Report of the Curriculum Committee  
Department of Computer Science  

May 9, 2006

1 Introduction

The committee met 23 times since September 26, 2005. Our work has been concerned primarily with a re-examination of our AB and ScB concentration requirements. We have a web site that presents the material that we collected in this study as well as the minutes of our meetings.

We took as our starting point the curriculum recommendations of the ACM and IEEE Computer Society and a white paper co-authored by Steven P. Reiss, Shriram Krishnamurthi, and Roger Blumberg on our undergraduate curriculum. The committee recommendations are presented in Section 2. A summary of the discussions leading to these recommendations is given in Section 4.

The committee also received and processed the new course proposals and course title changes shown in Section 5, were informed about an experimental version of CS 4, Introduction to Scientific Computing and Problem Solving taught in Matlab this semester by John Hughes to an audience of about 15 students, examined the nascent proposal for a concentration for a science cohort (no action taken), and received reports or presentations by current or former instructors of CS015 (Andy van Dam), CS016 (Roberto Tamassia), CS017 and CS018 (Philip Klein) CS022 (Franco Preparata and Anna Lysyanskaya), CS031 (Pascal van Hentenryck), CS032 (Steve Reiss), and CS036 (Tom Doeppner). We also met with Pascal to discuss strengthening our concentration requirements and Michael Black to discuss a proposed CS041.

We also engaged in a number of curriculum support activities. These included collecting course outlines (using a template provided by Franco Preparata) on key courses, a process that has as its long-term goal to collect such outlines on all courses below the 200 level. Tom Doeppner also produced a graph showing the prerequisite chains for our courses. All of this information is available on our web site.
Table 1: AB and ScB concentration requirements of May 9.

## 2 Recommendations Concerning Concentration

The committee recommends that the computer science faculty adopt the the AB and ScB concentrations shown in Table 1. Our rationale for recommending them is given below.

- We recommend the AB to students who desire a fundamental education in computer science as well as the flexibility to pursue an education in other fields.
- We recommend the ScB concentration as a strong degree program in computer science that guarantees breadth at an intermediate level while providing flexibility in the area of depth and experience. With good advising, we expect it to serve our students well.

Our current AB and ScB concentration requirements are divided into math and writing prerequisites, core CS courses, and advanced tracks for the AB and additional CS, math and science courses for the ScB. Our proposed AB and ScB concentration requirements have the same math and writing prerequisites and core courses.

The proposed AB would replace the requirement for two advanced courses in software systems, theoretical computer science, artificial intelligence, or systems with
a pair of approved courses. In addition, the new AB would require a third course, which would not have to be a computer science course.

The proposed ScB would have the same science requirement and would also require two math courses except that it would specify that one of these courses must be Math 52, Linear Algebra, or Math 54, Honors Linear Algebra. Our rationale for this requirement is stated in Section 4.

Finally, both the current and proposed ScB concentrations require seven additional 100-level courses, although CS32 or CS36 can be used if not taken to meet the breadth requirements. For both concentrations one of these courses must be a design or independent study course. Of the six remaining courses the current concentration requires that one be taken in each of the following areas: theory, AI, systems, EN 164 or another 100-level engineering course in digital logic design, communications or VLSI. The proposed ScB would replace this requirement with six depth and experience courses such that a) at least two must be in computer science and b) at least four of them must form two approved course pairs. Both of these requirements can be met at the same time.

3 Recommendations Concerning Curriculum Management

The committee makes the following recommendations:

1. That the Curriculum Committee collect course outlines on all courses below the 200 level and make them available to students and faculty.

2. While individual faculty members must be given a lot of flexibility on the exact choice of course topics, at some level, the areas covered should be prescribed by the faculty as a whole.

These areas might well change over time, thus there should be a continuing discussion of what’s covered in each of them. The course descriptions for these courses should be viewed as partly prescriptive in that they list the high-level areas covered, and partly descriptive, in that they also list topics covered in the current course at the discretion of the instructor. Flexibility should increase as the level increases.

3. Each faculty member should give a brief description of their course at a faculty meeting for the purpose of educating colleagues about its content.
3 Operating systems principles and design, Theory of programming languages, Software design
2 Computer architecture and organization; Operating systems configuration and use; Net centric principles and design; Human-computer interaction; Graphics and visualization; Intelligent systems (AI); Information management (DB) Theory; Information management (DB) practice; Scientific computing (numerical methods); Legal, professional, ethics and societal issues; Analysis of technical requirements; Security: issues and principles; Interpersonal communication

Table 2: Relative importance of topics in ACM/IEEE Computer Society degree programs.

4. Each 100-level special topics course should be submitted to this committee for review at least one week before the beginning of the pre-registration period for the semester in which it is to be taught.

4 Summary of Discussion of Concentrations

Our deliberations concerning concentrations began with reports given on October 3 by committee members of the ACM and IEEE Computer Society Curricula Recommendations. Claire reported on the Computing Curricula 2005, Chad report on Information Technology 2005 and Tom and John reported on CC 2001 Curriculum Guidelines for Undergraduate Degree Programs in Computer Science. In her report Claire cited Table 3.1 which lists 40 topics found in computer science and other concentrations. It also provides the relative importance that ACM and IEEE CS assign to these courses. A summary of their rankings are given in Table 2 using a scale of 0-5, 5 being the highest.

On October 17 and 24 we did a course-by-course comparison of the content of our courses with the courses recommended in Computing Curricula 2001. These courses are cited in Figure A-1 on page 85 of the document. The upshot is that there is no material recommended in this report that is not found in our courses.

On October 31 we began a discussion of the goals and objects of our concentrations using the white paper written by Steve Reiss, Shriram Krishnamurthi and Roger Blumberg.

Steve observed that a) we do want to increase enrollment in CS, b) the field is
changing and growing, and c) we can’t teach everything. He also noted that the ScB and AB concentrations should meet different objectives. The former should be targeted at students who want to work in industry, go to graduate school, or who want a background for life-long learning. The AB, while preparing a student for life-long learning in CS, should also serve to prepare students to work in a discipline inside and outside of CS. It should also fit into Brown’s philosophy of Liberal Education, meaning that students should not be overly constrained in their educational requirements. Finally, it should serve to attract students to CS courses.

We then engaged in a debate about the AB requirements. Claire argued that the AB should provide “exposure” to CS whereas the ScB should be prepare students to work in the field. We discussed to what extent practical skills should be taught. Chad asked if our AB requirements should be roughly equivalent to a minor in CS, noting that such a minor at Stanford looked pretty much like our AB requirements.

Franco said that we should be careful not to set requirements so low that the faculty would be embarrassed by the gaps in the education of our AB students. An argument offered in favor of a minimal set of AB requirements is that there is a tension between meeting concentration requirements and satisfying other educational interests.

We then turned to a general discussion of the types of concentration requirements, agreeing that they should include fundamentals, breadth, depth, and experience. The discussion ended without further conclusions.

We again discussed goals for CS concentrations on November 14 without reaching conclusions.

On November 21 we discussed the AB and ScB concentrations shown in Table 3 that were proposed by Steve Reiss.

The breadth option received the most discussion. Several committee members were concerned that providing AB students with a choice between CS31, 32 and 36 as well as a choice between CS41 and 51 would result in students graduating without a basic understanding of CS. Several of us were concerned that if CS31 (CS51) were not taken, students would not understand the basics of architecture (theory).

At the November 21 meeting the choice between 41 and 51 in the breadth category met with general approval if the content of 41 includes some formal languages and automata and NP-completeness. We also discussed the content of CS31, 32 and 36 under the assumption that students would have a choice between them. It was said by several of us that it is important that AB students understand the basics of computer architecture. Subject to this proviso, we agreed to this choice.

At our meeting of November 28 we resumed the discussion of the CS31, 32, 33 option. It was agreed that every AB concentrator should understand the basics of instruction execution and that if we drop the requirement for CS31, then CS32 and CS36 would include a practicum or module on this topic.
Table 3: AB and ScB concentration requirements of November 21.

On January 31 we considered two proposals that had been made to the Chair by Philip Klein, namely, whether it was desirable to combine CS22 and 51 into a new two-semester sequence and whether we should replace the first two years of our requirements with an integrated core. We decided against the first point on the grounds that not only are the first two years busy, some of our students postpone taking CS51 until their fourth year. We decided to take no action on the second point until we receive a formal proposal.

We took up this matter again when we heard from Pascal on February 9 about the need to strengthen our concentrations to better prepare our students for a competitive world. He said that our students should have sufficient knowledge of computer science fundamentals that they can see through the many layers of abstraction in computer systems so that they can understand how their design decisions affect performance. Steve responded by saying that the AB concentration shown above would increase the number of 100-level courses while making it easier for students to combine our concentration with other concentrations whereas the ScB would also require more courses than is currently the case.

On February 16 we decided that we needed to have more detail on our entry-level courses. Reports were heard on CS17/18 by Philip Klein on February 23, CS16 by Roberto Tamassia on March 9, CS22 from Franco on March 23, and CS41 by Michael Black on April 13.

On April 20 the revised AB and ScB concentrations shown in Table 4 were discussed. They are the same as those shown above except for the addition of CS57, an introductory algorithms course that was proposed earlier in our discussions.

Reflecting presentations to the committee, strong sentiment was expressed that it was not realistic to expect CS41 or CS57 to be taught to sophomores, should they be
Table 4: AB and ScB concentration requirements of April 20.

<table>
<thead>
<tr>
<th></th>
<th>AB</th>
<th>ScB</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fundamentals</td>
<td>15/16 or 17/18 + 22</td>
<td>15/16 or 17/18 + 22</td>
</tr>
<tr>
<td>Breadth</td>
<td>1 of 31, 32, 36 (Sys)</td>
<td>2* of 31, 32/36</td>
</tr>
<tr>
<td></td>
<td>1 of 41, 51, 57 (Thy)</td>
<td>2* of 41, 51, 57</td>
</tr>
<tr>
<td>Depth</td>
<td>1 pair of approved courses</td>
<td>2 pairs of approved courses</td>
</tr>
<tr>
<td>Experience</td>
<td>1 additional course</td>
<td>2 additional courses</td>
</tr>
<tr>
<td>Other</td>
<td>+ 2 semesters of math</td>
<td>+ two-semester science course</td>
</tr>
<tr>
<td></td>
<td>+ 1 writing</td>
<td>+ 2 semesters of math</td>
</tr>
<tr>
<td></td>
<td></td>
<td>+ 1 design</td>
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<tr>
<td></td>
<td></td>
<td>+ 1 writing</td>
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*These might be replaced by three courses from this set

We also noted that a proposed CS41 should require a linear algebra course (MA52 or MA54) as a prerequisite and a proposed CS57 would be better taught to juniors and seniors as part of a two-semester sequence. These conclusions caused us to reconsider our fundamental breadth requirement.

We then all agreed that students in both concentrations should take CS51 because it is the only fundamental theory that we offer. At Steve’s urging we also agreed to write our concentration requirements to read that students in both concentrations must take at least one fundamental theory course, noting that only one such course, CS51, is now offered. Steve argued that it would be easier to introduce new such courses in the future without requiring that our degree requirements also be reconsidered. John agreed to this language with the understanding we would not be bound to allow such flexibility without thinking through the consequences.

We resumed the discussion of requiring one of CS31, CS32 and CS36. Tom Doeppner reported that based on his experience teaching CS36 he would prefer that CS31 be a prerequisite for CS36. Franco and John said that they consider the material in CS31 fundamental and would like all students to take this course. Steve said that the material in CS31, while very useful and necessary for many of our students, was not necessary for all students and some would be better served with CS32 and CS36 if you have to require 2 courses, or with one of CS31,32,36 and an advanced course in some area.

With four members in agreement, one dissenting, and one absent the committee voted to recommend to the full faculty the concentration requirements shown in Table 5. Here the mathematics, science, design and writing requirements are unchanged from what are required today except that for ScB students one of the two math courses must be MA052 or MA054. Course pairs are courses from a common subarea.
Table 5: Second set AB and ScB concentration requirements of April 20.

<table>
<thead>
<tr>
<th>AB</th>
<th>ScB</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fundamentals</td>
<td>15/16 or 17/18 + 22</td>
</tr>
<tr>
<td>Breadth</td>
<td>31, 1 of 32, 36 (Sys) 51, (Thy)</td>
</tr>
<tr>
<td>Depth</td>
<td>1 pair of approved courses</td>
</tr>
<tr>
<td>Experience</td>
<td>1 additional course</td>
</tr>
<tr>
<td>Other</td>
<td>+ 2 semesters of math + 1 writing</td>
</tr>
</tbody>
</table>

*Two theory courses are required, one fundamental (CS51) and one basic, that is, CS141, CS157, CS159 or another approved course.

of CS. Rules for such pairs will be developed by the committee.

On April 27 we agreed to a) prepare a prerequisite DAG annotated with the course outlines that are being collect, b) collect course outlines on all courses below the 200 level, and c) request that each faculty give a brief description of their course at a faculty meeting.

We also agreed that it would serve the interest of each instructor if the faculty takes communal responsibility for our courses using our committee as a vehicle. While we recognize that individual faculty members must be given a lot of flexibility on the exact choice of topics, at some level, the areas covered are prescribed by the faculty as a whole. These areas might well change over time, thus there should be a continuing discussion of what’s covered in each of them. The course descriptions for these courses should be viewed as partly prescriptive in that they list the high-level areas covered, and partly descriptive, in that they also list topics covered in the current course at the discretion of the instructor. Flexibility should increase as the level increases.

The lengthy minutes of this meeting reflect the discussion. For the sake of brevity, the high points of the discussion are summarized here. We decided without voting that we could not make recommendations that included CS41 for reasons cited below and that it would be better to offer a two-semester algorithms sequence at the 100 level instead of introducing a CS57. This left us with one choice for the theory option under both concentrations, namely, CS51. We agreed that we should describe this situation as requiring one fundamental theory course in both concentrations.

After a discussion of the other breadth option, namely, one of CS31, 32, and 36, we took a vote on whether or not to change this requirement to CS31 and one of CS32 and 36. John, Tom, Franco and Claire agreed to it and Steve did not.
Tentative outlines for CS41 revealed the strong mathematical nature of contemporary AI. In particular, it appeared that linear algebra is playing a central role in the field. We then discussed the appropriateness of prior exposure to linear algebra as taught by the Math department. Our sensitivity to this need was raised by Michael Black at a previous meeting. We debated whether to require MA052 or MA054 as one of the two math courses required for the ScB. The argument given by Franco was that Math 52 (or the honors version, MA054) would be a better mathematical gateway to many of our courses and a course that would benefit all of our students. John, Tom, Franco and Claire liked this idea and Steve did not.

A vote was taken on the combination of these suggestions, as reflected in the concentrations shown in Table 5. John, Tom, Franco and Claire voted to recommend these concentrations to the full faculty and Steve did not.

On May 4 we further refined the concentrations shown in Table 5 by stating explicitly that both concentrations have mathematics prerequisites consisting of basic calculus, which is defined as the material in MA009 and MA010 or MA017. The two math courses shown for the AB concentration in Table 5 represent this prerequisite. We also debated whether or not to require one additional course in the experience category, thereby increasing the number of required departmental courses by one relative to our existing AB concentration. We agreed to keep this requirement.

For the ScB concentration we clarified our proposed requirements for the six depth and experience courses by agreeing that a) at least two must be in computer science and b) at least four of them must form two approved course pairs. Both requirements can be met at the same time. The new versions are shown in Table 7.

The proposed ScB differs from our current ScB concentration requirements in the area of depth and experience. The current concentration requires one course in each
Table 7: AB and ScB concentration requirements of May 4.

of the following areas: 1) theoretical computer science, 2) artificial intelligence, 3) systems, and 4) EN164 or another 100-level engineering course in digital logic design, communications or VLSI. The rationale for changing the ScB requirements is given below.

We recommend the ScB concentration as a strong degree program in computer science that guarantees breadth at an intermediate level while providing flexibility in the area of depth and experience. With good advising, we expect it to serve our students well.

5 Actions Concerning Courses

Below we list the courses and title changes approved by the committee. We also describe our discussions concerning other courses that have been proposed or considered.
5.1 Courses Approved

CS149 Introduction to Combinatorial Optimization
CS160 Introduction to Embedded and Real Time Software
CS244 Game Theoretic Artificial Intelligence
CS254 Advanced Probabilistic Methods in Computer Science
CS257 Nanocomputing

5.2 Approved Changes in Course Titles

CS22 Introduction to Discrete Structures and Probability
CS176 Introduction to Multiprocessor Synchronization
CS178 Parallel and Distributed Programming

5.3 CS19 – Accelerated CS15/16

CS19 has been discussed as an accelerated version of CS15/16 for those students who arrive at Brown with a good knowledge of Java and experience in writing programs of modest size. At our meeting of December 12 we agreed in principle that we should have a CS19. Brief discussions followed on January 31 and February 9. No formal recommendations were made on this course.

5.4 CS41 – Introduction to AI

We discussed CS41 Introduction to AI on December 12 and April 6 and 13. At the first meeting we noted that there are (at least) three separate ideas for the course. We made contact through our Vice Chair Tom Doeppner with the parties involved.

On April 6 we reviewed a proposal from Amy Greenwald sent to John Savage that she later said was assembled in haste and should be withdrawn. This proposal would have been primarily a course in linear algebra. After reading it we said that we would like to explore the relationship between a CS41 and Math 52 and other courses. In fact, as noted above, Franco argued that Math 52 (or MA054) would be a better mathematical gateway to many of our courses and a course that would benefit all of our students.

On April 13 we heard from Michael Black. He said that AI has grown dramatically in breadth and depth in recent years and that this has made it difficult to teach a course that provides a broad overview to the field. He went on to say that all AI students should have a background in linear algebra at the level of MA0052, reinforcing the views expressed at the previous meeting. He said that for his courses in vision he also would like them to have a background in statistics.
Michael said that if all CS students had a background in linear algebra, he was of the opinion that an AI course could be taught that could serve as a feeder course to other AI courses. Since this was his opinion and not one that had been discussed with his AI colleagues, he said that he would engage them in conversation to see if they would approve of this idea.

In light of these discussions we decided that it was not possible for the committee to consider using a CS41 as a curriculum requirement at this time.

5.5 Information Theory as a Theory Course

We discussed this matter on January 31 and decided that CS185 Information Theory (AM 171 Information Theory) cannot be used as a theory course.

5.6 CS122 Document Engineering

After discussing a proposal submitted by David Durand for a new course entitled CS122 Document Engineering on January 18 and February 9 and 16 we decided that the demand for the course does not justify its introduction as a permanent course.

Submitted by
Tom Doeppner
Chad Jenkins
Claire Kenyon
Franco Preparata
Steve Reiss
John Savage (Chair)