THE SCHOOL OF COMPUTING
AT CLEMSON UNIVERSITY

Executive Summary

A proposal to establish a School of Computing at Clemson University is provided. The plan calls for a significant expansion of the role of computing at Clemson to include research in a broad range of application areas. The new design, consistent with Clemson's Academic Plan, would allow rapid development of emerging, cross-disciplinary research and academic programs to better prepare students for a society in which computing has become truly ubiquitous. Immediate needs include a School Director, six full Professors, six Assistant Professors, a 50% increase in space, and four additional staff.

Objective: Establish Clemson University as a leader in computing. Our motivation for this intention is:

- To enrich the experience of the students
- To attract more and better students to computing and computing intensive disciplines
- To contribute toward Clemson University achieving top-20 public university status.

A leadership position implies nationally and internationally acknowledged scholarship. The nature of computer science as a discipline is rapidly evolving, and we believe that establishing a leadership position at Clemson cannot be based on an expanded, monolithic computer science department. Such a plan would relegate us to following the lead of others for the foreseeable future.

It is important that we embrace the reality that rapid progress in this evolving field requires inter-disciplinary research and the development of inter-disciplinary educational programs. Recognizing the evolutionary shift in computing, the traditional computer science funding agencies such as DARPA and NSF have started focusing their programs on application-specific areas, much as NASA, DOE and other funding agencies have been doing for years.

Many of the universities with which Clemson competes for top twenty public university status have larger and stronger traditional computer science programs. Focusing on inter-disciplinary application areas, such as seen in the highly-successful, Digital Production Arts program, will allow us to differentiate ourselves from other, more traditional programs, and, at the same time, move to the forefront of the evolutionary wave that is now beginning to sweep through computing. We propose to seek a leadership position by developing inter-disciplinary programs in the application of computing across the academy.

Background - The Evolution in Computing

The rationale for our proposal is based on a recognition that computing is evolving rapidly. While we recognize that this evolution introduces significant challenges for computer scientists throughout the nation, we believe it offers a significant opportunity for Clemson University to take a leadership position by adopting a progressive view of computing.

The Department of Computer Science at Clemson was established in 1978 as an outgrowth of the Mathematical Sciences Department. At that time, universities across the nation were beginning to accept computer science as a discipline that would discover and disseminate knowledge of how to build and use computers. For much of its early history, computer science focused on the efficient design and use of

computers, including the study of the ultimate limits of computation. This focus, on a new discipline, led to a highly prolific period of research in which an enormous body of knowledge was established. This knowledge today forms the core of computer science, both in the theory of computation and in the realities of hardware and software system design.

Computing has since become ubiquitous in our society, and it now affects countless aspects of our daily lives. Applications of computing, once restricted to a narrow range of disciplines within science and engineering, now include agriculture, athletics, the arts, business, health care, recreation, and the social sciences, in addition to all traditional science and engineering disciplines. It is thus no surprise that the effective use of computing can be found in most academic disciplines of our University. Consequently, computer science must face the challenge of adapting its science and engineering to an increasing set of applications.

The funding agencies have responded to this evolution by focusing funding priorities on applications. While many mission agencies such as NASA, DOE, EPA have always preferred research targeted to their respective applications, the agencies that have traditionally funded computer science and engineering, DARPA and NSF, are rapidly migrating to focus on applications.

Educating computing professionals and future citizens:

Students who would seek careers in computing continue to need core knowledge of the fundamentals of hardware and software system design, but such core knowledge is no longer enough. They must not only understand the science, be capable of applying engineering practices, but also understand the application domain and its culture to solve problems. Indeed, deep knowledge of the domain of application of computing is almost always a co-requisite for effective problem-solving and discovery. Those who study computer science to pursue a career outside the academy (the overwhelming majority of students) often find that what they learned in computer science is important to the effective application of computers, but they must learn other domains (finance, architecture, insurance, civil engineering, construction). Likewise, because we have made computers more accessible, professionals in other disciplines are using computers in their research and exposing their students to computer applications, often with less than effective results because they lack the foundation that computer science offers. While core computer science remains an important discipline, we believe we are missing significant opportunities to contribute more broadly to our society and better prepare our students for leadership roles in that society.

We need to prepare students to meet the information technology needs of business, government, healthcare, schools, and other kinds of organizations. There are numerous applications areas that offer significant long term challenges and require inter-disciplinary teams, composed of traditional computer scientists and professionals in other disciplines, who could develop the infrastructure (equipment, software, information) that would facilitate progress toward addressing these challenges. As these intersections broaden, more training in the intersection areas is required in order to function more effectively therein. Problems unique to these intersections will emerge, requiring the understanding and study of new underlying principles of computing in these domains. *What is needed therefore is the development of application-specific degree programs which are focused more directly on the central aspects of these intersections, rather than on the central areas of traditional computer science.*

Vision for The School

We propose that Clemson University establish a School of Computing. Our vision for this School is based on our shared beliefs, values, purpose, and mission.

We believe:

- Computing is a highly dynamic discipline. Research is therefore essential if faculty are to stay at the forefront of the discipline and provide appropriate educational experiences to their students.
- Research is an essential experience for all graduate students and for an ever-increasing number of undergraduates.
- Successful research is evidenced by refereed publications, but extramural funding provides a means to this end and is essential if we are to achieve levels of research productivity, from both faculty and graduate students, consistent with national leadership.
- As new disciplines emerge through the integration of computing with non-traditional application areas, those trained in the computing disciplines have an opportunity and responsibility to lead.
- Effective computing requires a constructivist approach to both research and education. We learn by building.

Mission:

Our mission is to provide leadership to Clemson University in the discovery, creation, and dissemination of the knowledge and technique of computing through research and teaching and to provide national leadership in the application of computing to selected areas.

Strategy:

Our strategy will be to:

- Identify application areas that offer significant long term challenges requiring inter-disciplinary teams to develop the infrastructure (equipment, software, data) that will facilitate progress toward addressing the challenges.
- Seek funding sources (e.g., corporate, Military Research Offices, EPA, DOE, NIH, NASA) that offer opportunities to focus on real-world problems in the chosen application areas to complement the traditional sources (e.g., NSF).
- Focus on areas in which Clemson has acknowledged leadership (Digital Production Arts, Advanced Materials, Automotive Engineering, Bioengineering, Environmental Engineering)
- Expose both graduate students and undergraduates to the application areas through projects and inter-disciplinary coursework.
- Involve School of Computing faculty in developing and teaching inter-disciplinary programs with faculty in other disciplines.

Goals:

This is clearly a long term effort. It cannot be achieved quickly, nor can it be achieved with simple organizational changes. Nevertheless, within seven years, we believe the following goals are achievable.

- Have established six application areas for focus of inter-disciplinary research and education (note that at least one such program has already been established – DPA)
- Have sufficient external funding to support every PhD candidate whose research supports the goals of one of the six centers
- Have 50 PhD candidates in the pipeline
- Have 600 undergraduates with an undergraduate class average SAT of 1200.
- Have research expenditures per tenure/tenure track/ research faculty at an average of $250K/yr.
- Have faculty teaching loads of one course per semester.
- Have 15% of faculty named as fellows of at least one professional organization

Structure:

The design of the School is strongly influenced by Clemson's Academic Plan, which calls for niche-based emphasis areas of research that allow dynamic additions and re-directions emanating from collaborative interests.

The School is to be composed of Divisions, each of which encompasses a broad range of applications, well beyond those of traditional computer science. The purpose of such structure is to allow members of each Division to focus on and be responsible for the decisions of curriculum, hiring, tenure, and retention that will be most effective for achieving success in their targeted areas, their areas of expertise. It is expected that the diversity of background and interest across the entire School will be enormous, a microcosm of the University itself, and that curriculum, hiring, tenure, and retention decisions made at School level would be less effective than those made at the Division level.

Our strategy here is to identify application areas that are sufficiently broad in scope to allow synergistic interactions therein, leading to lively research programs, and to provide natural homes for yet-to-be-developed research areas. We suggest that the major divisions of academic study at Clemson University, the Arts, Sciences, Engineering, and Business, plus the attention to pedagogical uses of computing provide a natural framework.

We propose six Divisions, as follows. For each we offer a necessarily *incomplete* list of research focus areas therein.

- **Computational Arts** - computer graphics, visualization, digital animation, film, image processing, virtual reality, human-computer interaction, game development, multimedia systems, computational aesthetics
- **Computational Science** - bioinformatics, computational geometry, mathematical modeling, quantum computing, systems simulation, optimization, computational geography, computational astronomy
- **Computer Science** - networks, embedded systems, sensor systems, operating systems, languages, theory of computation, computer architecture, software engineering
- **Computer Engineering** – digital systems, IC technology, VLSI technology, signal processing, system integration, robotics, embedded systems, wireless communication networks
- **Information Technology and Cyberinfrastructure** – security, database management, systems analysis, requirements analysis, infrastructure design and management, e-commerce, operations research

- **Educational Computing –** Pedagogical use of computing, distance learning, computing education for K-12

This is an initial list only, and we expect evolutionary changes. A principal objective is to establish a structure that is sufficiently flexible to accommodate the rapidly varying nature of the computing discipline.

Why a School?

From its current position as a department in the College of Engineering and Science, the computer science department could achieve some of the goals. Collaboration with other science and engineering disciplines is reasonably accommodated since the academic value systems that reward discovery are similar. Nevertheless, as the DPA program has demonstrated, value systems in other disciplines reward achievements such as performance (e.g., music), engineering tour de force, synthesis of established practices, artistic interpretation, innovative use of known techniques, as well as scientific discovery. As we extend collaboration to these other disciplines, faculty will be making contributions at the intersection of computing and those other disciplines. Value systems must be evolved to reward such contributions and encourage inter-disciplinary programs and research.

In addition, since faculty in many disciplines across college boundaries have embraced computing and will want to participate in these new programs, we need structure that accommodates rather than inhibits their participation. We anticipate that faculty from a broad range of disciplines across the University will seek fractional appointments in this School, and we will welcome such participation.

Finally, we need some definition that permits Clemson to begin differentiating itself. Establishing a school is a strong statement that will enable us to attract people who are interested in working across disciplines and help create excitement for the activity.

Reporting

Each Division will have a Chair, who will report to a School Director. The School will be housed in the College of Engineering and Science, and the School Director will report to the Dean. Nevertheless, because the anticipated range of applications will span most, if not all, University disciplines, we anticipate fractional appointments to positions in the School of faculty from other Colleges.

Degrees

We currently have three undergraduate degrees, a Bachelor of Arts, a Bachelor of Science in Computer Science, and a Bachelor of Science in Computer Information Systems. The B.S. in CIS degree will be renamed the Bachelor of Science in Information Technology, and its curriculum will be revised to reflect the increased IT focus. For all three degrees we will subscribe to an engineering model of a shared core curriculum. This core curriculum will cover the first two years of instruction in each program and be administered on a School-wide basis. Electives that serve to complete the final two years of instruction will be designed and selected by the individual Divisions. Thus a flexible structure that offers multiple tracks to the three degrees will be provided. The current M.S. degree in Computer Science will be administered by the Computer Science Division. The current M.F.A. in Digital Production Arts degree will

be administered by the Computational Arts Division. Additional Master's degrees will be developed as warranted. The current Ph.D. degree in computer science has no specific course requirements, although competency must be demonstrated in three core areas, programming languages and compilers, operating systems, and theory, and one additional area, chosen from graphics, networks, and software engineering. It is anticipated that this degree will continue as a School-wide doctorate with shared core competency requirements augmented by division-specific requirements, thereby providing multiple tracks to the same degree, the doctorate in Computing.

Resource Sharing

The common threads of our research, the significant overlap in course requirements for the degrees, and the dynamic nature of computing itself collectively dictate that many resources are most efficiently shared and managed at the School level rather than the Division level. This includes laboratory space for both research and teaching, instructional computing equipment, and all staff employees.

Teaching loads may not necessarily be balanced across the divisions. Research productivity, as measured by refereed publications, extramural funding, and graduate degrees awarded, as well as contributions to the teaching/training mission of the School will be used by the School Director in balancing total workloads. Those programs and Divisions able to secure funding will be able to augment traditional faculty positions with research faculty.

Required Resources

The indicated expansion represents an increase of more than 100% in both research and instructional activity. Although some savings of scale can be obtained by consolidating certain resources at the School level, such savings are clearly limited. Likewise, some of this increase can be accommodated by hiring research faculty as research funding is secured. We anticipate a need for twice the current space, 25 additional faculty members, 5 additional staff members, and an equipment budget that would allow maintenance of state-of-the-art instructional laboratories for 200 graduate students and 600 undergraduate majors, many of whom would be seeking dual majors in one of our divisions and another, targeted application area.

Implementation

The goals stated herein cannot be achieved instantly. Nevertheless, there is a narrow window of opportunity now opening at Clemson University, and failure to take advantage of this by moving expeditiously toward these goals would significantly and adversely impact long term prospects for success. Immediate needs are as follows:

- A School Director. We seek a nationally-known leader in computing with outstanding academic credentials who shares this vision and will offer sustained leadership in shaping the future of Computing at Clemson University for the next decade.
- An intellectual leader for each of the identified Divisions. We seek six nationally-known leaders with outstanding academic credentials to provide intellectual leadership to each of the Divisions. Appointments will be at the full Professor level.
- New faculty to provide a research critical mass for each Division. We seek six additional faculty positions, at the Assistant Professor level, to provide critical mass for research. It is unlikely that

current faculty in the Department of Computer Science will collectively choose appointments to the new Divisions (see mechanism below) that are balanced in research capability across all six of those Divisions. Thus it is unlikely that these six new positions will be allocated one per Division. The allocation will be determined by the Department of Computer Science after current faculty have made their choices for participation in the new Divisions.

- A 50% increase in space. Space in the newly constructed McAdams annex is already exhausted. Only one office (currently shared by Emeriti faculty) is possibly available for reassignment. Offices for the new faculty, the Director, the staff, and research labs will be required. To be most effective, the space must be contiguous with existing space, and thus additional allocation from McAdams Hall or new construction will be necessary.
- Two positions for computing systems staff. Current staff is already paid on an overload basis. Effective management of computing resources is critical to both research and instruction. As noted above, staff and computing resources will be shared on a School-wide basis.
- Two positions for administrative staff. The current staff/faculty ratio in the Department of Computer Science is lower than that in most, if not all, engineering departments in the College. A 50% increase in faculty cannot be accommodated without a minimal increase in attendant staff.

Current faculty in the Department of Computer Science will be given the opportunity to select their own appointments (at their current rank and tenure status) to any of the six identified Divisions. Fractional appointments to more than one Division will be permitted with commensurate weight given in the collective decisions (e.g. hiring, curriculum) made by that Division.

We anticipate interest in fractional appointments to the School by faculty from across the University and we welcome discussions on such participation.