Department of Information and Computer Sciences
Review of Provisional Ph.D. Program
University of Hawai‘i at Manoa

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In this document we provide the information requested in Appendix D: Guidelines for Assessment of Provisional and Established Programs for the Information and Computer Sciences Ph.D. program.

1 Assessment of need factors

Because it provides a useful introduction to the value and importance of the ICS Ph.D. program, we begin this report by responding to the final requested item of information in Appendix D.

In the case of graduate programs, attention should also be given to the following need factors:

- The direct relevance of the contribution of the field of study to the professional, economic, social, occupational and general educational needs of Hawai‘i;
- A “national needs factor” that emphasizes the direct relevance of the contributions of the field of study to national needs and where Hawai‘i and the University have unique or outstanding resources to respond with quality;
- An “international needs factor” that emphasizes the direct relevance of the contributions of the field of study to international needs and where Hawai‘i and the University have unique or outstanding resources to respond with quality;
- An educational needs factor that indicates the direct relevance of the field of study to basic education needs for which there is a demand by Hawai‘i’s population;
- The relevance of a field of study as a necessary supporting discipline for quality programs identified by the above criteria;

1.1 National and International need factors

Computer Science is a fundamental discipline whose advances in research and development impact the lives of millions of people every day across the globe. In 2009, a panel of 8 experts from the Wharton School of Business (University of Pennsylvania) was asked to name the 20 biggest innovations of the last 30 years, with the results published in the New York Times in March of that year. Out of the 20 innovations, 9 are directly from the field of computer science (the Internet, personal computers, email, the microprocessor, office software, open source software, e-commerce, media file compression, and social networking) and 5 of the remaining 11 are directly enabled by it.

Given this impressive coverage, it is not surprising that Computer Science Ph.D. programs are mainstays of virtually all first tier research universities worldwide. What makes Computer Science unique is its cross-cutting impact and relevance for other disciplines. Indeed, computers are used today not only in virtually all disciplines of science and engineering (where computer modeling and simulation are pervasive), but also in all the humanities (e.g., due to the use of large-scale and distributed digital databases), with direct involvement in fields as diverse as education (e.g., for internet collaboration technologies for learning) and even music (e.g., for computer-aided composition). Far from being straightforward applications of computers, many important developments
in those fields require that Computer Science challenges be addressed through innovative research and development activities, such as those pursued by ICS Ph.D. students. Consequently, advances in computer science research are fundamental for furthering human knowledge and progress in general.

1.2 University need factors

Since Computer Science’s relevance is pervasive across so many disciplines, our Ph.D. program is an invaluable resource for the university:

- ICS Ph.D. students are often engaged in collaborative projects between professors in ICS and in other departments. They are thus key contributors to the fostering of interdisciplinary research at UHM, which is highly strategic given the amount of federal funding available for such research.

- A significant fraction of our Ph.D. students are currently or were previously supported by Research Assistantships hosted in other departments. This is because many research projects require the type of expertise that only our students have through the training provided in our Ph.D. program. We regularly receive requests from Principal Investigators on campus asking us to advertise Research Assistantship opportunities to our graduate students. Thus, our Ph.D. students provide a unique and important research workforce for the university.

- Our graduate program offers courses that provide advanced training for graduate students outside of our programs. Every semester, such students take our graduate-level courses. For instance, Oceanography and Astronomy students have taken our high-performance computing course, Biology students have taken our bioinformatics course, Educational Technology students have taken our Human-Computer Interaction courses.

- Almost 30% of our Ph.D. graduates to date have chosen to stay in the University of Hawai‘i system and contribute either to research and development activities or to information technology management.

1.3 Hawai‘i need factors

Innovations in computing through Ph.D. research drive economic growth for the state of Hawai‘i. This growth occurs not just in the IT industry, but across the entire economy. A strong Computer Science Ph.D. program provides a nexus for this growth and the means to both build Hawai‘i’s capacity for technical innovation and to staff Hawai‘i’s research and development community. In the specific case of Hawai‘i, the benefit goes beyond economic growth to (much needed) economic diversification. Consequently, a strong ICS Ph.D. program can be a major contributor to growing a diversified economy in Hawai‘i.

The career paths of our Ph.D. graduates is a clear testimony of the dramatic impact that our students have on the state’s economy. Approximately 35% of our Ph.D. graduates so far have chosen to stay in Hawai‘i and work in local research and development organizations. The impact of these graduates is also felt at the level of the community. As just one example, many of our
Ph.D. students are active contributors to TechHui, Hawai‘i’s premier social network for science, technology and new media.

Our Ph.D. program fulfills a clear local educational need. We have admitted many outstanding local students who were exposed to research during their undergraduate experience at the University of Hawai‘i, and although many alternatives were available to them, they chose our Ph.D. program based on their interactions with our faculty and the opportunities this degree would make available to them.

In summary, the national and international need for Computer Science Ph.D. graduates is currently strong and will only grow stronger in future. Regionally, the diversification of the Hawai‘i economy requires skilled, innovative thinking in high technology areas which Computer Science Ph.D. graduates are ideally suited to provide. Finally, the ICS Ph.D. program provides students who are in high demand and a valued resource to other departments.

We believe strongly that the ICS Ph.D. program satisfies university, state, national, and international need factors.

2 Assessment of program organization and objectives

Following the guidelines in Appendix D, this section discusses the ICS Ph.D. program curriculum, requirements, advising, and counseling, with the goal of establishing that the ICS Ph.D. program is organized in such a way as to meet its objectives.

2.1 Objectives

The Ph.D. is the highest degree awarded by universities in the United States and thus represents the pinnacle of academic achievement. The Ph.D. Program in Information and Computer Sciences is designed for students who want to contribute to the study of the description and representation of information and the theory, design, analysis, implementation, and application of algorithmic processes that transform information.

ICS Ph.D. students receive advanced training in the scientific principles and technology required to develop and evaluate new computer systems and applications. We equip our students with the expertise necessary to independently perform state-of-the-art research, to formulate and develop creative solutions to novel and existing problems, and to intelligently manage the research of others. Our curriculum covers all major areas of Computer Science, with active research in areas including artificial intelligence, bioinformatics, human-computer interaction, software engineering, machine learning, high performance computing, digital democracy, computer vision, and computer systems.

An applicant may be admitted with a Bachelor’s degree or with an M.S. degree in Computer Science or a related field. If the applicant enters without the M.S., the applicant will earn the M.S. before proceeding to the “Ph.D. portion” of the program.

The ICS Ph.D. curriculum is designed to: (1) Certify the student’s core competency in Computer Science and address any deficiencies in this competency as efficiently as possible, so that the bulk of the student’s Ph.D. program is focused on research. (2) Prepare the student to do research through an apprenticeship with a faculty member, assessing readiness to do research with a research portfolio that is analogous to a professional tenure and promotion portfolio. We achieve these goals
by guiding the students through a curriculum with the following components: (1) Demonstration of core competency; (2) Participation in ICS 690; (3) Preparation of a research portfolio; (4) Proposal defense; and (5) Final defense.

2.2 Demonstration of core competency

The ICS Ph.D. student will demonstrate core competency in Computer Science by meeting the following two requirements:

1. Completion of a Master’s degree in Computer Science or a related field, where what counts as “related” is at the discretion of the graduate program chair, assisted by the admissions committee;

2. Successful completion of the comprehensive exam. The comprehensive exam covers core knowledge of Computer Science at a level that might be reasonably expected of a job interviewee with a Master’s degree. Students shall take the comprehensive exam at the end of the first semester of the the Ph.D. portion of their students. Students may attempt the comprehensive exam only twice, and must pass this exam no later than the end of the first year of their Ph.D. studies.

2.3 Coursework

According to Graduate Division guidelines, coursework is optional for University of Hawai‘i Ph.D. programs. However, the ICS Ph.D. program requires all ICS Ph.D. students to attend and pass the seminar course ICS 690 each semester they are in the program. ICS 690 is a one credit seminar course that meets once a week and is directed by the Graduate Chair. It provides an opportunity for all ICS graduate students (both M.S. and Ph.D) to regularly discuss their research issues and problems and gain insight from presentations by other faculty members, other graduate students, and guest lectures by visiting academic and industry professionals.

2.4 The research portfolio

By the end of the year following the passing of the comprehensive exam, the student must prepare and submit a research portfolio that includes the following:

1. A statement of purpose, which is a one to two page description of the student’s professional interests in research, teaching, service, and/or product development;

2. Evidence of core competency, as described above;

3. Evidence of scholarly ability, i.e. the ability to identify, critically analyze, and research a problem, and of written communication skills, in the form of two items authored by the student and reviewed by doctoral level scholars. The first item is a written literature review in the proposed area of study of 20-30 pages, following the graduate division dissertation format and reviewing at least 20 published works. The second item must be one of the following: a masters thesis by the student; a publication by the student in a reviewed conference or journal; or a technical report approved by at least two other faculty members.
4. (Optional) Other evidence of professional capacity, which might include a professional vita of employment, professional presentations, reviewing of papers for conferences and journals, competitive fellowships, patents, teaching, and service on committees or as graduate student representatives contribute to the candidacy decision. Letters of reference may also be included. Students should report all forms of research, teaching, and service to the community and to the discipline when preparing their portfolios.

The portfolio is approved by a two-thirds majority vote of a quorum of the ICS faculty (typically at a faculty meeting). The portfolio shall be distributed to the faculty in advance of the meeting at which it will be voted upon.

The graduate program chair shall designate one faculty to argue for the student’s case and one to argue against the student, who may both vote as they see fit. Faculty that have a conflict of interest with the student (e.g., advisor or co-advisor, co-author on research articles, direct supervisor) cannot serve in these capacities.

The portfolio must be approved before undertaking the Proposal Defense.

2.5 Proposal defense

Before commencing the final dissertation research, the student shall give a public defense of his or her Ph.D. proposal. Students prepare a research proposal that includes a literature review in the chosen topic area (this usually is but is not required to be derived from the literature review from the portfolio) and a description of research topics to be investigated. This work should be done under the direction of an appropriate faculty adviser. Students must also form their dissertation committee prior to the proposal defense.

The defense includes both a presentation of the student’s research proposal and an oral examination covering their general preparation for the research involved, as specified in the General and Graduate Information Catalog.

It is generally advised that the proposal defense be scheduled for a time period of 3 hours.

Once the student passes the proposal defense, they then conduct their research and write a dissertation under the direction of their advisor and their dissertation committee.

2.6 Final defense

The final defense is a public presentation of the student’s completed research and dissertation. The dissertation must be presented to and approved by a doctoral committee, as specified in the General and Graduate Information Catalog.

We believe that our five step process of demonstrating core competency, participation in ICS 690, preparation of a research portfolio, proposal defense, and final defense, when combined with our graduate curriculum and research areas, creates an effective and efficient program for students who wish to contribute to the study of the description and representation of information and the theory, design, analysis, implementation, and application of algorithmic processes that transform information. Our program is thus organized in such a way as to meet its objectives.
3 Assessment of student learning objectives

Following the guidelines in Appendix D, this section assesses the whether or not the program is meeting its learning objectives for students.

3.1 Learning objectives

We have defined nine student learning objectives for the ICS Ph.D. program, six of which are shared with our M.S. program plus an additional three learning objectives specific to the Ph.D. program.

The ICS M.S. graduate program provides courses for advanced education in Computer Science and affords opportunities to conduct research. Our objective is to help students achieve a high level of professional competence and lifelong learning, with the following Student Learning Objectives:

1. Master core Computer Science theoretical concepts, practices and technologies;

2. Identify, formulate and solve problems employing knowledge within the discipline;

3. Contribute effectively to collaborative team oriented activities;

4. Communicate effectively about Computer Science topics using appropriate media;

5. Demonstrate advanced knowledge in an area of specialization within the discipline;

6. Engage in significant research in their area of specialization within the discipline and/or in projects that respond to community and industry needs.

The ICS Ph.D. graduate program provides advanced, individualized training in research in Computer Science, preparing students for research careers in academia and industry. Beyond those for the M.S. program, the Ph.D. program involves the three following Student Learning Objectives:

7. Develop a research portfolio that demonstrates the capacity to carry out original research in the field;

8. Become an expert in the area of specialization including mastery of the relevant research skills and methods, develop a research vision, and formulate a research plan that will lead to novel scientific contributions;

9. Execute a research plan and demonstrate original contributions to the field, as shown through findings and/or publications, culminating in a Ph.D. dissertation and oral defense.

3.2 Assessment

Our development of empirically based assessment procedures for these student learning objectives is ongoing. For example, we are planning an “exit interview” procedure in which we can gather data directly from each graduating student regarding their subjective view as to whether each of these student learning objectives were achieved. We also plan to classify each course in the curriculum according to the program SLOs that it covers, which would provide an additional level of
evidence regarding assessment and coverage by noting which courses the student took during their program.

Although development of assessment procedures is ongoing, we believe strongly that the basic structure of our program as described above ensures that successful graduates have satisfactorily achieved all of these learning objectives, as illustrated in Table 1.

<table>
<thead>
<tr>
<th>Ph.D. program component</th>
<th>Student Learning Objective(s) Addressed</th>
</tr>
</thead>
<tbody>
<tr>
<td>Demonstration of core competency</td>
<td>1</td>
</tr>
<tr>
<td>Participation in ICS 690</td>
<td>3, 4,</td>
</tr>
<tr>
<td>Preparation of a research portfolio</td>
<td>2, 4, 5, 7, 8</td>
</tr>
<tr>
<td>Proposal Defense</td>
<td>1, 2, 4, 5, 6, 8</td>
</tr>
<tr>
<td>Final Defense</td>
<td>1, 2, 4, 5, 6, 8, 9</td>
</tr>
</tbody>
</table>

### 4 Assessment of program resources

Following Appendix D, this section addresses whether or not program resources are adequate through an analysis of the number and distribution of faculty, faculty areas of expertise, budget and sources of funds, and facilities and equipment.

#### 4.1 Faculty resources

In addition to the Ph.D. degree, the ICS department offers the following degrees: B.A. in ICS, B.S. in Computer Science, M.S. in ICS, and a MLISc. In addition, we contribute to 2 of the 4 programs in the interdisciplinary Ph.D. program in CIS, and we offer the BSCE with the Department of Electrical Engineering.

Table 2 shows an overview of the ICS faculty involved in the Ph.D. program and their areas of expertise.

The average instructional workload for each faculty member is two courses per semester. Using the Teaching Equivalent Workload Spreadsheet adopted by the College of Natural Sciences, we estimate that the faculty averages 8.82 semester credit hours for coursework (including directed reading courses, thesis advising and guest lecturing) and another 2.10 for additional teaching, for a total of 10.92 semester credit hours. On February 18, 2011 a comprehensive ICS Department Workload Documentation Procedure was approved by faculty. It is available for viewing at: http://goo.gl/IGRrr

#### 4.2 Administrative resources

In addition to the instructional staff, the department has two information technology (IT) specialists. They are responsible for system administration, networking, installation, and maintenance of the departments computer hardware and software infrastructure. The IT specialist also researches
<table>
<thead>
<tr>
<th>Faculty</th>
<th>Rank/Position</th>
<th>Primary expertise</th>
</tr>
</thead>
<tbody>
<tr>
<td>Martha Crosby</td>
<td>Professor and Chair</td>
<td>human computer interaction</td>
</tr>
<tr>
<td>Philip Johnson</td>
<td>Professor and Associate Chair</td>
<td>software engineering</td>
</tr>
<tr>
<td>David Chin</td>
<td>Professor</td>
<td>artificial intelligence</td>
</tr>
<tr>
<td>Daniel Suthers</td>
<td></td>
<td>computer learning</td>
</tr>
<tr>
<td>Kazuo Sugihara</td>
<td>Associate Professor</td>
<td>algorithms</td>
</tr>
<tr>
<td>Jan Stelovsky</td>
<td></td>
<td>hypermedia</td>
</tr>
<tr>
<td>Edoardo Biagioni</td>
<td></td>
<td>networks</td>
</tr>
<tr>
<td>Luz Quiroga (0.5)</td>
<td></td>
<td>information retrieval</td>
</tr>
<tr>
<td>Kimberly Binsted</td>
<td></td>
<td>artificial intelligence</td>
</tr>
<tr>
<td>Nancy Reed</td>
<td></td>
<td>autonomous agents</td>
</tr>
<tr>
<td>Susanna Still</td>
<td></td>
<td>information theory</td>
</tr>
<tr>
<td>Guylaine Poisson</td>
<td></td>
<td>bioinformatics</td>
</tr>
<tr>
<td>Henri Casanova</td>
<td></td>
<td>high performance computing</td>
</tr>
<tr>
<td>Scott Robertson</td>
<td></td>
<td>digital government</td>
</tr>
<tr>
<td>Kyungim Baek</td>
<td>Assistant Professor</td>
<td>computer vision</td>
</tr>
<tr>
<td>Richard Gazan (0.5)</td>
<td></td>
<td>information technology</td>
</tr>
<tr>
<td>Curtis Ikehara</td>
<td></td>
<td>biometrics</td>
</tr>
<tr>
<td>Julia Patriarche</td>
<td></td>
<td>medical informatics</td>
</tr>
<tr>
<td>Lipyeow Lim</td>
<td></td>
<td>databases</td>
</tr>
</tbody>
</table>
software and other products in response to instructional and research needs and manages the pur-
chasing and budget maintenance for the department. In 1998 we hired two Computer Specialists
to manage our Computer Labs and to manage our networking environment. Departmental research
efforts have produced several grants which employ student research assistants.

We have an administrative staff person who provides administrative and fiscal support to the De-
partment of Information and Computer Sciences. He works with the Department chair to develop
and track an annual department budget with corresponding projections for all sources of revenues
including general and all extramural funds. He assists faculty with budgetary matters related to
grant and contract proposals. He works with faculty and funding agencies (NSF, DARPA, etc.) to
obtain the necessary application and reporting forms. He generates timely fiscal status reports to
meet the needs of the college, department, accreditation bodies, and researchers. He works with
clerical staff to insure prompt and accurate payment of obligations to vendors upon delivery of
goods and services.

We have a Secretary II who performs secretarial and administrative duties for the Department,
including work relating to curriculum and instruction and personnel as well as services relating to
the clerical and administrative needs of the faculty members of the Department.

4.3 Program resources

The Computer Science department receives an annual budget assigned by the College of Natural
Sciences. This budget supports operational costs such as:

- Office Supplies
- Software Subscriptions
- Course Note Duplication
- Spare Parts
- Software Licenses
- Hardware and Hardware Repair Costs
- Minor Facility Renovations

In addition, in Fall 2001, the ICS Department was given a legislative appropriation of $1 million
to supplement our instructional budget for AY 2002. However, this appropriation was intended to
support development of undergraduate courses and thus does not impact directly on the resources
available for the ICS Ph.D. program.

4.4 Research areas and groups

Table 3 presents areas of research actively pursued by ICS Faculty members.

In addition, faculty have organized a variety of research laboratories to support larger, collabo-
ratrve, and potentially interdisciplinary research projects.
Table 3: ICS faculty research areas

<table>
<thead>
<tr>
<th>Algorithms</th>
<th>Artificial Intelligence</th>
<th>Robotics</th>
</tr>
</thead>
<tbody>
<tr>
<td>Biomedical Informatics</td>
<td>Bioinformatics</td>
<td>Collaborative Systems</td>
</tr>
<tr>
<td>Compilers</td>
<td>Computational Neuroscience</td>
<td>Computer Vision</td>
</tr>
<tr>
<td>Databases</td>
<td>Human Computer Interaction</td>
<td>Library and Information Science</td>
</tr>
<tr>
<td>Machine Learning</td>
<td>Mathematical Finance</td>
<td>Mobile Computing</td>
</tr>
<tr>
<td>Ubiquitous Computing</td>
<td>Renewable Energy</td>
<td>Security</td>
</tr>
<tr>
<td>Information Assurance</td>
<td>Software Engineering</td>
<td>Systems</td>
</tr>
<tr>
<td>Networking</td>
<td>High-Performance Computing</td>
<td>Computer Learning</td>
</tr>
</tbody>
</table>

The **Adaptive Multimodal Interaction (AMI) Laboratory** supports research involving various metrics and methodologies to study user data. Typical experiments collect eye movements, pressure grasping, and other physiological input to develop novel and effective interactive systems. Research in this area has fostered new design principles, user interfaces, multimedia interaction systems, and visualizations of complex information.

The **Bioinformatics Laboratory (BIL)** supports Bioinformatics and Metagenomics projects.

The **Collaborative Software Development Lab (CSDL)** has pursued well-funded research leading to innovative software technologies in use by many academic and industrial sites worldwide. Currently they are involved in renewable energy research.

The **Concurrency Research Group (CORG)** pursues research in parallel and distributed computing, computer system simulation, and high-performance computing.

The **Hawai‘i Computer-Human Interaction (HI’CHI) Laboratory** focuses on understanding how people use information systems and is dedicated to informing design based on human performance data. Current research on digital government applications and how people use the Internet to make political decisions.

The **Laboratory for Interactive Learning Technologies (LILT)** is forging partnerships with the Department of Education and other local educational agencies to support innovative uses of high technology in education.

The **Machine Learning (ML) Laboratory** supports machine learning, robotics and computational neuroscience projects.

The **Research Center for Information Assurance (RCIA)** provides a learning laboratory and test bed for investigations and applications related to the generation, organization, access, preservation, and secure use of digital information.

In conclusion, we believe that current resources are sufficient for the current size of the Ph.D. program, but that growth of the program will be challenging without recovery of lost resources.

5 Assessment of program efficiency

*Following Appendix D, this section assesses productivity and cost/benefit considerations within the overall context of campus and University “mission” and planning priorities.* It can include
quantitative measures comparing SSH/faculty, average class size, etc. with other programs in the college, campus, or as appropriate other universities.

We will assess these issues in two ways, through the use of the Academic Program Cost and Revenues template and through a time-to-degree analysis.

5.1 Academic program cost and revenues

![Academic Program Cost and Revenue Template]

Figure 1: Academic Program Cost and Revenue Template

Figure 1 presents an illustration of the Academic Program Cost and Revenues Template spreadsheet. Three spreadsheets were prepared for this program, one for AY 1997 - 2005, one for AY 2005 - 2011, and one for AY 2011 - 2016. All three of these spreadsheets show that the ICS Ph.D. program has positive revenue since its inception. The spreadsheet illustrated in Figure 1 shows projected revenues for this program for the next five years.

5.2 The Ph.D. program as virtuous circle

We can make a more qualitative argument regarding the Ph.D. program cost and revenues. This argument is that the incremental cost of the program to the department is extremely minimal: essentially, just the cost of faculty advising for the Ph.D. students, and a fraction of the cost of ICS 690 (since it is also taken by our M.S. students, so the Ph.D. students constitute less than half the enrollment.)

On the other hand, the revenue associated with the Ph.D. program is substantial, because the Ph.D. program supplies students who amplify the ability of our faculty to produce quality scientific findings. These findings, in turn, increase the ability of our faculty to obtain external funding. In addition, the presence of a Ph.D. program, and the quality of our students, help us attract higher
quality ICS faculty than we would be able to without the program. These higher quality faculty produce higher quality scientific findings, leading to increased ability to obtain external funding. To close this “virtuous circle”, the increased external funding provides opportunities to fund new Ph.D. students, who further amplify the ability of our faculty to produce quality scientific findings. Section 6.1 provides quantitative data on the funding and publications enabled by this virtuous circle.

5.3 Time to degree

An alternative measure of program “productivity” or “efficiency” for our Ph.D. program is time-to-degree (TTD). While the TTD can be predicted fairly accurately for students in M.S. or undergraduate programs (depending on whether they are full-time students or whether they have full-time jobs), the same cannot be said of the TTD for a Ph.D. program. This is due to the original research component, whose duration depends both on the student and on the chosen area of research within Computer Science. Variations among students in terms of one year or more is thus common. Furthermore, some Ph.D. students are admitted in our program right after obtaining their B.S., while others come into the program with a M.S. in hand, which shortens their TTD by at least 1 year and typically 1.5 years if that degree is in Computer Science or a related field.

According to data collected by Graduate Division, the mean TTD in our Ph.D. program is 5.8 years, with a median of 6.0 years. We can attempt a comparison with national averages. The report Time Degree of U.S. Research Doctorate Recipients available from the National Science Foundation (NSF) Web site presents data specific to Computer Science programs for academic year 2003. It reports mean TTD between 8.3 and 15.1 years depending on student categories (Research Assistants, Teaching Assistants, supported by fellowships, unsupported). The registered-to-degree (RTD) metric is also reported, which accounts for time during which the student is actually registered in graduate school, and which ranges between 7.0 and 9.0 depending on the student category. These times are “since obtaining a Bachelor.” We can thus see that our program compares favorably to nationwide averages, even accounting for the fact that the Graduation Division data does not account for M.S. degrees obtained in other institutions. A recent report on nationwide doctorate recipients is also available from the NSF Web site. It presents data for the 2007-2008 academic year, but unfortunately does not present data specific to Computer Science programs. Instead it shows aggregate data for “Physical Sciences.” A median TTD of 6.7 years is reported, which seems to confirm the above observations regarding our program.

The conclusion is that our program allows students to graduate at the same or at a faster pace than the national average. While this is good news, we still see some students who graduate in more than 8 years and up to 9.5 years. To try to reduce the maximum time to graduation, in 2005 we redesigned our Ph.D. program. Like many high-profile programs nationwide (UC Berkeley, Univ. of Washington, UC San Diego, etc.) we did away with the traditional comprehensive exam that occurs after the second or third year of study. Instead, our comprehensive exam occurs early on with a subsequent “research portfolio” exam that ensures our students are actively engaged in the research process.

Through this process, we expect to maintain our relatively low average TTD but also to reduce

2http://www.nsf.gov/statistics/nsf10309
our maximum TTD in the future. Our first graduate for the redesigned program, Mark Stillwell, successfully defended his dissertation in 2010. He graduated in 4 years (he already held a M.S. degree in Mathematics prior to applying to our program), has a very strong publication record, and has already found a post-doctoral position with a view to starting a promising Computer Science academic career.

6 Assessment of program quality

Following Appendix D, this section assesses the program with respect to student performance, satisfaction, placement and employer satisfaction, awards to faculty and students, etc.

6.1 Department reputation

The ICS department has a national and international reputation and our faculty have achieved many accomplishments over the years, including grants, fellowships, awards, contracts and commissions. The ICS faculty have productive research records and are involved in developing information enterprises, hold technological patents and have engaged with the community through consulting, public lectures, and presentations.

Faculty in the ICS Department have been awarded millions of dollars in external funding from both industry and government sources. They serve as editors on prestigious journals in their areas of expertise, have had their papers selected as the best paper at conferences, and have won prestigious awards. For example, W. Wesley Peterson was awarded the Japan Prize for his invention for the Cyclic Redundancy Check (CRC), a fundamental advance in error correcting codes. Kimberly Binsted, David Pager, Curtis Ikehara, Martha Crosby, Julia Patriarche, and Jan Stelovsky have all been awarded patents for their innovations.

Figure 2 provides a perspective on department quality based upon the aggregate value of external funding that ICS faculty have been awarded as PIs or co-PIs, along with the number of refereed publications that ICS faculty have authored or co-authored. This is a snapshot of ICS departmental trends for the four year period of 2006 to 2009, and was generated through review of faculty curriculum vitae and online sources.

Figure 2 shows that overall aggregate external funding in which ICS faculty were directly involved varied between $3M per year and $4.5M per year during this four year period, and the number of refereed publications by ICS faculty varies between 35 and 45 per year. This data shows that ICS faculty are productive, generating scientific contributions through refereed publications and helping to bring significant amounts of external funding to the university. In Section 5.2, we explain why we feel the ICS Ph.D. program creates a “virtuous circle” that supports and grows the ability of our department to generate funding and scientific advances.

6.2 Student application trends

The average GPA of students joining our Ph.D. program over the last 5 years is a high 3.82. The percentage of applicants that we accept in our program has ranged between 38% and 88%. The last two years have had inordinately high acceptance rates above 80%. In fact, our acceptance rates have increased steadily throughout the years. While this increase could be attributed to a
lowering our admission standards, this is absolutely not the case. In fact, our faculty have been absolutely amazed at the rising quality of applicants to our Ph.D. program in the last couple of years, leading to accepting 15 out of 17 applicants in 2009-2010. This increase in quality might in part be due to the fact that our Ph.D. program is recent and is just gaining momentum with our graduates beginning to make an impact. The percentage of accepted applicants who eventually join our program has ranged between 12.5% and 60% over the years. Remarkably, in the last two years, which have seen unprecedented top quality applicants, 50% and 60% of these applicants have joined our program. As discussed below, we do not believe this represents a drop in standards, but rather an increase in the reputation and stature of our program as it matures.

The data collected by Graduate Division regarding the drop rate for our Ph.D. program is misleading because it accounts only for students admitted between Fall 1989 and Spring 1999. This was when our program was in its infancy and the data is for 3 students only. With the help of a Graduate Division IT Specialist, on 8/30/2010 we obtained a full history of students in our Ph.D. program. A total of 30 students have entered our program and not graduated, for 32 students who have either graduated or are still in the program. This would seem to indicate a high drop rate close to 50%. However, out of those 30 students who never graduated, 12 never enrolled (likely due to personal reasons or late admission to other programs) and 6 dropped out after only one semester (likely for similar reasons). Discounting those students, the overall drop rate of our program is 12/48≈27%, which is basically the UHM average. Note that, out of these 12 students who dropped, 4 moved to a different PhD program at UHM (e.g., CIS), and 3 left after receiving their M.S. degree “on the way” to the Ph.D., seizing timely professional opportunities. We are left with only 5 students who entered our program, stayed in it more than one semester, and left without a degree. One of these students was recently dismissed due to poor academic performance. We conclude that most students admitted to our program are well-suited to it.
Table 4: Career Paths of Ph.D. Graduates

<table>
<thead>
<tr>
<th>Student</th>
<th>Year</th>
<th>Current Position</th>
<th>Location</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pei-Chia Chang</td>
<td>2010</td>
<td>Post-Doctoral Researcher, CTAHR, UH</td>
<td>HI</td>
</tr>
<tr>
<td>Mark Stillwell</td>
<td>2010</td>
<td>Post-Doctoral Researcher, ENS de Lyon</td>
<td>France</td>
</tr>
<tr>
<td>David Nickles</td>
<td>2010</td>
<td>Faculty Member at KCC</td>
<td>HI</td>
</tr>
<tr>
<td>Joshua Wingstrom</td>
<td>2009</td>
<td>Created his own startup company</td>
<td>TX</td>
</tr>
<tr>
<td>Xin Chen</td>
<td>2009</td>
<td>Software Designer, CTAHR, UHM</td>
<td>HI</td>
</tr>
<tr>
<td>Robert Fanelli</td>
<td>2008</td>
<td>Assistant Professor, West Point Academy</td>
<td>NY</td>
</tr>
<tr>
<td>Hongbing Kou</td>
<td>2008</td>
<td>Senior Software Engineer, CityGrid Media</td>
<td>CA</td>
</tr>
<tr>
<td>Xin Zhao</td>
<td>2008</td>
<td>Senior Scientist, Sanjole</td>
<td>HI</td>
</tr>
<tr>
<td>Nathan Dwyer</td>
<td>2007</td>
<td>Senior developer, Sega Studios</td>
<td>CA</td>
</tr>
<tr>
<td>David Pautler</td>
<td>2007</td>
<td>Principal Investigator, Institute of HPC</td>
<td>Singapore</td>
</tr>
<tr>
<td>Qin Zhang</td>
<td>2007</td>
<td>Senior Software Engineer, Kofax Systems</td>
<td>CA</td>
</tr>
<tr>
<td>Matthew Chapman</td>
<td>2007</td>
<td>Assistant Professor, West Point Academy</td>
<td>NY</td>
</tr>
<tr>
<td>Christoph Aschwanden</td>
<td>2006</td>
<td>Project Manager, TRI, UHM</td>
<td>HI</td>
</tr>
<tr>
<td>Holger Mauch</td>
<td>2005</td>
<td>Assistant Professor, Eckerd College</td>
<td>FL</td>
</tr>
</tbody>
</table>

7 Assessment of program outcomes

Following Appendix D, this section analyzes the number of majors, graduates, SSHs offered, employment, etc. in relationship to the objectives.

As noted above, ICS Ph.D. students receive advanced training in the scientific principles and technology required to develop and evaluate new computer systems and applications. A primary objective is to equip our students with the expertise necessary to independently perform state-of-the-art research, to formulate and develop creative solutions to novel and existing problems, and to intelligently manage the research of others. The following assessment of Ph.D. student graduates and career paths indicates that our program outcomes are meeting the program objectives.

7.1 Student graduation and career paths

The ICS Ph.D. program has 14 graduates to date, as listed in Table 4. Out of the 14 graduates, 6 have obtained faculty or post-doc positions, 3 work in a research or higher education institution, and the remaining 5 have positions in industry.

A primary objective of the ICS Ph.D. program is to produce graduates that become leaders in their field once they have achieved at least one major contribution to at least one area of Computer Science research. Our graduates who went to industry all hold senior software design and development positions, which allow them to be key leaders in the high technology and information technology sector. A perfect example of such leadership is provided by one of our 2009 graduates who has recently created his own startup company in Texas. Many of our Ph.D. graduates work in “R&D” organizations, for which the research training they acquired in our program proves invaluable. This training is also key for the 3 graduates that hold positions in research institutes. Finally, 25% of our graduates to date hold faculty positions in research and/or higher education institutions. Even though this number is typical for Ph.D. programs nationwide, we note that students increasingly enter our program with the goal of obtaining a faculty position in the future. For instance,
our two Fall 2010 graduates are moving on to post-doctoral positions as a transition to a faculty position hopefully within two years of their graduation.

Local Impact of Graduates – About 35% of our Ph.D. graduates have stayed in Hawaiʻi. These 5 graduates currently contribute the Hawaiʻi’s economy and higher education: 1 of them is a Senior Scientist for a local hi-tech company, 3 hold research and development positions at UHM, and 1 holds a faculty position at a Community College (KCC).

National Impact of Graduates – All our graduates have national impact in that their work and accomplishments further U.S. economy, research, and/or education. In general, our Ph.D. students are all engaged in original research in many fields of Computer Science. As a result, they publish their results in international competitive venues, thereby contributing to the nation’s (and Hawaiʻi’s) predominance in the international Computer Science research arena. The drive of these graduates to find high-profile positions that match their research interest often entails moving to a few specific locations nationwide. Consequently, a large fraction of our graduates (7 of our 14) currently hold positions on the U.S. mainland (CA, FL, NY, TX),

International Impact of Graduates – Those graduates that hold positions with a strong research component have an international impact in the sense that they further the field and the global technology landscape (through original research publications, patents, and products). To date, only two of our graduates has opted for a position abroad: one in a research institute in Singapore, and one at a research institute in France. While we expect this number to increase, this relatively low number can be simply attributed to the fact that U.S. organizations offer highly attractive positions for our graduates.

8 Assessment of program objectives

Following Appendix D, this section assesses whether the program objectives are still appropriate functions of the University mission and development plans, and can include evidence for the continuing need of the program, projections of employment opportunities for graduates, etc.

The Ph.D. program in Information and Computer Sciences remains not only appropriate but vital to the achievement of the University mission and development plans.

The mission of the Department of Information and Computer Sciences that include Information and Computer Sciences (ICS) and Library and Information Sciences (LIS) programs is to nurture a world-class community of students and faculty dedicated to innovative scientific and information-related research and education for the benefit of the participants, Hawaiʻi, the United States, and the world.

The ICS mission is to prepare students to be research and development leaders in Computer Science and computer technology. To this end, the program is a catalyst and a resource for shaping the future of the broad discipline of Computer Science. The faculty embraces the mutual interdependence of research and teaching to achieve excellence in both. As part of its mission the program brings the latest research findings into courses and actively involves students in research endeavors of the faculty. The program also provides leadership in the application of high technology to improve the educational experience.
8.1 Alignment with university objectives

The University of Hawai‘i system strategic plan approved by the board of regents in June 2002 has the following goals for the system:

- Educational Effectiveness and Student Success
- A Learning, Research, and Service Network
- A Model Local, Regional, and Global University
- Investment in Faculty, Staff, Students, and Their Environment
- Resources and Stewardship

The UH-Manoa mission is as follows:

As a land, sea, and space grant university, the University of Hawaii at Mnoa is dedicated not only to academic and research excellence but also to serving with aloha the local, national, and international communities that surround us. Taking as its historic trust the Native Hawaiian values embedded in the concepts of kuleana, ohana, and ahupuaa that serve to remind us of our responsibilities to family, community, and the environment, Mnoas hallmark is a culture of community engagement that extends far beyond the classroom to bridge theory and practice, fostering creative and critical thinking, and promoting students intellectual growth and success as contributing members of society.

Central to this mission is faculty dedication to a fertile, engaged, and ethical learning environment characterized by a free exchange of ideas, shared intellectual resources, cutting edge scholarship, and high academic expectations. With its unique geographic location bridging East and West, Mnoa serves as a portal to an exceptional educational experience while striving to improve quality of life in the region through collaborative partnerships that support innovations in education, health care, social development, culture and arts, earth, space, and ocean sciences, sustainable land management, and technological advancement.

The ICS departments mission statement closely aligns with both the system goals and the Manoa mission statement.

8.2 Alignment with state objectives

At the state level, Governor Neil Abercrombie’s Technology and Information platform states the need for human capital and education in the area of technology, specifically: The fuel of an innovation economy is our human capacity to learn and create. Everyone can contribute. Education at all levels is the fundamental investment we will make to improve our economy. Industry and public education must work very closely to support each other and ensure highly skilled employees are being prepared at the same rate that high skill jobs are being created.

The need for education in technical fields is further underscored by Office of Department of Business, Economic Development and Tourisms report on Hawai‘i’s Technology Workforce which
states: Computer Services accounted for the largest share of technology jobs in Hawai‘i with about 26% of the total in 2009.

Given the state’s focus on building its technology capabilities and the jobs available in these fields, the Computer Science departments mission statement is well aligned with the State of Hawai‘i’s technology goals.

8.3 Alignment with national objectives

As noted at the beginning of this document, Computer Science is a fundamental discipline and the innovations created by Ph.D. students and graduates in this field have fundamentally changed modern society.

In addition, according to a recent Bureau of Labor Statistics report, the category “Computer and information scientists, research” was one of the top 21 fastest growing occupations of the decade, with a 40% increase in growth.

In a U.S. Department of Commerce, Office of Technology Policy report entitled The Digital Workforce: Building Infotech Skills at the Speed of Innovation (June 1999) Alan Greenspan said, “The rapid acceleration of computer and telecommunications technologies is a major reason for the appreciable increase in our productivity in this expansion, and is likely to continue to be a significant force in expanding standards of living into the twenty-first century.

We believe that the ICS Ph.D. program has already produced research and graduates who have supported this “acceleration”, and that its conversion from provisional to permanent status is well warranted.

9 Conclusion

In this document, we have followed the guidelines in Appendix D to present what we believe are compelling arguments to convert the ICS Ph.D. program from provisional to permanent status. We have shown that the program fulfills university, national, and international needs; that it is congruent with the mission and objectives of the the university, state, and nation; that the program structure is congruent with its objectives; that resources are currently adequate to support the program at its current size; that the program is efficient and that revenues exceed expenses; and that program outcomes are positive for our university and state.

What Appendix D does not request is an analysis of the risks involved with denying the conversion from provisional to permanent status. In other words, what would be likely to happen if the University decided to terminate the ICS Ph.D. program? Here are some of the potential outcomes if the ICS Ph.D. program were to be terminated:

- The “virtuous circle” described in Section 5.1 will be broken; Ph.D. students will no longer amplify the power of our faculty to do quality scientific research, leading to a decrease in our extramural funding success;

- The Hawai‘i high tech community and the legislature will perceive the University as having withdrawn support for an important engine of economic development and diversification.
• Entrepreneurs and outside investors will be less willing to start and/or maintain companies in Hawai‘i, since the University will no longer be able to produce Computer Science Ph.D. graduates and their associated research innovations.

• The ICS Department will be less able to attract promising faculty to the Department, since there will not be a Ph.D. program available to provide them with students. This will lead to lowered scientific productivity, lessening our ability to attract extramural funding.

• The local, national, and international reputation of the ICS Department will be lowered due to the failure of the University to maintain its Ph.D. program. This will reflect negatively on the reputation of the University of Hawai‘i as a whole.

We sincerely hope the above “worst case scenario” will not come to pass, and look forward to celebrating the transition of the ICS Ph.D. program from provisional to permanent status.