Georgia State University
Department of Computer Science

Academic Program Review

Dr. Eileen T. Kraemer, Professor of Computer Science and C. Tycho Howle Director of the School of Computing, Clemson University, Clemson, SC

Dr. Mladen A. Vouk, Distinguished Professor of Computer Science and Associate Vice Chancellor for Research Development, North Carolina State University, Raleigh, NC

Dong Xu, James C. Dowell Professor of Electrical Engineering and Computer Science and Director, Information Technology Program, University of Missouri, Columbia, MO

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1. Executive Summary

The GSU Department of Computer Science (CS) has provided a comprehensive self-study. The review team of Eileen Kraemer (Clemson U.), Mladen Vouk (NC State U.), and Dong Xu (U. Missouri) have met with faculty, students and staff according to the provided schedule (see Appendix A). We have researched relevant national data sources (listed in Appendix B) and trends to place the Department with respect to other departments in the discipline.

The department is relatively young (PhD program started in 1999). According to Computing Research Association (CRA, cra.org) classification, it falls into the category of small to mid-sized (15 to 30 faculty) urban CS departments in public universities. Judging by its research output, undergraduate and graduate enrollment, its PhD production, its faculty composition, its student-to-faculty ratios, and so on, the department is beginning to transition from being primarily a teaching department to being a viable and nationally recognized CS research department. However, the road ahead is long and the department will require active and decisive college and university assistance in many aspects of its operations in order to continue and succeed on this path. Some of the key observations in that context are:

a) Status. The department is doing amazingly well given it is a relatively young program, and the constraints under which it currently operates. This CS department is a great asset to its college and to GSU. Its professional impact and its teaching output (in terms of the numbers of degrees) are nationally competitive in its class. However, the undergraduate graduation rate is lower than expected, and the program is at a disadvantage because of some of the space and capacity constraints the department appears to operate under. Diversity of the undergraduate student body is excellent. Diversity of the graduate student body and the faculty is within national norm for CS departments. The major strengths of the department are the faculty, the unique position of GSU in Atlanta and the state in terms of urban placement and opportunities, and the willingness of the faculty and the administration to advance and have the department be a leader in the CS domain. Some dissatisfaction exists among faculty (and students) regarding capacity, physical constraints (primarily space), and salary inequities with respect to the national discipline trends (see Appendix C). There are also concerns regarding some performance metrics (e.g., graduation rates), but the overall morale in the department appears to be good and the atmosphere is generally positive and hopeful. The current acting department head should receive much of credit for the positive aspects of the department’s operation. The department is ready for a transformative, strategic “big bet” investment to push it to the next level.

b) Rankings. GSU CS department is nationally competitive in its class, but a number of corrective actions need to be taken to ensure its stability, and to enable its continued growth as a research department. Rankings are discussed further in Section 2 and Appendix B.

c) Strategic. It would appear that both the CS department chair and the CS graduate administrator have been in an acting role for more than 3 years. This introduces considerable uncertainty, and is a major strategic issue. We believe that it is crucial to move the department, as soon as possible, from having an acting or interim department chair to having a permanent head/chair selected in an open nationwide search. This should bring the department (and GSU) the necessary long-term credibility, and the department long-term strategic stability, new badly needed resources, and a clear roadmap.

d) Change. We believe that the department’s physical and logical (undergraduate, graduate and operating) architecture needs to undergo a considerable change (restructuring) in order to bring the department’s teaching, research and outreach operations and performance metrics into a range that would keep it on a nationally competitive trajectory, and also in line with the GSU’s strategic goals and expectations (national model for undergraduate education, distinctive graduate and research programs, leading public research university, leader in understanding of urban complexity, globalization). Example areas where the department needs improvements are community and industry interactions, strategic planning and marketing, funding diversity and growth, class size management and curriculum restructuring, staffing, concentration streamlining, accreditation considerations (e.g., ABET), professional gap analysis, interdisciplinary activities, etc.

e) Tactical. In addition to strategic investments that will need to be made into the department to ensure its continued growth in reputation and national visibility, there are some immediate tactical needs without which the department advances may be derailed and the morale in the department may be impacted negatively. These include, but are not limited to, acute need for teaching laboratory spaces. Currently the GSU CS department appears to be severely handicapped in that domain. Teaching computer science well (and nationally competitively) does require access to a range of hands-on customized laboratories and computer science-specific learning spaces. This improves student knowledge acquisition and retention, and is a key catalyst for improving learning experience, student graduation rates, and national competitiveness of both undergraduate and graduate programs. Advanced research requires adequate graduate student offices, and in many CS areas it also requires state-of-the-art laboratories.

f) Relationship. In addition to the CS Department in the College of Arts and Sciences, GSU has a Department of Computer Information Systems (CIS) in the J. Mack Robinson College of Business. While the CIS program
appears to be well thought out and well run, it is not a CS program. These two programs have some overlap in what they teach, but for most part they are different. The CS program is a research and a “tool maker” program that deals with much more fundamental aspects of technology developments, while the CIS program is much more “tool user”, application, and business oriented. The two departments are in different colleges, and they operate under considerably different financial and environmental conditions, and have different missions and stakeholders. In many ways they are complementary. It is also important to note that in this day and age of the advanced analytics and data science focus, and the emphasis on interdisciplinary work, it may be advantageous for GSU to consider formation of a School of Computing (or a similar entity) that would streamline internal resources (faculty, funds, and space) to bring together into a coordinated environment several departments that can provide core research and translational strengths, which would help GSU make major steps forward into the next generation world where computing and data literacy, information, and computer assisted technologies and decision making are intimately intertwined with every aspect of the everyday life – from health, to security, to manufacturing, to social interactions, and to development of solutions to important societal problems.

2. Contributions to the Discipline

GSU-CS is a small to mid-sized public CS department (CRA\(^1\) data\(^2\), CRA classification: urban public 10 to 25 TT faculty). The department is in the GSU College of Arts and Sciences. According to the self-study report in FY 2015 (2014-15) the GSU Department of Computer Science (GSU-CS) had 16 tenured or tenure-track faculty, and two non-tenure track faculty. In the Fall 2016, the department added 4 excellent new tenure/tenure-track faculty, and 3 new lecturers. It is expected that in the department may be hiring several additional faculty who would start in the 2017-18 academic year. At the time of the visit, the department had a total of 21 tenured/tenure-track faculty and 6 lecturers/instructors\(^3\).

In the Fall 2015 GSU-CS enrolled close to 70 Ph.D. students (about the same number as in 2012, with about 12% of the PhD students being part-time), about 90 M.S. students (program has grown by about 40% since 2012, with about 15% being part-time), and 1,227 BS majors (up from 704 in 2012). In the Fall 2016, the department had 1,404 undergraduate and 177 graduate students. In 2014-15, the department had 18 faculty (16 tenure-track), and had awarded 110 BS degrees, 49 MS degrees, and 13 PhD degrees\(^4\). More recently, the number of PhDs awarded is in the 8 to 10 range. The number of MS degrees awarded is in the 40s.

GSU-CS’s current primary research interests are declared to be the areas of Artificial and Computational Intelligence, Bioinformatics, Computer Software Systems, Databases, Graphics and Human-Computer Interaction, Networks, and Parallel and Distributed Computing\(^5\). The department’s faculty have so far won six (6) prestigious NSF CAREER awards\(^6\) and a number of other accolades. The department’s research awards in 2014-15 amounted to $1,780,510\(^7\) (in 2015-16 the number appears to be closer to $2.1 million). The department’s annual research expenditures from external funding are in the $1.5 to $2 million range.

2.1 Discussion

We assessed GSU-CS performance based primarily on quantitative information that comes from proven and accepted sources regarding Computer Science activities – the Computing Research Association (CRA), American Society for Engineering Education (ASEE), National Science Foundation (NSF), Association for Computing Machinery (ACM), IEEE (ieee.org), and similar. Data sources are discussed further in Appendix B.

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\(^1\) Computing Research Association (CRA), [http://www.cra.org/](http://www.cra.org/)
\(^2\) CRA Taulbee, current report covers about 178 US public PhD granting CS departments (about 100 of which are public). The latest survey is attached/linked, it is available at [http://cra.org/wp-content/uploads/2016/05/2015-Taulbee-Survey.pdf](http://cra.org/wp-content/uploads/2016/05/2015-Taulbee-Survey.pdf). This report covers data that come primarily from the 2014/15 academic year, although some data, like salaries are from early 2015-16.
\(^3\) [http://cs.gsu.edu/role/faculty/](http://cs.gsu.edu/role/faculty/)
\(^4\) GSU CS Self-Study, sections 1, 1a, 1.b.7
\(^5\) [http://cs.gsu.edu/research/areas/](http://cs.gsu.edu/research/areas/)
\(^6\) Two awardees have since left GSU.
\(^7\) GSU Self-Study, Appendix 33
**Figure 1.** BS Enrollments per TT/T. From CRA Taulbee 2015 report (reporting on 2014-15 academic data). The GSU-CS BS ratio for Fall 2015 is 1277/18 = 70.9 (GSU-CS self-study report, 18 includes non-tenure track faculty). Compared to similarly sized departments (Public 10 to 20 TT faculty) GSU-CS is in the 90.4\textsuperscript{th} percentile range in terms of students per faculty member – red dot. With the recent hires (and including teaching faculty) this number is in the 55-58 range (orange dot). If only T/TT numbers are used, figures are grimmer. A very high load in either case. Capping enrollments to about 1,400 undergraduates, and perhaps 170 graduate students with emphasis on growing the PhD and MS student bodies, and hiring several more faculty could bring the department into a more normal range in a few years. Also please see the footnote\(^8\).

**Figure 2.** BS degrees granted per TT/T. From CRA Taulbee 2015 report. The GSU-CS ratio for the same period is in the 110/16 = 6.9 range (from the self-study) – orange dot. It is somewhat lower if non-tenure track faculty are also considered.

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\(^8\) Note: This and most other figures in this report are copied from the CRA Taulbee 2015 report (Appendix C). CS department categories are defined in the report. Whiskers show 90\textsuperscript{th} and 10\textsuperscript{th} percentiles, lighter box 25\textsuperscript{th} percentiles to median, and darker box median to 75\textsuperscript{th} percentiles.
When compared with over 180 CS departments in colleges of engineering (COE) and over 60 that are outside colleges of engineering that annually provide their data to ASEE\(^9\) (essentially most of the CS department in the US that matter), GSU-CS is mid-range by the number of tenure/tenure track (T/TT) faculty - in the 87 to 95 range. Its BS enrollments place it in the range of \(10^{th}\) to \(14^{th}\) in terms of the undergraduate size. By the numbers of its BS degrees granted department ranks in the 38 to 40 range.

Using the data from the CRA Taulbee survey (again, that survey encompasses most of the CS departments in the US that matter), the number of enrolled students per T/TT faculty is considerably above that of other similarly sized departments (in Figure 1, GSU would fall much above the \(90^{th}\) percentile point for its size category). This may indicate large class sizes, and/or use of temporary personnel (e.g., PhD students and adjuncts) in teaching those classes.

The number of undergraduate degrees granted per TT/T faculty by GSU-CS is also in the very high range (Figure 2). Indeed, our finding is that in GSU-CS a large number of class sections are taught by PhD students rather than faculty. At

\(^9\) ASEE 2015 data refer to 2014-15 academic year (http://www.asee.org/datamining/)
the same time, six year graduation rate appears to be in the 50-60th percentile range (from the self-study data). This is, in part, probably due to the rapid growth of the GSU-CS undergraduate population over the last several years. Large classes, use of temporary teaching personnel and low graduation rate may put the GSU-CS at a disadvantage with respect to its peers. But, the growth reflects the needs of the society, and it does need to be addressed. Low graduation rate is a recognized problem (see GSU-CS self-study report) that may benefit from addition of permanent undergraduate teaching faculty, and additional graduate TAs. We note that upper administration recognizes the problem at GSU level and is actively working on improving it\(^\text{10}\).

Figure 5. PhD Enrollments per TT/T. From CRA Taulbee 2015 report. GSU-CS ratio in the same period is about 70/16 = 4.3 which is very competitive with respect to similar sized departments – orange dot. With recent faculty additions, the number comes into the expected range of about 3.3, and perhaps emphasis needs to move from MS to PhDs for incoming graduate students – green dot.

Figure 6. PhD graduates per TT/T. From CRA Taulbee 2015 report. GSU-CS ratio for the Fall 2015 seems to be about 13/16 = 0.81, which is high compared to similarly sized departments, and perhaps is an anomaly – red dot. The current average appears to be more in the range of 8 to 9 range over 18 to 20 ~ 0.5 which is competitive – green dot.

\(^{10}\) E.g., [http://www.startribune.com/study-struggling-college-students-get-a-hand-to-graduate/414224893/](http://www.startribune.com/study-struggling-college-students-get-a-hand-to-graduate/414224893/)
GSU-CS MS program places about 80th or so in terms of both student enrollment size and about 60th in terms of the number of MS degrees granted (all CS departments covered by the 2015 ASEE data). We see from the Figures 3 and 4 that according to CRA data GSU-CS appears to be competitive in terms of enrolled and graduated MS students per TT/T faculty member. But, if further growth in MS program is desired, more faculty may need to be hired, and MS graduation rate will need to be improved.

GSU-CS rank is in the 40 to 50 range with respect to its PhD program graduation numbers (2014/15 ASEE data), and 50 to 60 range with respect to PhD enrollments. Figures 5 and 6 show PhD enrollment and graduation data with respect to similarly sized CRA surveyed departments. From PhD output perspective, the department is competitive.

The department’s annual research expenditures are in the range of about $1.8 to 2 million per year\(^\text{11}\) (Figures 7 and 8). This places the department into the 25 to 50th percentile range in terms of total expenditures from external sources for computing research for 72 CRA surveyed US public CS departments. When the funding is normalized per tenure track size (Figure 7), GSU-CS places in the 25th to 50th percentile range. If the department wishes to grow its research expenditures (and by implication its PhD program) more research support staff will need to be hired.

\(^{11}\) Based on GSU-CS provided information
2.2 Specific questions

a. To which subfields of the discipline does the department make the most significant scholarly, creative, or clinical contributions (as appropriate)?

The research program in the department is comprehensive, covering basically all core subfields of computer sciences, including software systems, algorithms, database, graphics, human-machine interaction, security, networks, high-performance computing, computational intelligence, big data analytics and bioinformatics. Such a comprehensive coverage serves the teaching mission of the department well, given the small faculty size and the unusually high student-to-faculty ratio. A number of faculty members are well known in their fields, such as high-performance computing and bioinformatics. As individuals, they made some high-profile contributions to their fields. Many faculty are productive scholars and researchers, and this is reflected in their publication and funding records. Unfortunately, the number of faculty is not sufficient for building a national reputation in a particular subfield of computer science. That typically requires at least 5-10 highly productive faculty in one particular subfield. A major strength of the department is interdisciplinary research. The department’s faculty are involved in multidisciplinary research projects related to biology, chemistry, education, mathematics and statistics, neuroscience, physics and astronomy, and psychology. Some of them, such as astro-informatics, are niche areas that leverage the strengths in other departments of the university. These interactions may become significant growth areas for high impact and large funding. Another area to consider is the emerging focus on “smart cities” – application of advanced technologies to improve life in a city – ranges from internet of things technology, to advanced analytics. Partnership with Atlanta could play an important role in this context.

b. To what extent are the faculty number, composition, and diversity sufficient to support the research and educational missions of the department?

The number of faculty in the department appears to meet the minimum requirements for both research and teaching, but in our opinion, it may be a challenge to support a high-quality (ABET-accredited) education program and high-profile research at the same time. The composition of the faculty has good coverage for essential areas of computer science. This provides a good foundation for the education program, and also some readiness for emerging research topics, such as deep learning and smart cities. However, there is no focus area that has a critical mass working in it. As the research moves into “big science” era, this could be a significant disadvantage. For example, it may be hard to form a large research center (where more and more of new funding is going) for tackling a big research problem. It may also be hard to attract high-quality Ph.D. students, as there may not be enough courses to cover some research areas in depth.

The gender diversity of the faculty is in the normal range among the national universities. For example, in 2016-17 the female to male ratio is about 23.5% for tenured/tenure-track faculty. This is in line with the national average reported by CRA. Ethnic distribution of faculty can be compared with data in Table F7 of the CRA distribution. Diversity of the department is nationally competitive.

Gender diversity of the GSU-CS population is about the same as the national average for CS departments - females are in the 17% range. Ethnic diversity of the department’s undergraduates is much better from the minority perspective than the national averages. Graduate student numbers are in the national average ranges.

In the academic year 2016-17 department has 21 tenure-track faculty (5 assistant, 9 associate, and 7 full professors) and 2 instructors and 4 lecturers. With 1404 undergraduate students and 177 graduates students, student to faculty ratios (assuming everyone is teaching, which in reality is not the case since two faculty appear to be on leaves of absence) are 1404/27 = 52 and 177/21= 8.4 respectively - total 58.5. As already mentioned, this is a very high ratio for a research department, and it reduced competitiveness of the department from that perspective.

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12 CRA Taulbee 2015 Report, Table F6.
13 Appendix 6 of the self-study
14 CRA Taulbee 2015 Report, Table B8
15 http://cs.gsu.edu/department/computer-science/
c. Based on your knowledge of similar departments in the discipline, evaluate the overall strength of the department.

A more detailed analysis related to this question is presented in at the beginning of Section 2 of this report. There are about 100 public universities with CS departments. In the context of this group, the computer science department at Georgia State University has several major strengths:

1. The department’s research effort is growing (as measured through funding) and is competitive.
2. The research program covers a broad range of computer science subfields.
3. A large fraction of the faculty are research active.
4. In several niche areas the department has demonstrated major successes. For example, there are two active million-dollar grants in astro-informatics and in application of high-performance computing in education.
5. The number of publications per faculty member appears to be very high. In the past three years department faculty have produced 456 publications (195 peer-reviewed journal papers and 261 peer-reviewed conference proceedings papers). On a per-faculty basis, this is competitive. However, there is no critical mass in a subfield\(^\text{16}\).
6. The Ph.D. program is very active. The number of Ph.D. student enrolled per faculty member is competitive, as is the number of Ph.D. degrees awarded per faculty member. The Ph.D. students are co-authors on many papers. Ph.D. students appear to get good job offers, and some of those include tenure-track faculty positions.

We also note some gaps that may be an impediment in moving the department to the next level:

1. The student-to-faculty ratio is too high, so many faculty are overwhelmed by their teaching loads and do not have enough time to do research. Even though the nominal teaching load (number of courses per faculty member per year) is in line with what is common in the comparison group, the large class size (and the fact that many courses are four credit courses) put an excessive strain on faculty time and capacity.
2. Despite decent funding per faculty member and decent publication records, faculty research areas are sufficiently diverse that critical mass in a particular computer science subfield is not nationally visible. For example, examination of the rankings based on important publications in principal computer science subfields\(^\text{17}\) does not list GSU-CS in the top 100.
3. The research space has repeatedly come up as an issue. There are research active faculty who do not have a lab space to accommodate either their graduate students or their special equipment.
4. There appears to be a lack of internal support for research, such as, in the form of matching funds to hire postdocs, or seed money (beyond start-up funds for new faculty) to encourage research collaborations and new initiatives.
5. Interactions that can result in direct and indirect research funding (grants and gifts) by industry and foundations appears to be an ad hoc, random activity. Given the rich industrial environment in the city, there should be many more research contracts with companies, and win-win arrangements with both industry and the city. Further exploration of this alternative source of funding is critical. This will require hiring of an external relations person who can focus on both marketing and exploration of corporate funding opportunities. Currently, the department is missing out on hundreds of thousands in external funding from corporate and foundation sources.

3. Quality of the Department’s Undergraduate and Graduate Programs

a. For each of the department’s programs, evaluate the quality and currency of the curriculum in terms of disciplinary standards and trends.

The GSU Computer Science department offers one undergraduate degree: the B.S. in Computer Science. The degree program includes a core curriculum of university degree requirements (Areas A – E, 42-43 hrs.) and USG or GSU-specific requirements (Fed & State Constitution and History, Critical thinking, etc.). Beyond the core, students must complete the lower division major requirements (Area F, 18 hrs) (Calc II, CS 1, CS2, Theory and Data Structures), and Major requirements (Area G, 48 hours). Of these 48 hours, 41 hours are in the CS major and include Software Engineering, Computer Organization, System-Level Programming, Architecture, Programming

\(^{16}\) http://csrankings.org/
\(^{17}\) http://csrankings.org/
Languages and Design and Analysis of Algorithms. In addition, the students take 20 hours of electives, structured around six concentration areas, with 3 courses in a selected concentration and two outside that concentration.

Overall, the curriculum is rigorous and appropriate, and appears to be consistent with requirements for ABET accreditation. However, the currency of some of the courses, such as Software Engineering, needs to be assessed. For example, it appears that course curriculum does not cover some modern software process methodologies such as Agile Programming. The department may find it useful to engage in the exercise of comparing their curriculum with the ACM 2013 curriculum guidelines (www.acm.org/education/CS2013-final-report.pdf) 18.

The review team questions the necessity of the “concentrations” - students report that they just take whatever concentration they can get into classes for in order to graduate, and that the concentration notation on the degree is not of importance to them. Data in Appendix 4 support this notion, with the vast majority of students currently enrolled in the “undecided” concentration. Faculty report that the concentrations structure imposes constraints on scheduling.

The review team recommends that the concentrations be dispensed with, allowing greater flexiblity in course scheduling and selection for both the students and the faculty, with no discernible impact on quality of education.

Although co-op and internship offerings appear in the catalog and in the self-study, students report that those who have participated in internships have done so by locating the positions on their own. A better-supported program would improve student educational and employment outcomes as well as morale. The self-study reports that only one student completed an honors thesis 19.

Student evaluations and comments indicate some issues with quality, tied largely to the high number of courses taught by graduate students, and some issues with keeping courses up-to-date.

At the graduate level, the self-study lists the M.S. and Ph.D. in Computer Science. The department web page also lists an M.S. in Analytics, which we assume is outside the scope of this review.

The MS program is relatively unstructured: students take 30 credit hours of graduate-level coursework, six of which may be associated with a project or thesis. Foundation coursework in the core of computer science must either have been taken prior to entry or students must remediate by enrolling in the corresponding 6000-level class. Foundation coursework may not be counted toward the 24 non-thesis/project hours. The curriculum is standard and reasonably rigorous, given the requirement for completing foundation courses. Flexibility of the curriculum allows the department to remain current in the graduate offerings without the need to frequently revise the degree program requirements.

An M.S. with a concentration in Bioinformatics is also offered, and requires 4 computer science courses, 3 biology courses, one chemistry course and a biostatistics course. Similar requirements to the MS CS exist for foundation courses.

The Ph.D. program requires 48 of coursework, no more than 12 of which may be taken at the 6000 level. All students must complete core coursework at the doctoral (8000) level by taking one course in each of three core areas: Algorithms, Architecture and Systems. A breadth requirement ensures that students take three additional courses from three different breadth areas. Additional electives are selected in consultation with the dissertation committee, and a standard process for research hours, qualifying process, candidacy, dissertation and defense is described. Students must maintain a 3.5 GPA. The curriculum is reasonable and appears to be rigorous.

A Ph.D. with a concentration in Bioinformatics is also offered and appears similarly reasonable and rigorous.

18 The department may find it useful to engage in the exercise of comparing their curriculum with the ACM 2013 curriculum guidelines (www.acm.org/education/CS2013-final-report.pdf). These guidelines are focused not on specific courses but rather on coverage of topics in “Knowledge Areas”, which may be distributed across courses in different ways at different institutions. The guidelines recommend that a curriculum cover all the topics in Tier-1 for all students, cover all or most of the topics in Tier-2 and that students should encounter the vast majority of those topics, and should also include significant elective material.

19 Appendix 15 appears to erroneously report some other data, listing 66, 91 and 124 students for the past 3 years, respectively.
b. Evaluate the quality of both incoming and graduated students in the department’s programs, relative to discipline-specific norms.

Undergraduate students entering the Computer Science major appear, on average, to be solid though not stellar. The average high school GPA of approximately 3.4 is in line with the incoming class at the university, and the average combined SAT score of 1132 is good, and higher than the 1080 score of the average entering GSU student. These values are in-range for other similar programs (e.g., Southern Poly, Georgia College and State University, U. of North Georgia, Georgia Southern) though lower than for entering classes at “flagship” universities in the region (e.g., U. of Georgia, Georgia Tech, Florida State, U. Florida, U. South Carolina). This may be a factor resulting in a relatively low graduation rate, especially given that the math requirement for smoothly finishing a BS in CS is generally high. The department/college may consider elevating the admission requirement in SAT for the program. This is often achieved in a college of engineering automatically in some other universities, but may require some attention in a college of arts and sciences.

The new plan to institute a GPA requirement for a selection of early courses in the major should further improve the quality of the student body. Recently the number of Honors students has been increasing and now makes up close to 10% of the undergraduate majors. Certainly, the department has many very good students and the review panel was impressed with the students we met during our visit.

The alumni survey indicates that students are generally satisfied with their degree programs (4.56 out of 6), and 92% of the respondents were currently employed. Appendix 5 lists a few students as having been placed into Advanced Degree Programs and the student survey indicates that relatively few have pursued additional degrees. Student surveys and in-person student feedback indicate that the overall quality of undergraduate instruction could be improved by increasing the number of classes offered, updating course content to reflect current industry standards, and reducing reliance on graduate student instructors. Current students expressed concerns about competing for employment with graduates of Georgia Tech and UGA. Greater support for industry connections (capstone courses, internship opportunities) would be helpful.

The quality of entering graduate students appears to be good, based on GRE quantitative scores averaging around the 78th percentile. Verbal scores are low, but this is not unusual for Computer Science programs, in which the majority of students are international. Admissions are relatively selective, at around 30%. These values are not broken out by MS versus PhD and we suspect that the PhD students are significantly more highly qualified than the MS students.

Based on surveys, graduate students are more pleased with the quality of their programs than are the undergraduate students, and 100% were either currently employed or had been employed during the prior year. Student outcomes after graduation for MS students did not appear in the data. Student outcomes after graduation for PhD students are good: a number of PhD students have been placed in academic institutions as tenure-track faculty (North Georgia, Troy, St. John’s, South Carolina-Beaufort, Georgia State, LaSalle, Kennesaw, University of Washington), as research faculty (Stony Brook, Georgia Tech), in post-doc positions (Georgia State, Oak Ridge National Labs, UCLA) and in industry (Hewlett-Packard, Oracle, Microsoft, Ericsson, Amazon, Google). This list is impressive and speaks to the quality of the program, the faculty and the graduates.

c. Based on your professional experience, are the enrollment, retention, and graduation rates appropriate? If not, what changes might the department make to improve them?

Undergraduate enrollment numbers have been growing rapidly. This is in line with national trends. As the results the number of undergraduates (1404 in the Fall 2016) and the undergraduate to graduate ratio (1404/177 = 7.9) are both quite high. Coupled with the relatively flat growth in the faculty size, the student to faculty ratio is roughly 55 (or more) to 1, which is extraordinarily high.

Nationally, STEM disciplines experience a retention rate of about 50%, with 25% changing majors to a non-STEM field and the remainder exiting college before earning a degree or certificate. Full-time freshman retention rates in CS at GSU approximate this national average. It appears that 6-year graduation rates are increasing, with only 33% of

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Some confusion appears to have surrounded the preparation of this table, as it lists a few schools that do not offer advanced degrees (Northern Virginia Community College, Central Georgia Technical College).
the Fall 2007 Cohort graduating within six years, but with 49% of the 2009 Cohort doing so, which is close to the GSU 6-year graduation rate of 53%. (For comparison, overall 6-year graduation rates at Kennesaw, GCSU, UGA and nationally for four-year institutions are 42.6%, 60%, 83% and 59%, respectively.) One complicating factor in evaluating retention rates at GSU is that some number of students are conditionally accepted for transfer to Georgia Tech, with the condition being that they enroll at an accredited college (such as GSU) for one year and earn a grade of B or better in a selection of challenging freshman courses (CS 1301 among them). It is not clear how many students are involved nor how they impact the GSU retention and graduation numbers.

**Actions that could be taken to increase the quality of the undergraduate program include:**

- Additional space for teaching labs to permit greater use of inquiry-based versus lecture-based instruction. Such instruction will benefit all students but also has the potential to differentially benefit women and members of traditionally under-represented groups in computing.
- Conduct an inventory of courses that require or could benefit from the hands-on use of specialized equipment and ensure the allocation of space to accommodate these lab-based courses.
- Allocate resources to transition from the excessive use of graduate student instruction to make good use of lecturers and faculty members.
- Provide oversight of lower-division course offerings to ensure uniform quality.
- Review and refresh course content to reflect current industry practice and standards.
- Offer an industry-sponsored capstone course experience to benefit students and promote industry interaction.
- Support a well-organized program of internship and co-op experiences.
- Review (and possible elimination) of the concentrations.
- Modernization of some of the curricula (e.g., in software engineering).

Additional faculty and staff will be required to undertake these initiatives.

d. **Are there appropriate resources and support structures for the department’s educational programs?**

As already mentioned, there are some major resource deficiencies. For example, the department requires additional space – computer classrooms and labs, additional instructional faculty, additional administrators to oversee consistency and quality in the delivery of undergraduate courses, and additional staff member to assist with industry interactions and internships. It is possible that the additional staff members could also take on the role of assisting with major-specific advising (Advising 1400+ students could be a full-time job for 4 advisors).

e. **Evaluate the potential for growth of the department’s graduate programs.**

The quality of the graduate program is very good and the growth potential is also good. Certainly, hiring additional faculty is the key to this growth. However, the allocation of additional space for faculty offices, research labs and graduate student space must move forward in concert with the growth in faculty. Merely adding faculty members who are then forced to compete for a limited pool of graduate students and subsist in cramped quarters will only lead to frustration across the board.

The ability to attract high-quality graduate students is key to faculty success. An organized program of graduate student recruiting should be undertaken; the current approach is ad hoc, varying from one faculty member to another. In addition to a well-structured and resourced program of graduate student recruiting, potential students must be offered a competitive package. The current stipend of $19K for 12 months, coupled with high fees, puts GSU at the low end of the spectrum. Table G2 of the Taulbee survey lists percentile-based ranges of assistantship amounts, categorized by department type and assistantship type. If GSU were to match the 75th percentile assistantship for CS departments in US Public institutions, the 9-month assistantship for TAs would be $19,279 ($25,705 for 12 months) and for RAs it would be $20,000 ($26,667 for 12 months). We recommend a move to this market rate. However, these numbers may need to be somewhat higher than market rate in order to mitigate student fee impacts.

4. Quality of the Department’s Research Culture

a. Based on your knowledge of the discipline, what is your assessment of the quality of the department’s faculty?

Individually, GSU-CS faculty have considerable professional visibility and impact. They publish in some of the most prestigious venues relevant to their subdomains and area of specialization, they serve on a number of prestigious professional and national committees and boards (including as a program officer at NSF), their work is well cited, and their PhD students have excellent placement record. In the domain of computer science, most of the faculty are competitive and have a rank appropriate to their level of professional visibility.

b. From a disciplinary perspective, what is your assessment of the research areas in which the department is already strong, and areas with the potential for further growth?

The research program in the department is comprehensive, covering basically all core subfields of computer sciences, including software systems, algorithms, database, graphics, human-machine interaction, security, networks, high-performance computing, computational intelligence, big data analytics and bioinformatics. A number of faculty members are well known in their fields, such as high-performance computing, bioinformatics, and astro-informatics. As individuals, they have made some high-profile contributions to their fields.

Unfortunately, the number of faculty alone is not sufficient for building a national reputation in a particular subfield of computer science. That typically requires at least 5-10 highly productive faculty in one particular subfield (critical mass). Based on its strategic plan, the department needs to consider focused hiring in area(s) it wants to be known for. Currently, despite an acceptable funding level per faculty member (for the department’s CRA category), and a decent publication record, faculty research areas are sufficiently diverse that the critical mass in a particular computer science subfield is not there and neither is nationally visibility. For example, examination of the rankings based on important publications in principal computer science subfields\textsuperscript{22} does not find GSU-CS listed in the top 100 in any of the subfields.

A major potential strength of the department is interdisciplinary research. The department’s faculty are involved in multidisciplinary research with a number of other fields. These interactions may become significant growth areas for high impact and large funding. Another area to consider is the emerging focus on “smart cities” – application of advanced technologies to improve life in a city – ranges from internet of things technology, to cloud based services, to security, to advanced analytics. A well-developed partnership with Atlanta could play an important role in this context.

c. What is your assessment of the support structures for faculty and student research (e.g., grant-writing support, travel grants, laboratories, student funding, administrative support, etc.)?

Existing support structure for faculty and student research needs improvements. While there are some research labs and graduate student spaces, those facilities are not sufficient if more comprehensive growth of the department and program is desired. Most of the PhD students are supported to some extent, but full fellowships and organized injection of students (both MS and PhD) into industrial environments is currently an ad hoc process that will require a dedicated person to better organize external and corporate relations. Both pre- and post-award administrative support is limited and would need to be bolstered for the department to move the department into the tier-1 organized research domain.

d. Do you have any recommendations for improvements in the department’s research culture, productivity, and results?

The culture needs to change from individualist to collaborative group-based advancement of strategically defined sub-disciplines and specialties of import to the department’s future. To start with, leadership needs to stabilize. In addition, the undergraduate program needs to be stabilized by restructuring it and adding several more teaching

\textsuperscript{22} http://csrankings.org/
faculty. This would reduce the burden on the faculty involved in research and allow them to focus on increasing their research productivity in strategically defined domains. Strategic hires of top faculty would need to be made, and every effort needs to be made to attract the best PhD students. If research prominence is desired, it is important not to derail the transformation that has begun – from a primarily teaching department into a research department that also has a strong undergraduate program, and one of the top graduate programs. Transformative and continuing investments into department’s resources and culture are needed.

5. Goals

a. Are the goals the department has outlined in its self-study appropriate for the unit?

The goals listed in the self-study reflect to goals of GSU.

G1: STRENGTHEN UNDERGRADUATE PROGRAM with O1: Obtain 3 new teaching laboratories equipped with modern software and hardware; and O 2: Improve undergraduate retention, progression, and graduation rates

G2: STRENGTHEN AND EXPAND GRADUATE PROGRAM with O1: Establish 2 new graduate teaching labs with modern software and hardware; O2: Introduce innovative M.S. programs; and O3: Improve quality of Ph.D. students

G3: ENHANCE RESEARCH PROGRAMS with O1: Secure 3 departmental research labs and adequate faculty research space; O2: Acquire additional financial support for faculty development, graduate students and supplies; O3: Increase the number of faculty; O4: Obtain more external funding; and O5: Enhance interdisciplinary research in bioinformatics and big data via interdepartmental, national and international collaborations

G4: EXPAND COMMUNITY OUTREACH with O1: Develop connections with local high schools; and O2: Develop connections with local industry.

G5: ENRICH INTERNATIONAL INITIATIVES with O1: Expand international research collaborations; and O2: Develop international education programs

a. Are they in accord with disciplinary trends?

Yes, they are, but not all may apply in the case of GSU-CS. GSU-CS is in a situation in which no extra resources are available, and some of the disciplinary trends may not be viable in this context, or may need to have lower priority. For example, G5 probably should be a low priority effort. If an opportunity arises, perhaps, but primary focus needs to be on G1, G2 and G3. To do G4 right will require additional resources.

b. Are the priorities reasonable?

To some extent, but perhaps not exactly as described in the self-study. What is really needed is a strategic plan to guide the priorities and distribution of available (old and new) resources. G1O2 definitely needs to happen, but the way it is done will depend on the restructuring of the undergraduate program and resources. G1O1 can perhaps be done in stages. The same is true of G2O1. G2O2 may need to be delayed, while G2O3 should be top priority. Majority of G3 may need to wait for development of a good strategic plan.

c. Are the resource needs realistic?

The request is conservative. For a transformational change, considerably more will need to be invested.

d. Are any changes or additions warranted?

Solving the departmental leadership situation is paramount.
6. Summary and Recommendations

a. **Summarize the department’s major strengths and challenges.**

The department is relatively young. It falls into the category of small to mid-sized (15 to 30 faculty) urban CS departments in public universities. The department is beginning to transition from being primarily a teaching department to being a viable and nationally recognized CS research department. Given the constraints under which it operates, the department is doing amazingly well and is a great asset to its college and to GSU. Its professional impact and its teaching output (in terms of the numbers of degrees) are nationally competitive in its class, but may not continue to be unless some corrective actions are taken. Diversity of the undergraduate student body is excellent, and diversity of its graduate student body and the faculty is within national norms for CS departments. The major strengths of the department are the faculty, the unique position of GSU in Atlanta and the state in terms of urban placement and opportunities, and the willingness of the faculty and the administration to advance and have the department be a leader in the CS domain. Its major tactical challenges are stabilization of its leadership, its space situation, and teaching capacity of its faculty. Its major strategic challenges are development of a strategic plan and development roadmap, and growth of its research identity and profile. The department is ready for a transformative strategic “big bet” investment to push it to the next level.

b. **List your recommendations.**

1. **Leadership:** permanent leadership must be established: chair and graduate coordinator have both been in "acting" status for 3+ years; this adversely impacts on ability to make decisions, assign workload, re-allocate resources, etc.

2. **Space** appears to be a major practical issue
   a. **Teaching space** – From what we can tell, there is only one computer-based teaching lab for program of 1400+ undergraduates. That is woefully inadequate. Also, some classes need access to specialized hardware. GSU needs to perform an inventory of classes with lab needs, and generate an associated space request to satisfy that need.
   b. **Research space** - Additional space is required to meet research needs of current faculty; addition of new faculty will require additional research space. The current configuration/allocation of space on the sixth floor could be optimized to better meet the needs. However, residual needs will remain even after that reconfiguration. A detailed analysis of space needs should be performed, and a faculty committee should be formed to develop a policy for ongoing, annual re-allocation of space to meet changing demands. This policy would be advisory for the department chair, who should have the final authority in the space allocation decisions. Keeping as much of the department together is important. This amplifies and catalyzes interactions, collaboration and prominence.

3. **Teaching capacity.** The undergraduate student to faculty ratio is out-of-range. A detailed analysis of teaching needs should be performed. We recommend reduced use of graduate students as teachers, and an increase to both lecturer (teaching faculty) and TT/T faculty ranks to meet the demand. Alternatively, GSU may consider an enrollment control on its BS in CS program, by imposing a more stringent admission standard.

4. **Restructure undergraduate program.** Undergraduate degree requirements need to be evaluated in the light of capabilities of the incoming students and the desired student outcomes. GSU-CS should consider eliminating concentrations. In order to increase student retention and graduation probability, the number of undergraduates per class section of lower division courses needs to be reduced. For example, introductory programming section may need to be limited to 30 students, with one or two TAs and a non-tenure-track instructor. This will require additional resources. Also, the current curriculum needs to be evaluated for currency, or it will not meet expectations of employers. The department should seriously consider creation of a capstone/senior design course. This will considerably increase the program’s competitiveness. The department should designate a person (with a graduate degree in CS, but no research load) to "lead the charge" on reforming delivery of the undergrad program - assignment of courses to regular faculty "course content coordinators and supervisors" who vet syllabus and course content, regular evaluations of instruction and guidance and feedback to instructors, organize delivery of office hours, etc. See also Section 3c for more details.

5. **CIS – CS Synergy:** In this context GSU-CS and CIS should consider selective cross-listing of courses (recognizing that same named courses may have different course content across departments). These departments should also consider other forms of collaboration and synergies, such as joint research centers and fast-track programming between BS in CS and MS in CIS.
6. **ABET**: We strongly encourage GSU-CS to pursue ABET accreditation, which will address many curricular and teaching issues in an organized way. An ABET-accredited degree is a great service to students, as some opportunities are only available to ABET-accredited degree holders.

7. **Industrial/Corporate Relations and Marketing**: We advise GSU-CS to form an Industrial Advisory Board and ramp-up interaction efforts with industry, government, the city. For example, the department can invite industry representatives to give talks at seminar series, organize a "research day" event for graduate students, and so on. Currently the interactions with corporation, industry and foundations are ad hoc, and we believe that the department is missing out on many opportunities. GSU-CS should consider creation of a staff position to serve as recruiter and coordinator for industry contacts, internship and co-op opportunities, point person for student organizations, marketing person for department, creator of materials, webmaster, etc.

8. **Strategic**: The department should develop a strategic plan (consistent with the GSU plan) that will guide its growth and evolution. GSU should consider a transformative investment into GSU-CS that would not only provide adequate space, but also consolidate it, and at the same time would enable GSU-CS to coalesce nationally prominent research group(s) in one or two subfields relevant to both GSU and GSU-CS interests. Some examples may be cybersecurity, perhaps a niche informatics area, and one or two domains relevant to “smart cities”. This certainly needs to involve stable GSU-CS leadership, adequate personnel and other resources (including perhaps hiring of one or two senior faculty that could spearhead formation of nationally visible research groups), and formation of the School of Computing (or similar). A pre-cursor to that could be campus-level, inter-disciplinary research centers: e.g., in cybersecurity, big data, etc.

9. **Stipends**: Graduate student stipends appear to be lower than what is nationally competitive for the CS discipline. Furthermore, fees are high and that reduces the value of the stipend, and has an adverse impact on the recruiting of good graduate students. Stipends should be compared with peer and aspirational departments and pay market rates.

10. **Faculty hiring**: The department needs to start hiring strategically. It needs to build around core areas of expertise and competence to maximize impact, and avoid scattershot or "breadth" approach. Rather than hiring the best that apply, the department should actively search to hire the best in one or two subdomains it wants to be nationally known for.
Appendix A – Review Schedule

Computer Science Department
Georgia State University Academic Program Review External Reviewer Schedule

Sunday, February 19
6 pm DINNER with Drs. Sunderraman, Bourgeois, and Cao

Monday, February 20
9.30 – 10.00 Provost Risa Palm, Associate Provost for Academic Affairs, Lisa Armistead, Associate Provost for Graduate Studies and Kavita Pandit, Associate Provost for Faculty Affairs, Michael Galchinsky
10.15 – 10.45 Dean Sara Rosen, Associate Dean Binghe Wang, Department Chair Raj Sunderraman
11.00 – 11.45 Department Chair Raj Sunderraman
12.00 – 1.30 LUNCH @ Sun Dial (Vouk, Kraemer, Xu, Angyry, Belkasim, Harrison, Hu, Prasad)
1.30 – 2.30 Q/A with Department Faculty, Room 755, 25 Park Place
2.30 – 3.00 Free Time, Room 713, 25 Park Place
3.00 – 3.20 Meeting with Faculty (Skums, Hu), Room 713, 25 Park Place
3.20 – 3.40 Meeting with Faculty (Wei Li, Harrison), Room 713, 25 Park Place
3.40 – 4.00 Meeting with Faculty (Prasad, Weeks), Room 713, 25 Park Place
4.00 – 4.20 Meeting with Faculty (Ashok, Zelikovsky), Room 713, 25 Park Place
4.20 – 4.40 Meeting with Faculty (Henry, Long), Room 713, 25 Park Place
4.40 – 5.00 Meeting with Faculty (King, Mussa), Room 713, 25 Park Place
6 pm DINNER with Ashok, Zelikovsky, Zhang

Tuesday, February 21
8.15 – 9.15 Review Team Discussion, Location: Langdale Hall 9th Floor Conference Room
Breakfast/Coffee
9.30 – 10.15 Meeting with Director of Undergraduate Studies (Bourgeois)
10.15 – 11.00 Meeting with Director of Graduate Studies (Cao)
11.00 – 11.20 Meeting with Faculty (Angryk, Yingshu Li), Room 713, 25 Park Place
11.20 – 11.40 Meeting with Faculty (Bhola, Glebova, Manandhar), Room 713, 25 Park Place
11.40 – 12.00 Meeting with Faculty (Belkasim, Wu), Room 713, 25 Park Place
12.00 – 1.00 Working Lunch with Selected Undergraduate Students, Room 755, 25 Park Place
1.00 – 1.40 Meeting with Selected Graduate Students, Room 755, 25 Park Place
1.40 – 2.00 Meeting with Dr. Yi Pan, Interim Associate Dean and Professor of CS
2.00 – 2.45 Preparation for Exit Interview, Room 755, 25 Park Place
3.00 – 4.00 Exit Interview, 100 Auburn Avenue, Participants: Provost Risa Palm, Kavita Pandit, Associate Provost for Faculty Affairs and John Duffield, Director of Academic Assessment and Accreditation, Associate Provost for Institutional Effectiveness, Michael Galchinsky
Dean Sara Rosen, Associate Dean Binghe Wang, Department Chair Raj Sunderraman
Appendix B – Data Sources

The data we use in discussing GSU-CS come primarily from the GSU-CS self-study, its appendix, and our visit observations. It is important to note that rankings, while useful, invariably do not fully capture a particular university environment or a full set of department-specific and department-relevant context and parameters. Therefore, it is necessary to consider those rankings in the framework and the spirit in which they are made. In addition to the self-study and visit information, we also have considered GSU-CS performance based on quantitative information that comes from proven and accepted sources regarding Computer Science discipline.

The sources we have used include (but may not have been limited to):

- Association for Computing Machinery (ACM), [http://acm.org](http://acm.org)
- IEEE ([http://ieee.org](http://ieee.org))
- Google Scholar ([https://scholar.google.com](https://scholar.google.com))
- CS Rankings ([http://csrankings.org/](http://csrankings.org/))
- Phds.org ([http://phds.org](http://phds.org))

Note 1: Appendix 36 of the GSU-CS self-study lists National/International Rankings of the Unit and lists three sources: US News and World Report (NWR, 112th), Phds.org (35th) and the National Research Council (55th). Comments on the validity of these sources follow.

Note 2: The US NWR rankings available online as of the date of this writing (3/1/2017) indicates that the most recent ranking for Computer Science graduate programs was performed in 2014. GSU is tied for 112 along with a number of other programs (SUNY- Binghamton, Missouri U of Science & Technology, Southern Methodist University, Temple, Cincinnati, Oklahoma, Wayne State, and West Virginia), and followed in the rankings of 177 schools by another ~60 schools for whom ranks were not published. This ranking is based solely on the results of opinion surveys sent to department heads and directors of graduate studies in the discipline.

Note 3: The Phds.org rankings use the 2010 NRC data set, the Integrated Postsecondary Education Data Systems (IPEDS) data, the Survey of Earned Doctorates (SED) conducted by national funding agencies (NSF, NIH, etc.) and the Survey of Graduate Students and Postdoctorates in Science and Engineering (GSS) conducted by the National Science Foundation. Their online data, reviewed on 3/1/2017 reports ranges of rankings, with GSU coming in the 24th - 67th of 128 programs in the histogram-based rankings and in the range 38th – 91st of 128 programs in the regression-based rankings. This broad range makes it difficult to meaningfully interpret the rankings.

Note 4: The National Research Council (NRC) rankings from 2010 assessed programs according to 21 different criteria. Five different rankings are reported, each with a high and low value based on various regression analyses. Most meaningful are likely the S-Rank (criteria that scholars say are important) for which GSU ranged from 18th – 59th of 125 programs considered, and from 43rd – 78th for the R-rank (based on similarity to programs viewed by faculty at top-notch). Again, these ranges make it difficult to meaningfully interpret the rankings data. Further, the CRA (Computing Research Association, a national organization of CS departments) has serious concerns about the accuracy and consistency of the CS data in the NRC study. Overall, the high variability in the rankings renders these statistics largely meaningless. The good success in grant funding and excellent record of placement of PhD students is likely a much more meaningful indicator of the steadily increasing quality of the department.
Appendix C – CRA Taulbee Survey 2015