UNIVERSIDAD DE PUERTO RICO
RECINTO DE RÍO PIEDRAS

Certificación Núm. 50
Año Académico 2019-2020

Yo, Claribel Cabán Sosa, Secretaria del Senado Académico del Recinto de Río Piedras, Universidad de Puerto Rico, **CERTIFICO QUE**:

El Senado Académico, en la reunión ordinaria celebrada el 14 de noviembre de 2019, acordó por consentimiento unánime:

- Aprobar la ***Propuesta para el Establecimiento de una Maestría con Especialidad en Ciencias de Cómputos y un Doctorado en Filosofía con Especialidad en Ciencias de Cómputos,*** de la Facultad de Ciencias Naturales.

- La Propuesta forma parte de esta Certificación.

Y para que así conste, expido la presente Certificación bajo el sello de la Universidad de Puerto Rico, Recinto de Río Piedras, a los quince días del mes de noviembre del año dos mil diecinueve.

Dra. Claribel Cabán Sosa
Secretaria del Senado

yrs

Certifico correcto:

Dr. Luis A. Ferrao Delgado
Rector

Anejo

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University of Puerto Rico
Río Piedras Campus
Faculty of Natural Sciences
Department of Computer Science

Proposal for the establishment of a graduate program with a Master of Science in Computer Science and a Doctorate of Philosophy in Computer Science at the Department of Computer Science of the University of Puerto Rico, Río Piedras

Aprobada por el Departamento de Ciencia de Cómputos el 21 de junio de 2017.
Aprobada por la Junta Graduada de la Facultad de Ciencias Naturales el 25 de abril de 2018.
Aprobada por el Comité de Asuntos Académicos de la Facultad de Ciencias Naturales el 21 de septiembre de 2018.
Aprobada por la Facultad de Ciencias Naturales el 24 de octubre de 2018.
Aprobada por Consejo de Estudios Graduados e Investigación el 25 de enero de 2019.
Aprobada por el Comité de Asuntos Académicos del Senado Académico el 29 de octubre de 2019.
Aprobada por el Senado Académico el 14 de noviembre de 2019. (Certificación Núm. 50, Año Académico 2019-2020)

I. Introduction

A. Name of Program and Academic Degree to be Conferred.

The Department of Computer Science of the Faculty of Natural Sciences proposes the creation of a Graduate program in Computer Science. The purpose is to offer a Master of Science (MS) with a Specialty in Computer Science and a Doctorate in Philosophy (Ph.D.) with a Specialty in Computer Science.

B. Description of the Program

1. Proposed Academic Programs

1. Master of Science (M.S.) with a Specialty in Computer Science
2. Doctorate in Philosophy (Ph.D.) with a Specialty in Computer Science.

2. IPEDS Classification

11.07 Computer Science

3. Graduate Profile

Master Graduates of this program are capable of:

- Easily navigate the ever-changing area of Computer Science based on their solid theoretical foundation and their lifelong-learning skills.
- Contribute to the computer science community and share their work with a vast audience.
- Develop applications that have direct impact on the community and society following aspects of universal design.
- Promoting diversity in all aspects of their profession.
- Present their work of an expository nature related to the courses taken at international conferences.
- Develop projects that would solve a problem or a task for a specific target audience.
- Obtain and hold jobs in the technology industry or continue to a Ph.D. program.
- They will obtain and hold jobs in the technology industry or continue to a Ph.D. program.

Ph.D. graduates of this program are capable of:

- Easily navigate the ever-changing area of Computer Science based on their solid theoretical foundation and their lifelong-learning skills.

- Contribute to the computer science community and share their work with a vast audience.
- Develop applications that have direct impact on the community and society following aspects of universal design.
- Promoting diversity in all aspects of their profession.
- Publish their work in renowned international peer-reviewed journals and conferences. This work will be a substantial, original and independent contribution to the knowledge in the field of Computer Science.
- Hold positions in academia or industry.
- Be recognized as innovators as well as leaders by their employers, and research and academic peers

Table 1. Mapping of Graduate Profiles of UPR Río Piedras and Computer Science Program

Graduate profile of UPR Río Piedras	Graduate profile of Computer Science Graduate Program
Conduct research or projects in order to create, offer solutions or generate knowledge.	Contribute to the computer science community and share their work with a vast audience. Present their work at international conferences Publish their work in international journals Develop applications that have direct impact on the community and society following aspects of universal design.
Critically evaluate knowledge from a variety of theoretical and methodological approaches.	Easily navigate the ever-changing area of Computer Science based on their solid theoretical foundation and their lifelong-learning skills. Present their work at international conferences Publish their work in international journals Develop applications that have direct impact on the community and society following aspects of universal design.
Exercise independence of criteria and show creativity and initiative.	Contribute to the computer science community and share their work with a vast audience. Present their work at international conferences

	Publish their work in international journals
Integrate theories, practical protocols and ethical codes to your professional or investigative work.	Contribute to the computer science community and share their work with a vast audience. Present their work at international conferences Publish their work in international journals Develop applications that have direct impact on the community and society following aspects of universal design.
Handle information in a critical, effective and ethical manner.	Easily navigate the ever-changing area of Computer Science based on their solid theoretical foundation and their lifelong-learning skills. Contribute to the computer science community and share their work with a vast audience. Present their work at international conferences Obtain and hold jobs in the technology industry
Incorporate technology in your professional or investigative work	Easily navigate the ever-changing area of Computer Science based on their solid theoretical foundation and their lifelong-learning skills. Contribute to the computer science community and share their work with a vast audience. Present their work at international conferences Publish their work in international journals Develop applications that have direct impact on the community and society following aspects of universal design.
Communicate effectively the knowledge of your field or study discipline.	Easily navigate the ever-changing area of Computer Science based on their solid theoretical foundation and their lifelong-learning skills.

	Contribute to the computer science community and share their work with a vast audience. Present their work at international conferences. Publish their work in international journals
Learn autonomously and continuously.	Easily navigate the ever-changing area of Computer Science based on their solid theoretical foundation and their lifelong-learning skills. Contribute to the computer science community and share their work with a vast audience. Present their work at international conferences. Publish their work in international journals
Show commitment to the protection and enrichment of natural and cultural heritage.	Contribute to the computer science community and share their work with a vast audience. Present their work at international conferences. Publish their work in international journals. Develop applications that have direct impact on the community and society following aspects of universal design.
Demonstrate respect for human rights through actions of social inclusion and commitment to diversity.	Promoting diversity in all aspects of their profession. Develop applications that have direct impact on the community and society following aspects of universal design.
Demonstrate collaborative actions through multidisciplinary or interdisciplinary teamwork.	Contribute to the computer science community and share their work with a vast audience. Present their work at international conferences Publish their work in international journals Develop applications that have direct impact on the community and society following aspects of universal design.

Assume and promote leaderships that contribute to individual and collective transformations.	Obtain and hold jobs in the technology industry. Be recognized as innovators as well as leaders by their employers, Ph.D. advisors or research and academic peers. Develop applications that have direct impact on the community and society following aspects of universal design.

4. Relevance of the Program

a) A Fundamental Area

Computer science is one of the careers with the highest demands globally. As we present in the Justification, the need for computer science professionals has increased in the last decade and will continue this upward trend in the foreseeable future. Computer programs are present in most aspects of our lives. Every industry uses computers and many of them require the use of computers for their operation. Many problems and tasks in science, engineering, health care, and many other areas are and will be solved by computer scientists who study how to solve them and design software to implement these solutions. Computer scientists theorize, design and develop the software and hardware used to advance scientific discovery and enhance communications, among others.

Computer Science is widely expected to play an increasingly important role in the global economy. For instance, Machine Learning (a branch of Computer Science) is currently revolutionizing nearly all aspects of human life, including communication, transportation and medicine. The role of CS is equally important in the development of most other branches of science that increasingly rely on vast computations and simulations that drive scientific discovery (e.g. computational physics, computational biology, etc.). Similarly, Cybersecurity, the technologies that protect from cyber-attacks, has become fundamental as the number of breaches keep increasing as more and more entities are doing business in the Internet.

b) A Department on the Rise

The Department of Computer Science at the University of Puerto Rico, Río Piedras was officially established on December 16, 2002, and it is part of the College of Natural Sciences.

Since then, the Department of Computer Science has had an important impact on the Institution. Currently the professors of our department are PI or co-PI of 10 funded projects that positively impact our faculty, campus and institution. On top of those responsibilities we have maintained active participation in Campus level committees and multidisciplinary projects, including having a professor as one of the four representatives of the College of Natural Sciences in the Campus Academic Senate.

One of the unwritten policies of the department is the practice that limits the tenure of the department's chair to three years. This has happened because our professors see the position as a sacrifice that must be undertaken for the good of the department possibly at the expense of their career, putting the professor's research endeavors on hold. Aside from the upside that the burden is shared, a very positive byproduct is the fact that of the full time professors of the department three are former chairs. This means that the department has plenty of working experience and contacts at different levels of the University's academic administration level. Still more important to the program is that each chair brings to the department its personality and ideas that end up becoming part of the fabric of the program. As a result, the department encourages students to participate in a very diverse set of opportunities: university service, undergraduate research, apply to graduate schools, participate in programming competitions and in internships.

Another strength of the department is that the computer science undergraduate program is founded upon a strong curricula, research and assessment. These principles were acknowledged by the accreditation agency ABET when in 2010 accredited our program and was confirmed in 2016 when the reviewers reiterated the accreditation without any findings, meaning that they did not find any deficiency, weakness or concern.

External funded projects to further development of the department

The Department of Computer Science encourages its faculty to develop projects to further the development of the program and expects them to acquire external funding for this purpose. The rigor of submitting, implementing and assessing an NSF project gives the endeavor a formality that stands on its own. The results have been outstanding as the following projects show.

1. Asserting Parallel Computational Thinking into Undergraduate 4-year Computer Science Curriculum, CPATH-NSF

An important project developed for the program was the NSF funded "Asserting Parallel Computational Thinking into Undergraduate 4-year Computer Science Curriculum,

CPATH-NSF". The goal of this project that started in October of 2009 was to enhance the 4-year undergraduate Computer Science (CS) with Parallel and Computational Thinking (PCT). PCT was defined as a set of competencies and mental tools that allow its practitioners to envision solutions to complex problems in terms of concurrent, coordinated, and collaborative computational processes. This project represented the first building block for the successful integration of CT into our undergraduate curriculum. Hence, it provided a foundation for further growth toward a CT-centric and interdisciplinary Computer Science program.

The members of our faculty underwent development in Computational Thinking (CT) and parallel concepts in order to redesign CS core courses by infusing PCT concepts. Also, assessment tools were developed and used for measuring student aptitudes and attitudes toward PCT. In terms of infrastructure, a parallel computation platform was implemented locally and access to remote supercomputing centers was established. This hardware support provided the practical setting for the PCT class experiences. Similarly, seminars on topics using CT and PCT were sponsored and open to the general K-20 community.

2. Development of engaging and readily transferable laboratory experiences for the introductory programming course, NSF

The main goals of this NSF funded project that started in September 2013 were to: (1) enhance the delivery of the introductory level computer science programming course through a set of well-structured laboratory online lab experiences that are engaging, applied, and meaningful, (2) facilitate the adoption of the developed materials by other instructors, and (3) make the results and materials of this project available both in Spanish and English and accessible online as a turnkey solution.

This will make the laboratory resources attractive and easy to adopt by other Hispanic serving institutions. The project provides a turnkey solution that significantly eases an instructor's change in classroom techniques toward more hands-on, active and engaging courses. In essence, the turnkey solution consists of a set of well-structured online laboratory experiences that are applied, meaningful, easily accessible and transferable. All the components are packaged into a virtual appliance preconfigured with all the necessary software (compilers, libraries, and data files). The laboratory experiences contain a strong continuous assessment component to establish students' skills, concept mastery and attitudes towards the concepts and theme of the lab experiences. The experiences are designed following Merrill's five principles of instruction, i.e. be task-centered, and have processes of activation, demonstration, application and integration. Product development follows the ADDIE model (analysis, design, development, implementation, evaluation).

Student learning assessment is conducted before, during and after each laboratory experience. Promotion and dissemination of the project is achieved through exhibitions and publications in major CS Education conferences, as well as supported by a dedicated website.

3. Academics and Training for the Advancement of Cybersecurity Knowledge in Puerto Rico, NSF

This NSF funded project that started on September 2014 was the first step in creating a research, development, and education program in cybersecurity at the institution (a minor in cyber security was created as a result of these efforts). The project team focused on the infusion of cybersecurity educational activities into the computer science core courses, along with the development of new cybersecurity courses and a cybersecurity laboratory. In addition, the project team increased student awareness and mastery of cybersecurity concepts and skills through invited speakers, trainings with outside experts, student research projects, and travel to cybersecurity conferences. The team is also developing web materials that will be available in both English and Spanish, improving the dissemination of relevant cybersecurity information throughout Latin America.

The cybersecurity laboratory, new courses, and curricular infusions make it possible for students to learn about numerous aspects of cybersecurity. Through the new laboratory, students are able to do experiments involving digital forensic analysis, network traffic analysis, malware analysis, and suitable countermeasures. Through infusion into existing courses, students study topics such as the role of regular expressions in input validation, which can help prevent malware injection into existing programs. The courses cover topics such as systems and networks security, secure and trusted hardware, as well as an introductory level course for students outside of computer science, including students in the information systems program. The project team performed extensive development and refinement of course materials, subsequently working with members of the Computer Science Department to adopt the materials into their courses. Project evaluation was accomplished primarily using the ADDIE (Analysis, Design, Development, Implementation, and Evaluation) model, combining quantitative and qualitative data. This approach track aspects such as student knowledge, identification of learning gaps, and the quality of learning achievement.

4. Scholarship fund for excellence in Computer Science and Mathematics, NSF

This project, which started on 2014, has provided more than 100 scholarships to high-achieving financially disadvantaged undergraduate and masters students enrolled in

Computer Science and Mathematics at the University of Puerto Rico-Rio Piedras (UPR-RP). Since 98% of all students at UPR-RP are eligible to receive some form of financial assistance, and 56% of undergraduates receive Pell grants, the need for these scholarships is great. Scholarship amounts range from $2,500 in the first year of study to $4,800 in the last year. The project is a model program, which can be replicated to support financially disadvantaged students from underrepresented groups in different regions.

In addition to scholarship support, the project sponsors activities to 1) increase the awareness of scholars about opportunities for further studies and careers in industry, 2) strengthen academic and professional skills of scholars, 3) build a sense of community, 4) highlight the social and applied aspect of computer science and mathematics, and 5) support student learning through tutoring and mentoring. The overall goals of the project are to improve recruitment, retention, and preparation for employment or graduate school. The project prepares Puerto Rican students to work in two high demand disciplines, which helps meet the expanding need for computer science and mathematics professionals both locally and nationally.

5. The creation of the Computational Development and Consulting Center (CDC^2)

The Department of Computer Science has been very successful in obtaining federal funds to support research, education and even infrastructure (equipment) through the National Science Foundation (NSF) and the National Institute of Health. (NIH). However, direct efforts to generate collaborations and offer services to the government and the private sector has been limited. Our department has not even been used by the administration of the UPR as a resource to help modernize its infrastructure and to help reduce costs through open source technology. To resolve these issues, we are working to create the Computational Development and Consulting Center (CDC^2).

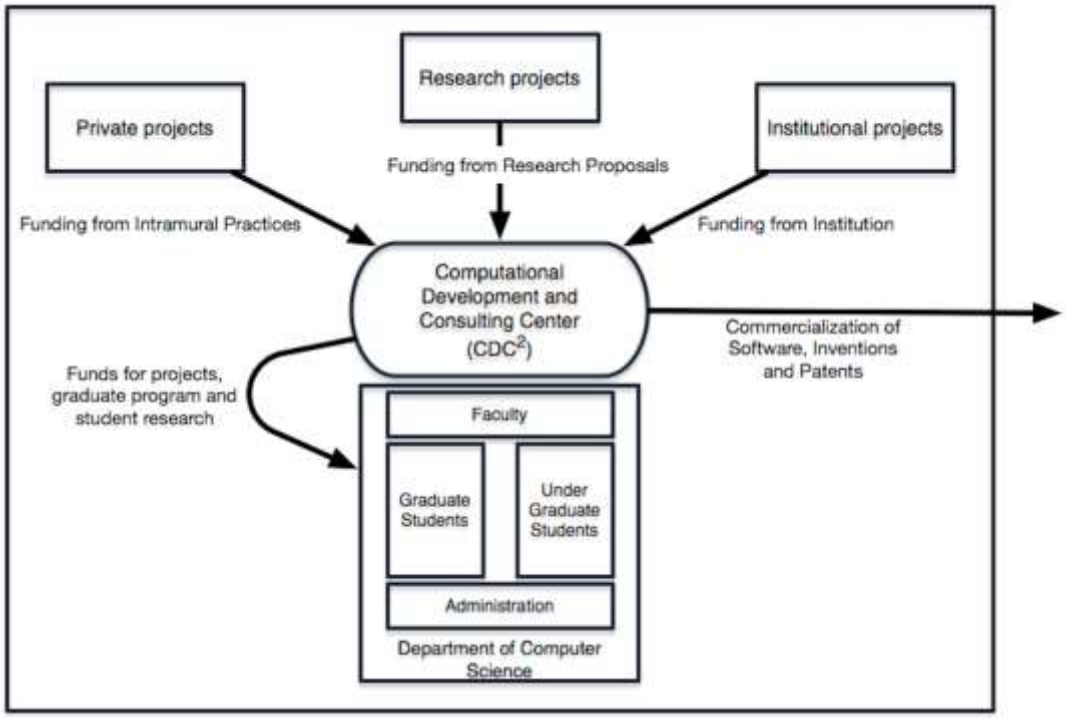

Figure 1. Diagram of the Proposed CDC2 Center

The center would be able to offer among other things the following services:

- Development of applications (around $10,000 each).
- System virtualization using open source technology (around $10,000 each).
- Training of employees, support and consulting on software development and Internet services. Particularly using open source technology (around $125 per hour).
- Training of employees, support and consulting on cyber security (around $125 per hour).
- Security analysis of information systems and applications (around $125 per hour).
- Installation of Internet services (around $125 per hour).
- Configuration of network equipment (around $125 per hour).

The creation of the graduate program will bring a fundamental support for the center as well as to provide our students with a great working experience under a great environment.

c) At the Center of the Hub

The fact that our department is at the Río Piedras campus of the University of Puerto Rico has many advantages. According to the Puerto Rico Industrial Development Company (PRIDCO) of the 43 companies at the Information Technology and communication

segment 22 are at the greater metropolitan area (San Juan, Caguas, Guaynabo and Trujillo Alto) and an additional 5 are at the east of the main island (Las Piedras, Canovanas, Luquillo and Humacao). Therefore, professionals currently working in those companies will have a natural partner in our program to continue with their preparation.

Another important advantage is that our department is part of the College of Natural Sciences. No other graduate program in Puerto Rico has the privilege to be that close to the best scientists in Puerto Rico. As we have mentioned, the intra and interdisciplinary nature of Computer Science allows our professors and students to collaborate in very important projects with our colleagues in the biology, chemistry, environmental sciences and physics departments. The current collaborations will further and increase with the creation of the proposed graduate program.

Of importance is also the fact that the Puerto Rico has been a very attractive destination for students and professionals from Latin America and the Caribbean. With this, the fact that the Department of Computer Science has an accredited program puts the proposed graduate program in a great position to become an important player in the development of professionals in the area.

5. Guidelines of the Conceptual Framework

The graduate program in computer science will be a highly dynamic and diverse educational and research-intensive environment that will become the primary source of computer science professionals in the Caribbean and a major source in Latin America by providing an excellent theoretical as well as practical educational and research experience that allow graduates to be leaders in all endeavors of science and technology.

6. Outstanding Elements of the Curricular Design

The flexibility of the proposed graduate program will attract students from different backgrounds and professional development. For example, it will have a master, a Ph.D. for students with masters, and a Ph.D. directly from a bachelor's degree. It will offer many of the courses at night so it would be very easy and convenient for the professionals of the local industry to access the program. In terms of the requirements the program will have only 3 specific courses as requirements in order to provide leeway to the program to adapt to the ever-changing field. It also gives students the opportunity to define their interests and take courses related to them. In the Curriculum Design section, we present various examples of this.

One of the requirements is the course "Development of Applications with a Social Impact". This course will give students the opportunity to develop an application that will have a direct impact on the community and society. They will work on groups under the supervision of the professor following the human-centered and universal designs process where the students go to the environment of the users to evolve an understanding of the required tasks within that environment.

7. Development Projections

In order to have a stable growth we are proposing to start the implementation of the Master program on the first year but wait until the third year to start the Ph.D. part of the program.

We are proposing the recruitment of 3 new professors, one the first, one the third and another the fifth year. We are also requesting laboratory spaces and seed funds for the new hires, to foster a productive research performance.

The expectation is that at least 3 professors of the department will have externally funded projects by the end of the third year with funds for research assistantship for students as well as to bring international researchers to collaborate and to participate in the proposed graduate research seminar.

C. Academic Offering's Modalities

All tracks of the program will follow a conventional modality. Nonetheless, it will offer the three required courses through some non-conventional modalities that include distance learning with the hybrid and web enhanced courses. Currently, two of the three required courses (Algorithms and High-Level Languages) were developed as hybrid courses and the third one (Development of Applications with a Social Impact) will be created as such. Similarly, the program will offer daytime, evening and Saturday courses to better serve a sector of the constituents of the program that have full time jobs.

D. Commencement Date

This proposal was approved by the Department of Computer Science on June 21, 2017, by the Faculty of Natural Sciences on the 24th of October 2018 and by the CEGI (Consejo de Estudios Graduados e Investigación) on January 25, 2019. It is currently under the review of the Academic Senate of the Río Piedras Campus so is expected the be approved by January 2021 with the program starting the first semester of the 2021-22 academic year. Hence, we plan to start the Ph.D. program by the academic year 2023-24.

E. Length of the Program and Maximum Time to Complete the Degree

Full time Master students should complete their degree in **two years** and the maximum time to complete the degree is four years. Part-time Master students should complete their degree in **three years** and the maximum time to complete the degree is five years. Ph.D. full time students with a master in computer science should complete their degree in **three years** and the maximum time to complete the degree is five years. Ph.D. part-time students with a master in computer science should complete their degree in **four years** and the maximum time to complete the degree is six years. Ph.D. full time students without a master in computer science should complete their degree in **four years** and the maximum time to complete the degree is seven years. Ph.D. part-time students without a master in computer science should complete their degree in **six years** and the maximum time to complete the degree is eight years.

Table 2. Length of the Program and Maximum Time to Complete the Degree

		Full-time		**Part-time**	
Degree	**Crds**	**Length**	**Maximum**	**Length**	**Maximum**
Master	30	2 yrs	4 yrs	3 yrs	5 yrs
Ph.D. after Master	30	3 yrs	5 yrs	4 yrs	7 yrs
Ph.D. without Master	54	4 yrs	7 yrs	6 yrs	8 yrs

II. Professional Accreditation and Requirements for Professional Practice

A. Professional Accreditation.

Currently, there is not a recognized accreditation agency that offers an accreditation of graduate programs in Computer Science.

B. Requirements for Professional Practice

There are no law requirements for professional practice.

III. Justification

Computer Science is expected to play an increasingly important role in the world's economy. For instance, Machine Learning (a branch of Computer Science) is currently revolutionizing nearly all aspects of human life, including communication, transportation and medicine. The role of CS is equally important in the development of most other branches of science that increasingly rely on vast computations and simulations that drive

scientific discovery (e.g. computational physics, computational biology, etc.). Similarly, Cybersecurity, the technologies that protect from cyber-attacks, has become fundamental as the number of breaches keep increasing as more and more entities are doing business in the Internet.

1. Demand of Computer Scientists

The need for computer science professionals has increased in the last decade and will continue this upward trend in the foreseeable future. The U.S. Bureau of Labor Statistics in its Occupational Outlook Handbook (http://www.bls.gov/ooh/computer-and-information-technology/home.htm) stated that: "Employment of computer and information technology occupations **is projected to grow 12 percent from 2014 to 2024**, faster than the average for all occupations." By their statistics this means about **488,500 new jobs** and specifically they state that this demand in part is due to "a greater emphasis on cloud computing, the collection and storage of big data, more everyday items becoming connected to the Internet in what is commonly referred to as the "Internet of things," and the continued demand for mobile computing." As Figure 1 shows, by the year 2020, 4.6 million jobs are expected in computer related fields.

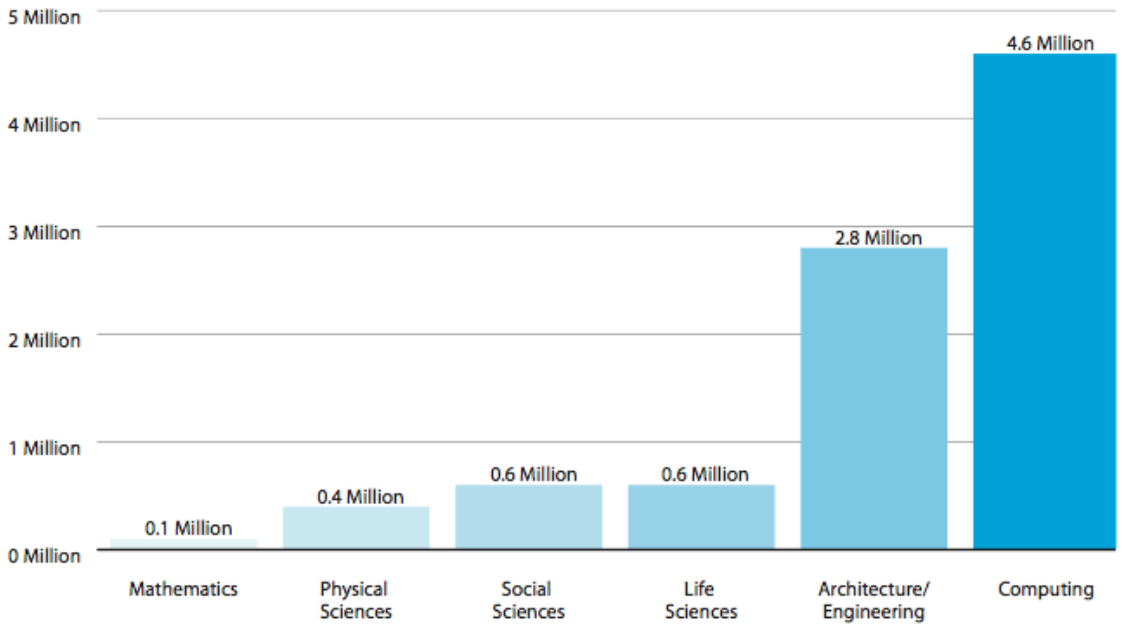

Figure 2. Total Employment in STEM and CS Fields in 2020. Source: ACM Pathways Report.

The reasons that are stated in the cited handbook still do not offer a complete picture of the demand for well-prepared professionals and academics. On January 30, 2016 the president of the United States Barack Obama presented a document entitled "FACT SHEET: President Obama Announces Computer Science For All Initiative" (https://www.whitehouse.gov/the-press-office/2016/01/30/fact-sheet-president-obama-announces-computer-science-all-initiative-0) where he stated that "Providing access to CS is a critical step for ensuring that our nation remains competitive in the global economy and strengthens its cybersecurity" and continued "CS is not only important for the tech sector, but also for a growing number of industries, including transportation, healthcare, education, and financial services, that are using software to transform their products and services. In fact, more than two-thirds of all tech jobs are outside the tech sector." Moreover, the president continued explaining that "Last year, there were over **600,000 tech jobs open** across the United States, and by 2018, **51 percent of all STEM** jobs are projected to be in **CS-related** fields. The Federal government alone needs an additional **10,000 IT and cybersecurity professionals**, and the private sector needs many more.

2. Demand of Computer Scientists of Diverse Backgrounds

Those statistics alone provide a need and pertinence that goes unrivaled among the sciences and probably among all areas of knowledge. But our Department of Computer Science at the Río Piedras Campus of the University of Puerto Rico has the privilege to participate in the development of highly qualified computer scientist with another advantage, their culture. In their "Rebooting the Pathway to Success: Preparing Students for Computing Workforce Needs in the United States" (http://pathways.acm.org/) the Education Policy Committee of the Association for Computing Machinery, one of the two most important grouping of computer professionals stated that **"**Diversity figures in the current computing workforce are low. According to the BLS (U.S. Bureau of Labor Statistic), only a quarter (25.6%) of the workers in computer and mathematical occupations in 2012 were women. Only 7.4% were Blacks/African Americans, who comprise 13% of the U.S. population, and **only 6.1% were Hispanics/Latinos, who comprise 17% of the U.S. population.**" With this they presented the necessity of "building a diverse computing workforce" as a "business, economic and social benefit" because "Diverse perspectives are critical for developing innovative products and services, as well as for identifying ways to use technology to enhance the performance and productivity of U.S. businesses. Equally important are the significant equity issues the United States will face as a country if women, minorities, and people with disabilities are left behind as computer science becomes increasingly relevant to a range of high paying occupations."

Between 2008-2013 the median percentage of female graduates from the UPRRP in all disciplines is 68.4% and the percentage of female graduates from the College of Natural

Sciences is 68%, yet within the College there is a big difference between the median percentage of female graduates in Mathematics, Computer Science, and Physics from the other disciplines as displayed in Figure 2. On examining the data more closely, in the field of computer science, two factors become clear. 1) It is most difficult to recruit women into computer science. 2) Retention is not as significant an issue for women as it is for men.

The Department of Computer Science has been developing initiatives in this direction. For example, through our web page ccom.uprrp.edu with campaigns such as "Examples to follow", on the YouTube channel from the departmental project "Engaging Introductory Programming Laboratory Experiences" and the facebook page of the department among others. In addition, our department was instrumental in the creation of a group of women in Computer Science #include<girls>, the Association of Computer Science Students (AECC) is a chapter of the Association for Computing Machinery (ACM) that encourages the participation of women through their ACM-W chapter and within our University, Dr. Ivelisse Rubio, a professor of our department, belongs to the external committee of the Women's and Gender Program of the Río Piedras Campus.

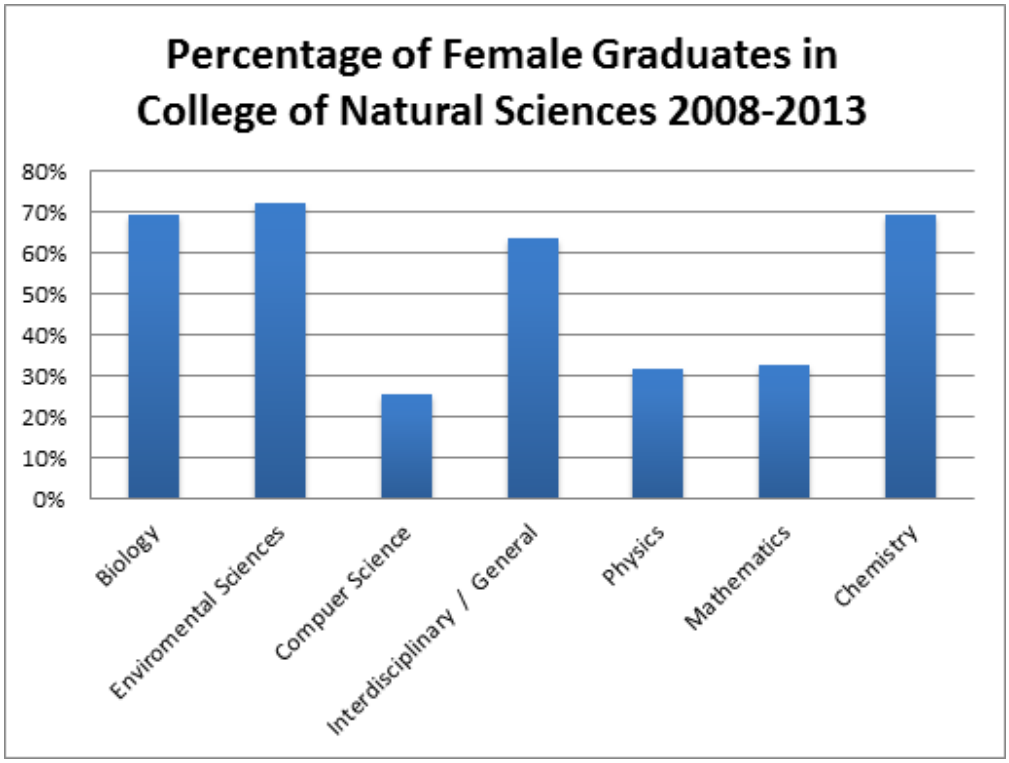

Figure 3. Percentage of Female Graduates in the College of Natural Sciences 2008-2013.

3. Participation in the Economic Development of Puerto Rico

Of particular importance is also the fact that computer science has become an economic engine in comparable areas of the world and Puerto Rico has the opportunity to do the

same. In a study commissioned by Microsoft, Inc. in 2014, Estudios Técnicos (the company that did the study) presented that the "ecosystem (the information technology-related industries) has the potential to become a new way to bring money into the economy with the development of software, applications for smartphones, vehicles, social interaction, games and complete systems for process management in the public and private sectors, among others. The greatest potential lies in the ability to export these goods globally with very little investment." Continuing by saying that the "IT sector, precisely because it is an enabling technology, has to be the foundation on which to build a sustainable economic development in the near future" and that it should receive special attention as part Puerto Rico's economic future because of "the immense wealth of human and social capital that it incorporates."

It is clear, however, that Puerto Rico, even now, is far from fulfilling the need of the local industries. This is patently clear from the business strategies of local companies that are either outsourcing work to companies in places like Dominican Republic or hiring professionals from places like India.

In the work "The new software exporting nations: success factors", Carmel described the development of human resources as one of the 8 fundamental aspects of this economic development and specifically point to universities as one of the most important sources of training, education and therefore, development of this resource. "The software sector's Human Capital encompasses the collective characteristics and abilities of its software professionals: national orientation and traditions, quantity, composition, language skills, and managerial skills. We discuss each of these in turn. The strength of a nation's human capital stems from a multi-generational tradition of science and engineering that has its roots in strong universities, polytechnics, and vocational schools. Thus, the recent success cases in this area - India, Israel, and Ireland, all benefited from a strong national emphasis on advanced technical education that dates back at least one or two generations."

4. Necessity of a Graduate Program in Computer Science in Puerto Rico

The graduate programs in most public universities around the world did not begin as a reaction to meet the demand for CS enrollment, which wasn't historically as high as today. They rather began as an **investment** in a new and upcoming scientific field. The creation of graduate programs essentially created virtuous cycles: the universities became more attractive to highly rated computer scientists. In turn, their presence generated related financial activity, like startups and such, and higher potential for local research. This in turn increased the social visibility and popularity of Computer Science, which progressively expanded to its current position.

The creation of a new graduate program in Computer Science at UPR-RP should be viewed as a long-overdue public investment in Computer Science. The necessity for such an investment is **even more justified by the current fiscal crisis**: in contrast to other fields of science whose operating costs include large budgets for laboratories and materials, investment in CS goes mostly to human capital, thus requiring relatively moderate expenditures. At the same time, investment in CS has the highest potential payout for the local economy: even a relatively small core of top-rated computer scientists is often able to disrupt market segments, start new ventures that can become significant at the international level, and quickly create new jobs and new revenue for the PR economy.

5. Necessity to Strengthen the Computer Science Department and Computer Science in the Río Piedras Campus

The creation of graduate program in CS will also be specifically beneficial for the UPR-RP campus. Despite its small size, the CS department has been consistently attracting significant amounts of external, federal funding. It currently ranks among the highest in UPR-RP in the amount of indirect cost per faculty. This will certainly improve with the qualitative and quantitative expansion that will be achieved by the graduate program. Funding will increase not only through purely CS grant proposals, but also through the continuous collaborations with faculty in other departments.

The success of our department was recognized by ABET, probably the most important accreditation agency in the field. In their last visit in the fall of 2015 to evaluate our bachelor's program, the committee decided not only to renew our accreditation for six more years but they did so by presenting zero shortcomings and even more they commented that the “addition of a graduate program is important in order to attract and retain faculty who can support the research expectations of the college and university”.

Moreover, the presence of a CS graduate program will help maintain and improve the quality of both **education and research,** campus wide. UPR-RP is currently one of the very few research-intensive campuses that do not host a graduate program in CS. As other scientific branches increasingly rely on computation the lack of such a program can impact negatively both the quality of education, as well as the quality and amount of research grants to UPR-RP. Ultimately, the addition of the CS graduate program will advance the campus' Carnegie Classification as research-intensive as it will increase the number of master and doctoral graduates, the production of state-of-the-art research and the external funds generated.

6. Necessity of Computer Science Teachers

In addition to the necessity of professionals there is also and increasing need for computer science teachers. In its press release 16-009

(http://www.nsf.gov/news/news_summ.jsp?cntn_id=137529) entitled "Building a foundation for CS for All" the National Science Foundation explained that it is "committing **$120 million over five years** to accelerate its efforts to enable **rigorous and engaging CS education** in schools across the nation. These funds will support the development of prototypes of instructional materials, assessments, scalable and sustainable professional development models, and teacher resources, along with research to study their effectiveness. The acceleration of these efforts could enable as many as **9,000 additional high-school teachers to be well prepared to teach CS** over the next five years." Of course, combined with the growth of the Spanish speaking population this means that our students will be more capable of serving communities that otherwise would be left behind or completely aside of this endeavor. Currently, the Department of Computer Science is working with professors of the Faculty of Education in projects related to the training of teachers in computer science with the programs Exploring Computer Science for Puerto Rico (ECS4PR) and the Google Computer Science for High School (CS4HS).

IV. Relationship with the University Mission, Plan and Existing Programs

A. Relationship with the Mission and the Development Plan of UPR, and the Mission and Planning of the Unit

In Table 1 we pair the Institution's mission with the program educational objectives.

Table 3. Mapping Institution, College and Department's Mission with Program's Objectives.

Institution's Mission Statement	Program's Educational Objectives
Foster the integrated education of its students through programs of study which promote intellectual curiosity, the capacity for critical thinking, constant and ongoing learning, effective communication skills, an appreciation for and cultivation of ethical and aesthetic values, involvement in campus governance, and a sense of social awareness and responsibility.	● Graduating students will possess a solid theoretical foundation in Computer Science. ● Graduating students will become productive researchers. ● Graduating students will possess the necessary skills to become productive professionals in Computer Science. ● Graduating students will become innovators in their selected career path. ● Graduating students will become lifelong-learners. ● Graduating students will display leadership skills. ● Graduating students will contribute to the computer science community as well as to society.

Provide graduate education of the highest quality, with research and creative activity as key elements that strengthen undergraduate education; offer post-baccalaureate programs for the education and training of professionals of the highest caliber, persons who will be committed to the ideals and values of Puerto Rican society.	● Graduating students will possess a solid theoretical foundation in Computer Science. ● Graduating students will become productive researchers. ● Graduating students will possess the necessary skills to become productive professionals in Computer Science. ● Graduating students will become innovators in their selected career path. ● Graduating students will become lifelong-learners. ● Graduating students will display leadership skills. ● Graduating students will contribute to the computer science community as well as to society.
Develop teaching and research skills; promote participation in the life of the community as well as service to that community; promote respect for the historical and social conditions of Puerto Rico, taking into account its Caribbean and Latin American surroundings yet reaching out into the international community; enrich and strengthen the storehouse of knowledge associated with the consolidation of Puerto Rican nationality, history, language, and culture; and simultaneously foster the growth and dissemination of knowledge at an international level.	● Graduating students will possess a solid theoretical foundation in Computer Science. ● Graduating students will become productive researchers. ● Graduating students will possess the necessary skills to become productive professionals in Computer Science. ● Graduating students will become innovators in their selected career path. ● Graduating students will become lifelong-learners. ● Graduating students will display leadership skills. ● Graduating students will contribute to the computer science community as well as to society.
Develop innovative, relevant programs of research, community service, and continuing education which will support and contribute to the academic and professional activity of the campus; contribute to the transformation and continuing progress of Puerto Rican society, to the analysis of its socioeconomic and political problems, to the	● Graduating students will possess a solid theoretical foundation in Computer Science. ● Graduating students will become productive researchers. ● Graduating students will possess the necessary skills to become productive professionals in Computer Science. ● Graduating students will become innovators in their selected career path. ● Graduating students will become lifelong-learners. ● Graduating students will display leadership skills. ● Graduating students will contribute to the computer

formulation of solutions to these problems, and to the improvement of quality of life.	science community as well as to society.
To foster the intellectual and humanistic formation of professionals in various scientific disciplines.	● Graduating students will possess a solid theoretical foundation in Computer Science. ● Graduating students will become productive researchers. ● Graduating students will possess the necessary skills to become productive professionals in Computer Science. ● Graduating students will become innovators in their selected career path. ● Graduating students will become lifelong-learners. ● Graduating students will display leadership skills. ● Graduating students will contribute to the computer science community as well as to society.
To promote the search for the truth by means of scientific research and the sharing of ideas and information across diverse scientific disciplines.	● Graduating students will possess a solid theoretical foundation in Computer Science. ● Graduating students will become productive researchers. ● Graduating students will possess the necessary skills to become productive professionals in Computer Science. ● Graduating students will become innovators in their selected career path. ● Graduating students will become lifelong-learners. ● Graduating students will display leadership skills. ● Graduating students will contribute to the computer science community as well as to society.
To contribute to the chain of human knowledge and to meet the needs of our society.	● Graduating students will possess a solid theoretical foundation in Computer Science. ● Graduating students will become productive researchers. ● Graduating students will possess the necessary skills to become productive professionals in Computer Science. ● Graduating students will become innovators in their selected career path. ● Graduating students will become lifelong-learners. ● Graduating students will display leadership skills. ● Graduating students will contribute to the computer science community as well as to society.

To foster research and advanced studies in the fields of Computer Science.	● Graduating students will possess a solid theoretical foundation in Computer Science. ● Graduating students will become productive researchers. ● Graduating students will possess the necessary skills to become productive professionals in Computer Science. ● Graduating students will become innovators in their selected career path. ● Graduating students will become lifelong-learners. ● Graduating students will display leadership skills. ● Graduating students will contribute to the computer science community as well as to society.
To foster the development of research projects in all areas of Computer Science (e.g. programming systems, Theory of computing, computer architecture, and so on.) and interdisciplinary research.	● Graduating students will possess a solid theoretical foundation in Computer Science. ● Graduating students will become productive researchers. ● Graduating students will possess the necessary skills to become productive professionals in Computer Science. ● Graduating students will become innovators in their selected career path. ● Graduating students will become lifelong-learners. ● Graduating students will display leadership skills. ● Graduating students will contribute to the computer science community as well as to society.

B. Relation with the Academic Offer in Effect Within and Outside of UPR

In their "Computing Curricula 2005: The Overview Report" the Association for Computing Machinery (ACM), the world's largest association on computing, provides definitions for various computing disciplines and explains their difference and their similarities. Here we present a summary of those definitions to help distinguish and compare between the existing programs in Puerto Rico and our proposed graduate program.

1. Computer Science

As stated before, our proposed program is a master and a Ph.D. in Computer Science. As it can be seen in Figure 4, it is an area with a strong emphasis in theory, principles and innovation specially in application technologies, software methods and system infraestructure that includes more applied concepts specially in the area of software methods. Now, according to the ACM "Computer science spans a wide range, from its theoretical and algorithmic foundations to cutting-edge developments in robotics,

computer vision, intelligent systems, bioinformatics, and other exciting areas. We can think of the work of computer scientists as falling into three categories.

• They design and implement software. Computer scientists take on challenging programming jobs. They also supervise other programmers, keeping them aware of new approaches.

• They devise new ways to use computers. Progress in the CS areas of networking, database, and human-computer-interface enabled the development of the World Wide Web. Now CS researchers are working with scientists from other fields to make robots become practical and intelligent aides, to use databases to create new knowledge, and to use computers to help decipher the secrets of our DNA.

• They develop effective ways to solve computing problems. For example, computer scientists develop the best possible ways to store information in databases, send data over networks, and display complex images. Their theoretical background allows them to determine the best performance possible, and their study of algorithms helps them to develop new approaches that provide better performance."

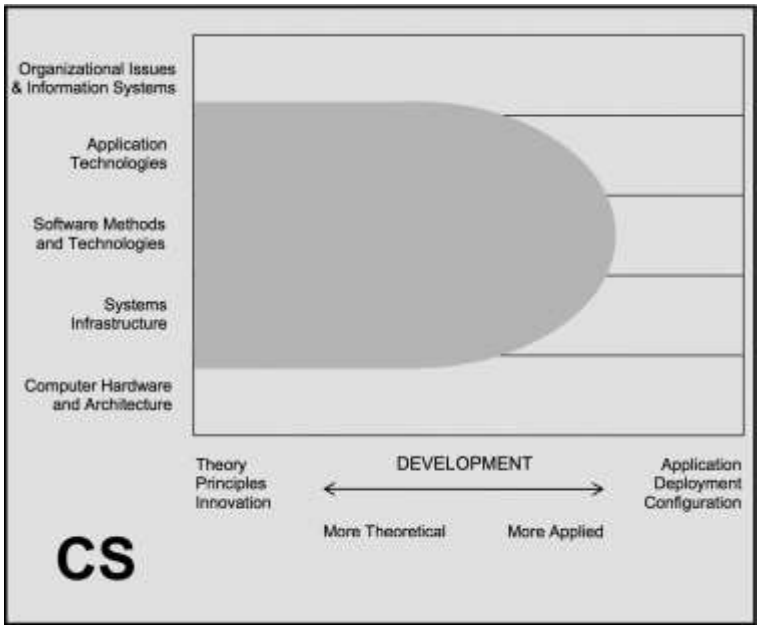

Figure 4. Problem Space of Computer Science. The horizontal range runs from Theory, Principles, Innovation on the left, to Application, Deployment, Configuration on the right and the vertical range runs from Computer Hardware and Architecture at the bottom, to Organizational Issues and Information Systems at the top. Source: ACM Computing Curricula 2005.

In this area, the only graduate programs are outside the University of Puerto Rico. Namely,

Bachelors

- UPR Río Piedras – Computer Science
- UPR Arecibo – Ciencia de Cómputos

- UPR Bayamón – Ciencia de Cómputos
- UPR Mayagüez – Computer Sciences and Engineering

Masters

- Universidad Interamericana - Maestría en Ciencias en Computadoras – 33 crs
- Universidad Politécnica - Master of Computer Science – 33crs (with thesis), 39crs (without thesis)

There might be some duplicity regarding the area of computer science at the master level for professionals that want to complete a master while holding full-time jobs. However, the level of preparation and production of our professors and the fact that our department is in tight collaboration with researchers of the Faculty of Natural Sciences, one of the more productive faculties in the country, make our program stand out from the existing programs. Additionally, those masters at private institutions that are significantly more expensive and with our plan to provide nocturnal courses we believe that we could access a large number of professionals that will find our offer more appealing.

Regarding our proposed Ph.D. program, is easy to see that many of the graduates of those master programs would be interested in completing our doctoral program given that if they are employed in Puerto Rico and in the San Juan area ours will be a perfect fit. Also, our graduates will be perfect candidates to become faculty in these programs.

2. Computer Engineering

An area related to computer science is computer engineering. According to the ACM, "Computer engineering is concerned with the design and construction of computers and computer-based systems. It involves the study of hardware, software, communications, and the interaction among them. Its curriculum focuses on the theories, principles, and practices of traditional electrical engineering and mathematics and applies them to the problems of designing computers and computer-based devices."

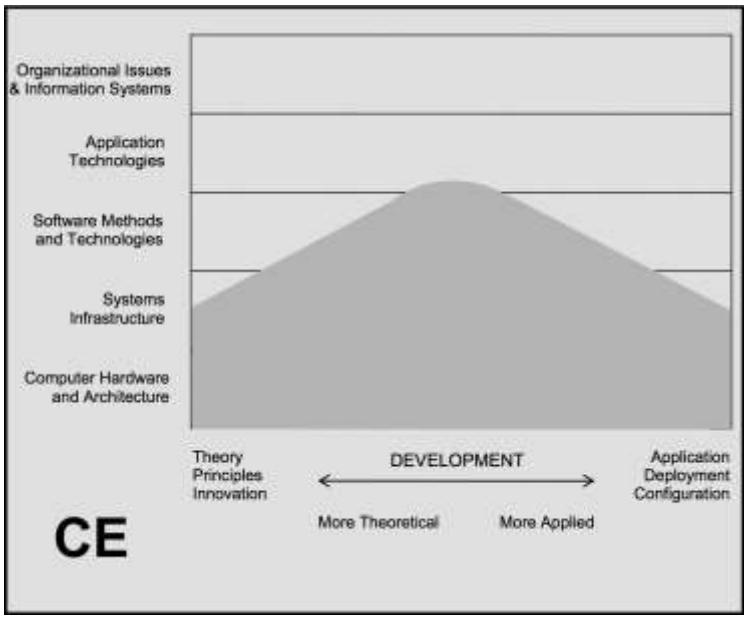

Figure 5. Problem Space of Computer Engineering. Source: ACM Computing Curricula 2005.

As it can be seen in Figure 5 there is a lot of overlap in the area related to system infrastructure although computer science has many aspects of software methods and application technologies that are not covered in computer engineering.

Bachelors

- UPR Mayagüez - Computer Engineering

Masters

- UPR Mayagüez - Master of Computer Engineering – 30 crs
- Universidad Ana G. Méndez - Gurabo - Maestría en Ingeniería de Computadoras – 30crs
- Universidad Politécnica - Master of Computer Engineering– 33crs (with thesis), 39crs (without thesis)

In terms of the bachelor programs their graduates can see in our master program a possibility to delve in work related to software and application development. If this is the case, the student will have to take the algorithms course in order to bridge this gap.

3. Software Engineering

An area that is closely related to computer science is software engineering. According to the ACM, "Software engineering is the discipline of developing and maintaining software systems that behave reliably and efficiently, are affordable to develop and maintain, and satisfy all the requirements that customers have defined for them."

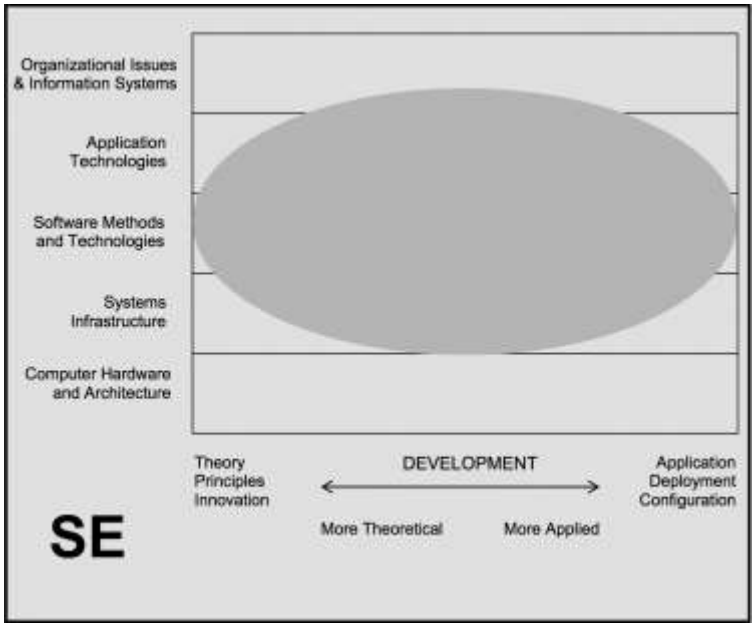

Figure 6. Problem Space of Software Engineering. Source: ACM Computing Curricula 2005.

As it can be seen in Figure 6 there is a lot of overlap in the area related to software methods and system infrastructure although computer science has some theoretic aspects that are not covered in software engineering.

Bachelors

- UPR Mayagüez – Software Engineering

The graduates of this program are perfect candidates to become students in our master and Ph.D. program, since there does not exist a doctoral program in this area.

4. Information Systems

Another area that is related to computer science is information systems. According to the ACM, "Information systems specialists focus on integrating information technology solutions and business processes to meet the information needs of businesses and other enterprises, enabling them to achieve their objectives in an effective, efficient way."

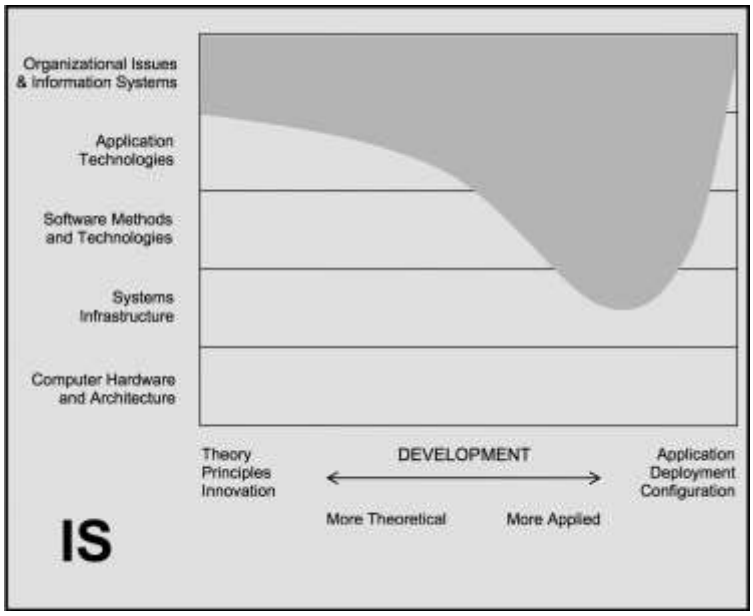

Figure 7. Problem Space of Information Systems. Source: ACM Computing Curricula 2005.

As it can be seen in Figure 7 there is a bit of overlap in some applied areas of application development, specifically, the area of cybersecurity is an area that intersects both computer science and information systems. We have a solid group working in this area and have received funding from NSF to advance the academics and training of it. A big difference between information systems and computer science is the development of software. IS programs teach students to program as a tool to organize and manage systems but do not cover either the more theoretical aspects of programming or the bigger software development projects.

Bachelors

- UPR Río Piedras - Sistemas Computadorizados de Información
- UPR Aguadilla - Sistemas Computadorizados de Información
- UPR Mayagüez - Computerized Information Systems
- UPR Ponce – Ciencias en Sistemas de Información Computadorizados

In this area, the graduate programs in Puerto Rico are the following:

Masters

- EDP University of Puerto Rico - Maestría en Sistema de Información – 40 crs
- Universidad Metropolitana – Maestría en Sistemas y Tecnologías de Información – 45 crs
- Universidad del Sagrado Corazón - Maestría en Gerencia de Sistemas de Información – 48 crs

- Universidad Interamericana – Maestría Sistemas de Información Gerencial - 45 crs
- Universidad Interamericana - Maestría en Ciencia en Computación en Sistemas Abiertos de Información - 39 crs

Doctorates

- Universidad Ana G. Méndez - Gurabo – Doctorate in Business Administration in Management Information System – 60 crs

In terms of the bachelor programs their graduates can see in our master program a possibility to delve in a little more theoretic work. If this is the case the student will have to take the data structure and the algorithms courses in order to bridge the gap between the applied nature of information systems and computer science.

Regarding our proposed Ph.D. program, is easy to see that many of the graduates of those master programs would be interested in completing our doctorate program however, they will probably have to take some of the more theoretic courses in order to bridge the gap between the applied nature of information systems compare to computer science. Also, some of our graduates will be perfect candidates to become faculty in these programs.

5. Information Technology

Another area that is related to computer science is information technology. According to the ACM, "IT programs exist to produce graduates who possess the right combination of knowledge and practical, hands-on expertise to take care of both an organization's information technology infrastructure and the people who use it. IT specialists assume responsibility for selecting hardware and software products appropriate for an organization, integrating those products with organizational needs and infrastructure, and installing, customizing, and maintaining those applications for the organization's computer users".

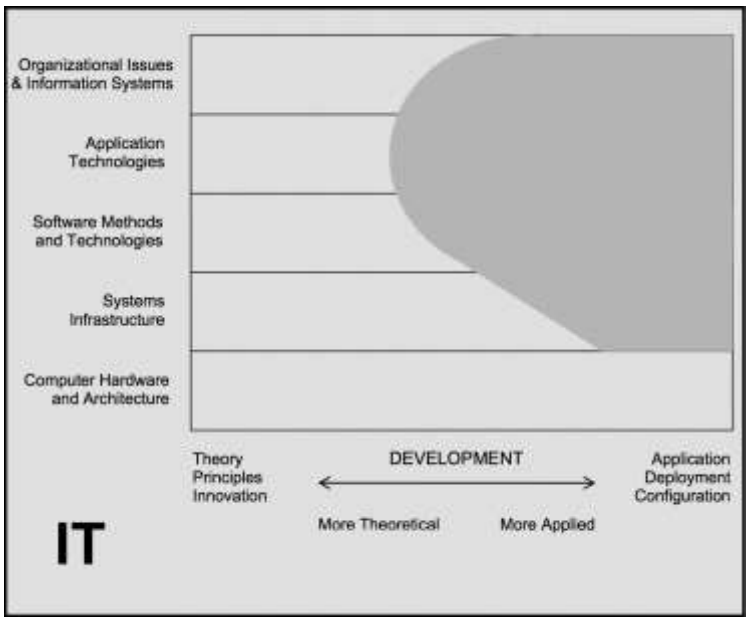

Figure 8. Problem Space of Information Technology. Source: ACM Computing Curricula 2005.

As it can be seen in Figure 8 there is a bit of overlap in the more applied aspects of configuration, specifically the area of cybersecurity is an area that touch both computer science and information technology. Although we have a solid group working in this area not all information technology programs have the expertise to provide this area at the master level program.

Masters

- Universidad Ana G. Méndez – Carolina - Maestría en Tecnología de Información y Desarrollo de Empresas Virtuales (WEB)
- Universidad Internacional Iberoamericana - Maestría en Dirección Estratégica con Especialidad en Tecnologías de la Información.

In terms of the bachelor programs their graduates can see in our master program a possibility to delve in a little more theoretic work. If this is the case, the student will have to take the data structure and the algorithms courses in order to bridge the gap between the applied nature of information technology and computer science.

Regarding our proposed Ph.D. program, many of the graduates of those master programs would be interested in completing our doctorate program, however, they will probably have to take some of the more theoretic courses in order to bridge the gap between the applied

nature of information technology compare to computer science. Also, some of our graduates will be perfect candidates to become faculty in these programs.

6. Other Programs

Bachelors

- UPR Mayagüez – Mathematics in Computer Sciences
- UPR Humacao - Matemáticas Computacionales

Masters

- UPR Río Piedras – Master of Science in Applied Mathematics – 30 crs
- UPR Mayagüez – Master of Science in Scientific Computing – 32 crs or 36 crs (without thesis or project)
- Atlantic University College - Maestría en Ciencias de Programación de Tecnología Interactivas – 48 crs
- EDP University of Puerto Rico - Seguridad de Información e Investigación de Fraude – 36 crs
- Universidad Ana G. Méndez - Carolina - Maestría en Gerencia en Seguridad de Información – 42 crs
- Universidad Interamericana – Maestría en Ciencias en Computadoras con Especialidad en Redes y Seguridad – 39 crs
- Universidad Ana G. Méndez - Gurabo- Maestría en Ciencias en Administración de Sistemas de Telecomunicaciones y Redes – 30 crs
- Universidad Internacional Iberoamericana – Maestría en Dirección Estratégica con Especialidad en Telecomunicaciones – 66 crs

Doctoral

- UPR Mayagüez – Computer and Information Science and Engineering (CISE) – 57 crs

The bachelor and master programs in this list are in more specialized areas within computer science and the other four areas described above. In terms of the bachelor programs, the graduates of these programs can become students of our master program with very little upkeep to be had. In terms of the masters the ones in areas related to security have a bit of overlap with the cyber security group working at our university. However, those masters are at private universities where the cost of education is much higher than at our proposed program.

Regarding the Master in Applied Mathematics at the Department of Mathematics at UPR Río Piedras, is important to mention that our department collaborates in this program but

the proposed program will work in many areas of Computer Science that are not within the grasp of the applied mathematics professors except for some areas of machine learning that could approached topics worked by the Computational Mathematics and Statistics group. There are also some areas of coding theory that could approached topics worked by some professors in the Discrete Mathematics group.

In terms of the Master of Science in scientific computing at UPR Mayagüez there is a slight overlap in the areas of mathematical modeling and coding theory. Similarly, the graduates of this master are excellent candidates to pursue the proposed Ph.D. program.

In terms of the Ph.D., the CISE program is much broader in their definition that ours. They include areas of engineering that we do not plan to develop in our program. We are proposing to focus in computer science and use all of our resources towards that end. In terms of possible overlapping, when going to the list of professors in the program one can see that their areas of expertise complement well with those of our professors with a slight overlap in the following areas: machine learning, field-programmable gate array, mathematical modeling and coding theory. However, since 2011 the doctoral thesis produced by the graduates of this program are: three in hyperspectral remote sensing and one in pattern recognition, signal processing, mathematical modeling and machine learning of which only the last two areas have some overlap with the work being produced at our department. Is important to mention that four of our professors are graduates of the CISE program so there is a natural kinship with the program.

For these reasons, we believe that we could become partners with the CISE program and since it does not have a master, our program can serve also as a gateway to students that want to pursue their doctoral work in the areas of researched at Mayagüez.

V. Conceptual framework.

A. Vision

The graduate program in computer science will be a highly dynamic and diverse educational and research-intensive environment that will become the primary source of computer science professionals in the Caribbean and a major source in Latin America.

B. Mission

The graduate program in computer science provides an excellent theoretical as well as practical educational and research experience that allow graduates to be leaders in all endeavors of science and technology.

C. Goals

1. To provide advanced knowledge in computer science that develops graduates with strong foundations that allow them to become leaders that can adapt to the ever-changing nature of the area.

2. To provide practical experiences related to computer science that allow graduates to participate in as well as to create projects that promote the economic development.

3. To provide a research-intensive environment that will prepare graduates to be internationally competitive in their field of research.

4. To increase the contributions of the Department of Computer Science to the computer science community as well as to society.

D. Objectives

1. Graduating students will possess a solid theoretical foundation in Computer Science.

2. Graduating students will become productive researchers.

3. Graduating students will possess the necessary skills to become productive professionals in Computer Science.

4. Graduating students will become innovators in their selected career path.

5. Graduating students will become lifelong-learners.

6. Graduating students will display leadership skills.

7. Graduating students will contribute to the computer science community as well as to society.

E. Educational Philosophy

Computer science encompasses rapidly changing technologies; however, it is based on essential concepts, perspectives and methodologies that are constant. Therefore, much of the body of basic knowledge remains unchanged and the students must be aware of these fundamentals. However, the constant development in computer science and in education mean that some aspects of the core evolve, and some of the previous structures and organizations may not be appropriate to describe the discipline.

Therefore, the educational philosophy of the Computer Science Program is based on critical thinking, research and creative work to channel the practice, production and dissemination of knowledge promoted through diversity, solidarity and human freedom.

The student builds knowledge assisted by the professors and feedback from other students. Professors actively guide the students in building viable mental models based on the knowledge structures of each of the student. This is a recursive process where students develop the capacity to take responsibility for their own acquisition of knowledge as part of a complete, active and permanent activity.

The development of knowledge is promoted as a process of change and continuous enrichment generated to be shared with others and to promote the advancement of the fields of interloping as a service to society through the search of solutions.

F. Graduate Profile

Graduates of this program will be able to easily navigate the ever-changing area of Computer Science based on their solid theoretical foundation and their lifelong-learning skills. Similarly, they will contribute to the computer science community as well as, to society, by sharing their work with a vast audience while promoting diversity in all aspects of their profession. They will also be capable of developing applications that have direct impact on the community and society following aspects of universal design.

Masters graduates will present their work, of an expository nature related to the courses taken, at international conferences and develop projects that would solve a problem or a task for a specific target audience. They will obtain and hold jobs in the technology industry or continue to a Ph.D. program.

The Ph.D. graduates will publish their work in renowned international peer-reviewed journals and conferences. This work will be a substantial, original and independent contribution to the knowledge in the field of Computer Science. They will hold positions in academia or industry. They will be recognized as innovators as well as leaders by their employers, and research and academic peers.

G. Coherence and Adequacy of the Conceptual Framework

The vision, mission, goals, objectives, educational philosophy and the profile of the graduate are interleaved coherently with the theoretical framework presented in the academic and curricular justification (section IV A and B).

VI. Curriculum Design

A. Curriculum Scheme and Balance

1. Basic Structure

a) Master of Science - Total credits: 30[1]

(1) Required Courses

- CCOM 6XXX Algorithms – 3 credits, 45 contact hours.
- CCOM 6XXX High Level Languages – 3 credits, 45 contact hours.
- CCOM 6XXX One Systems[2] course – 3 credits, 45 contact hours.
- CCOM 6XXX Development of Applications – 3 credits, 45 contact hours.
- 3 credits for thesis or project

(2) Computer Science Electives

- 6 credits in CCOM courses

(3) Free Electives

- 9 credits free electives

b) Ph.D. with Master - Total credits: 30

(1) Required Courses

- 6 credits for dissertation

(2) Computer Science Electives

- 18 credits in CCOM courses or courses in related disciplines selected with the consent of the adviser at the 8000 level.

(3) Free Electives

- 6 credits free electives

c) Ph.D. without Master - Total credits: 54[3]

(1) Required Courses

- CCOM 6XXX Algorithms – 3 credits, 45 contact hours.
- CCOM 6XXX High Level Languages – 3 credits, 45 contact hours.

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[1] As a comparison the MS program at the University of Miami requires 30 credits.

[2] Some possible system courses are: Operating Systems, Databases, Networking, Cyber security and Computer Architecture.

[3] As a comparison the Ph.D. program at the University of Miami requires 60 credits with at least 24 classroom course credits.

- CCOM 6XXX One Systems course – 3 credits, 45 contact hours.
- CCOM 6XXX Development of Applications with a Social Impact – 3 credits, 45 contact hours.
- 6 credits for dissertation

(2) Computer Science Electives

- 27 credits in CCOM courses or courses in related disciplines selected with the consent of the adviser (21 credits at the 8000 level)

(3) Free Electives

- 9 credits free electives

Students of both tracks of the Ph.D. level are required to pass a Qualifying Exam before continuing to their dissertation work.

1. Flexibility – Example of Curricular Options

Here we present examples of how the students can select electives in computer science to satisfy their interests. Of course, these are only a few of the possible examples that the curriculum provides.

Interest in Cyber Security

CCOM 6XXX Algorithms - 3 credits
CCOM 6XXX High Level Languages (Programming elective) - 3 credits
CCOM 6XXX Operating Systems (System elective) - 3 credits
CCOM 6XXX Cyber Security- 3 credits
CCOM 6XXX Cryptography- 3 credits
CCOM 6XXX Development of Applications- 3 credits
9 credits free electives
3 credits Project

Interest in Data Science

CCOM 6XXX Algorithms- 3 credits
CCOM 6XXX High Level Languages (Programming elective) - 3 credits
CCOM 6XXX Databases (Systems elective) - 3 credits
CCOM 6XXX Machine Learning- 3 credits
CCOM 6XXX Data Science- 3 credits
CCOM 6XXX Development of Applications- 3 credits
MATE6601 Probability and Statistics 1 - 3 credits
MATE6602 Probability and Statistics 2 - 3 credits

3 credits free electives
3 credits Project

Interest in Computer Science Education
CCOM 6XXX Algorithms - 3 credits
CCOM 6XXX High Level Languages (Programming elective) - 3 credits
CCOM 6XXX Cyber security (Systems elective) - 3 credits
CCOM 6XXX Computational Thinking for Educators- 3 credits
CCOM 6XXX Problem solving in the real world- 3 credits
CCOM 6XXX Development of Applications - 3 credits
9 credits free electives (could include graduate courses in Education)
3 credits project for the K-12 environment

Interdisciplinary Courses that Can Prepare Students to Develop their Interests
BIOL6360 Bioinformatics
MATE6685 Computer applications in biology
CIAM8118 Ecological Informatics and Socio-Ecological Models.
PLAN 6020 Introduction to Geographic Information Systems for Planning
EDUC 6726 Design and development of assistive technological alternatives
LING 6340 Introduction to Computational Linguistics
ECON 6051Statistics and Econometrics I
ECON 6052 Statistics and Econometrics II
ECON 6495 Econometrics

B. Courses which Make Up the Curriculum

Required Courses

MATE6682/CCOM 6XXX. Algorithms. *Three Credits. 45 contact hours* This course teaches solid foundations to solve computational problems with an algorithmic approach. In this course, we present advanced design techniques such as greedy methods, divide-and-conquer, dynamic programming, and randomized algorithms. Asymptotic notation as well as amortized analysis is introduced as means to measure complexity of algorithms. Most of the examples are related to bioinformatics and graph applications. An introduction to parallel algorithms is given through the model of dynamic multithreading programming. Finally, an introduction to NP-completeness is presented.
MATE6681/ CCOM 6XXX. High Level Languages. *Three Credits. 45 contact hours* In the pragmatic sense this course completes the education of programming languages by explaining nuances of programming language syntax, their origins and evolution. In the

philosophical sense this course benefits students by providing answers to the basic questions why there are so many programming languages and why there is not a single unified programming model.

CCOM 6XXX. Development of Applications with a Social Impact. *Three Credits*. *45 contact hours*

This course will give students the opportunity to develop an application that will have a direct impact on the community and society. They will work on groups under the supervision of a professor following the human-centered design process where the students go to the environment of the users to develop an understanding of the required tasks within that environment. The student will also apply the fundamentals of Universal Design to their projects. There will be weekly meetings to understand the user-centered design process and to discuss the progress made and approaches necessary to complete the project. At the end of the semester each group will turn in the software application with a usage manual. The development of the application is driven by the evaluation of the client and the users.

Computer Science Elective Courses

MATE 6680/CCOM 6XXX. Computational Analysis I. *Three Credits*. *45 contact hours*

Numerical analysis aims to provide computational methods to study and solve mathematical problems involving real variables. Because the methods provide approximations to the true solution of the problem, the study of errors is very important to numerical analysis. In this course, we will: provide the mathematical foundations of numerical methods; analyze the method basic theoretical properties–stability, accuracy, and computational complexity; and illustrate the method performance by means of computational examples and counterexamples by using a high-level programming language, such as MATLAB /Octave.

MATE 6882/CCOM 6XXX. Optimization. *Three Credits*. *45 contact hours*

This is a course on nonlinear optimization problems, both unconstrained and constrained. We will study optimality conditions and the basic numerical optimization methods with their convergence analysis. The numerical methods include: basic descent methods, conjugate direction methods, quasi Newton algorithms, reduced gradient method, gradient projection method, penalty and barrier methods, duality, and Lagrange methods.

MATE6685/CCOM6XXX. Computer Applications in Biology *Three Credits*. *45 contact hours*

Introductory graduate course in bioinformatics to be offered Spring 2017 in UPR-RP. Topics covered will include biological sequences, programming in python, UNIX, sequence alignments, sequence phylogeny, sequence database searches, and gene expression analysis, including

microarray and RNA-Seq analysis, and gene set or pathway analysis. We will emphasize the fundamental theory behind the analysis, and also present practical problems and their solutions. The course will use open-source bioinformatics tools such as bioconductor, and show how to construct such tools using python, R, or other languages.

CCOM 6XXX. Operating Systems. *Three Credits*. *45 contact hours.*

Operating Systems are the vehicle for user level applications and serve as a guard between these applications and the resources of the computer. The diversity and functionality of computer's resources, in conjunction with execution of concurrent software processes and servicing multiple users, make design and implementation of Operating Systems a challenge. For this graduate course, we will emphasize on virtualization and distributed systems.

CCOM 6XXX. Introduction to Computer Vision. *Three Credits*. *45 contact hours.*

Computer Vision is the field of study in which models and algorithms are developed to extract information from images. This includes in particular the detection, recognition or reconstruction of objects from images. This course introduces to several approaches that target a variety of problems in that field, including image processing algorithms, modeling and reconstruction of geometry and recognition of objects or concepts from images.

CCOM 6XXX. Applied Bioinformatics. *Three Credits*. *45 contact hours.*

This course will introduce the student to algorithm design and analysis of molecular biology data. It will use examples of cellular processes to motivate concepts and techniques used in computational molecular biology. Progressively it will increase the complexity of the biological data modeled with mathematical and computational techniques that will also increase in complexity. The course will focus on the analysis of biological sequences.

CCOM 6XXX. Research and Teaching Techniques for Computer Scientists. *Three Credits*. *45 contact hours.*

Students will learn basic skills that are essential to becoming a successful researcher and graduate student. The objective of the course is to teach research skills in a systematic fashion, early in a student's graduate program. Lecture topics will include pedagogy, research methodology, experimental design, career options, professional ethics and academic integrity, and oral and written presentation techniques in English as that is the language of the most prestigious international conferences in computer science. CCOM faculty members and senior graduate students will give short invited presentations on their own research so that students may engage in research in a laboratory sooner than later.

CCOM 6XXX. Data Visualization. *Three Credits*. *45 contact hours.*

Visualization is a powerful tool to get insight on raw data, by providing the user with interactive and informative graphics from the data. The goal of this course is to train students in the concepts and tools used to perform such visualization on a variety of types of data. Of particular interest will be the visualization of spatial data in 2D and 3D, traditionally known as scientific visualization, as well as the visualization of non-spatial data such as tables, time-series or relations, seen as information visualization. This course will involve programming projects.

CCOM 6XXX. Computational Cell Biology. *Three Credits*. *45 contact hours.*

This course will introduce the student to mathematical modeling of different cell activities. It will use examples of cellular processes to motivate concepts and techniques used in computational cell biology. Progressively it will increase the complexity of the cellular functions modeled with mathematical and computational techniques that will also increase in complexity. The course will focus on the simulation of functions that describe certain physiological behavior in the cell.

CCOM 6XXX. High Performance Computing. *Three Credits*. *45 contact hours.*

In this course students will design and implement high performance computing systems: clusters, co-processors, interconnect, parallel file systems. Students will learn software design techniques for achieving high performance, performance measurement, and the factors affecting performance. Students will apply these techniques to analyze novel high-performance architectures.

CCOM 6XXX. Algorithms for Molecular Biology. *Three Credits*. *45 contact hours.*

This course will introduce the student to algorithm design and analysis of molecular biology data. It will use examples of cellular processes to motivate concepts and techniques used in computational molecular biology. Progressively it will increase the complexity of the biological data modeled with mathematical and computational techniques that will also increase in complexity. The course will focus on the analysis of biological sequences.

CCOM 6XXX. Introduction to Machine Learning. *Three Credits*. *45 contact hours.*

Machine learning is a wide collection of concepts and techniques that allows machines to improve their performance at a given task, using 'experience' or 'guidance'. It is a dynamic and evolving field with numerous successes in everyday computing. The class provides a smooth introduction to machine learning, at a level appropriate for advanced undergraduate students or beginning graduate students.

CCOM 6XXX. Data Mining. *Three Credits*. *45 contact hours.*

Data mining is the analysis of large data to discover hidden properties and relationships and to summarize the data in ways that are useful to the analyst.

The goal of the course is to provide an overview of key topics in data mining, provide the algorithmic background, and expose the students to hands-on experience. Topics include data modeling, frequent item set mining, clustering, classification, sketching, dimensionality reduction, regression, link analysis ranking, network statistics and importance measures for links and nodes.

CCOM5XXX. Computer Architecture 2. *Three Credits*. *45 contact hours.*

"Computer architecture is the science and art of selecting and interconnecting hardware components to create a computer that meets functional, performance and cost goals. This course qualitatively and quantitatively examines computer design tradeoffs. We will learn, for example, how uniprocessors execute many instructions concurrently and why state-of-the-art memory systems are nearly as complex as processors." [1][2] In contrast to an introductory computer architecture course, this course will focus on the techniques to design "the best" processor, rather than just a working processor.

CCOM 6XXX. Topics in Computer Science. *Three Credits*. *45 contact hours.*

In this course students will perform a detailed study on one or more specific topics in computer science. Given the changing nature of the subject, the topics will vary frequently. The course offers the students the opportunity to learn about current topics related to computer science. The course might be taken several times if the topics are different.

CCOM 6XXX. Software Engineering. *Three Credits*. *45 contact hours.*

Provides an overview of the principles and concepts of software engineering. Presents elements of the software life cycle, requirements analysis, implementation, verification and validation as well as ethical issues related to software development process. The students will develop a group project that will put them in the position of designers and developers of software.

CCOM 6XXX. Master Project. *One-Three Credits.*

In this course students will perform requirement acquisition, planning and development of the master project. The resulting work is expected to solve a problem or a task for a specific target audience. A final written report is required following the guidelines of our departmental manual.

CCOM 6XXX. Master Thesis. *One-Three Credits.*

In this course students will study the selected topic and perform research leading to the preparation of the master thesis. The resulting work is expected to be of an expository nature related to the courses taken and written in a format following the guidelines of our departmental manual.

CCOM 8XXX. Doctoral Research. *One-Three Credits.*

In this course students will study the selected topic and perform research leading to the development of the doctoral research project

CCOM 8XXX. Doctoral Dissertation. *One-Three Credits.*

In this course students will study the selected topic and perform research leading to the preparation of the doctoral dissertation.

CCOM 8XXX. Continuation of Doctoral Dissertation. *Zero Credits.*

In this course students will continue studying the selected topic and research the study leading to the preparation of the doctoral dissertation when the student had completed the credits of the Doctoral Dissertation course.

CCOM 8XXX. Advanced Topics in Computer Science. *Three Credits*. *45 contact hours.*

In this course students will perform a detailed study on one or more specific topics in computer science. The topics in this course are expected to be of the theoretical nature. The course offers the students the opportunity to learn about current topics related to computer science. The course might be taken several times if the topics are different. Examples of topics are quantum computation, computational complexity and programming language theory.

CCOM 8XXX. Advanced Research in Computer Science. *Three Credits*. *45 contact hours.*

In this course students will study and perform research in an advanced topic in Computer Science. The course offers the students the opportunity to deepen knowledge in current research topics related to computer science. The course might be taken several times if the topics are different. Examples of research topics are convolutional neural networks, bio-informatics and cryptography.

CCOM 8XXX. Advanced Topics in Operating Systems. *Three Credits*. *45 contact hours.*

Operating Systems are the vehicle for user level applications and the layer between these applications and the resources of the computer. The diversity and functionality of computer's resources, in conjunction with execution of concurrent software processes and servicing multiple users, make design and implementation of Operating Systems a challenge. In this advanced graduate course, the student will go in depth into appropriate methods of modern operating systems like multi-threading control and distributed file system concepts.

CCOM 8XXX. Advanced Topics in Machine Learning. *Three Credits*. *45 contact hours.*

In this course students will study and perform research in an advanced topic in Machine Learning. The class provides a deeper look into machine learning, at a level appropriate for an advanced graduate student. Example of topics are kernel-based methods, reinforcement learning and convolutional neural networks.

CCOM 8XXX. Advanced Topics in Compiler Design. *Three Credits*. *45 contact hours.*

In this course students will study and perform research in an advanced topic in Compiler Design. The class provides a deeper look into Compiler Design, at a level appropriate for an advanced graduate student. Examples of topics are interprocedural analysis, garbage collection and symbolic execution.
CCOM 8XXX. Advanced Topics in Algorithm Analysis and Design. *Three Credits*. *45 contact hours.* In this course students will study and perform research in an advanced topic in Algorithm Analysis and Design. The class provides a deeper look into the design and analysis of algorithms, at a level appropriate for an advanced graduate student. Examples of topics are greedy algorithms, online algorithms and streaming algorithms.

C. Curricular Sequence

Table 4. Curricular Sequence of the Master of Science – 30 credits

First Year First Semester		**First Year Second Semester**	
CCOM 6XXX Algorithms	3 crd	CCOM 6XXX High Level Languages	3 crd
CCOM elective course	3 crd	CCOM elective course	3 crd
CCOM 6XXX Systems course	3 crd	Free elective	3 crd
Second Year First Semester		**Second Year Second Semester**	
Free elective	3 crd	CCOM 6XXX Thesis or project	3 crd
Free elective	3 crd		
CCOM 6XXX Development of Applications	3 crd		

Table 5. Curricular sequence of the Master of Science (Part-time students) – 30 credits

First Year First Semester		**First Year Second Semester**	
CCOM 6XXX Algorithms	3 crd	CCOM 6XXX High Level Languages	3 crd
CCOM elective course	3 crd	CCOM elective course	3 crd
Second Year First Semester		**Second Year Second Semester**	
CCOM 6XXX Systems course	3 crd	Free elective	3 crd
CCOM 6XXX Development of Applications	3 crd	Free elective	3 crd
Third Year First Semester		**Third Year Second Semester**	
CCOM 6XXX Thesis or project	1 crd	CCOM 6XXX Thesis or project	2 crd
Free elective	3 crd		

Table 6. Curricular Sequence of the Ph.D. without Master – 54 credits

First Year First Semester		**First Year Second Semester**	
CCOM 6XXX Algorithms	3 crd	CCOM 6XXX High Level Languages	3 crd
CCOM elective course	3 crd	CCOM elective course	3 crd
CCOM 6XXX Systems course	3 crd	Free elective	3 crd
Second Year First Semester		**Second Year Second Semester**	
CCOM 8XXX elective course	3 crd	CCOM 8XXX elective course	3 crd
Free electives	3 crd	CCOM 8XXX elective course	3 crd
CCOM 6XXX Development of Applications	3 crd	Free elective	3 crd
Third Year First Semester		**Third Year Second Semester**	
CCOM 8XXX elective course	3 crd	CCOM 8XXX elective course	3 crd
CCOM 8XXX elective course	3 crd	CCOM 8XXX elective course	3 crd
CCOM 8XXX Thesis	1 crd	CCOM 8XXX Thesis	1 crd
Fourth Year First Semester		**Fourth Year Second Semester**	
CCOM 8XXX Thesis	2 crd	CCOM 8XXX Thesis	2 crd

Table 7. Curricular Sequence of the Ph.D. without Master (Part-time students) – 54 credits

First Year First Semester		**First Year Second Semester**	
CCOM 6XXX Algorithms	3 crd	CCOM 6XXX High Level Languages	3 crd
CCOM elective course	3 crd	CCOM elective course	3 crd
Second Year First Semester		**Second Year Second Semester**	
CCOM 6XXX Systems course	3 crd	CCOM 8XXX elective course	3 crd
CCOM 6XXX Development of Applications	3 crd	Free elective	3 crd
Third Year First Semester		**Third Year Second Semester**	
CCOM 8XXX elective course	3 crd	CCOM 8XXX elective course	3 crd
Free elective	3 crd	Free elective	3 crd
Fourth Year First Semester		**Fourth Year Second Semester**	
CCOM 8XXX elective course	3 crd	CCOM 8XXX elective course	3 crd
CCOM 8XXX elective course	3 crd	CCOM 8XXX elective course	3 crd
Fifth Year First Semester		**Fifth Year Second Semester**	
CCOM 8XXX Thesis	1 crd	CCOM 8XXX Thesis	1 crd
Sixth Year First Semester		**Sixth Year Second Semester**	
CCOM 8XXX Thesis	2 crd	CCOM 8XXX Thesis	2 crd

Table 8. Curricular Sequence of the Ph.D. after a Master – 30 credits

First Year First Semester		**First Year Second Semester**	
CCOM 8XXX elective course	3 crd	CCOM 8XXX elective course	3 crd
CCOM 8XXX elective course	3 crd	CCOM 8XXX elective course	3 crd
Free elective	3 crd	Free elective	3 crd
Second Year First Semester		**Second Year Second Semester**	
CCOM 8XXX elective course	3 crd	CCOM 8XXX elective course	3 crd
CCOM 8XXX Thesis	1 crd	CCOM 8XXX Thesis	1 crd
Third Year First Semester		**Third Year Second Semester**	
CCOM 8XXX Thesis	2 crd	CCOM 8XXX Thesis	2 crd

Table 9. Curricular Sequence of the Ph.D. after a Master (Part-time Students) – 30 credits

First Year First Semester		**First Year Second Semester**	
CCOM 8XXX elective course	3 crd	CCOM 8XXX elective course	3 crd
CCOM 8XXX elective course	3 crd	CCOM 8XXX elective course	3 crd
Second Year First Semester		**Second Year Second Semester**	
CCOM 8XXX elective course	3 crd	CCOM 8XXX elective course	3 crd
Free elective	3 crd	Free elective	3 crd
Third Year First Semester		**Third Year Second Semester**	
CCOM 8XXX Thesis	1 crd	CCOM 8XXX Thesis	1 crd
Fourth Year First Semester		**Fourth Year Second Semester**	
CCOM 8XXX Thesis	2 crd	CCOM 8XXX Thesis	2 crd

D. Curricular Coherence and Adequacy

The proposed curriculum is framed in the educational philosophy and is oriented towards the achievement of the mission, goals and objectives. The following table shows the contribution of the courses to the achievement of the knowledge, skills and dispositions that comprise the profile of the graduate through the educational objectives.

Table 10. The Contribution of the Courses to the Achievement of the Educational Objectives.

1. Students will possess a solid theoretical foundation in Computer Science.	● **S**ystem course ● Algorithm course ● Thesis or project course
2. Students will become productive researchers.	● **P**rogramming course

	● Development of Applications course. ● Thesis or project course
3. Students will possess the necessary skills to become productive professionals in Computer Science	● **S**ystem course ● Programming course ● Algorithm course ● Thesis or project course ● Development of Applications course. ● Any elective in computer science
4. Students will become innovators in their selected career path.	● **T**hesis or project course ● Development of Applications course
5. Graduating students will become lifelong-learners.	● Development of Applications course. ● thesis or project course
6. Students will display leadership skills	● Development of Applications course.
7. Students will contribute to the computer science community as well as to society.	● Development of Applications course ● thesis or project course

E. Educational Methodologies

The educational methods that will be used in this program will be based on our philosophy that the students must build their knowledge guided by the professors. Therefore, the courses include a combination of lectures, laboratories and projects. These will at times be performed by the students on their own while at other times will be as part of group activities.

F. Assessment Plan for Student Learning

1. Student Learning Assessment Plan

Academic Program: Graduate Program in Computer Science **Academic Years: 2020- 2023**

Table 11. Student Learning Assessment Plan.

Domains of the mission statement	**Learning Objectives**	**Direct and Indirect Measures**	**Expected Outcomes**
1. Effective Communication	- Students will become productive researchers. - Students will possess the necessary skills to become productive professionals in Computer Science.	**Early in program** - Analysis of an article in the system course **Later in program** -Presentation and written document of the thesis or project course.	At least 80% of students, will obtain scores higher than 3 (in a scale of 0-5) based on the rubric. At least 80% of students, will obtain scores higher than 3 (in a scale of 0-5) based on the rubric.
2. Research and Creation	- Students will possess a solid theoretical foundation in Computer Science. - Students will become productive researchers. - Students will possess the necessary skills to become productive professionals in Computer Science. - Students will become innovators in their selected career path. - Students will become lifelong-learners.	**Early in program** -Analysis of an article in the system course **Later in program** - Written document of the thesis or project course	At least 80% of students, will obtain scores higher than 3 (in a scale of 0-5) based on the rubric. At least 80% of students, will obtain scores higher than 3 (in a scale of 0-5) based on the rubric.
3. Critical Thinking	- Students will possess a solid theoretical foundation in Computer Science. - Students will become productive researchers.	**Early in program** - Exam problem in the algorithm course **Later in program**	At least 80% of students, will obtain scores higher than 3 (in a scale of 0-5) based on the rubric.

	- Students will possess the necessary skills to become productive professionals in Computer Science. - Students will become innovators in their selected career path.	- Written document of the thesis or project course.	At least 80% of students, will obtain scores higher than 3 (in a scale of 0-5) based on the rubric.
4. Contents of Discipline	- Students will possess a solid theoretical foundation in Computer Science. - Students will become productive researchers. - Students will possess the necessary skills to become productive professionals in Computer Science. - Students will become innovators in their selected career path.	**Early in program** - Programming assignment in the algorithm course **Later in program** - Written document of the thesis or project course.	At least 80% of students, will obtain scores higher than 3 (in a scale of 0-5) based on the rubric. At least 80% of students, will obtain scores higher than 3 (in a scale of 0-5) based on the rubric.".
5. Information Literacy	- Students will possess a solid theoretical foundation in Computer Science. - Students will become productive researchers. - Students will possess the necessary skills to become productive professionals in Computer Science. - Students will become innovators in their selected career path.	**Early in program** - Group programming assignment in the language course **Later in program** - Presentation of the thesis or project course.	At least 80% of students, will obtain scores higher than 3 (in a scale of 0-5) based on the rubric. At least 80% of students, will obtain scores higher than 3 (in a scale of 0-5) based on the rubric.".
6. Technology Integration	- Students will possess a solid theoretical foundation in Computer Science. - Students will become productive researchers. - Students will possess the necessary skills to become productive professionals in Computer Science.	**Early in program** - Programming assignment in the algorithm course **Later in program**	At least 80% of students, will obtain scores higher than 3 (in a scale of 0-5) based on the rubric.

	- Students will become innovators in their selected career path.	- Group project in the Development of Applications course.	At least 80% of students, will obtain scores higher than 3 (in a scale of 0-5) based on the rubric.".
7. Ethical Sensibility	- Students will become productive researchers. - Students will possess the necessary skills to become productive professionals in Computer Science. - Students will display leadership skills. - Students will contribute to the computer science community as well as to society.	**Early in program** -Questionnaire **Later in program** - Service application in the Development of Applications course.	At least 80% of students, will obtain scores higher than 3 (in a scale of 0-5) based on the rubric. At least 80% of students, will obtain scores higher than 3 (in a scale of 0-5) based on the rubric.".
8. Social Responsibility	- Students will contribute to the computer science community as well as to society.	**Early in program** - Questionnaire **Later in program** - Service application in the Development of Applications course.	At least 90% of students, will obtain scores higher than 3 (in a scale of 0-5) based on the rubric. At least 80% of students, will obtain scores higher than 3 (in a scale of 0-5) based on the rubric.
9. Life-long Learning	- Students will become lifelong-learners.	**Early in program** - Analysis of an article in the system course **Later in program** - Written document of the thesis or project course	At least 80% of students, will obtain scores higher than 3 (in a scale of 0-5) based on the rubric. At least 80% of students, will obtain scores higher than 3 (in a scale of 0-5) based on the rubric.".
10. Team Work	- Students will become productive researchers. - Students will possess the necessary skills to become productive professionals in Computer Science.	**Early in program** -Group programming assignment in the language course	At least 80% of students, will obtain scores higher than 3 (in a scale of 0-5) based on the rubric.

	- Students will display leadership skills.	**Later in program** - Group project in the Development of Applications course.	At least 80% of students, will obtain scores higher than 3 (in a scale of 0-5) based on the rubric.
11. Leadership	- Students will display leadership skills.	**Early in program** -Group programming assignment in the language course **Later in program** -Group project in the Development of Applications course.	At least 80% of students, will obtain scores higher than 3 (in a scale of 0-5) based on the rubric. At least 80% of students, will obtain scores higher than 3 (in a scale of 0-5) based on the rubric.

2. Assessment Data Collection

Data will be collected in the following courses:

- CCOM 6XXX Algorithms
- CCOM 6XXX High Level Languages
- CCOM 6XXX One Systems course
- CCOM 6XXX Development of Applications
- 3 credits for thesis, project or development

And the following questionnaires

- Entrance
- End of the first year

3. Assessment Activities

1. Algorithm course Activities
   - Exam problem in the algorithm course for Critical thinking and Contents of discipline domain
   - Programming assignment for the Technology integration domain
2. System course Activities
   - Analysis of an article for the Research and creation, Effective communication and the Life-long learning domains.
3. Languages course Activities
   - Group programming assignment for the Information literacy, Teamwork and Leadership domains
4. Development of Applications course Activities
   - Group project with a service component application for the Social responsibility, Ethical sensibility, Teamwork, Leadership and Technology integration domains
5. Thesis, project or development course Activities
   - Presentation for the Effective communication, and Information literacy domains
   - Written document for the Effective communication, Research and creation, Life-long learning and Contents of discipline domains
6. Questionnaires
   - Entrance and end of year questionnaires for the Social responsibility and Ethical sensibility domains

Table 12. Curricular Matrix of Assessment of Student Learning.

Course	Learning Domains										
	Effective commun.	**Research and creation**	**Critical thinking**	**Contents of discipline**	**Infor. literacy**	**Techno. integration**	**Ethical sensibil.**	**Social respon.**	**Life-long learning**	**Team work**	**Leader ship**
Algorithms			**I**	**I**		**I**					
Languages					**I**					**I**	**I**
System	**I**	**I**							**I**		
Development						**A**	**A**	**A**		**A**	**A**
Thesis or Project	**A**	**A**	**A**	**A**	**A**				**A**		

(I) - Initiate; The essentials in the domain are evaluated.
(A) - Advanced; all the peculiarities of the domain are evaluated.

Adapted from http://oeae.uprrp.edu/wp-content/uploads/2015/02/Matriz-Curricular-de-Assessment-del-Aprendizaje-Estudiantil-OEAE.docx

G. Course Syllabi

See Addenda.

VII. Admission, Registration, and Graduation

A. Admission Requirements

Master of Science and Ph.D. without a Master

- Bachelor degree in Computer Science or a bachelor degree and the equivalent of Data Structures (CCOM3034) and Algorithms (CCOM5050). Students without the skills of these courses could be accepted with special permission so they can complete these requirements.
- 3.3 GPA

Ph.D. after a Master

- Master degree in Computer Science or related field (applicants from related fields will be evaluated by the graduate committee)
- 3.5 GPA

Additional Requirements for Admission for All Students

- GRE general test or PAEG
- Letters of recommendations
- Interview
- Statement of purpose
- Ability to communicate orally and in writing in Spanish or English.

B. Projected Enrollment

Table 13. Projected Enrollment of the First Five Years of the Program.

Level	First Year	Second Year	Third Year	Fourth Year	Fifth Year
Master students	10	10	15	15	15
Ph.D. students	0	0	5	7	10

C. Academic Requirements for Conferring the Degree

1. Master of Science

Requirements - Total credits: 30

- CCOM 6xxx Algorithms
- CCOM 6xxx High Level Languages
- One Systems course
- CCOM 6xxx Development of Applications
- 6 credits in CCOM courses
- 9 credits free electives
- 3 credits for thesis or project
- Prepare a thesis or a project. Even though the new academic policy for Graduate Studies encourages the substitution of a master's thesis with a project we provide for both alternatives. Students working in theoretical aspects of Computer Science will be better served with a thesis that may lead to publications and motivate them to pursue doctoral degrees. The minimum level of the master thesis should be that of a scholarly paper of an expository nature related to the courses the student has taken. The minimum level of the project should be that of an application that can serve a specific target audience. Both, the thesis and the project, should follow the Department of Computer Science manual[4].

2. Ph.D. after Master

Requirements - Total credits: 30

- 15 credits in CCOM courses at the 8000 level
- 9 credits free electives
- 6 credits for dissertation

3. Ph.D. without Master

Requirements - Total credits: 54

- CCOM 6xxx Algorithms
- CCOM 6xxx High Level Languages
- One Systems course
- CCOM 6xxx Development of Applications with a Social Impact
- 27 credits in CCOM courses selected with the consent of the adviser (21 credits at

[4] The manual will be created based on the manual for preparation developed by the Decanato de Estudios Graduados e Investigación (DEGI) with the incorporation of the idiosyncrasies of our area.

the 8000 level)

- 9 credits free electives
- 6 credits for dissertation

Additional Requirements to Complete the Ph.D.

- **Pass a Qualifying Exam** prepared by the graduate committee where the student can prove fundamental knowledge of Algorithms, High Level Languages and Development of Applications (for the students in the MS/PhD program, if one do not pass the exam after two tries the student could move to the master program and after completion of the requirements obtained an MS)
- Pass a dissertation proposal defense
- Prepare a dissertation – The doctoral dissertation must represent a substantial, original and independent contribution of the student to the existing knowledge in Computer Science. The thesis should follow the Department of Computer Science manual[5].

VIII. Faculty

The graduate program faculty consists of:

- **Regular graduate faculty** members, which are CCOM faculty members that are interested in participating in the Graduate Program, have a PhD degree and are actively publishing in the discipline, and have external funding or are actively applying for it.
- **Collaborating faculty** members, which have to apply to the graduate program and fulfill the requirements of the regular faculty (except being CCOM faculty). They could teach graduate courses, direct research, student projects, or dissertation, and be members of thesis committees.

[5] The manual will be created based on the manual for preparation developed by the Decanato de Estudios Graduados e Investigación (DEGI) with the incorporation of the idiosyncrasies of our area.

A. Profile of the Regular Faculty

Table 14. Regular Faculty Profile

Faculty Name	Highest Degree Earned-Field and Year	Rank [1]	Type of Academic Appointment[2]	FT or PT[3]	Years of Experience			Professional Registration/ Certification	Level of Activity[4] H, M, or L		
					Govt./Ind. Practice	Teaching	This Institution		Professional Organizations	Professional Development	Consulting/summer work in industry
Rafael A. Arce-Nazario	PhD – CISE, 2007	ACS	T	FT	0	17	9	None	L	M	M
Carlos J Corrada Bravo	PhD - EE, 2002	P	T	FT	3	14	14	None	L	M	M
Mariano Marcano	PhD – Applied Math, 1998	P	T	FT	0	16	16	None	L	L	L
Patricia Ordoñez	PhD – CS, 2012	AST	TT	FT	12	5	3	None	L	M	L
Edusmildo Orozco	PhD – CISE, 2005	ACS	T	FT	0	12	9	None	L	H	L
José Ortiz Ubarri	PhD – CISE, 2010	ACS	T	FT	12	5	5	None	L	M	L
Humberto Ortiz Zuazaga	PhD – CISE, 2008	AST	TT	FT	22	5	5	None	L	M	L
Ivelisse Rubio-Canabal	PhD– Applied Math, 1998	P	T	FT	0	17	7	None	H	H	L
Remi Megret	PhD – CS, 2003	AST	T	FT	0	14	1	None	M	H	L

1. Code: P = Professor ASC = Associate Professor AST = Assistant Professor I = Instructor A = Adjunct O = Other
2. Code: TT = Tenure Track T = Tenured NTT = Non-Tenure Track
3. At the institution
4. The level of activity, high, medium or low, should reflect an average over the year prior to the visit plus the two previous years

B. Other Considerations

1. Faculty Qualifications

The full time (tenure track and tenured) faculty members have a strong academic background and are actively participating in research areas of their choice. Our faculty members are encouraged to publish their results in peered reviewed venues, and to seek external funding to support their research projects. In addition, our faculty members are also involved in reshaping and improving the educational model offered by our department in order to provide students with a high-quality education.

The faculty is very active, and their research projects include collaborations with researchers from Mathematics, Biology, Chemistry, Physics, Electrical Engineering and other areas. Specifically:

Dr. Carlos J. Corrada Bravo

- Research collaborations with the ARBIMON Project with Dr. Mitchell Aide of the Biology Department.
- Collaboration in "A Cloud-Based Application Using Ecological Momentary Assessment to Evaluate the Impact of Undergraduate Research Experiences on Self-Efficacy, Scientific Identity and Career Decidedness" with Juan S. Ramírez Lugo of the Biology Department.
- Undergraduate research supervision of Biology student - Ian Flores
- Director of thesis of students in the Applied Mathematics Master - Giovany Vega and Rafael Álvarez

Dr. Ivelisse Rubio

- Collaborations in the mathematics department:
    - Research collaborations with Dr. Luis Medina of the Mathematics department program. Offers courses in the Mathematics department. Master's and PhD thesis committee of the Mathematics Graduate Program.
    - Collaborative Research: Some Fundamental Problems in Coding Theory, Cryptography and Information Theory: An Interdisciplinary and Collaborative Research

Dr. José Ortiz Ubarri

- Collaborated with Dr. Abel Baerga of the Biomolecular
- Collaborates and has submitted proposals with the Department of Chemistry: Kariluz Dávila, J. Ortiz-Ubarri, Rafael Arce, Liz Díaz. IUSE: EHR: Development of Educational Materials to Integrate Computing in the General Chemistry Course, NSF-IUSE.

- Collaborated in the development of the proposal: G. Morel, O. Mayol, P. Mendez, J. Ortiz-Ubarri, Towards a Better Understanding of African Dust Impacts on the Greater Caribbean Basin (ADI-Carib). NASA EPSCoR.
- Collaborated with Dr. Eduardo Nicolau in computer workshops for graduate students for the renewal of the AMP proposal.
- Participated in the proposal of EPSCoR IFN Track II

Dr. Rafael Arce

- Collaborates and has submitted proposals with the Department of Biology with Dr. Carla Restrepo.
    - Diana Delgado (with Rafael Arce-Nazario - member of the thesis committee), PhD in Biology. Patterns of exotic vine dispersal in a tropical watershed. Dr. Carla Restrepo, director of thesis committee. May 2015
    - Carla Restrepo, Humberto Cavallin, Rafael Arce Nazario. RAPID: Multi-scale responses of a hyper-connected macrosystem to extreme atmospheric events - Testing the underpinnings of resilience theory in tropical areas prone to landslides. $ 199,413.00 (proposal submitted in December 2017)
- Collaborates with Dr. Humberto Cavallín of the Faculty of Architecture
    - Orlando X. Nieves. Software for multitouch table to assist in architecture design reviews. 2014.
    - Jennifer Goldfarb (master of architecture student - member of the thesis committee), Woven in world + algorithms: in the era of digital architecture. December 2016
    - Jeffrey Chan Designing a platform to simulate the tracing process. 2017
    - He has submitted proposals with the Department of Chemistry with Dr. Ingrid Montes, and the proposal J. Ortiz-Ubarri, Rafael Arce, Liz Diaz. IUSE: EHR: Development of Educational Materials to Integrate Computing in the General Chemistry Course. NSF-IUSE.
- Collaborated with the Engineering faculty of UPRM
    - Victor Montalvo. Design and Analysis of a Scalable Floating Point Fast Fourier Transforms on Field Programmable Arrays. Thesis Committee. Master's Degree in Computer Engineering - UPR -Mayagüez. December 2009
    - Arnaldo Cruz. Software Optimization for Low Energy Consumption in Embedded Systems. Thesis Committee. Master's Degree in Computer Engineering - UPR -Mayagüez. December 2014
- Collaborates with Dr. Heidi Figueroa, Dept. Psychology in the project: Perceived vs real time in smartphone usage.

Dr. Humberto Ortiz-Zuazaga

- It offers workshops and undergraduate and graduate courses in the Department of Biology, the Interdisciplinary program and Mathematics.
- Student supervision Aristides Colon Castillo, BIOL 4990.
- Thesis Committee PhD Biology Edgardo Santiago, Carlos Ortiz Alvarado.
- Participates in multiple interdisciplinary proposals of Chemistry, Biology and the comprehensive cancer center. The most recent follow:

- RII Track-2 FEC: Genomic Logic Underlying Adaptive Morphological Divergence. NSF OIA 1736026
- Increasing Diversity in Interdisciplinary Big Data to Knowledge. NIH NIMHD R25 MD010399
- ADVANCING COMPETITIVE BIOMEDICAL RESEARCH IN PUERTO RICO. NIH NIGMS P20GM103475
- UPR / MDACC Partnership for Excellence in Cancer Research NIH National Cancer Institute U54CA096297

Dr. Edusmildo Orozco

- It offers graduate courses in the Mathematics department.
- Collaborates actively with the Faculty of Education. E. Orozco, A. Corchado, L Lopez, J. Carroll-Miranda, M. Borrero. Exploring Computer Science for Puerto Rico (ECS4PR).
- He has collaborated in the INBRE project and with Dr. Massey of Biology.
- He has collaborations with Dr. Bollman and Dr. Omar Colón from the Mayagüez campus.

Dr. Mariano Marcano

- Collaborates with the Department of Mathematics as graduate thesis director of 8 students, has been a member of various thesis committee, member of the graduate committee and teaching, and teaches graduate courses. He also directs undergraduate research of mathematics students.
- Collaborates with the Department of Environmental Sciences as a member of the graduate faculty. He was director of a Ph.D. thesis and is a member of various thesis committees.
- Collaborate with the Department of Biology. He was a faculty of the graduate program until February 2018 and directed a Ph.D. thesis. Led undergraduate student research through the MARC program. He collaborates in research with Dr. Paul Bayman in a study of coffee infection by the insect the coffee borer.
- He is a CoPI in the submitted proposal "Collaborative Research: NRT-HDR: Enhancing Diversity of Research and Education on Interdisciplinary Time-Critical Data Science" with Luis Raul Pericchi (Mathematics), María Eglee Pérez (Mathematics) and Miguel Acevedo (Biology).
- He collaborates in research with Claudia Patricia Ruiz Diaz (Environmental Sciences) and Aniel Nieves González (Institute of Statistics and Computerized Information Systems) in a study of coral infection caused by a pathogen.

Dr. Patricia Ordoñez

- Actively collaborates with the faculty of education in the Google CS4HS project and ECS4PR with the professors: Joseph Carol, Luis Lopez, Agustín Corchado, Carmen Pacheco. And other faculties: Kariluz Dávila (Chemistry), Mayra Lebrón (General Stats)
- Actively collaborates with the Department of Biology and the Department of Mathematics.

- Increasing Diversity in Interdisciplinary Big Data to Knowledge. NIH NIMHD R25 MD010399
- Supervises undergraduate student Giovanni Colón

Dr. Remi Megret

- Collaborates with the Department of Biology and the Mathematics Department of the UPRM.
  - BIGDATA: Collaborative Research: IA: Large-scale multi-parameter analysis of honeybee behavior in their natural habitat. Joint projects NSF 1707355 (CCOM), NSF 1633184 (BIO). BIOL UPRRP # 1633184 343k $ (PI J. August, Co-PI T. Giray) CCOM UPRRP # 1707355 446k $ (PI R. Megret, Co-PI E. Acuna.
  - NSF REU Site "IQ-Bio-REU: Interdisciplinary and Quantitative Biology", submitted by Juan S. Ramires Ludo (PI, Biology UPRRP) and Patricia Ordoñez (Co-PI, CCOM UPRRP
- Collaborates with the Mathematics department:
  - He gave the MATE 6990 course: Machine Learning in Computer Vision in the Mathematics graduate program.
  - Supervises graduate and undergraduate students of the program
  - He is a Senior Person in the submitted interdisciplinary proposal: NSF-EPSCoR Track I-Local competition: "Center for Information Theory, Genomics, and Network Sciences" EPSCoR Research Infrastructure Improvement Program Track-1: (RII Track-1) submitted by Heeralal Janwa (PI) (Math, UPR-RP) for local competition

2. Faculty Workload

The normal load of our faculty is six credits for teaching and six credits for research. This has allowed the development of an active and very productive department in terms of not only academic endeavors but also in terms of research articles and external funding. Exceptions are the cases of the chair that is required to offer a course *ad honorem*.

Is important to note that our faculty has the additional load of student advising (three credits), accreditation (three credits) and assessment (three credits) and currently these duties has been performed as additional compensation on top of the regular load.

This situation has been acknowledged by the campus administration and currently, even with the dire economic situation, is in the process of approving at least one and probably two tenure track positions to address the current situation.

3. Faculty Size

The required courses have been offered regularly as detailed in Section 1. We have offered from one to four electives courses per semester during the past two years. However, the faculty has been working at its limit. Aside from the undergraduate program one or two

professors from our department have covered two graduate courses for the Applied Mathematics Master program each semester for the past four years. Also, two of our professors are PIs or CoPIs of campus wide projects that serve the campus network and security. Furthermore, many of our professors are participating as members of thesis committees in the Departments of Mathematics, Biology and Environmental Science as well as thesis advisors in the Departments of Mathematics and Biology. Also, one of our professors has worked *ad honorem* in the development of customized applications for the campus, the first to allow professors to submit course grades electronically and another a mobile app with its entire infrastructure to improve campus safety including immediate alerts.

C. Faculty Development

Regular faculty members get 50% teaching load and 50% research load. All of our tenured or tenure track faculty members are active in research. The Department of Computer Science provides its faculty members with laboratory space for conducting their research. Moreover, the Department has funds for covering travel expenses of faculty members and/or their students to attend to professional meeting. Furthermore, these faculty members that are supported by external funds use it to cover their travel expenses.

Faculty members routinely attend local and international meetings to present their research results. They are publishing in peer-reviewed journals and competing for external funding to maintain their research projects. The faculty accomplishments that have resulted from this support include: 41 publications in the last 5 years; obtaining about $2,347K in external funding during that period; the number of presentations in international and local meetings is about 14 per year; and software developed by faculty members are used by others.

IX. Program Administration

The graduate program will be housed under the Department of Computer Science and will have a program committee that will be at the center of all its operations. It will consist of **regular** faculty members and will oversee the evaluation of:

1. Student applications;
2. Student committee composition;
3. Student sequence of courses;
4. The applications of regular and collaborating faculty members;

It would also have a program coordinator that will preside over the program committee and will respond to the Chair of the Computer Science Department. The coordinator will also

serve as the liaison of the program with the Dean of Graduate Studies and Research of the Faculty of Natural Science.

The program should have an administrative assistant to assist in all the endeavors of the program coordinator and the program committee. We are requesting a full position for the fourth year.

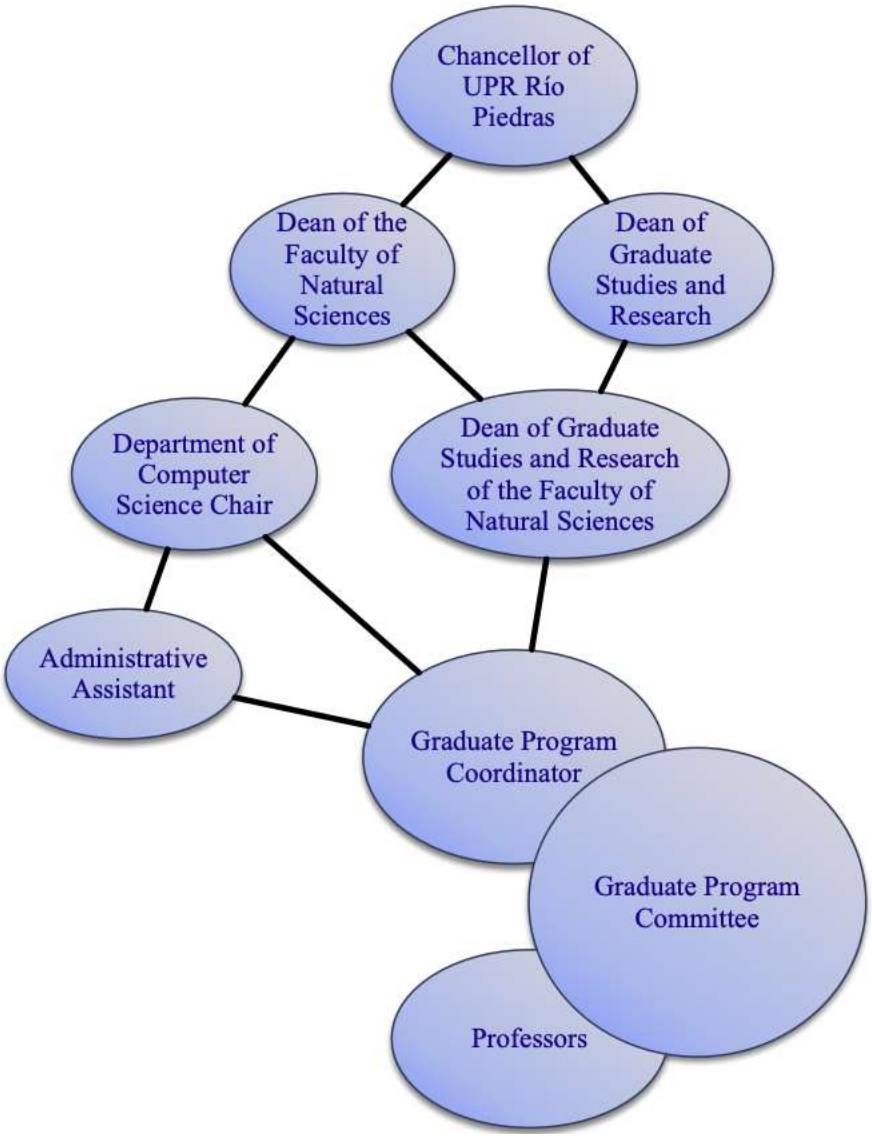

Figure 9. Administrative Structure of the Program.

X. Information Resources

Library Staffing

There are eight librarians, two of them with PhDs, there is a secretary and a coordinator for student services.

Library Technical Collection

The facilities of the College Library are now part of the Center for Information and Technology (CITEC). It holds a building of three levels of approximately 35,000 square feet and a capacity to accommodate two hundred (200) seats and two hundred fifty thousand (250,000) volumes of books and magazines. The bibliography collection includes two hundred thousand (200,000) printed volumes and various information resources in the fields of biology, physics and chemistry and is in the process of expansion in the areas of math, environmental science and computer science. It also contains approximately one thousand (1000) active subscriptions to professional journals, of which three hundred and sixty-six (366) titles are available in electronic and printed format and seventeen (17) subscriptions to specialized indexes in the disciplines of natural sciences in print and electronic format. Because of the breadth and depth of the development of their collections, the library is regarded as the major natural sciences information resource in Puerto Rico and the Caribbean.

Library Electronic Access

The facilities have an infrastructure and electronic wire fence with wireless access in all its areas. The Library has its own website (http://bcn.uprrp.edu).

XI. Infrastructure for Teaching, Research and Service

A. Facilities, Laboratories and Supporting Equipment for Teaching

1. Administrative Offices

Presently we have an administrative office with space for 5 persons. They are well equipped with desktop computers and two multi-function printers.

2. Faculty Offices

Similarly, we have offices for all the professors that are under the purview of our Department and one office that is under the authority of the Mathematics Department and is lent to one of our professors. All the offices have sufficient space and are well equipped with desktop computers and printers.

3. Classrooms and Associated Equipment

Rooms A-141 and A-143 are computer laboratories that are used to teach courses where the students need access to computers during class. Room A-141 has 25 PC Laptop computers. The professor uses one of the computers that it is connected to a multimedia projector. Room A-143 has 25 Apple Laptop computers and a multimedia projector. All of the computers in our laboratories are running the Linux the operating system and have

the Orca screen reader, Magnus screen magnifier and virtual keyboards. They will also contain speech recognition as well as text to audio software.

Other courses where the students do not need access to a computer use any of the classrooms available on Phase I and II of the College of Natural Sciences.

4. Research Laboratories

All of our professors have research laboratories under the administration of the program except for Dr. Megret's that is a facility lent by the Department of Biology.

Table 15. Location of Research Laboratories

Dr. Rubio's Laboratory	A-144 D
Dr. Marcano's Laboratory	A-144 E
Dr. Orozco's Laboratory	A-150 B
Dr. Arce's Laboratory	A-150 C
Dr. Ortiz Ubarri's Laboratory	CN-19
Dr. Ordoñez's Laboratory	CN-18
Dr. Corrada's Laboratory	CN-307
Dr. Ortiz Zuazaga	A-144 A
Dr. Remi Megret	CN-116

5. Computing Resources

The Department has a Dell server with 8 cores of 2.80GHz Intel Xeon, 4GB memory and 300GB of hard drive for student's projects. It also has 2 Dell 410 xenserver running gluster with 4 cores 1.80GHz, 8 GB memory and 1TB of hard drive and 2 Dell 420 xenserver running gluster with 4 cores 2.13GHz, 16 GB memory and 1TB of hard drive. These servers run virtual machines that hosts the Department web server and database server as well as any other services that the department and the professors require. For more advanced courses including the parallel programming course the department has 2 Microway Whisper Stations, one with 16 cores 1.4GHz, 32GB of memory, 1TB of hard drive and 2x GTX580 GPU and the other with 16 cores 800Mhz, 32GB of memory, 1TB of hard drive and 2x Tesla C7070 GPU.

The Division of Academic and Administrative Technologies (DTAA for its Spanish acronym) provide support personnel to install, maintain, and manage the PCs, laptops and desktops hardware and software. They also install, maintain, and manage all the University's networks. They have a fairly fast response time and can solve most of the problems.

The Department's servers, databases and web pages are installed, maintained, and managed by the Department's faculty. At the moment, Dr. Ortiz Ubarri is in charge of these tasks.

6. Guidance

The guidance on the use of tools, equipment, computing resources, and laboratories is provided by the professors teaching the courses and laboratories with the help of students hired to help with various tasks in the department.

7. Maintenance and Upgrading of Facilities

As presented in Section 8.b the Department of Computer Science receives an annual budget for equipment and materials that are used to maintain and upgrade the computing laboratories. The department tries to replace the computers in the laboratory every five years as the financial situation permits. Also, the university has a student's technology fee that is distributed based on the decision of a campus wide committee. This committee has representatives from all colleges and our department has occasionally received funds to upgrade computers and network infrastructure.

B. Centers of Practice or External Locations

The use of external facilities is not required.

XII. Student Services

A. Systems of Service and Support for Student

1. Mentorship and Academic Counseling

A faculty member will be assigned to each admitted student as an academic mentor or as a research advisor. The academic mentors help the students in the selection of courses and the sequence of courses that harmonizes with the student's interests while the research advisors will be in charge of guiding the students in their dissertations and projects. Students will have an academic mentor until they choose a research advisor which will also fulfill the duties of the mentor.

The academic counseling primary purpose is to provide students support in the planning and execution of their academic careers in a way that they can complete it within a reasonable amount of time. Timely academic mentoring allows detecting problems early and allows for proper resolution before these problems adversely affects the student's pursuit of the degree. During the counseling meeting, the student together with the academic mentor make decisions regarding course selection for the upcoming semester, and reevaluate the academic goals agreed upon and how these align with the long-term academic plan leading to the degree completion. As an aid, the mentors will use an electronic evaluation system (created by a professor from our Department) to prepare an individual academic evaluation.

For professional counseling, students can visit the Department of Counseling for the Student Development (http://dcode.uprrp.edu/) at the Office of the Dean of Student Affairs which has qualified personnel and various counseling services.

2. Needs of Students with Disabilities

The Office of Services for Students with Disabilities (OSEI for its initials in Spanish) have the mission of ensuring the faithful fulfillment of the rights of persons with disabilities guaranteeing their equal participation and access to the services, programs and activities available to the university community in general. The proposed program will promote the services of the office and will provide the adequate environment following its recommendations.

Accessibility guides following federal, local and international organizations will be implemented in documents, information, online platform, web pages of the Department of Computer Science, as well as the computers and technologies used in the courses. Students with disabilities will be able to access integrated development environments (IDE) that are accessible to their respective technology assistance programs, to write their programming codes in the courses.

All documents used in courses including course record, assignments, code, references, power point presentation, Google docs, etc. will follow the accessibility guides to ensure that the information in these documents can be accessed as texts. The information presented in the documents will follow a structure and sequence according to the accessibility guidelines. The information presented on online platforms of the courses will follow the accessibility guidelines for its accessible publication. Likewise, the website of the Department of Computer Science will be accessible so that future students can learn about the program, as well as current students with disabilities can stay informed. This includes forms that require the entry of texts, including buttons identified in texts, as well as describing all the images on the website with alterative texts.

B. Economic Assistance

We are requesting funds for teaching assistantships for 2 students the first year, 4 the second year and 6 the years after. Our professors will include research assistantships in their funded research projects, and we are ready to apply for various training grants including to the NSF Research Traineeship (NRT) Program and the NSF CyberCorps(R) Scholarship for Service (SFS) Program.

XIII. Catalog and Publicity

We propose to create advertising materials, including brochures, stickers and such, but also, we are going to develop a social media campaign as most of our possible candidates will be more adept at consuming their content through those mediums. Also, we will have undergraduate students guided by a professor from our department to create and maintain the electronic portal of the program through the current web presence of the department.

XIV. Budget Plan

A. Detailed Budget for the First Year

1. Budget for the First Year

Table 16. Detailed Budget for the First Year.

	Recurrent Costs	Non-Recurrent Costs	Total
Totals	**$133,298.00**	**$92,000.00**	**$225,298.00**
Faculty	**$88,998.00**	**$0.00**	**$88,998.00**
Salaries	$60,000.00	$0.00	$60,000.00
Fringe Benefits	$22,698.00	$0.00	$22,698.00
Compensations	$6,300.00	$0.00	$6,300.00
Services	**$400.00**	**$2,000.00**	**$2,400.00**
Materials	$200.00	$0.00	$200.00
Acquisition of Equipment	$0.00	$2,000.00	$2,000.00
Maintenance of Equipment	$200.00	$0.00	$200.00
Research	**$23,500.00**	**$90,000.00**	**$113,500.00**
Graduate seminar	$18,000.00	$0.00	$18,000.00
Research and dissemination of results	$5,000.00	$0.00	$5,000.00
Seed money for new hires	$0.00	$40,000.00	$40,000.00
Research Laboratories	$0.00	$50,000.00	$50,000.00
Materials	$500.00	$0.00	$500.00
Student Services	**$18,000.00**	**$0.00**	**$18,000.00**
Financial aid	$18,000.00	$0.00	$18,000.00
Catalog and dissemination	**$2,400.00**	**$0.00**	**$2,400.00**
Creation and maintenance of the electronic portal	$2,400.00	$0.00	$2,400.00

2. Budget Justification for the First Year

Faculty - For the first year, we are requesting salary and fringe benefits, for one assistant professor. Also, a 3 credits compensation for the Graduate coordinator and 3 credits (a total of $6,300) for a course offered by an adjunct professor

Services - We are proposing $200 for office materials, $200 for equipment maintenance and $2,000 for acquisition of equipment.

Research - In terms of research infrastructure, we are requesting $50,000 to refurbish and prepare research space as well as $40,000 in seed money for the new hire. Also, we are proposing $18,000 for the establishment of a Graduate Research Seminar. For this seminar, the program will be inviting 3 researchers per semester ($3,000 each) to present their work and create collaborations with our professors. Finally, we are requesting $5,000 for research dissemination and $500 for materials.

Student Services - We are proposing $18,000 for teaching assistantships for 2 master students.

Catalog and Dissemination – We are requesting $2,400 for the creation and maintenance of electronic portal.

B. Projected Five-year Budget

1. Five-year Budget Justification

The detailed budget is presented as a table in Addendum 1 for **a total budget of $1,388,970.00**.

Faculty - $747,270
We are proposing the hiring of one new professor the first, the third and the fifth year, therefore, we are requesting a total of $540,000 in salaries and $169,770 for fringe benefits and $6,000 for the recruitment costs of those new hires for the 3rd and 5th years.

We are also requesting $6,300 per year for 9 credits of compensation except for the second year that we are requesting $8,400 for 12 credits of compensation for the graduate coordinator and for courses offered by adjunct professors.

Services - $16,200
We are requesting a total of $1,000 for office materials and $1,000 for maintenance of equipment. We are also requesting $2,000 the first and the fourth year for the purchase of

new equipment and $4,000 the fifth year for replacement of equipment. Similarly, we are requesting $5,000 the fourth year for the actualization of the infrastructure.

Research - $397,500
For the new hires, we are requesting $50,000 each of the first, third and fifth year to refurbish and prepare research space for them as well as $40,000 in seed. Also, we are proposing $18,000 per year for the establishment of a Graduate Research Seminar. In this seminar, the program will be inviting 3 researchers per semester ($3,000 each) to present their work and create collaborations with our professors. Finally, we are requesting $5,000 for research dissemination and $500 for materials for the five years.

Student Services - $216,000
We are requesting funds for teaching assistantships for 2 students the first year, 4 the second year and 6 the years after.

Catalog and Dissemination - $12,000
We are requesting $2,400 for the creation and maintenance of electronic portal per year.

C. Expected Income

Each of the last seven professors who have been hired in our Department since has obtained external funds during their probationary years (an average of $500k per professor). After obtaining tenure they persist in their efforts to raise funds, e.g. our professor are PIs, CoPIs or Senior Staff in projects with external funding totaling $44 millions. In other words, each professor hired by our Department has been a guaranteed investment of external funds for the University. That is an average of $11 million a year in external funding that with an average indirect cost of 35% (some are educational projects) it represents $3.85 million. If we assume that our participation accounts for 10% of the effort it represents $48,125 per professor per year. Assuming that the new hires will take two years to obtain funds and including a conservative estimate on the production of the Computational Development and Consulting Center (CDC2) we can estimate that after the fifth year the Graduate Program will produce $2,267,500. That represent a net income of $878,530.

Table 17. Estimate of Graduate Program Income

	First Year	Second Year	Third Year	Fourth Year	Fifth Year	**Total**
Indirect Costs	$385,000	$385,000	$433,125	$433,125	$481, 250	**$2,117,500**
CDC2 Center	$10,000	$20,000	$30,000	$40,000	$50,000	**$150,000**
Total	**$395,000**	**$405,000**	**$463,125**	**$473,125**	**$531, 250**	**$2,267,500**

XV. Assessment and Evaluation Plan

The program will have a continuous assessment of the program as well as the student learning (see the Student learning section). In Table 11 we show the activities and instruments that will provide the data for the assessment process.

The program will administer a yearly questionnaire both to students and collaborators. Also, we will prepare a yearly report with the number of students with good academic standing, number of graduates, number of publications, number of software developed and the number of externally funded projects as well as the amount of money they acquire.

Table 18. Activities and Instruments for the Program Assessment Process

Goals	Activities	Instruments
To provide advanced knowledge in computer science that develops graduates with strong foundations that allow them to become leaders that can adapt to the ever-changing nature of the area.	• Student progress • Timely graduation • Achievement of the profile of the graduate • Satisfaction of the "clients" of the course of applications with social impact • Relevance of our graduates after graduation	• Yearly report • Yearly report • Student learning assessment • Yearly questionnaire • Graduates questionnaire
To provide practical experiences related to computer science that allow graduates to participate in as well as to create projects that promote the economic development	• Satisfaction of external collaborators • Achievement of the profile of the graduate • Articles published • Applications developed • Satisfaction of the "clients" of the course of applications with social impact • Relevance of our graduates after graduation	• Yearly questionnaire • Student learning assessment • Yearly report • Yearly report • Yearly questionnaire • Graduates questionnaire
To provide a research-intensive environment that will prepare graduates to be internationally competitive in their field of research	• Achievement of the profile of the graduate • External funding • Articles published • Relevance of our graduates after graduation • Participation of external collaborators	• Student learning assessment • Yearly report • Yearly report • Graduates questionnaire • Yearly report

Goals	Activities	Instruments
To increase the contributions of the Department of Computer Science to the computer science community as well as to society	• Satisfaction of external collaborators • Achievement of the profile of the graduate • External funding • Articles published • Applications developed • Satisfaction of the "clients" of the course of applications with social impact • The relevance of our graduates after graduation • Participation of external collaborators	• Yearly report • Student learning assessment • Yearly report • Yearly report • Yearly report • Yearly questionnaire • Graduates questionnaire • Yearly report

XVI. Development Plan

We are proposing the recruitment of 3 new professors, one the first, the third and the fifth year. For them we are also proposing laboratory space as well as money to help them develop a productive research agenda. Based on that and the expected enrollment we present in Table 12 the number of course to be offered by the program the first 5 years.

A. Courses to be Offered by the Graduate Program in the First 5 Years

Table 19. Courses to be Offered by the Graduate Program in the First 5 Years.

1st Year First Semester		**1st Year Second Semester**	
CCOM 6XXX Algorithms	3 crd	CCOM 6XXX High Level Languages	3 crd
CCOM 6XXX course	3 crd	CCOM 6XXX course	3 crd
One Systems course	3 crd		
Total Credits	**9**	**Total Credits**	**6**
2nd Year First Semester		**2nd Year Second Semester**	
CCOM 6XXX Algorithms	3 crd	CCOM 6XXX High Level Languages	3 crd
CCOM course	3 crd	CCOM course	3 crd
CCOM 6XXX Systems course	3 crd		
CCOM 6xxx Development of Applications	3 crd		
Total Credits	**12**	**Total Credits**	**6**
3rd Year First Semester		**3rd Year Second Semester**	
CCOM 6XXX Algorithms	3 crd	CCOM 6XXX High Level Languages	3 crd
CCOM 6xxx Development of Applications	3 crd	CCOM 6XXX course	3 crd
CCOM 6XXX Systems course	3 crd	CCOM 6XXX course	3 crd
CCOM 6XXX course	3 crd		
CCOM 8XXX course	3 crd		
Total Credits	**15**	**Total Credits**	**9**
4th Year First Semester		**4th Year Second Semester**	
CCOM 6XXX Algorithms	3 crd	CCOM 6XXX High Level Languages	3 crd

CCOM 6XXX Development of Applications	3 crd	CCOM 6XXX course	3 crd
CCOM 6XXX Systems course	3 crd	CCOM 8XXX course	3 crd
CCOM 8XXX course	3 crd	CCOM 8XXX course	3 crd
CCOM 8XXX course	3 crd		
Total Credits	**15**	**Total Credits**	**12**
5th Year First Semester		**5th Year Second Semester**	
CCOM 6XXX Algorithms	3 crd	CCOM 6XXX High Level Languages	3 crd
CCOM 6XXX Development of Applications	3 crd	CCOM 6XXX course	3 crd
CCOM 6XXX Systems course	3 crd	CCOM 8XXX course	3 crd
CCOM 6XXX course	3 crd	CCOM 8XXX course	3 crd
CCOM 8XXX course	3 crd		
CCOM 8XXX course	3 crd		
Total Credits	**18**	**Total Credits**	**12**

The program will administer a yearly questionnaire both to students and collaborators. Also, we will prepare a yearly report with the number of students with good academic standing, number of graduates, number of publications, number of software developed and the number of externally funded projects as well as the amount of money they acquire. Based on those findings the graduate committee will have a meeting to analyze and discussed the findings. If a major problem is detected recommendations are discusses with the Faculty who will evaluate the results and recommendations and decide whether they should be implemented.

XVII. Additional Information

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