PURDUE
UNIVERSITY

The Case for a

School of Computer Science and Engineering

at Purdue University[1]

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"*Computer science is interdisciplinary. It is firmly rooted in engineering and mathematics, with links to linguistics, psychology and other fields.*" ***University of Cambridge.***

"*Being in the College of Engineering creates the vision and emphasis that Computer Science and Engineering is a professional discipline; more problem solving and solution finding—building trans-disciplinary bridges and crossing diverse disciplines….. Engineering emphasizes innovation and problem solving using the knowledge created in Math, Sciences, and Humanities. Math is known as the Queen of Sciences, and Computer Science is rightly the Queen of Engineering and Technology*. " ***C. V. Ramamoorthy, Professor Emeritus, University of California, Berkeley.***

[1] This document was prepared during February 16-May 4, 2009. It is intended for Purdue faculty, staff, and administrators likely involved in considering a proposal to move the Department of Computer Science to the College of Engineering, and for all the well wishers of Purdue University.

Table of Contents

Executive Summary

The Purdue Computer Science Department has evolved significantly over the years, and there are now compelling reasons why it should be moved from the College of Science to the College of Engineering. Like other well-established engineering disciplines, computer science deals with real processes and artifacts, its primary intention being the production of software and hardware of direct value to society. It uses the basic principles and tools of engineering design and analysis to produce these artifacts. Most graduates of Computer Science work alongside engineers. Relocating the Department to the College of Engineering will create a multitude of new opportunities for students, allow the outstanding CS faculty to fully exploit their research potential, and better align Purdue with its peer institutions without in any way sacrificing linkages with other academic units at Purdue. Based on the experience of several other universities, looking back in a few years one will likely conclude that the move was just the right decision.

1. Preamble

This document makes a case in favor of moving the Department of Computer Science at Purdue University to the College of Engineering and creating a new School of Computer Science and Engineering. It is shown that doing so would create a multitude of benefits for Purdue students and faculty, and better align the Computer Science education and research at Purdue with its peers and other leading institutions in the United States and the rest of the world.

2. The Past

The following table summarizes the history of the Department of Computer Science at Purdue since its inception in 1962.[4]

1959	Harold DeGroff, Head of Aeronautical Engineering, recommends to George Hawkins, Dean of Engineering the creation of a computer laboratory "…with an emphasis on graduate work in the field."
1961	President Hovde moves Mathematics Department to the School of Engineering, renaming it as Division of Mathematical Sciences (DMS) and significantly increasing its budget
1962	(a) DMS given control of Computer Sciences Center in the School of Engineering; (b) DMS organized into three separate academic departments: Mathematics, Statistics, and Computer Sciences plus Center for Computing Services; (c) Samuel D. Conte from Aerospace Corporation appointed department head; (d) DMS moved to the Science, Education, and Humanities; (e) Sam Conte appointed Head of CS.
1963	School of Science, Education, and Humanities reorganized as School of Science.
1964	First M.S. degree awarded.
1966	First two Ph.D. degrees awarded; both in Numerical Analysis.
1968	First B.S. degree awarded. Regular faculty size reaches 10
1969	Computer Sciences splits from the Division of Mathematical Sciences

	becomes an independent department with its own budget.
1972	Regular faculty size reaches 20.
1981	First enrollment crisis arrives; an overabundance of undergraduate students
1979	Sam Conte steps down after 17 years as the department head; Peter Denning succeeds Conte as the department head.
1982	One hundredth Ph.D. awarded.
1985	Move to new building (now the Felix Haas Hall). Software Engineering Research Center (SERC) becomes operational with Conte as interim director.
1987	Regular faculty size reaches 30; Richard DeMillo becomes the permanent Director of SERC in 1987
1995	John Rice resigns as department head over resource conflicts; Wayne Dyksen takes over as the interim head.
1996	Second enrollment crisis arrives; an overabundance of undergraduate students; external search begins for head.
1997	Ahmed Sameh succeeds John Rice as the department head.
2000	Three thousandth B.S. degree awarded.
2002	Sameh completes his five-year term; internal search begins; Susanne Hambrusch takes over as the department head.
2007	Regular faculty size exceeds 40; move to new building (Lawson Computer Science Building); Hambrusch completes her five-year term; search begins; Aditya Mathur assumes responsibility as head.
2008	Faculty begins considering a proposal to move the department to the College of Engineering; Provost consulted on a procedure; undergraduate enrollment reaches a significant low; graduate enrollment experiences significant growth.
2009	Fact-finding committee set up to consider a proposal to move to engineering; Dean of the College of Science spells out the charge to the committee

3. Computer Science: A Historical Perspective

Computer science as a discipline has evolved since its beginning and continues to do so at a rate that seems faster than any other discipline in the sciences or engineering.

Electrical engineers, physicists, and mathematicians could be considered as the ones whose work led to the establishment of computer science as a discipline. Depending on a variety of factors, historical and personnel, departments of computer science across the country were established in different colleges in different universities, but the majority of the highly ranked departments are currently in engineering colleges. A brief history follows.

- At Purdue, the Department of Computer Science was created in 1962 in Engineering within the Division of Mathematical Sciences and soon after moved to Science as a part of the same Division. [4,7]
- At the University of Illinois the Department of Computer Science was created in 1965 in the College of Liberal Arts and Sciences. In 1972 the department established its undergraduate degree program in the College of Engineering. The department is now located in Engineering and continues to offer undergraduate degree programs to both Engineering and Liberal Arts & Science (LAS) majors.
- Stanford established its Department of Computer Science in 1965 in the School of Humanities and Sciences. In 1985 the department moved to the School of Engineering. An agreement between the CS and EE departments allowed faculty to transfer from one department to the other as they wished.
- At UC Berkeley, the Department of Computer Science was formed in 1968 in the College of Letters and Science.[3] In 1973 this department was moved to the College of Engineering and joined with Electrical Engineering as an independent division with its own Chair "greatly broadening the scope of education and research activity."
- At UCLA the Computer Science Department was established in 1968 in the School of Engineering and Applied Science and has remained there since.
- At Rice "The Department of Computer Science was formed as a separate department within the George R. Brown School of Engineering in March 1984…Prior to 1984, the computer science program, which had a long tradition of excellence, was offered jointly by the mathematical sciences and electrical engineering departments."[10]

Above, we have listed the creation and move of a few departments of computer science. Similar stories exist in other disciplines. For example, at MIT Physics faculty taught subjects related to Electrical Engineering until 1902 when a separate Electrical

Engineering department was formed [2]. Thus, moving an academic department from its current to its appropriate administrative location is a well-known practice.

4. Engineering, Mathematics, Science, and Computer Science

Let us briefly review the relationships among the four disciplines included in this section's title. First, a sample of definitions:

> **Engineering** is the practice of safe and economic application of the scientific laws governing the forces and materials of nature by means of organization, design and construction, for the general benefit of mankind." [S. E. Lindsay (1920)]
>
> **Engineering** is the discipline and profession of applying scientific knowledge and utilizing natural laws and physical resources in order to design and implement materials, structures, machines, devices, systems, and processes that realize a desired objective and meet specified criteria…. [from en.wikipedia.org/wiki/Engineering]
>
> **"Science** is the systematic observation of natural events and conditions in order to discover facts about them and to formulate laws and principles based on these facts." [Academic Press Dictionary of Science & Technology]

In the 19th century, Engineering became recognized as a discipline separate from Science. What used to be tools became machines that in turn were connected and became systems. Some of these systems now function in a mostly automated way, electric power station being an example of such a system. Thus, while Science and scientists continue to fathom the secrets of nature, Engineering and engineers feverishly work to improve existing systems. Certainly, there are situations where they work together, such as in genomics, where machines built by engineers aid scientists to uncover nature's secrets. [5,6]

George Forsythe, a noted computer scientist who established the Department of Computer Science at Stanford said: "What can be automated? is one of the most inspiring philosophical and practical questions of contemporary civilization." [8] Engineers aim at automation, and so do computer scientists. Engineers aim at constructing new artifacts or improving the existing ones, and so do computer scientists.

Engineering is predominantly an applied discipline, and so is computer science. There are so called “theorists” in Engineering who do not consider themselves as applied and that too is true of computer science.

Mathematics serves as the foundation of many disciplines and certainly all disciplines in engineering and the sciences. Of mathematics, Carl Gauss said it is “the Queen of the Sciences.” Neither a scientist nor an engineer can abandon Mathematics without hampering progress. Mathematics allows abstraction of natural processes and enables the creation of artificial reality. Engineers use various kinds of mathematics to model, approximate, and then implement. Scientists use it to model, experiment, and conjecture. Thus mathematics is neither engineering nor a science discipline, it is simply Mathematics. Computer scientists use mathematics for exactly the same purpose as engineers.

The question of importance to us is, “Where does computer science belong?” To answer this, let us examine some activities that a computer scientist engages in. Consider a researcher who desires to make applications secure. [1] A formal model of access control policy is developed. The model allows organizations developing and deploying an application to specify a policy tailored to their organization. The policy is implemented in the application, and the application is tested to ensure that access violations couldn’t take place under reasonable assumptions. The process described so far makes use of mathematical formalisms and software engineering to produce an artifact that improves the ability of businesses to function without fear of malicious attacks. Clearly, the researcher (and all others involved) has aimed at practical ends. There was no intention to discover laws of nature, but there was the intention of improving how things work.

As another example, consider the problem of predicting the reliability, integrity, and survivability of micro electromechanical systems (MEMS), also known as micro switches. “A major challenge is creating multiscale simulations that bridge a broad range of size and time scales associated with objects measured in nanometers, or billionths of a meter, to objects measured in millimeters.”[9] Meeting this challenge, among other things, requires modeling and the development of parallel algorithms for creating very large-scale simulations that will exploit the power of peta-scale computers. Once again, the intention here is not the discovery of fundamental laws of nature, but to understand what will and will not affect the manufacturing of MEMS and nano-devices. Thus, the

entire project is an engineering enterprise with computer science serving as a key enabler.

Many more examples analogous to the ones above can be drawn from specific sub-disciplines of computer science. An examination of such examples could be used to define computer science as a field that applies algorithmics[2] to create new or evaluate existing artifacts. These artifacts in turn improve people's lives through, for example, improved services such as communication and transportation.

Today, computer science and computer scientists are at the forefront of improving automation. Furthermore, the most basic tools, e.g., an operating system, and techniques, e.g., information transfer via networks, developed by computer scientists are used in every engineering discipline. Thus, just as a given engineering discipline supports other disciplines through its innovations, so does computer science.

5. Computer Science and Other Disciplines

Like several other disciplines, computer science is highly interdisciplinary by nature. Computer scientists, who work on problems of an applied nature, work with engineers from all areas, with linguists, with artists, with scientists, and so on. Computers and computer scientists are playing an active role in the advancement of other disciplines. However, it would be wrong to use this role of computer science to classify Computer Science as a discipline in Natural Science or Liberal Arts. Doing so would force us to ask the question "Is Electrical Engineering a discipline in the natural sciences simply because biologists and chemists use a lot of highly advanced electrical equipment?"

One might argue that computer scientists develop algorithms that help scientists or artists to solve problems. This, too, is the wrong argument to use to classify computer science as a discipline of natural science or liberal arts. Any such classification would be inconsistent with the basic goal of most subfields of computer science and that is to improve automation. Thus regardless of the linkage of Computer Science to any other discipline, it remains an intrinsically applied field that finds new ways of improving peoples lives through automation and, hence, is engineering.

[2] Algorithmics here refers to the use of a class of software development and analysis techniques.

6. Culture Match

Goals and environment shape the work culture in an organization. This belief holds at universities, colleges, and their departments. Computer science matches the culture in engineering better than in science. Scientists work towards understanding how nature works. They attempt to uncover the laws and machinations of nature. The infinite complexity of nature forces scientists to be extra careful and deliberate in their work. For many a scientist, the path to a new discovery is a reward in itself. In contrast, engineers work to create new artifacts or improve existing ones. In this process they often use scientific theories and laws, as well as mathematics. Engineers are elated at the construction of new artifacts that outperform existing ones in some ways. Thus, while the glory of many a scientist lies in discovery that of an engineer lies in creation.

The differences in the pursuits of scientists and engineers lead to different reward systems and work methods. For example, a publication in a top tier conference is considered an achievement for a computer science faculty member. A scientist, on the contrary, aims at getting a publication in high impact journals such as Science or Nature. At a more abstract level, a scientist often has longer-term goals than an engineer. Such differences in the two cultures affect various processes and policies within departments in the Colleges of Science and Engineering. These differences include the tenure and promotions processes, teaching loads, as well as the definition, meaning, interpretation, and reward for scholarly activities, and several others.

Traditionally, universities have understood and acknowledged cultural differences and organized departments into colleges such as engineering, science, agriculture, and liberal arts. Moving the Department of Computer Science to the College of Engineering will enable Purdue to correct a historical aberration in its organizational structure, and will most likely lead to higher national ranking for Purdue in Computer Science as well in Computer Engineering.

7. Advantages of the Proposed Move

Below is a brief list of what many consider as advantages of moving the Department of Computer Science to the College of Engineering.

a. *Synergy and cost savings*: Improved synergy between departments in the College of Engineering and Computer Science. Computing is now a critical element of every engineering discipline and such a synergy is essential to educate and graduate engineers of the future. Such synergy will likely enhance collaboration among faculty in CS and departments in the College of Engineering. For example, there exists a significant overlap between faculty from CS and CE in areas such as compilers, distributed computing, networking, parallel computing, and software engineering. Moving CS to the CoE will lead to new possibilities for collaboration among these faculty resulting in research and curricular innovations. In the long run, such collaboration will likely lead to significant cost savings to the University.
b. *Rankings*: In the long run, the move will likely lead to improved departmental ranking among its peers. The increase in ranking is expected as a consequence of (a) improved student quality at both the undergraduate and graduate levels, (b) increased research funding as a consequence of increased pressure on faculty to seek research funding, and (c) change in culture of the environment and, hence, increased appreciation for applied research.
c. *Funding*: Improved chances of collaborative and interdisciplinary funding from programs in the NSF's Directorate of Engineering.
d. *Degree programs*: The department will be able to initiate new degree programs for undergraduate and graduate students. Many of these programs will be interdisciplinary with other Schools within the College of Engineering.
e. *Enrollment and quality*: The undergraduate enrollment in the department will likely double assuming that undergraduate degrees will be offered in both the Colleges of Engineering and Science. This will also improve the quality of incoming undergraduates. The overwhelming majorities of excellent CS students, who seek graduate education, are the products of engineering colleges and prefer to remain in Engineering.
f. *Faculty quality*: The overwhelming majority of excellent fresh CS doctorates are graduates of Engineering Colleges and wishes to remain so. Our department will have more of a chance to recruit such junior faculty if we are in the College of Engineering.
g. *Organization*: Computer Science will be placed where it truly belongs as a predominantly applied discipline. Thus, the administrative home of the

Department will be in line with seven out of the eleven of Purdue's peer universities. Among Purdue's peers only three CS departments are in Science.

h. *Corporate engagement*: Nearly all members of the department's Corporate Partners are primarily engineering companies. Placing the department in the College of Engineering will likely improve the potential of these companies to recruit graduates with a computing and engineering orientation.

i. *K-12 interaction:* Pre-college instruction in computing needs a significant change. A large fraction of students entering CS are ill prepared. This has led to poor retention. In collaboration with departments in engineering, in particular ECE, CS will have a rich opportunity to work with the State of Indiana education board to significantly alter this situation. CS will be able to launch high school teacher training programs with the goal of introducing across the state, classes in the area of problem solving using computers. Collaboration with engineering will allow such classes to be hands on where students actually build and program real-life objects.

8. Benefits to Students

The single largest beneficiary of the proposed move to engineering will be the student at Purdue. While learning computer science in the College of Science, the students rarely connect with students and faculty in other science departments, except of course when they take classes to fulfill their science requirements. Thus, while they learn the foundations of CS and how to apply these to building artifacts, they rarely work on "science" related projects. Their internships are in predominantly engineering environments. Upon graduation they find employment in companies where they work alongside, among others, Electrical Engineers, e.g., at Cisco, Garmin, Intel, Motorola, Qualcomm, and Siemens; Software Engineers, e.g., at Amazon, Arxan, Booze Allen Hamilton, Citadel, Crow Horwath, EDS, FactSet, Google, ICF, Microsoft, IBM, HP, Principal Financial Group, State Farm Insurance, and Target; Mechanical and Aerospace engineers, e.g., at Boeing, Caterpillar, Exxon Mobile, Harris, Lockheed Martin, Northrop Grumman, Ontario Systems, and Raytheon; and Biomedical engineers, e.g., at Beckman Coulter and Eli Lilly.

The move will allow students who enter CS through engineering to spend a year taking courses within the freshman engineering core curriculum. This in turn enables them to carefully assess their interest in CS before they decide whether or not this is the right discipline for them. Thus a move to engineering will likely lead to improved retention.

Placing CS in engineering will add to the opportunities the students are exposed to. For example, they will be able to learn more about the interaction between computer architecture and software. An understanding of such interactions is crucial to the efficient development of software that will drive, for example, the cars and airplanes of the future. The students will get an opportunity to minor in other engineering disciplines and improve their skill and knowledge set. While such a minor is possible now, the difference in the requirements of the two colleges places a significant barrier for the students.

The students will get a unique opportunity to embark on specialized joint degrees with other engineering disciplines. Such opportunities exist today in only a few universities that include Berkeley and MIT. Thus, for example, Purdue will be able to graduate a completely new breed of engineers that have a sound knowledge of the foundations of both Mechanical Engineering and Computer Science. Such a graduate would be a unique asset to organizations such as NASA and companies such as Boeing.

Computational modeling and high performance simulation is a fast growing area. Moving CS to engineering will provide new opportunities to mathematically inclined students where they learn to apply the skills of a computer scientist, and their mathematical abilities, to engage in projects such as modeling nano devices, cells, and other physical and natural objects.

9. Disadvantages of the Proposed Move[3]

Clearly, an organizational change such as the one proposed here will likely lead to tensions and anxiety among faculty and staff. The prospects of a change in culture would generate among faculty and staff concerns about workload, promotions, and tenure. It is therefore important that the move be implemented carefully in close cooperation with the Deans of Engineering and Science, and CS faculty. The next section suggests possible logistics of the move.

[3] While this section might appear overly short, so far no one in CS has come forward to create a document that presents arguments against the move to engineering.

10. Logistics of the Proposed Move

Move the department of Computer Science to the College of Engineering and rename it as the **School of Computer Science and Engineering.** To ensure a smooth transition to the new college, there should be a *transition period of four years*. Responsibilities and activities during the transition period are as follows:

- *Reporting*: The department head will report to the deans of the College of Science and the College of Engineering. A high level committee will review during the third year all aspects of the department and recommend that either (a) the department be moved from the College of Science and be fully integrated into the College of Engineering or (b) the department remain in the two colleges until any further administrative changes are recommended. Note that the Department of Agricultural and Biological Engineering uses the model implied in (b).
- *Planning*: The department will develop a strategic plan with clearly articulated goals aimed at improving its rankings and the overall quality of education offered at both the undergraduate and graduate levels to CS majors and to those who need education in the basics of computing.
- *Tenure and promotion*: All tenure and promotion cases will be routed through the area committee of the College of Science.
- *Hiring*: All faculty hiring will be done through the College of Engineering. Current joint appointments will remain unchanged and new joint appointments with other colleges and departments will be encouraged to enhance inter- and trans-disciplinary activities.
- *Educational programs*: After consultation with faculty, an undergraduate degree program will be established in the College of Engineering while retaining the one in the College of Science. This program will take students from Freshman Engineering. The program will be designed in collaboration with the Computer Engineering faculty. Note that several other universities, e.g., UIUC and University of Michigan, offer such programs. This program could begin as early as in 2010-11 or latest in 2011-12.
- *Admissions*: All admissions into the CS graduate program will be through the College of Engineering.
- *Others*: All other aspects of the department functions, including the business office and budgeting, will be adjusted based on inputs from the deans of the two

colleges keeping in view the best short and long term interests of the students, faculty, and staff.

11. Finally, a Vision!

Below is a list of goals that the department ought to strive for by 2015. Realization of these goals will bring the department back to its days of glory in the 80's and early 90's. The likelihood of achieving these goals increases if the department were to be located in the college that is academically the best fit, and that is the College of Engineering. Eventually the goals below will likely be part of a departmental strategic plan developed with the involvement of all members of its faculty.

Ranking:

- Top 12 in the nation as determined by the NRC and US News and World Report.
- Top 4 among peer institutions
- Top 2 among CIC institutions

Faculty strength, research and academic programs:

- Faculty strength increased to 50 FTEs.
- Department offers B.S. degrees in both colleges, Engineering and Science and offers a new B.A. degree in collaboration with the College of Liberal Arts.
- Department offers dual degree programs with other engineering disciplines.
- Research expenditure increased from $130K/FTE to $250K/FTE with a total research expenditure of around $12Million/year.
- Significantly increased collaboration with ECE in terms of teaching and research leading to a significant reduction in course overlap and increase in resource sharing.
- At least one new interdisciplinary undergraduate degree program and one new graduate degree program added.

Enrollment and graduation:

- Number of women in the undergraduate program increased three fold.
- Number of underrepresented minority students doubled.
- Number of domestic students graduating with an MS or a PhD degree doubled.
- Undergraduate enrollment stabilized at around 600 (faculty/student ratio of 1:12).

- Graduate enrollment stabilized at around 300 (faculty/student ratio of 1:6).
- Average PhDs graduated increased from 0.35/faculty/year to 1/faculty/year.

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Appendix A: Faculty Concerns and Frequently Asked Questions

1. *Who initiated the move to engineering?*
    - Aditya Mathur, Head CS, initiated discussions on a possible relocation of the Department of Computer Science to the College of Engineering. He did so after consulting with senior administrators, Deans of Engineering and Science, and the three past department heads of Computer Science. It was important to consult the administration prior to initiating the discussion to avoid potential waste of faculty time. It was important to consult the past department heads as they had knowledge of past efforts at moving CS to Engineering.
2. *Why will we become better just by moving to Engineering?*
    - College of Engineering offers a better culture match for Computer Science than the College of Science.
    - Departments in the College of Engineering use and enforce performance evaluation criteria appropriate for Computer Science faculty.
    - Interaction with industry is likely to increase as a consequence of moving to engineering. This will improve our chances of technology transfer and having impact in the real world.
    - In the short term, say 3-5 years, change in CS rankings is not likely to be significant. However, in the long run, primarily due to culture match, many believe that CS will surely be a much better, highly regarded, and highly ranked department.
3. *We are concerned about morale.*
    - If the move takes place, those against the move might be unhappy. If the move does not take place, some other faculty might be unhappy. However, every effort will be made to ensure that there is no negative effect of the move on the research and teaching activities of CS faculty.
4. *Some ECE faculty members want to move to CS. Why should we move to Engineering?*
    - It is one thing to say and another to actually do. Given an option to move to CS, they actually might not move given that CS is not as highly ranked as ECE. On the contrary, many faculty hired in CoE are from highly ranked schools.

- It is important for us not to look at policies and procedures only in ECE; instead we should be broader in our examination.

5. *How will I suddenly become "prettier" by moving to Engineering?*
    - You might not, but the department will most likely will become better. At least those who did move, e.g., Michigan and Berkeley, claim that they took the right actions a few decades ago. None of those CS departments who moved from science to engineering regret having done so.
    - As the older generation leaves the department due to retirement, etc., the new generation will quickly adapt to the Engineering culture that promotes meeting more short-term goals than Science.
6. *ECE faculty members do not get adequate TA support and hence their research suffers. One person has 40 students in his class but no TA support, so his RA doubles as TA.*
    - It is true that schools in Engineering have a rather rigid policy for assigning teaching assistants. However, as we consider the move to Engineering, Science has already proposed reducing our TA budget by 20% during 2009-2011.
7. *We are quite happy here, why should we move to Engineering?*
    - The move is not intended to make happy people unhappy.
8. *Many on our faculty collaborate with CoS faculty, why then should we be in CoE?*
    - We conduct research towards building better, efficient, reliable, and high performance products. Such activity is in line with what engineers do. While scientists aim at discovering laws of nature, engineers work on building new and improved things.
9. *Our supposedly dismal numbers look even worse when compared to engineering departments.*
    - The goal of the proposed move is to place the department in an environment where it can flourish. With support from engineering administration, and being in the right environment, the potential exists for growth across all areas including research and education.
10. *Less active faculty can be squeezed equally well here – why is squeezing in engineering more effective than in CoS?*
    - The words "less active" grossly misrepresents CS faculty. No faculty member in CS is "less active." Also, it is not the goal of the proposed move to "squeeze" faculty. The goal is to place CS in its right environment. Doing

so will allow, over time, for the true culture of Computer Science to seep into its faculty and hence the potential to flourish.

11. *How should we interpret the statistics that are shown to us?*
    - Rankings of CS are down across almost all criteria used by faculty and ranking agencies. Our enrollments are down while our faculty size is up significantly. Hence our cost of educating students is higher than most departments in CoE and CoS. We ought to think creatively and boldly to change this situation for the better.
12. *Some students like to be known as "scientists." They might be disappointed if a CS degree is now being offered through engineering.*
    - There is no need to stop offering CS degrees to students entering through the College of Science. Thus students who want to enter CS through the College of Science would continue to be able to do so. In fact, the move is an opportunity for the department to offer a rich degree that provides new options to the students. For example, one new option could be an "embedded systems" specialization in which students take courses in CS as well as more architecture-oriented courses in computer engineering. Several universities where CS is located in engineering, such as UIUC and U of Michigan, already offer such options.
13. *In engineering it is very difficult to make any change in course textbooks or weekly lecture plan.*
    - All departments in the College of Engineering are ABET accredited. This does force the departments to adhere to well-defined procedures to make any changes in their curriculum. These procedures are not prescribed by ABET. These procedures are believed to be beneficial to the students in engineering as it leads to some level of consistency in course offerings regardless of the instructor, and ensures that the expected outcomes from each course are indeed realized. However, CS faculty would have the option of not going after accreditation. Of the 36 top CS departments in the colleges of engineering across the country, only 14 are ABET accredited, 22 are not.
14. *Should CS follow the hybrid model of the Department of Agricultural and Biological Engineering (ABE) and simultaneously be in the colleges of Engineering and Science?*

- This appears to be a good approach in the interim. It will allow a gradual transition from Science to Engineering. However, it should be noted that ABE as a discipline is rooted in Agriculture as well as in Engineering, and hence a hybrid model seems most appropriate. On the contrary, CS has clearly evolved into a predominantly applied and an engineering discipline and hence, in the steady state, College of Engineering is its most appropriate home. The fact that CS uses a significant amount of mathematics would not be the right argument to keep it in the College of Science; note that all engineering disciplines rely heavily on mathematics.

15. *What would be the benefits of the move to CS faculty with joint appointments within science? Will they need to move out of CS to the majority/minority science department?*
    - Faculty with joint appointments will continue to receive all the benefits they currently enjoy in science. In addition, the move will provide them access to students who enter CS via the College of Engineering.
    - Several faculty members in the College of Engineering have joint appointments with departments in other colleges including science and liberal arts. Thus, CS faculty with joint appointments will not need to make any changes to their joint appointments.
16. *We want to know the advantages of moving to the College of Engineering.*
    - *Synergy and cost savings*: Improved synergy between departments in the College of Engineering and Computer Science. Computing is now a critical element of every engineering discipline and such a synergy is essential to educate and graduate engineers of the future. Such synergy will likely enhance collaboration among faculty in CS and departments in the College of Engineering. For example, there exists a significant overlap between faculty from CS and CE in areas such as compilers, distributed computing, networking, parallel computing, and software engineering. Moving CS to the CoE will lead to new possibilities for collaboration among these faculty resulting in research and curricular innovations. In the long run, such collaboration will likely lead to significant cost savings to the University.
    - *Rankings*: In the long run, the move will likely lead to improved departmental ranking among its peers. The increase in ranking is expected as a consequence of (a) improved student quality at both the undergraduate and graduate levels, (b) increased research funding as a

consequence of being in an environment that better matches CS culture, and (c) change in culture of the environment and, hence, increased appreciation for applied research. It is worth noting that a large fraction of research grants that flow into the College of Engineering are from corporations. This helps maintain a large number of graduate students with financial support, which in turn leads to increased research and improved chances of technology transfer. In the long run, departments with a predominantly applied bent benefit from interactions with corporations.

- *Funding*: Improved chances of collaborative and interdisciplinary funding from programs in the NSF's Directorate of Engineering.
- *Degree programs*: The department will be able to initiate new degree programs for undergraduate and graduate students. Many of these programs will be interdisciplinary with other Schools within the College of Engineering.
- *Enrollment and quality*: The undergraduate enrollment in the department will likely double assuming that undergraduate degrees will be offered in both the Colleges of Engineering and Science. This will also improve the quality of incoming undergraduates. The overwhelming majority of excellent CS students, who seek graduate education, are the products of engineering colleges and prefer to remain in Engineering.
- *Faculty quality*: The overwhelming majority of excellent fresh CS doctorates are graduates of Engineering colleges and wish to remain in Engineering. Our department will have more of a chance to recruit such junior faculty if we are in the College of Engineering.
- *Organization*: Computer Science will be placed where it truly belongs as a predominantly applied discipline. Thus, the administrative home of the Department will be in line with Purdue's peer universities.
- *Corporate engagement*: Nearly all members of the department's Corporate Partners are primarily engineering companies. Placing the department in the College of Engineering will likely improve the potential of these companies to recruit graduates with a computing and engineering orientation.

Appendix B: Administrative Location of Computer Science Departments

Sources: (a) Rankings: US News and World Report, 2008-09. (b) Administrative Location: University web sites. (c) Comparison with engineering departments at Purdue: Office of Institutional Research. (d) Various web sites that rank universities across the world.

A. In top 10 Engineering Schools

[Total: 10. In Engineering: 7. In Engineering and Applied Science: 1. In separate college: 2. In Science 0.]

University	Administrative Location of CS Department
Massachusetts Institute of Technology	School of Engineering
Stanford University	School of Engineering
University of California--Berkeley	College of Engineering
Georgia Institute of Technology	College of Computing
University of Illinois--Urbana-Champaign	College of Engineering
California Institute of Technology	Engineering and Applied Science
Carnegie Mellon University	School of Computer Science
University of Southern California	School of Engineering
Cornell University*	College of Engineering
University of Michigan--Ann Arbor	College of Engineering

* In College of Computing and Information Science offering degrees in College of Arts and Sciences and College of Engineering.

B. In schools where programs in Undergraduate Computer Engineering are in top 10

[Total: 10. In Engineering: 6. In Engineering and Applied Science: 1. In separate college: 2. In Science: 1.]

University	Administrative Location of CS Department
Massachusetts Institute of Technology	School of Engineering

Stanford University	School of Engineering
Carnegie Mellon University	School of Computer Science
University of California--Berkeley	College of Engineering
University of Illinois--Urbana-Champaign	College of Engineering
Georgia Institute of Technology	College of Computing
University of Michigan--Ann Arbor	College of Engineering
California Institute of Technology	Engineering and Applied Science
Cornell University*	College of Engineering
University of Texas--Austin	College of Natural Sciences

* In College of Computing and Information Science offering degrees in College of Arts and Sciences and College of Engineering.

C. In schools where graduate programs in Computer Science are ranked from 1 through 61

[Total 64. In Engineering: 26. In Engineering and Applied Science: 13. In Arts/Science: 18. In both: 1. In Technology: 1. In separate college: 5.

University	**Administrative Location of CS Department**
Massachusetts Institute of Technology	School of Engineering
Stanford University	School of Engineering
University of California--Berkeley	College of Engineering
Carnegie Mellon University	School of Computer Science
University of Illinois--Urbana-Champaign	College of Engineering
Cornell University**	College of Engineering
Princeton	School of Engineering and Applied Science
U of Washington	College of Engineering and College of Science*
Georgia Institute of Technology	College of Computing
University of Texas--Austin	College of Natural Sciences
Caltech	Division of Engineering and Applied Science

U of Wisconsin	College of Letters and Science
UCLA	School of Engineering and Applied Science
U of Maryland	College of Computer, Mathematical and Physical Sciences
U of Michigan	College of Engineering
Columbia	School of Engineering and Applied Science
Harvard	School of Engineering and Applied Science
UC San Diego	School of Engineering
Purdue	College of Science
Brown	Physical Sciences
Duke	College of Arts & Sciences
Rice	School of Engineering
U of Mass, Amherst	College of Natural Sciences and Mathematics
UNC, Chapel Hill	College of Arts and Sciences
U of Pennsylvania	School of Engineering and Applied Science
USC	School of Engineering
Yale	School of Engineering and Applied Science
Johns Hopkins	Whiting School of Engineering
Penn State	College of Engineering
U of Virginia	School of Engineering and Applied Science
NYU	College of Arts and Science
Ohio State	College of Engineering
Rutgers	School of Arts and Sciences
SUNY-Stony Brook	College of Engineering and Applied Sciences

UC Irvine	Bren School of Information and Computer Science
U of Minnesota	Institute of Technology
UC Davis	College of Engineering
UC Santa Barbara	College of Engineering
Northwestern University	College of Engineering
U of Arizona	College of Science
U of Chicago, Illinois	The College, Physical Science Division
U of Colorado, Boulder	College of Engineering an Applied Science
U of Florida, Gainesville	College of Engineering
U of Utah	College of Engineering
Washington University, St Louis	School of Engineering and Applied Science
Texas A&M, College Station	Texas A&M Engineering
Virginia Tech	College of Engineering
Boston University	College of Arts and Sciences
Dartmouth College	School of Arts and Sciences
IU Bloomington	School of Informatics
NC State University	College of Engineering
Rensselaer Polytechnic	School of Science
U of Pittsburgh	College of Arts and Sciences
U of Rochester	School of Arts and Sciences
Arizona State University	Ira A. Fulton School of Engineering
Michigan State University	College of Engineering
SUNY, Buffalo	Engineering and Applied Science
UC Santa Cruz	Baskin Engineering
UI Chicago	College of Engineering
Vanderbilt University	School of Engineering
Iowa State University	College of Liberal Arts and Sciences

Northeastern University	College of Computer and Information Science
University of Iowa	College of Liberal Arts and Science
University of Tennessee, Knoxville	College of Engineering

*Except for the department names, the exact same department is listed in both colleges. In CoS it is referred to as Computer Science and in CoE as Computer Science and Engineering.

** In College of Computing and Information Science offering degrees in College of Arts and Sciences and College of Engineering.

D. Among Purdue's Peer Universities

[Total: 11. In Engineering: 7. In separate college: 1. In Science: 3.]

University	**Administrative Location of CS Department**	**National Rank**
Cornell University	College of Engineering	6
Georgia Institute of Technology	College of Computing	9
Penn State	College of Engineering	29
Texas A&M	College of Engineering	46
U of Arizona	College of Science	40
U of Wisconsin	College of Letters and Science	12
UC Davis	College of Engineering	37
University of California--Berkeley	College of Engineering	3
University of Illinois--Urbana-Champaign	College of Engineering	5
University of Michigan--Ann Arbor	College of Engineering	15
University of Texas--Austin	College of Natural Sciences	10

E. Colleges of Computing and their rankings

University	Administrative Location of CS Department	National Rank
Carnegie Melon	College of Engineering	4
Cornell University	Computer and Information Science	6
Georgia Institute of Technology	College of Computing	9
UC Irvine	Ben School of Information and Computer Science	31
Northeastern University	College of Computer and Information Science	61
DePaul University	College of Computing and Digital Media	72
Florida International University	College of Engineering and Computing	72
Illinois Institute of Technology	Babson College of Computing	72
NJIT	College of Computing Sciences	72
University at Albany	College of Computing and Information	72
U North Florida	Computing, Engineering and Construction	Not ranked
Southern Utah University	College of Computing, Integrated Engineering, and Technology	Not Ranked
Rochester Institute of Technology	Golisano College of Computing and Information Sciences	Not Ranked

* US News and World Report combined a number of schools into a single rank—72 and listed their score as N/A.

F. In schools of the letter writers for this year's promotion cases in CS (fall 2008):

Total: 25. In Engineering: 12. Separate School: 6. In Science (or Arts): 6. Unknown: 1

Aalborg University	Faculties of Engineering, Science and Medicine
Brown University	Physical Sciences
Carnegie Mellon University	School of Computer Science
Dartmouth University	Arts & Sciences
Duke University	College of Arts & Sciences
Georgia Institute of Technology	College of Computing
Harvard University	School of Engineering & Applied Sciences
Johns Hopkins University	School of Engineering
National Technical University of Athens	School of Electrical and Computer Engineering
National University Singapore	School of Computing
Penn State University	College of Engineering
Stanford University	School of Engineering
SUNY at Albany	College of Computing and Information
TU Darmstadt	?
Universit di Padova	Faculty of Engineering
University of California, Los Angeles	School of Engineering & Applied Science
University of Illinois at Urbana-Champaign	College of Engineering
University of Massachusetts, Amherst	College of Natural Sciences and Mathematics
University of Michigan (EECS)	College of Engineering
University of Texas at Austin	College of Natural Sciences
University of Toronto (ECE)	Faculty of Applied Science & Engineering
University of Waterloo	Faculty of Mathematics
University of Wisconsin-Madison	College of Letters & Life Science
Washington University in St. Louis (CS & E)	School of Engineering & Applied Science
Weizmann Institute of Science	Faculty of Mathematics and Computer Science

G. At CIC Institutions [Rankings from US News and World Report Feb 16, 2009]

[Total: 13. In Engineering: 8. In Arts/Science: 4. In separate School: 1

University	**Administrative Location of CS Department**	**Rank**
Indiana University	School of Informatics	48
Michigan State	College of Engineering	55
Minnesota	Institute of Technology*	31
Northwestern	College of Engineering	39
Ohio State	College of Engineering	31
Penn State	College of Engineering	29
Purdue	**College of Science**	**19**
U of Iowa	College of Liberal Arts and Science	61
U of Michigan	College of Engineering	13
UIC	College of Engineering	58
UIUC	College of Engineering	5
University of Chicago	The College, Physical Science Division	39
Wisconsin	College of Letters and Science	11

* Engineering departments are in the Institute of Technology.

H. At academic institutions represented on committee for department's external review

[Total: 8. In Engineering: 4. In Arts/Science: 2. In separate School: 2.]

University/Company	**Review Year**	**Administrative Location of CS Department**
U of Washington	1999/2005	College of Engineering
U of Maryland	1999	College of Computer, Mathematical, and Physical Sciences
UC Riverside	1999	College of Engineering

Georgia Tech	1999	College of Computing
U of Arizona	2005	College of Science
Boston University	2005	College of Arts ands Sciences
Stanford	2005	College of Engineering
U of Illinois	2005	College of Engineering

I. In Top 10 universities outside of the United States

Source TopUniversities [http://www.topuniversities.com/university_rankings/results/2008/overall_rankings/top_100_universities/]

[Total: 10. In Engineering/Technology: 3. In Engineering and Science: 3. In separate college: 2. In Science: 1. Other: 1]

University	**Country**	**Administrative Location of CS Department**
University of Cambridge	UK	School of Technology
University of Oxford	UK	Division of Mathematical, Physical, and Life Sciences
IMPERIAL College London	UK	Faculty of Engineering
University College London	UK	Faculty of Engineering Sciences
Australian National University	Australia	College of Engineering and Computer Science
University of Tokyo	Japan	Graduate School of Information Science and Technology.
MCGILL University	Canada	Faculty of Science
KING's College London	UK	Physical Sciences and Engineering
University of Edinburgh	UK	College of Science and Engineering
ETH Zurich	Switzerland	Engineering (Ingenieurwissenshaften)

J. In top universities in India

Source: http://www.graduateshotline.com/univworld.html

[Total: 6. In Engineering: 6. In Engineering and Science: 0. In separate college: 0. In Science:0.]

University	Administrative Location of CS Department*
Indian Institute of Science	Engineering
IIT Bombay	Engineering
IIT Kanpur	Engineering
IIT Delhi	Engineering
IIT Kharagpur	Engineering
IIT Chennai	Engineering

**All CS departments in the IITs are named Computer Science and Engineering. Many other reputable institutions of higher leaning in India have, from the beginning, located Computer Science in their respective colleges of engineering.*

K. In Top 10 universities in China

Source: http://i.cs.hku.hk/~tse/topten.html#China

[Total: 10. In Engineering/Technology: 5. In Engineering and Science: 4. In separate college: 1. In Science: 0.]

University	Administrative Location of CS Department*
The University of Hong Kong	Faculty of Engineering
The Hong Kong University of Science and Technology	School of Engineering
The Chinese University of Hong Kong	Faculty of Engineering
Peking University	College of Engineering
Tsinghua University	School of Information Science and Technology
Fudan University	School of Information Science and Engineering
University of Science and Technology of China	Information Science and Technology
Nanjing University	School of Technology
Shanghai Jiao Tong University	School of Software

City University of Hong Kong	College of Science and Engineering

** "Technology" is mostly understood as Engineering outside of USA and is quite different in its focus from the departments in the College of Technology at Purdue.*

L. Selected universities outside of the United States

Source: http://www.topuniversities.com/university_rankings/results/2008/overall_rankings/top_100_universities/

[Total: 16. In Engineering: 7. In Engineering and Science: 4. Separate department by itself: 2. In Science: 3.]

University	**Country**	**Administrative Location of CS Department***
University of Queensland	Australia	School of Information Technology and Electrical Engineering
Katholieke Universiteit Leuven	Belgium	Faculty of Engineering
University of Copenhagen	Denmark	Faculty of Science
Alexandria University	Egypt	Faculty of Engineering
École Normale Supérieure de Lyon	France	Computer Science
University Of Karlsruhe	Germany	Computer Science
Politechico Di Milano, Milano	Italy	School of Engineering
Kyoto University	Japan	Faculty of Engineering
University of Amsterdam	Netherlands	Faculty of Sciences
The University of Auckland	New Zealand	Faculty of Science
Lahore University of Management Sciences	Pakistan	School of Science and Engineering
Nanyang Technological University	Singapore	College of Engineering
Seoul National University	South Korea	College of Engineering
UPPSALA University*	Sweden	Faculty of Science and Technology
National Tsing-Hua University	Taiwan	College of Electrical Engineering and Computer Science
Middle East Technical University	Turkey	Faculty of Engineering

Appendix C: ABET Accreditation of Departments of Computer Science

Data in the following table is compiled from 57 departments. This data indicates that a majority of the CS departments that are in Engineering do not opt for ABET accreditation.

Location	Accredited	Not Accredited
Eng/Eng&AS	14	22
Science	1	13
CoC	3	4
TOTAL	**18**	**39**

Eng/Eng&AS: Engineering or Engineering and Applied Science

CoC: College of Computing (or a separate college)

Appendix D: Possible New Degree Programs Consequent to the Move

The CS faculty, in consultation with faculty from other schools in engineering, could consider establishing the following new academic programs in addition to continuing to offer the existing BS degree in the College of Science.

Program	Description	Benefits
Computer Science and Engineering for undergraduates	This will be a new track, possibly joint with Computer Engineering, for students admitted in the College of Engineering.	• New opportunities for Purdue students • Increased collaboration with ECE • Increased enrollment for CS
Joint BS with other engineering schools	This will be a 4-year degree intended to generate a new breed of students who will reshape the future of product design and development. MIT and Berkeley offer such degrees.	• New opportunities for Purdue students • Increased collaboration with other schools in engineering
MS in CS for engineers	This will be a 2-year degree program in CS for engineering graduates who wish to expand their knowledge and skills in Computer Science.	• New opportunities for Purdue students
International BS degree in CS	This will be a 4-year degree program developed in collaboration with selected international universities.	• Will serve as a catalyst to Purdue's global programs and help promote the goal of Meeting global challenges in Purdue's strategic plan.

Appendix E: A Sample of Multiple Undergraduate Degrees Offered by CS Departments Located in Engineering

Department	University	Degrees offered and colleges
College of Computing	Georgia Tech	• BS, CS, College of Computing • BS, Computational Media, College of Computing and College of Liberal Arts
Computer Science	Johns Hopkins	• BS, CS, College of Engineering • BA, CS, College of Engineering
Computer Science and Engineering	Ohio State	• BS, CSE, College of Engineering • BS, CIS, College of mathematical and Physical Sciences • BA, CIS, College of mathematical and Physical Sciences
Computer Science	Stanford University, Stanford	• BS, CS, College of Engineering • BS, CSE, College of Engineering
Electrical Engineering and Computer Science, CS Division	University of California, Berkeley	• BS, College of Engineering • BA, College of Letters and Science
Computer Science	University of Illinois, Urbana-Champaign	• BS, College of Engineering • BS, Math and CS, College of Liberal Arts and Sciences • BS, Statistics and CS, College of Liberal Arts and Sciences
Electrical Engineering and Computer Science, CS Division	University of Michigan, Ann Arbor	• BS, College of Engineering • BS, College of Literature, Arts and Science
Computer Science	University of Southern California	• BS, CS, School of Engineering • BS, CS (Games) College of Letters, Arts, and Sciences • BS, CS and Business Administration, School of Engineering and School of Business • BS, CS and CSE, School of Engineering and School of Business

* Several departments mentioned here also offer dual degrees that are not listed.

Appendix F: Synergies: Research in Computer Engineering and Computer Science

Several faculty members in the departments of Computer Science and Electrical and Computer Engineering overlap in their interests in research and teaching. Following is a (partial) list of such faculty. Moving CS to engineering would assist both departments to better harness the strengths of their faculty and thus enhance research and educational offerings. Note that not all faculty listed here are formally associated with the CE program in ECE, but they are in the ECE department and their areas of interest overlap with those of CS faculty.

Area	**Faculty**	
	Computer Engineering	**Computer Science**
Bioinformatics and Computational Biology	Ersoy, Ghafoor	Grama, Kihara, Pandurangan, Pothen, Qi, Si, Skeel, Szpankowski, *O. Vitek*
Computational Science and Engineering (includes modeling, simulation, and parallel algorithms)	Clark, Doerschuk, Eigenmann, Jamieson, Pai, Siskin	Grama, Hoffmann, *Lucier*, Mathur, Pothen, Ergo, Sacks, Sameh, Skeel
Databases and Data Mining	Allebach, Ghafoor	Aref, Bhargava, Bertino, Clifton, Elmagarmid, Hambrusch, Neville, Prabhakar, Si
Distributed Systems	Bagchi, Hu	Bhargava, Eugster, Grama, Hosking, Jagannathan, Killian, Nita-Rotaru, Pandurangan, Park, Rego, Xu, Yau
Graphics and Visualization	Ebert, Elmqvist	Aliaga, Hoffmann, Popescu, Sacks, Tricoche
Information Security and Assurance	Delp	Atallah, Bertino, Bhargava, Clifton, Fahmy, Nita-Rotaru, N. Li, Nita-Rotaru, Park, Prabhakar, Rego, Spafford, J. Vitek

Machine Learning and Information Retrieval	Gelfand, Givan, Lebanon, Lee, Siskind	Clifton, Neville, Si, Qi, *Viswanathan*
Networking and Operating Systems	Ersoy, Ghafoor, Hu, Lin, Lu, Pai, Raghunathan, Rao, Zoltowski	Comer, Fahmy, Killian, Kompella, Nita-Rotaru, Park, Xu, Yau
Programming Languages and Compilers	Harper, Midkiff, Eigenmann, Vijaykumar	Eugster, Hosking, Jagannathan, Z. Li, J. Vitek. Zhang
Software Engineering	DeCarlo, Ghafoor, Kak, Jesiek	Dunsmore, Eugster, Jagannathan, Mathur, Rego, Spafford, J. Vitek, Zhang
Theory of Computing and Algorithms	Siskind	Atallah, *Basu*, Frederickson, Hambrusch, Pandurangan, Szpankowski

- Names in italics denote faculty with primary appointment in another department.

Appendix G: Synergies: Course Offerings in Computer Engineering and Computer Science

Several courses offered independently by the departments of Computer Science and Electrical and Computer Engineering overlap in their contents. While the courses might not have 100% overlap, their primary objectives remain the same. Following is a partial list of such courses. Moving CS to engineering would assist both departments to collaborate in a cost-effective way. The differences in the way the corresponding courses are taught, and in their contents, are mostly due to individual preferences, and could certainly arise when two people teach the same course at different times in the same department.

Area	**Courses with overlapping objectives**	
	ECE	**CS**
Artificial Intelligence	• ECE 473 Introduction to Artificial Intelligence • ECE 570 Artificial Intelligence	CS 47100 Introduction to Artificial Intelligence
Compilers	• ECE 468 Introduction to Compilers and Translation Engineering • ECE 573 Optimizing Compilers	• CS 35200 Compilers Principles and Practice • CS 50200 Compiling and Programming Systems
Graphics and Visualization	• EE 495E Computer Graphics • EE 595E Visualization	• CS 33400 Fundamentals of Computer Graphics • CS 53000 Introduction to Scientific
Computer Security	ECE 404 Introduction to Computer Security	CS 42600 Computer Security
Data Structures	ECE 368 Data Structures	CS 25100 Data Structures
Databases	ECE 562 Introduction to Data Management	CS 44800 Introduction to Relational Database Systems
Discrete Mathematics	ECE 369 Discrete Mathematics for Computer Engineering	CS 18200 Foundations of Computer Science
Distributed Systems		CS 50500 Distributed Systems
Networking	• ECE 463 Introduction to Computer communication Networks • ECE 547 Introduction to Computer Communication Networks	• CS 42200 Computer Networks • CS 53600 Data Communication and Computer Networks
Operating Systems	ECE 469 Operating Systems Engineering	• CS 35400 Operating Systems • CS 50300 Operating

		Systems
Parallel Programming	ECE 563 Programming Parallel Machines	CS 52500 Parallel Computing
Programming	• ECE 264 Advanced C Programming • ECE 435 Object-Oriented Design Using C++ and Java • ECE 462 Object Oriented Programming Using C++ and Java	CS 24000 Programming in C CS 18000 Programming I
Software Engineering	• ECE 364 Software Engineering Tools Laboratory • ECE 461 Software Engineering	CS 30700 Software Engineering CS 51000 Software Engineering

Appendix H: Membership in National Academies

The National Academy of Sciences (NAS) places “Computer and Information Sciences” as category 34 under Class III: Engineering and Applied Science. The National Academy of Engineering (NAE) places “Computer Sciences and Engineering” as Primary section 05. Currently 2% of the NAS members belong the “Computer and Information Sciences” category and 12% of the NAE members belong to the “Computer Sciences and Engineering” category. Note that some computer scientists are members of both the NAS and the NAE.

<End of document. V2.1. 7/21/2009>