enrollment in this program will be limited to ENTS students, so the admission requirements are the same as the ENTS program.

II. CURRICULUM

A. Title

The proposed title is: Graduate Certificate in Networking Software Development.

B. Structure and Course Requirements

The ENTS program has grouped its electives into course series according to specialization areas within telecommunications. The course series relevant to computer networking are Special Topics in Networking and Advanced Topics in Networking. The course series relevant to software development is the Special Topics in Computing. These course series will be included in the certificate program in order to maintain dynamic and up-to-date program offerings. New courses are offered almost every year to effectively respond to the dynamic changes in the telecommunications industry and to produce graduates who are well versed in the latest technology and telecommunications industry trends. At the end of this section, we will provide an example set of courses satisfying the certificate requirements based on our Spring 2016 and Fall 2016 offerings.

The Graduate Certificate in Networking Software Development is a 12-credit program, by coursework only. The courses taken to earn the Graduate Certificate may also be counted toward meeting the MS degree requirements, and the MS degree and the Graduate Certificate may be earned and awarded in the same semester. Each student must complete four 3-credit courses according to the following description.

1. At least two of the following courses or from the course series:

- ENTS 689A Special Topics: Algorithms and Data Structures
- ENTS 669X Series: Special Topics in Computing

2. At least two of the following courses or from the course series:

- ENTS 689G Special Topics: Design and Analysis of Communication Networks
- ENTS 649X Series: Special Topics in Networking
- ENTS 749X Series: Advanced Topics in Networking

Course Descriptions:

ENTS689G: Special Topics: Design and Analysis of Communication Networks

Prerequisite: ENTS 640. This advanced-level graduate course is designed to build on the material covered in ENTS640 and to provide a practical and more in-depth view of the protocols and architectures used in real-world communication networks. The objective of this course is to give the students a reasonable combination of analytical and practical knowledge that is expected from graduate-level network engineers. Due to its practical nature, this course is highly project-oriented and multiple network design problems are visited both in the class and also as homework assignments. OPNET simulation and modeling software is used as the main tool for homeworks and projects. This course covers a combination of theoretical and practical concepts and a tentative list of covered subjects is as follows: Delay calculation in communication networks; QoS techniques in IP networks; Wired/Wireless medium access protocols and LAN technologies; Routers, Switches and other networking devices; Network planning and design; TCP protocol and traffic analysis. The course material and its projects are designed to highlight the main properties of some well-known protocols used in today's networks. Students will learn the role of fundamental theories in the initial stage of a design cycle and subsequent use of modeling and simulation tools for performance evaluation and tuning of their designs.

ENTS 689A: Special Topics: Algorithms and Data Structures (3)

This course provides both a broad coverage of basic algorithms and data structures and an in-depth discussion on selected important topics. We will learn exact algorithms, heuristics, and counter-example development skills in solving problems in sorting, graph, string, and job scheduling problems. Moderate to heavy programming (in C under UNIX) is expected. Through this study and practice, students will develop and improve their programming and problem solving techniques.

ENTS669X Series: Special Topics in Computing

ENTS 669A Special Topics in Computing: Embedded Systems

Prerequisites: Equivalent to undergraduate course on Computer Architecture, equivalent to undergraduate course on Digital Logic Design, equivalent to undergraduate course on programming (preferably C). The first decade of the 21st century was marked by the emergence of smart devices that are used in everyday life. Smart phones, smart cars, smart TVs, smart thermostats, smart vacuum cleaners, just to name a few. These developments are powered in large part by the embedded systems. This course will provide students with the essential knowledge base that will enable them to tackle complex problems encountered in embedded systems design. In addition to the overview of associated hardware components and software methodologies and tools used in the development of modern embedded systems, and theory behind them, the course will include a carefully selected collection of hands-on lab exercises that would help students get a sense of how the presented theoretical concepts connect with the real-world embedded systems applications.

ENTS649X Series: Special Topics in Networking

ENTS649A Special Topics in Networking: Optical Communication Networks

Optical communication has become a classic networking technology. This course will present the state-of-the-art in optical communication networks and their applications. It will provide coverage of basic optical technology and networking topics, presented in a format that is easy to understand for practical engineers and networking specialists. The course will start with a broad coverage of different physical aspects of light propagation, basic components and modulation/demodulation methods, and fundamentals of the physical-layer design. It will then proceed with optical networking, starting with a description of technologies for which optical networking is used. The course will also provide an overview of next-generation SONET technologies along with optical transport network, the generic framing procedure, and Ethernet solutions. The IEEE new resilient packet ring (RPR) protocol will be discussed. Besides the theoretical coverage, the students will be engaged in developing their understanding of optical communication networking through hands-on projects.

ENTS649B Special Topics in Networking: Cloud Computing

The course will present the state of the art in cloud computing technologies and applications. The course will explore potential research directions, as well as the technologies that will facilitate the creation of a global marketplace for cloud computing services that support scientific, industrial, business, and consumer applications. Topics will include: telecommunications needs; architectural models for cloud computing; cloud computing platforms and services; security, privacy, and trust management; resource allocation and quality of service; cloud economics and business models; pricing and risk management; interoperability and internetworking; legal issues; and novel applications. Course projects will expose students to different tools and technologies used to build and utilize clouds and the related security, privacy and trust management issues.

ENTS749X Series: Advanced Topics in Networking

ENTS749A Advanced Topics in Networking: Network Traffic and Application Performance Analysis

Prerequisite: ENTS 640. This graduate-level course covers the fundamentals of network traffic measurement and how the information in traffic traces can be used for different purposes. We will target an important use-case of traffic analysis which is application performance management. Due to the growing trend in online services, application performance management has become an important requirement for all organizations. Furthermore, maintaining the necessary infrastructure to guarantee acceptable user experience is critical to their success. This course will take a top-down approach by reviewing the basics of application and transport layer protocols as well as the effects of various network components on the performance of an application. Through lecture and lab sessions, students will learn different traffic measurement tools and how the traffic traces can be used to evaluate the performance of an application under different conditions. The course also briefly discusses another use-case of traffic measurement i.e., network security, through hands-on experiments with available software packages. Cryptography and security fundamentals are not covered and they are presented in detail by other specialized courses.

ENTS749B Advanced Topics in Networking: Software Defined Networking

Prerequisite: ENTS 640 and ENTS 641. This advanced-level graduate course covers software-defined networking (SDN), its key principles, building blocks, and design as well as its recent applications and uses cases in industry. SDN is a new paradigm in telecommunications that re-thinks conventional network design/operations/abstractions and makes networks openly programmable, controllable, and affordable. SDN is widely accepted by industry as a game changer, with use in domains ranging from home networks to large-scale wide-area backbone networks. The objective of this course is to provide students with practical knowledge and in-depth understanding of SDN along with the ability to design and program the control plane of networks. Programming assignments and a project in this course provide students with opportunities to work hands-on with Python programming language and with popular open-source SDN tools. Students will gain familiarity with networking needs, opportunities, and challenges in environments such as data centers.

ENTS749C Advanced Topics in Networking: Vehicular Networks

Prerequisite: ENTS 640 and ENTS 622. Modern vehicles on roads and in air use telecommunication networking for enhancing their features, operations, controls, and performance. These "connected vehicles" have in-vehicle networks of embedded systems and can communicate with passenger carried devices, neighboring vehicles, and the Internet for new features and applications. This advanced topics course studies communication network principles, designs, protocols, and standards of connected vehicles and offers practical insight into this rapidly growing networking industry. Students get hands-on experience with building Python-based applications using automobile and aircraft networked embedded systems data. Students will also learn to simulate realistic vehicular networks (e.g., in ns-3 and Matlab).

ENTS749D Advanced Topics in Networking: Networking Design and Configuration Lab

Prerequisite: ENTS 640 and ENTS 641. This networking lab course will provide hands-on experience with the configuration and management of routers and switches in a real-world networking environment using Juniper Networks devices. Students will learn how to interact with networking devices through the Junos OS and how to navigate the command line interface (CLI). Topics will include router HW and SW architecture, interfaces, routing policies, static route configuration, configuring RIP and OSPF, VLANs and their configuration, firewall filters and security policies, class of service (CoS) management, network operation monitoring, and troubleshooting. During the lab sessions, students will write and test configurations for routers and switches given a set of network specifications, policies and conditions.

An example course sequence:

1. ENTS 669A Special Topics in Computing: Embedded Systems (3 credits)
2. ENTS 689A Special Topics: Algorithms and Data Structures (3 credits)
3. ENTS649B Special Topics in Networking: Cloud Computing (3 credits)
4. ENTS 749B Advanced Topics in Networking: Software-Defined Networking (3 credits)

III. STUDENT LEARNING OUTCOMES AND ASSESSMENT MEASURES

Since this graduate certificate program will be embedded in the standard ENTS curriculum, the learning outcomes will also be similar to those of the ENTS program. The items relevant to the Graduate Certificate Program are as follows:

1. Academic outcome goals:
 - Students acquire specialized knowledge and skills in the technical area of networking software development.
 - Students acquire/develop practical problem-solving, programming and analytical skills necessary to succeed in industry.
2. Academic outcome assessment measures:
 - Percentage of students mastering the foundations of computer networking and the most important communication and routing protocols used today such as HTTP, DNS, TCP, UDP, IPv4 and IPv6, ARP, Ethernet, RIP, OSPF, and BGP.
 - Percentage of students becoming familiar with programming languages used in the development of state-of-the-art software systems such as C, Java or Python.
 - Percentage of students acquiring hands-on lab experience using state-of-the-art networking equipment, network design, trouble-shooting and performance evaluation tools.
 - Percentage of students acquiring improved computer programming skills, working knowledge of state-of-the-art algorithms and data structures and hands-on experience with commonly used debugging and profiling tools.
3. Non-academic outcome goals:
 - Diversity: The ENTS program promotes diversity and strives to admit and educate a diverse student population.
 - Degree completion and student retention: The ENTS program will make every effort to help its students from admission to degree completion and minimize the number of students who leave the program without a degree.
 - Quality of learning experience: The ENTS program will actively improve the student experience and increase its perceived value.
4. Non-academic outcome assessment measures:
 - Diversity: Percentage of female students; percentage of female faculty /instructors; percentage of minority faculty /instructors
 - Degree completion and student retention: Percentage of students who obtain the graduate certificate within two years after entering the program
 - Quality of learning experience: Graduate student to faculty ratio in the classroom; number of students receiving education in state-of-the-art facilities/labs or using state-of-the-art tools; number of offered elective courses in computer networking and programming/software development.

IV. PROGRAM ADMINISTRATION

Administrative oversight and program management will be provided by ENTS staff. This includes student services, academic advising, marketing and outreach, program evaluation and assessment, and degree requirement verification.

A. Program Faculty

The courses for this certificate program are all ENTS courses, so they will be taught by ENTS instructors.

B. Program Offerings

The program will be wholly residential. There will be no off-campus locations nor distance/online education components.

IV. FINANCE (Budget Resources)

The ENTS program is a self-support unit and the Graduate Certificate in Networking Software Development program will be administered through its resources.

V. ADDITIONAL RESOURCES

A. Library

No additional resources are needed.

B. Facilities

No new facilities are required.

C. Outside Academic Units

This program will not rely upon courses provided through other academic units.

D. Personnel

No new personnel are required. The new program will involve a small increase in administrative work for some staff. Existing staff members have experience in handling ENTS student records.



February 13, 2017

VPAC - PCC Committees
University of Maryland
College Park, MD 20742

To whom it may concern:

The R. H. Smith School of Business hereby expresses its support for the new initiatives of the MS in Telecommunications Program to establish graduate certificate programs in (a) Networking Software Development, (b) Wireless Communications and (c) Computing. It is understood that the Electrical and Computer Engineering Department will be responsible for managing all aspects of the above certificate programs as they are based on technical/engineering discipline rather than business discipline.

Sincerely,

A handwritten signature in black ink, appearing to read "M. Faulkender".

Michael Faulkender
Associate Dean, Masters Programs
R. H. Smith School of Business
University of Maryland

DATE: November 3, 2016

TO: Leah Grosse
Program Coordinator, Masters in Telecommunication Program

FROM: On behalf of the University of Maryland Libraries:
Elizabeth Soergel, Engineering Librarian
Maggie Saponaro, Head of Collection Development
Daniel Mack, Associate Dean, Collection Strategies & Services

RE: Library Collection Assessment

We are providing this assessment in response to a proposal by the Department of Electrical and Computer Engineering's Masters in Telecommunications program in the A. James Clark School of Engineering to create a Graduate Certificate in Networking Software Development. The Masters in Telecommunications program asked that we at the University of Maryland Libraries assess our collection resources to determine how well the Libraries support the curriculum of this proposed program.

Serial Publications and Research Databases

The University of Maryland Libraries currently subscribe to a large number of scholarly journals—almost all in online format—that focus on telecommunications and software development. Most articles in journals that we do not own electronically are available through either the Libraries' Scan and Deliver program or via Interlibrary Loan. The Libraries' "Database Finder" offers online access to databases that provide indexing and access to popular and scholarly journal articles, and other information sources. Many of these databases cover subject areas that would be relevant to this proposed graduate certificate. These databases can be accessed remotely by authenticating using UMD login credentials.

Most of the relevant research is available through the following databases to which the Libraries subscribe:

- IEEExplore
- ACM Digital Library
- Web of Science

In addition, the general, multidisciplinary database Academic Search Complete provides information for nearly every area of academic study, including software development. Includes an enormous collection of the most valuable peer-reviewed full text journals, as well as additional journals, magazines, newspapers and books.

As noted previously, in those instances in which either the Libraries do not subscribe to the journal or the journal articles are available only in print format, the Libraries can supply copies through the Libraries' Scan and Deliver program or via Interlibrary Loan.

Monographs

The Libraries regularly acquire scholarly monographs in software development and allied subject disciplines. The ongoing acquisition of scholarly books is expected to be adequately covered through existing acquisition practices and budgeting. As the University of Maryland already has a robust tradition of acquiring materials related to software development, current collection development practices in the Libraries should adequately support the new graduate certificate. Monographs not already part of the collection can usually be added upon request.

Monographs are typically purchased in electronic format, but the Libraries have a large collection of print materials related to software development. Students will be able to take advantage of the print book collection by checking out these items or requesting specific chapters be sent to them through the Libraries' Scan and Deliver program. Faculty can also request, within fair use copyright guidelines, that sections of print books be made available digitally through course reserves.

Scan and Deliver and Interlibrary Loan

The Scan and Deliver program (<http://www.lib.umd.edu/access/scan-deliver>) mentioned above allows students to request chapters of books or journal articles that the University Libraries own in print. Digital copies of these resources are sent directly to the student. For materials not owned by the University Libraries, students can request either digital or physical delivery of bibliographic materials that otherwise would not be available to the UMD community via Interlibrary Loan (<http://www.lib.umd.edu/access/ill-classic>). As a member of the Big Ten Academic Alliance, UMD students have access to physical materials from other institutions in the Big Ten. These items can be requested through the UBorrow service (<http://www.lib.umd.edu/access/uborrow>) and users typically receive the items within one week. Scan and Deliver and Interlibrary Loan are available free of charge.

Conclusion

The University of Maryland Libraries' serials holdings and research databases have an established record for providing bibliographic support for researchers and professionals in subject disciplines that are relevant to software development and computer engineering. These materials are supplemented by relevant monograph collections. In addition, the Libraries' Scan and Deliver and Interlibrary Loan services make materials that otherwise would not be available online or through the UM Libraries. The Libraries also offer students a wide range of services to ensure their success. Additionally, the libraries are already supporting the Master of Science in Telecommunications, so no additional library resources should be necessary for the proposed graduate certificate, which compliments the Masters program. As a result, our assessment is that the University of Maryland Libraries are able to meet the curricular and research needs of the proposed Graduate Certificate in Networking Software Development.