BUILDING A COLLEGE of COMPUTING 1990-2002[1]

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The visions, ideas, and hard work of forward looking leaders and dedicated faculty and staff from the middle 1950's to early 1990 laid the intellectual, programmatic, and organizational foundations for a broad, innovative academic unit combining research and education for undergraduates, graduates, and professionals[2]. In 1990, when the School[3] of Information and Computer Science (ICS, its predecessor) became the College of Computing (CoC), it had a good record, a moderate sized faculty, eager students, and decent resources of space, equipment, and budget.

THE CONTEXT

Even with a new, well thought out mandate, it was a college in name only. The school did not have sufficient infrastructure, size, and resources needed to meet the operational demands on a college at Georgia Tech (GT). Moreover, it lacked sufficient connections to leading universities and companies strong in computing to be a leader nationally as well as to lead the campus in forward-looking programs. It was one of the two smallest of the six colleges and smaller even than several of the larger schools in the College of Engineering. Also missing was a coherent group vision and the group aspiration to work together to achieve it.

The vision of President Crecine to reorganize the campus in the late 1980s to recognize the importance of all academic units in a university, as well as his understanding of the coming fundamental importance of computing, unleashed a new energy in Computing and the other units operating in the new structures. His leadership extended further to his insistence that we all strive to be the best in our areas nationally and internationally, not just the best in the Southeast; to his constant exhortations to hire new people of the highest quality available, who had experience with the nature of a top-rank research university; and to helping us develop the resources and connections enabling us to advance meaningfully toward those lofty ambitions. Crecine had two overarching objectives for the College: First, to "be at the table when resource decisions are made, not just be represented by a dean whose personal background and interests might not be in computing." Second, his mandate to the new dean was to "lead, not own, computing at Georgia Tech."

Rather than being turned off by these ambitions and the hard work implied by them, most faculty and staff already in the new college understood the great opportunity that had been handed to them and were eager to begin; they met the challenge with energy and imagination. In some

[1] Primary sources for this article are given at the end of this paper.
[2] This history is detailed in *Origins of the College of Computing* cited below.
[3] 'Schools' at Georgia Tech are organizationally the same as 'departments' elsewhere.

ways, that was biggest advantage that the new dean, Peter Freeman, had when he officially began work on July 1, 1990. The next twelve years is a story of innovative ideas and hard work from the faculty and staff coupled with the leadership of senior faculty leaders and the Dean. This encouraged, harvested, combined, and supported the best of those ideas and work to build a new and productive community.

Georgia Tech in 1990 was a large organization (almost 12,000 students, 400+ faculty, 500+ staff) that was undergoing major and rapid changes. The reorganization in the late 1980's was just starting to settle out with the hiring of new deans, operational establishment of new organizations, and development of new working relationships. Tech was a part of a system of thirty-four higher education campuses supported by the State of Georgia, and was primarily dependent on Federal support for research. Further, the early 1990's was a time of recession, putting stress on and even cuts to campus budgets. As a result, the College was hardly the complete master of its own fate!

In addition to this general context, three factors impinged directly on CoC: The choice in September 1990 of Atlanta to host the 1996 Olympics (with GT as the Olympic Village), resulting in a huge amount of planning, construction, and other activity on campus; Crecine himself, always supportive and protective of CoC but with other personal characteristics that caused consternation and eventually led to his resignation in 1994; campus-wide responsibilities of the Dean that were valuable to the campus and indirectly to the College, but did not leave sufficient time for internal matters.

PRINCIPLES AND THEMES FOR SUCCESS

It was clear to the President, the Dean, and many of the initial College faculty – although, perhaps, not to everyone on campus – that computing was going to continue to expand exponentially in amount, importance, and wide impact throughout society. Thus, it seemed obvious from the start that expansion and purposeful activity would be necessary to fulfill the mandate and vision on which the College had been founded.

Five themes characterize the work of the next twelve years:

- Development of collective human resources
- Infrastructure development
- Educational reform and innovation
- Research depth and breadth
- Aggressive outreach.

Actions taken in all of these themes were largely guided by five principles:

- Breadth of computing
- Importance of community
- Importance of every individual
- Quality in everything
- Key role of infrastructure.

Before surveying chronological events from 1990-2002, it will be useful to begin with a brief discussion of the principles followed by a description and illustration of each of the themes.

Principles

Breadth of computing: There are a multitude of views of what constitute computing, but to simplify, there are exclusive and inclusive definitions. The *exclusive* view might be characterized as being concerned primarily with a small number of topics that are academically rigorous, strive for fundamental verities, and change slowly over time. This has traditionally been called "computer science;" physics is an example in another such area. The *inclusive* view is that the topics encompassed by the exclusive view of computer science are used by and are a foundation for a much broader set of topics that involve other organized disciplines as well; most engineering disciplines fall into this category.

The groups and individuals that carried out the 1988-1990 Transition endowed the College with an inclusive charter. They explicitly chose the name "computing" to signify that the new unit should be concerned with much more than "computer science" in the exclusive sense. Although the exclusive view tended to be dominant nationally at that time, this far-sighted view was the most fundamental principle on which the College was founded, and continues to this day.

Importance of community: An organization has some set of relationships – structure – that differentiate it from a random collection of people. An academic unit, like a military unit, is an organization, but it is not a community. 'Community' is a diffuse term that describes a group of people, who may or may not form an organization. It usually involves a certain amount of respect between members, commonality of interest, knowledge of each other's activities, and distinction from similar communities. Because of these characteristics, a community can be more powerful than an organization in some situations. Consider how a military organization that operates in close, extended, and stressful situations often becomes a community and is then capable of achievements not seen in a simple organization of the same size.

Importance of every individual: Beyond the fundamental ethical importance of this statement, there are two givens about an academic organization: It is made up of people and its success will be a reflection of the success of *all* the individuals in the organization. Most academic organizations have three (or more) tiers of people – faculty, staff, and students – based on their roles and it is not uncommon for staff to be underappreciated, mismanaged, or even mistreated by faculty. Aside from the simple humanistic principle of respecting everyone as a person, this ignores the fact that rarely can faculty perform their roles properly without the support of staff. This principle means making sure everyone is well-suited to and likes his or her role, helping each grow in their capabilities, or helping them find an appropriate role elsewhere if needed.

Quality in everything: The most successful organizations in almost any domain are composed of quality people. Beyond outstanding faculty and staff, appropriate organization and good leadership, the principle also applies to inanimate things as well. Everything from the cleanliness of buildings to the usefulness of websites to the organizational structure, and

execution of events reflects on the quality of the people and the organization – and in some cases, to the effectiveness of those activities. In practice, the principle must be applied with common sense and the clear understanding that it not an end in itself.

Key role of infrastructure: Infrastructure is rarely of much interest to most people – until they find that their work and simple daily activities are hindered by substandard, or even missing, infrastructure. Generally, there are two forms – tangible (e.g. buildings, equipment) and intangible (e.g. organizational structure, defined procedures). Everyone understands that having the right tool for a task (e.g. a good computer terminal) is important as is appropriate space in which to carry out the task (e.g. a classroom). Less well understood, but often equally important, are organizational processes (e.g. for recruiting new faculty) and appropriate staffing (e.g. so that researchers don't have to spend their time repairing broken equipment). While this is a very practical principle, it nonetheless differentiates successful organizations from the less successful.

Themes

Development of collective human resources: In 1990 the College was already a functioning community and it was understood that this community needed to be maintained and strengthened if it was to achieve goals that require coordinated and mutually supportive cooperation of the majority. Academic units are not always also communities, a fact recognized by many in ICS and by the new Dean. Over the next twelve years they explicitly maintained and worked to strengthen the sense of community. An integral part of this theme was also the professional development of each individual coupled with efforts focused on individuals to strengthen their sense of belonging to and being important to the larger community.

Two early activities illustrate this theme. In September 1990 a two-day faculty/staff retreat was held off-site in the relaxed conference facilities of a local company. This event helped build on the nascent spirit of community already present and start the process of envisioning a shared future and of strategic planning to achieve it. This was followed up by a set of faculty committees that met over the next several weeks to come up with ideas and suggestions for different areas of importance to the *entire* College – education, research areas, technical support, and so on – specifically not *discipline* focused.

A second important action followed as a result: A presentation of a "*Vision for the College of Computing*" to an initial meeting of an Advisory Board in October 1990. This seminal event extended the community to an important group of external supporters and began the process of engaging faculty leaders with a group of well-placed national leaders in academia and industry. This presentation, while not a complete strategic plan, contained many of the elements of a plan and were then developed into an explicit strategic plan in the following year.

Importance of infrastructure: Given the objectives of the College and based on the experience of the best computing groups in academia, it was obvious that infrastructure needed to be addressed immediately and continuously to insure there was a solid foundation to support programmatic efforts. This set a tone of importance of this issue for the faculty and set a level of expectation for the staff most responsible for building and maintaining our infrastructure.

The College started with a decent physical infrastructure – two large floors of an almost new building and a reasonable complement of computers. The building (now called the College of Computing Building - CCB), while sufficient in size for the moment, had deficiencies in network wiring and did not afford much space for expansion in size of faculty, staff, labs, and student work space. Efforts to obtain more space were largely unsuccessful or minimal for most of the twelve years covered by this paper.

The substandard network wiring was successfully tackled almost immediately and was greatly augmented in the mid-90's by campus-wide upgrades (led by the Dean and others in the College) in preparation for the Olympics. Having newer and more equipment, while directly addressed from the start, was always a race between expanding needs and advancing technology. Of equal importance, however, was the organization whose job it was to plan for and maintain the equipment and address the needs of everyone no matter what their role was.

The College started with a few highly competent people on the Technical Services staff, some of whom went on to form the technical core and leadership of the campus computing office. At the same time, their mission was not clear beyond the technical needs of the equipment and as a result, changes were made to emphasize service to all components of the College. The size and responsibilities of the technical staff were increased to serve faculty, staff, and students better, based on their expressed immediate and long-term needs. The result was an outstanding support organization without which the resulting programmatic results could not have been achieved. It also serves as an excellent example of the relationship between tangible and intangible infrastructure, motivated people, and results.

Educational reform and innovation: The College (and its predecessor, ICS) have operated from their start counter to the norm of infrequent, meaningful educational reform found in research-intensive universities. Overlaying the normal course changes one might expect, a clear and distinguishing theme has been true innovation in content, form, and delivery. These efforts have ultimately involved almost all faculty in one way or another, with leadership provided by the Dean, LeBlanc, Kurt Eiselt, and, later, Mark Guzdial.

Two activities illustrate this. Starting in the first year, there were many efforts to improve services to students. Over time, much of it led by Eiselt, this included increased academic and career counseling, physical facilities such as a central meeting/group work area, 24x7 access to computer clusters (before the days of personal laptops and ubiquitous Wi-Fi), and expanded technical services and equipment for student's individual/group use and in the classroom. Several of these efforts soon established a reputation of being among the best on campus.

Second, the earliest truly substantive innovations of a broad and impactful nature were efforts to experiment with and make major changes in the introductory areas of the undergraduate curriculum to do two things: First, to focus it more on lasting principles of computing rather than on the ever-changing technology and software, and second to democratize it to serve all students on campus.

1991 marked the beginning of a series of educational innovations that have distinguished the history of the College. A redesign of the undergraduate curriculum was completed that included

a set of second-year courses designed to give students an early introduction to three key areas of the discipline: systems, software design/engineering and artificial intelligence followed by choices of specialized elective courses that built on this foundation. Russ Shackelford, a Ph.D. graduate of CoC who had done research on the process of learning to program, was hired as an Instructor and began teaching the introductory programming course. Within a few years, he created a two-course introductory sequence that began with students programming in pseudo-code.

Research depth and breadth: It is impossible to single out one area that best illustrates the focus on research depth, but one early effort that succeeded well was to develop more strength in computer science theory. Through strategic hiring and careful attention to providing encouragement, strength was added to the existing theory faculty. Outreach to CS theoreticians in math and operations research schools on campus further strengthened the group, as did internal interaction with faculty in other fields who had strong theory backgrounds and interests. Mentoring of all faculty, including through the annual review and normal promotion processes, helped all faculty perform at higher levels of competitiveness. This helped them develop their strengths, while also helping some find better homes for their talents.

Educational research, an area entirely new to campus as a research area, is a second area in which there were early efforts that have made an impact. The EduTech Institute, founded by Janet Kolodner and focused on bringing knowledge from cognitive science research to bear on pedagogy, developed a strong national reputation. Those efforts resulted in more ties across campus as well as to an important national research community. It also resulted in a strong presence of Georgia Tech in cognitive science. Later those efforts were expanded and taken in new directions by the hiring of additional faculty whose research was in the general area of educational innovation. While educational research illustrates depth, it also illustrates breadth of the research activity in the College.

Building on roots developed before 1990 and others entirely new, strengths in graphics, visualization, usability, robotics, cybersecurity, networking, human-computer interaction, social computing, computer systems, data bases, and software engineering were all developed in subsequent years. As strength in numbers and activity in several areas developed, research centers in graphics, such as visualization and usability (GVU) and educational technology (EduTech) were formed and a number of smaller labs and groups developed and grew.

All hiring was a combination of strategic and opportunistic action. For example, it was clear from the start that computer networking was going to change the nature of telecommunications. CoC/ICS had a long history of being at the forefront of telecomm and networking, with several established faculty in place. This made a buildup in that area a good strategic move. At the same time the Georgia Research Alliance (GRA), a partnership of the State, industry, and universities was just starting and preparing to provide matching funds for senior faculty hires – a good opportunity. Utilizing these funds, CoC in 1993-94 hired John Limb as a GRA Eminent Scholar. As a long time networking researcher with Hewlett-Packard he was able to establish quickly productive working relationships with other efforts on campus.

Aggressive outreach: From the start there was awareness that a unit larger than a department and, most especially, one that had aspirations to join the existing top computing units in the country, needed a broad portfolio of outreach activities. Two activities illustrate this.

Research outreach to industry was increased in a variety of ways to develop the connections necessary for the two-way flow of ideas and insights between basic and more applied research. This included encouraging interactions with industry, creating specific advisory boards for centers, encouragement of campus visits by major technology firms and reciprocal visits to their research centers by the Dean and others, active outreach to top employers including starting a CoC-specific Career Fair, and inclusion of major industry leaders on the College's Advisory Board.

Georgia Tech had long been a leader in Continuing Education but computing had only been marginally involved. In 1990, broad segments of industry were beginning to see the value of computing in new and advancing areas. This was recognized as a win-win situation if it was more closely tied to the faculty and operated in a professional manner operated by the College, not just a part of a larger program run centrally on the campus. This developed rapidly into a very popular program with professionals across the country. It was based on the experience and knowledge of the faculty and the expressed needs of the attendees. The service to the community was substantial as were the fiscal and relationship-building contributions to the College. By putting many of the faculty in touch with practicing professionals and their companies it helped change faculty attitudes toward applied research coupled with basic research and involvement in the formation of companies.

While these themes are treated separately above for expository purposes, they clearly were intimately tied together in dependent and empowering ways. With the initial context and guiding principles described above, let's turn now to an overview of the major activities and representative events that directly impacted the College.

MAJOR EVENTS AND ACTIVITIES 1990-2002

The first twelve years can be divided roughly in half by two dominant activities – preparing for growth, preceded in the first six months by a jump start, and then expansion.

Jump Start (July – December 1990)

Two fortuitous and unexpected events helped get the College off to a very productive start in 1990-91: Encouragement to hire a specific, well-known faculty leader, and a tip that led to the hiring of an experienced and capable administrator.

The first event occurred the day the new dean accepted the offer to be the founding dean and the encouragement, from Crecine, was to hire another of the candidates for the position: James D. Foley, a well-known pioneer in computer graphics. At the time he was Chair of EE&CS at The George Washington University. Several months of discussions ensued during the late spring and

summer of 1990 and resulted in Foley's acceptance of an offer in the early fall. He agreed to move to Atlanta and join the faculty effective January 1, 1991.

This added an experienced, capable, well-connected, and cooperation-oriented leader to the thin ranks of senior faculty. Moreover, it fit perfectly with the plans and objectives of a group of faculty, led by Larry Hodges and advised by Pete Jensen, who had started an interdisciplinary Imaging Consortium of researchers from multiple units on campus, including the Georgia Tech Research Institute (GTRI). Foley immediately started discussions with the members of the consortium regarding developing an interdisciplinary research and education center with a broader scope. By the end of AY91 plans for the new center were developed and regular meetings and interactions begun under the name Graphics, Usability, and Visualization (GVU) Center. The further development and impact of GVU (as it later became known) is an important part of the growth of the College.

The tip in the summer of 1990 came from a young faculty member, Richard Fujimoto, who mentioned to the Dean that Vicky Jackson, long-time administrator in the CS Department at the University of Utah, one of the best departments in the country, was moving to Atlanta and might be interested in a job. Although ICS had been a functioning academic unit in a larger college (COSALS, which went out of existence as an administrative unit in the reorganization), it did not have sufficient support and administrative organizations to operate effectively as a college alongside established and larger units on campus, especially Engineering.

An immediate contact resulted in her joining CoC first as a consultant and then as the first Director in CoC – essentially a chief of staff role. She continued in that position for the next decade and played a pivotal role in the development of the College. She not only managed much of the staff but personally assisted in key tasks such as making high-level contacts, drafting important correspondence, strategizing in a variety of areas, and doing whatever else needed to be done to build a strong, effective organization.

These very early events within the first few months of the life of the College were seminal in the history of the College. Taken together, they set initial standards and sense of forward movement within the College that made a strong statement to the campus regarding our intention to fully implement the vision developed during the campus reorganization of 1988-1989.

Initial Operation (AY91-AY96)

A number of other actions were taken over the first six months that had both short-term, and in most cases, lasting impact. At the start of the Fall Term, a new administrative/technical structure and set of operating principles for the College were announced. This was designed to improve support for students, faculty, and staff This enabled future growth in size as well as growth in capability, personal satisfaction, productivity, and contribution to the common good by everyone.

Among the actions taken were realignment of some staff and research faculty assignments, addition of personnel at multiple levels including other senior staff including Billie Ann Rice as Director of Continuing Education, establishment of new and expanded industry contacts,

development of good working relations between the College and service units on campus, and hiring of Shackelford as an additional full-time instructor. All of these actions, and others taken in the first year including strengthened review and counseling of graduate students, as well as faculty, continued and were strengthened over the period covered by this paper. Most had immediate impact and all had long-term impact in one form or another.

The remainder of the first year and the next two academic years saw several more seminal events. In March 1991 the College held an Inaugural Convocation – an event designed to focus on the intellectual content and potential of computing – with several well-known figures as speakers and panelists. It attracted quite favorable comment and attendance from across campus, setting a standard of quality and innovation for the College and announcing our intention of making a difference. This was followed by a similar event in October 1992, a convocation officially opening GVU. In July 1991, Molly Ford Croft joined as Director of Communications and later moved into development to obtain donated funds for scholarships and other purposes and to strengthen industry ties. This was the initiation of a fund-raising effort focused on the College. That October David Leonard joined as Director of Technical Services.

One of the key hires made in the early days (1992) was Jessica Hodgins. Her research was ground breaking and helped expand the College's efforts in non-traditional aspects of computing greatly; indeed, she was our first "trifecta winner" of an NSF Young Investigator Award, a Sloan Fellow award, and a Packard Faculty Fellowship award all in the same year. She also served as an Assistant Dean (the College's first) focused on our use of space, a perennial problem, and was the first to bring the open lab/office concept to the College, and to Georgia Tech as far as can be determined. She was crucial in helping us hire a string of additional faculty from MIT as well as other places, starting with her then-fiancé, Chris Atkeson, who foreshadowed CoC's major expansion in the robotics area.

The formation begun in 1990 of a strong Advisory Board with academic and corporate members from across the country (and later internationally) continued and illustrated the importance of development as well as communication beyond the normal publishing and personal contact modalities; both activities have continued and strengthened over the years. The bi-annual meeting of the Board in Fall 1991 provided the opportunity to unveil to a broader audience the strategic plan. It was noted in the Plan that

> *"In a world where computer science is very closely blended with a variety of other disciplines in the context of challenging strategic applications, our research activity must push forward the frontiers of basic computer science and selected computing areas in which computer science is a key, but not exclusive, component. Our real specialty, however, will be in knowing how to effectively mix computer science and other areas."*

These initial efforts of the Dean and the faculty to formulate a realizable vision coupled with evolving strategic plans were key to the early and continuing successes of the College and its members. In Fall 1991 a Student Services organization was created with Eiselt as the first Director and April 1992 saw the appointment of LeBlanc as Associate Dean after Jensen resumed his retirement.

In January 1993 the Robert W. Woodruff Foundation gave Georgia Tech a gift of $3 million for support of educational and multi-media efforts. Ninety percent of these funds were placed under the control of the College and were used to found the EduTech Institute. Its objective was "to be one of the top five places in the world that develops and implements innovative and effective applications of technology to education, utilizing cognitive science as a guide."

The first three academic years were a period of starting new activities, establishing new organizational structures, changing existing ones, selectively changing and augmenting staff, and adding a few, new faculty to replace departing or retiring faculty members. The next three years – academic years 1994, 1995, and 1996 – were dominated by internal operational activities, some initial notable research and educational successes, and increasing activity on campus on two dimensions that impacted the College.

AY 1993-94 began on a sad note with the sudden passing of William A. "Gus" Baird, an instructor of lower-division courses since 1977, a favorite of thousands of students, and honored as one of the best lecturers on campus. By fall 1993, construction of new dorms and facilities along with renovation and upgrade of many buildings on campus to form the Olympic Village was obvious and somewhat disruptive. Planning for volunteer engagement, surrendering much of the campus to the Olympic Committee for the summer of 1996, and related activities began to impinge on normal campus operations. Added to this was a mandate from the University System of Georgia that all units must change from the quarter system to semesters beginning Fall Term 1998 – prompting rethinking and redesign of curricula and programs geared to the academic year (just about everything!). Even though Georgia Tech was granted a year's delay because of the Olympics, this, too, was a major, externally imposed distraction.

The rising tide of criticism of Crecine resulted in his resignation as of June 30, 1994. A search begun earlier in the year brought a new president, G. Wayne Clough, to campus on September 1, 1994. Wisely, he didn't disrupt the preparations well underway for the Olympics, which by then were dominating much of the administrative activity on campus. This change in leadership, especially given Crecine's strong support for CoC, took some adjustment. The strength and independence of the College's efforts had already proven themselves, so that the forward motion already established continued.

The Computing Support Organization, led by Leonard, continued to increase technical support for faculty and graduate student research, as well as classrooms and student computer clusters. The addition of several very experienced staff, some of whom had worked with ICS dating back to the 1970s, brought additional depth and new expertise. By the end of AY96, this group was operating as a very professional support group that made a significant contribution to the growth and strength of the College.

The administrative side of CoC's operations – finance, personnel, student services, support for proposal preparation and management of grants, faculty hiring and Reappointment, Promotion, and Tenure (RPT) processes - were all in a much improved condition and running on a regularized basis due to the work of Jackson. The quality and value of this aspect of the College also began to be recognized and respected across campus. Most importantly, it contributed in unseen, but effective, ways to the successes of the faculty and students in their endeavors – the

purpose and intent of all of those operations. In March 1996 outreach and fund-raising activity expanded with the establishment of several endowed student scholarships for CoC students. Utilizing donated funds from John P. Imlay, Jr., the Imlay Faculty Fellowships were set up to support mid-level faculty; the first award was to Gregory Abowd.

GVU, under the leadership of Foley, added strength in numbers of students, faculty from across campus, and industrial interest. Their outreach programs began operation to great success. Research activity in several areas flourished with its support and guidance, and they obtained a large NSF training grant. EduTech, led by Kolodner, also expanded its activities and, with the key involvement of Guzdial and other faculty across campus, obtained a significant DARPA grant for educational software and curricular development.

There is not room here to catalogue all the faculty and student successes, but a sampling of facts and events gives the flavor:

- In October 1993, two Ph.D. students, Rob Kooper (now a senior research programmer at the University of Illinois) and Jim Pitkow (now a successful serial entrepreneur), began taking an annual survey of World Wide Web users. As the first such survey in the world it quickly became very popular and useful. It continued for nine years until it was replaced by a commercial service.
- The first of many future DARPA robotics research contracts to Georgia Tech was awarded to Ron Arkin in 1993, who the year before had guided the first GT robotics Ph.D. graduate, Robin Murphy (now an endowed professor at Texas A&M), to completion.
- Undergraduate John Selbie (now a senior developer at Microsoft developed software that streamed campus radio station WREK broadcasts over the Internet, one of the first two such efforts in the world that both started on the same day. The software is still widely used.
- Hodges and his collaborator, Barbara Rothbaum of Emory, published the first controlled study on the use of virtual reality exposure for psychotherapy in the American Journal of Psychiatry in 1995. It received national media attention, led to the creation of the Virtually Better startup building systems for therapy that is still in business today, and showed the value of such treatment for PTSD among other conditions.
- *US News & World Report* in early 1996 ranked Georgia Tech #1 for graduate programs in Graphics and Human Interaction, beating out Brown, CMU, UNC, and MIT.
- When Foley announced at the start of AY96 that he was stepping down as GVU Director at the end of the academic year, a nation-wide search attracted several prominent researchers from which Jarek Rossignac, a senior researcher at IBM, was chosen.
- In AY96, CoC research expenditures exceeded $5 million, almost 2½ times what was spent in AY90 when the College came into existence.

While not as visible, these and most other successes would not have been possible without the dedicated staff and organizational processes that had been built up over the previous six years.

Beyond the activities overviewed above, the first six years was a period of frantic activity across campus preparing for the Olympics, developing three new colleges created by the reorganization

in 1989-1990, and changing most of the top administration (including all new deans). The staging of the Olympics provided a definite endpoint and an enforced "quiet time" for the College of Computing (and the rest of the campus) over the summer of 1996. Most faculty and graduate students worked from home, took industry internships, traveled, wrote papers and theses, attended technical meetings – and probably spent more time than normal with their families!

Expanding and Adding Depth (AY97-AY02)

External to the College, the campus quickly returned to the new normal of changed leadership, utilization of new facilities, and planning for further expansion – a less frenetic atmosphere emphasizing operational effectiveness and response to new external imperatives, including support for economic development. Beyond campus this period saw the full blooming – and crash – of the dotcom boom, significant improvement in Federal funding for computing research, and an economic decline.

Over the next six years the College pivoted from foundation building to effective leveraging of the infrastructure, relationships, and culture built during the first six years. College-wide activity focused on strategic actions to build in size and impact along multiple dimensions; individual activities expanded rapidly in productivity and recognition too numerous to chronicle here.

Just The Numbers. Table 1 below clearly shows the pivot that took place in AY97. The most measurable expansion for the College from 1996 to 2002 was in faculty, staff, and student enrollments, research funding, space, and external recognition. After only adding a net of four new faculty members in the first six years, twenty-one were added in the next six years due to the increase in student hours taught, including non-major service courses. The expansion in funded research and research faculty (including post-docs) was a direct result of the faculty expansion. The significant increases in M.S. and Ph.D. students was another direct result of having more faculty. The added students, coupled with a variety of non-classroom and graduate advising activities of the older faculty, led to the expansion in the number of lecturers and instructors. The number of Ph.D. graduates understandably did not show a significant increase until after 2002 because of two factors – there was an upsurge in students returning to do graduate work after the dot-com bust and the time it typically takes to complete a Ph.D.

Infrastructure Expansion. Building on the foundations laid prior to AY97, the College endeavored to stay ahead of the rapidly growing cohorts of faculty, staff, students, programs, and research. In spite of best efforts, however, most infrastructure expansions were just in time, at best. As is usually the case, space was the most critical item.

While the space expansion shown in Table 1 might appear to be substantial, it was never sufficient. Lack of faculty offices, graduate student space, and lab space, especially for fields like robotics and systems, meant that every increase in personnel precipitated a scramble for space.

Support below the level of the administrative department leaders staff had to increase proportionally. Although not shown and not readily obtainable, staff other than senior staff increased from ~10 in AY91 to ~20 in AY97 to 59 in AY2002 (first year for which an exact number could be obtained). Little or no space was available for meeting rooms, seminar rooms, and student work spaces. Utilization of the space the College could beg, borrow or steal continued to be a major problem in spite of the best efforts of Hodgins, Jackson, and, later, Ellen Zegura. However, one truly major step forward occurred in AY99 with Regental approval for a new computing building and the encouragement of Clough to raise private donations and to make an architectural statement with the design.

	AY91	AY97	AY02
Tenure-track faculty[4]	31	35	56
Research faculty[5]	~8	~15	36
Lecturers and instructors[6]	1	1	9
Senior Staff	~5	~9	~9
Undergraduate majors	427	769	1539
UG graduates[7]	92	79	238
Master's students	73	74	132
Master's graduates[7]	57	46	61
Ph.D. students	109	117	220
Ph.D. graduates[7]	12	13	16
Research expenditures	$2.6M	$5.1M	$13.7M
Space (qualitative only)	Note[8]	Note[9]	Note[10]
National Ranking	~32	18	12

TABLE 1: CoC Snapshots

In addition to adding more staff to the Technical Services Organization (TSO), Finance, Student Services, and other support areas, all these groups matured and developed more procedures and services to try to keep the non-academic load on faculty and students to a minimum. In many ways, this was as important – or

[4] Faculty numbers are of tenure-track faculty in residence only, which may differ for a variety of reasons from a roster of names (such as in the General Catalog).
[5] Institute records do not record in an accessible manner personnel numbers except for tenure-track, teaching, and research faculty. Further, some older records are inaccessible.
[6] Some research faculty also teach a course some terms.
[7] Numbers for graduating students in AY97 may be skewed up or down because of the disruption to the normal graduation progress of students at all levels of the Olympics in 1996.
[8] Two floors of the CoC Building.
[9] All of the above plus five faculty offices, graduate student carrels, and two labs in the GCATT Building; faculty office, graduate student carrels, and high-bay lab in Manufacturing Research Center; substantial leased space in Colony Square for Continuing Education.
[10] All of the above plus most of one floor and part of another in the Centennial Research Building and the start of design of the Klaus Advanced Computing Building.

more so – than just adding more staff. Two areas deserve more detailed description. On the negative side, several attempts to develop a communications activity that would be able to get the positive story of the work of the faculty and students out to a broader audience than the traditional means of just publishing scholarly papers never fully met expectations. On the positive side, TSO made excellent use of the high-quality campus fiber network to reduce the isolation of the increasingly dispersed faculty and students across campus and to work with the faculty to utilize the very advanced network to win major research awards, due in part to the existence of such powerful technical infrastructure.

Student Expansion: The number of highly qualified applicants from the best undergraduate schools here and abroad increased in the latter half of the 1990s. Graduates at all levels were in high demand by industry and academia. Others joined startups or even started them. All had bright prospects. The growing reputation of CoC nationally and locally, as well as the dot-com boom, resulted in steep enrollment increases at all levels.

Undergraduates recognized the value, financial and academic, that a Georgia Tech education provided and flocked to "where the action was" - computing. This was not just for incoming freshmen but transfers from other universities and other majors on campus to the point that the College had to restrict the number of transfers. At the same time, the quality and preparation of the new students continued to increase to make CoC students among the top two or three majors on campus in terms of standardized test scores. They were also seen anecdotally as among the hardest working and highest achieving students. In addition to the very large enrollments in beginning CS classes due to the College's efforts to provide entry level education for all Tech students, non-major enrollments expanded in highly popular fields such as networking, HCI, and robotics. CoC students increasingly were sought out by the best tech companies (e.g. Cisco, Google, IBM, Microsoft), won prestigious awards, went to the very best graduate schools (e.g. CMU, MIT, Stanford) – sometimes in diverse fields not directly related to computing (e.g. divinity, medicine, management), and started companies even while students.

Ph.D. students were attracted by the growing research reputation of the College. Applications actually increased as the dot-com boom became a crash. Many startups failed and established companies contracted so the natural tendency of younger students was often to return to school when job prospects lessened. In a few cases, however, the students that returned for more advanced education had been very successful financially and were able to return to their first love - research and teaching. Master's Students were attracted for some of the same reasons, as well as an increasing need for advanced training in industry even as the total numbers needed were declining for a few years. Some graduates found positions at top schools (e.g. Berkeley, Illinois, Santa Barbara) and the best industrial labs (e.g. Microsoft, IBM, Xerox PARC), as well as excellent positions in a wide variety of industries and government.

There were two very positive results of the large increase in students in CoC classes in the late 1990s. One was to earn the College increased respect on campus as a leader and an important component of campus. The second was to justify significant increases in the funds provided to the College by the Administration due to the obvious need to staff properly the many classes and, in turn, to earn the campus additional support from the State because of the funding formula used by the Regents of the University System of Georgia.

At the same time, the enticements of the dotcom startups were hard to resist for many students and some faculty, including potential new hires. This was a distracting factor but the College did not suffer a debilitating loss of students or faculty. The net result was to broaden and change the prevailing view of what undergraduates should be learning about innovation and marketable skills. The expected role of a faculty member also changed to include applied research and service in supporting economic development.

Faculty Expansion. Expansion of the faculty was enabled by budget growth due to the expanding enrollments, importance to economic development, and the foresight of the campus administration. This resulted in strategic buildups in robotics, new media, educational technology, telecom, information security, and systems. The number of full-time Lecturers was also expanded.

A number of junior faculty were hired as well as mid-level faculty with strong records; many of these faculty have gone on to be major leaders in research and of CoC as an organization. At the senior level established senior people with significant research reputations were hired. Among these were Dick Lipton, a member of the National Academy of Engineering and a widely respected researcher in CS theory, security, and related subjects. At the time he was hired, Lipton was a professor at Princeton, but his involvement with ICS went back to the 1970s via collaboration with several faculty members at that time and extended well into the 1980s. Calton Pu, a researcher in systems with significant DARPA funding at the Oregon Research Institute, was hired as the first John P. Imlay, Jr. Software Chair. A third was Rossignac from IBM (mentioned above as new GVU Director), a noted researcher in computer graphics and visualization. In addition, several senior faculty members with primary appointments in other GT units were added as partial appointments in CoC. Faculty research activity not only expanded in total amount, but amount per faculty member – leveraged by more senior leadership and strong staff and equipment support. Student accomplishments also continued to expand.

There is not room here to catalogue all the faculty and student successes, but a sampling of facts and events gives the flavor:

- The late Karsten Schwan, as PI, in 1997 received a multi-million dollar grant of equipment and cash from Intel to form a High-Performance Computing (HPC) laboratory with Co-PIs in multiple campus units. This was the first multi-unit effort in HPC at GT, leading to the eventual formation of the Center for Experimental Research in Computer Systems (CERCS). One of Schwan's students on the project, Phyllis Schneck, became the first GT Ph.D. in cybersecurity in early 1999. She is now Deputy Under Secretary for Cybersecurity and Communications at the U.S. Department of Homeland Security.
- Undergraduate student Andy Ozment won the prestigious British Marshall Scholarship, only the second GT student in 20 years to win. Ozment went on to a Ph.D. from Cambridge and is now Assistant Secretary for Cybersecurity & Communications, U.S. Department of Homeland Security.
- Gregory Abowd's work on automated capture of live experiences for later access and its implementation in Classroom 2000 receives outstanding national attention. His successful application of software engineering techniques and structures to HCI becomes one of the

leading examples of the emerging field of ubiquitous computing and he is recognized internationally as one of the leaders in that field.

- *US News & World Report* ranked Georgia Tech #12 in 2002 for graduate programs in computer science, with several specialties also highly ranked.
- One of the hires made in the buildup of the robotics/vision group in the late 1990s was Aaron Bobick, at the time a research faculty at MIT. In short order it became clear he was not only an excellent researcher but a leader. In 2001 he was appointed the 3rd Director of GVU. Later, he became the first Chair of the School of Interactive Computing and is currently dean of engineering at Washington University in St. Louis.
- In AY02, CoC research expenditures were almost $14 million, more than 2½ times what was spent in AY96 and over five times was spent in AY90 when the College came into existence.

The Reference Tables cited at the end of this paper, especially Reference Table 1A, provide additional details of faculty expansion.

Programmatic Expansion. As the size of the faculty expanded and junior faculty progressed in their careers, activity in almost all areas grew from individual efforts to more programmatic and group efforts. Between 1996-2002 two new M.S. degree programs and further specializations in the Ph.D. program were developed, educational programs were initiated and/or expanded, and new formal research centers were created.

As information security became more important, the GT Information Security Center (GTISC) was formed in 1998, grew rapidly in engagement, and hired its first full-time director in 1999. Its first impact was in education with establishment of an M.S. in Information Security, and then, with the addition of more faculty and the reorienting of existing faculty interests, it became a presence on the research scene. CERCS, mentioned above, was formally organized and strengthened with an outstanding industrial advisory board.

GVU, the College's oldest and largest center continued to grow. Bobick became the 3rd GVU Director in the summer of 2001 and reframed the mission of GVU "to advance the state of the art of the interaction between people, computing machines, and information by developing technologies that naturally reflect the abilities and behavior of people." In the fall of 1997 an M.S. in Human-Computer Interaction was offered for the first time. It was an interdisciplinary degree program spanning the College of Computing, School of Psychology, and the School of Literature, Communication, and Culture led by Albert Badre.

Involvement of CoC individual faculty with overseas universities had started in the 1960s in ICS and even included some direct agreements with foreign universities in the 1970s. The first institutional agreement between CoC and a foreign university was signed with the 500-year old Universidad de Santiago de Compostela, Spain in 1997. Led by Hodges, it resulted in exchanges of graduate students and post-docs, and a series of short courses given there by CoC faculty and longer visits by their faculty to CoC. A summer abroad program was established for Georgia Tech undergraduates (primarily CoC but open to others), led by Norberto Ezqeurra. It was established in cooperation with the Universitat Politécnica de Cataluña (Barcelona) in 1998 and continues today.

The introductory courses developed by Shackleton in the early 1990s were taken by two large engineering majors along with computer science students by the mid 1990s. By 1998 the introductory course (1501/1502) enrollment was over 2000. By the end of the decade, a course based on the first course of the sequence became a requirement for all Georgia Tech undergraduates. This was a challenging role for the College, both logistically and intellectually, requiring more adaptation and innovation. The challenge of obtaining enough teaching assistants, providing timely feedback on assignments, and meeting the needs of all units on campus as they rapidly upgraded their needs for computing instruction ultimately resulted in a switch to a more traditional programming course.

Nonetheless, the experience was valuable and clearly positioned the College as the campus leader in computing education. It also showed the durability and usefulness of the curriculum redesign done in the early 1990s. As part of the switch to semesters, the faculty first developed a new curriculum which when evaluated proved too inflexible for students and created too many courses to be handled by the size of the faculty. The final design built on the gateway courses concept from the 1991 curriculum, defining a core of required courses that ended in the sophomore year, with students then choosing two specialization tracks plus a capstone project to complete their degree requirements – a forerunner of the Threads curriculum introduced in 2006.

Continuing Education, headed by Tom Pilsch who had joined CoC in 1997, built up and modified its offerings to meet better the needs of practicing professionals; this resulted in increased attendance as the national demand for more computing professionals exploded in the late 1990s. Eventually, this demand dropped in the early 2000's due to the dot-com crash and the economic recession in 2001-2002, causing a not unexpected rapid decline in Continuing Education enrollments.

Outreach. Building on the foundations laid in the early 1990s, the College successfully reached out in a number of ways beyond the ever-increasing research results, reputations, and activities of the faculty and the students. The most notable and certainly the most durable success came in 2000.

Through the efforts of Tom Noonan, chair of the Advisory Board and co-founder of Internet Security Systems (ISS) and aided by the new Director of Development Mary Alice Isele, former GT student Christopher Klaus, founder of ISS, gave $15 million in April 2000 for the construction of the Advanced Computing Technology (ACT) Building. The donation was the largest cash donation to Georgia Tech up to that time and was remarkable because of the young age of Klaus. The donation largely fulfilled the State's requirement for private funds for a portion of the building, thus enabling the project to move forward. The building was later dedicated as the Klaus Advanced Computing Building, and Klaus continues to this day as an active Advisory Board member and participant in many CoC activities.

The first endowed chair was created in 1997 with a donation by Frederick G. Storey, with Lipton later becoming the first holder of the chair. That effort was aided by Croft, whose efforts also enabled an additional donation from John P. Imlay, Jr. which with funds previously donated by him were used to created the first Dean's Chair on campus, named in his honor.

The Sam Nunn Nations Bank Policy Forum, held in April 1998, brought together over 150 major CEOs and government officials for a day-long symposium on information security. Keynote addresses were given by the CEO of IBM, Lou Gerstner, and the Director of the Central Intelligence Agency, George Tenet. Planning for the event was led by the Dean and several faculty helped formulate the program. Clough announced the formation of GTISC in his opening remarks. It also made a strong impact on campus, again establishing CoC as a leader.

Incoming Governor Roy Barnes announced in January 1999 an ambitious economic development program, the Yamacraw Project. A key feature of the program was endowment of new chaired professorships, including in CoC. Foley returned from leave to become Executive Director of the Project, and shortly afterwards LeBlanc stepped down as Associate Dean to become Yamacraw Director of Education.

In 2001 a Tenth Anniversary Celebration was held with a variety of events, including: (Former) Attorney General of the United States, Janet Reno giving the Inaugural Thomas E. Noonan Lecture on Information Security; a banquet featuring Crecine; a convocation, "Computing the Next Ten Years," featuring talks by Raj Reddy (CMU), William Malik (Gartner Group), and Craig Mundie (Microsoft); a picnic lunch for everyone in CoC; and a reception to which the entire campus was invited and over 400 came.

EPILOGUE

In early 2002, Freeman announced he was stepping down as dean in May, returning to the faculty, and taking leave to accept a position in Washington, D.C. as Assistant Director of NSF for the Computer and Information Science and Engineering (CISE) Directorate. This was a position in which he was responsible for NSF funding in all areas of Computer Science, Computer Engineering, High-Performance Computing, and related fields as well as being part of the team that managed NSF broadly.

Zegura was appointed by Provost Jean Lou Chameau to serve as Interim Dean until a new dean was in place. As Assistant Dean, she had been heavily involved in developing requirements for the new building and then, as CoC representative, monitoring the design and construction of the Klaus Advanced Computing Building. She continued in that role while Interim Dean.

The story of the College of Computing does not end here, of course. The principles used from the start – breadth of computing, community, importance of individuals, quality, and role of infrastructure – can be seen in the five themes that characterize twelve years of growth along multiple dimensions – development of collective human resources, infrastructure development, educational innovation, research depth and breadth, and aggressive outreach. These twelve years have carried forward and realized the visions of Dorothy Crosland, Vladimir Slamecka, and Crecine to make Georgia Tech a world leader in the new world of information processed by computers – *computing*. Most of all, the overall quality and leadership of the faculty and leaders assembled starting in 1964-65 and continuing to the present have built the internationally ranked College of Computing.

The solid foundation that was built from 1990-2002 on the farsighted visions that preceded the College have enabled the growth and innovations and individual accomplishments since. Taken together, this remarkable fifty-year history is poised to propel the College, Georgia Tech, the field of computing and all that it touches into the future.

REFERENCES

This paper is the third in a project supported by the College of Computing in 2015 as part of a year long 25-50 Celebration of the founding of ICS (50 years ago) and CoC (25 years ago). The papers and other relevant documentation can be found at http://gtcomputing25-50.gatech.edu/timeline and currently consists of:

1. "College of Computing: Timeline of Significant Events 1945-2015," July 27, 2015, 36 pp.
2. "A Brief History of the College of Computing 1964-2015," October 19, 2015, 8 pp.
3. "Origins of the College of Computing 1945-1990," July 27, 2015, 19 pp.
4. "Building a College of Computing 1990-2002," December 4, 2015, 19 pp.
5. 2015 Thomas E. Noonan Distinguished Lecture: "Surprises in CoC History: Who Was Responsible for Starting Computing at Georgia Tech?" Peter Freeman.
    - Lecture video
    - Lecture full text
    - Lecture slides (126MB)
    - Lecture handout
6. Data Tables
    - Data Table1A: Tenure-Track Faculty
    - Data Table1B: Lecturers & Instructors
    - Data Table1C: Research Faculty
    - Data Table1D: Adjunct Faculty
    - Data Table2: Senior Staff
    - Data Table3: PhD Graduates
    - Data Table4: MS Graduates
    - Data Table5: Financial & Enrollment Data
    - Data Table7: COC Chairs

Items 2, 3, 4, and 5 are complete, except for errors that are discovered and corrected. Items 1 and 6 will be updated in the first half of 2016.