Personal Statement

Jonathan W. Berry

January 3, 2002

1 Research Accomplishments and Plans

My research areas are experimental algorithmics and software systems for discrete mathematics. Specifically, I am interested in using computer tools to aid the process of developing new algorithms and heuristics for discrete optimization problems. I also have experience in the design and development of general-purpose software for discrete mathematics. It is a long-term project of mine to help DIMACS (the Center for Discrete Mathematics and Theoretical Computer Science) increase the influence of discrete mathematics in education at all levels.

My favorite discrete optimization problems are those involving *graph partitioning*. The goal of this type of problem is to split the vertex set of a graph into two or more parts, with approximately the same number of vertices in each part, such that the number of relationships (edges) between the vertices in different parts is maximized or minimized. This turns out to be crucially important in computer design and in parallel computation. It is remarkable that nobody knows how to solve these problems both optimally and efficiently.

I have had success both with algorithm design and with software systems. My highest-visibility research accomplishment to date has been the Path Optimization heuristic, developed jointly with Mark K. Goldberg, which uses a novel definition of "neighborhood" for neighborhood search. The latter is a technique in which the "neighbors" of a solution to a problem are determined and examined. For example, the neighbors of a candidate graph partitioning solution might be those obtained by swapping two vertices between partitions. In Figure 1, a split vertically down the middle would create the partitioning $\{\{1,3\},\{2,4\}\}$ with a cut size of four edges. A neighboring solution could be found by swapping vertices 1 and 2, resulting in the partitioning $\{\{2,3\},\{1,4\}\}$ with a cut size of 3 edges. Our journal paper on this topic in *Discrete Applied Mathematics* (90), 1999 has been named to that publication's "Editor's Choice, 1999" edition.

I was also project leader for the multi-institutional *LINK* software system. The canonical paper describing the system appears in *Software Practice & Experience* (30), 2000. My leadership in this effort resulted in an invitation to be one of the primary lecturers in DIMACS' 1998 "Reconnect" conference, designed to reconnect scholars at non-research institutions with the research enterprise. It was gratifying to be chosen as one of the leaders, considering that since my institution is a teaching institution, presumably I should have been one of those needing "reconnection." I was also invited to give a plenary lecture at DIMACS' "DREI" (DIMACS Research and Education Institute), which was similar to Reconnect, but sought to create bonds between high school teachers

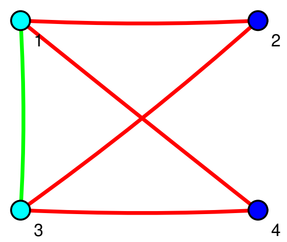

Figure 1: An example graph

and researchers. I had trained some of my students to serve as teaching assistants to help the various faculty learn to use *LINK*, and they had a rewarding experience that summer.

In addition to these largely individual successes in two different areas, I have been able to sponsor undergraduate students to work with me during four of my five summers at Elon. I was also able to sponsor an REU student during my last summer at DIMACS, where I was a postdoctoral fellow. My students and I have worked in both of my areas, and the work has been steady and incremental. I am particularly excited about my work with then-undergraduate John D. Marshall, II, who is currently a graduate student at Florida State University.

John and I spent the summer of 1999 developing extensions to the *LINK* system that were tailored to help designers of graph partitioning heuristics build customized visualizations. This work built upon that of myself and then-undergraduate Damon DeSonier, who had worked with me in the summer of 1997. At the end of the summer with John, we were both invited to Rice University by Dr. Nate Dean. Our task was to help Rice graduate students implement similar extensions to *LINK*. We were successful in this regard, but much more significantly, we used that week to develop a new heuristic for graph partitioning. The new work, as yet unpublished, is quite unrelated to Path Optimization.

Local optimization techniques such as the Path Optimization or the famous Kernighan-Lin algorithm must be supplied with initial partitionings. Furthermore, there is significant evidence that the choice of initial partitioning is important. My work with John Marshall proposes a new algorithm for creating initial partitionings in a novel way. Our work, which has been ongoing for the past year and a half, meshes nicely with the state of the art in local optimization, "Reactive Randomized Tabu Search," by Battiti and Bertossi. We have combined our ideas with theirs to achieve new world-best partitionings on a familiar testbed of graphs often cited in parallel computation literature.

Although our work is not yet finished, John presented some preliminary results at the 2000 ACM Southeast Regional Conference, and won third prize in their student research contest. A fair question to ask might be, "Why should we hire the mentor of a *third* place effort?" My defense is that the only research projects rated ahead of John's were large-scale, long-term, team research projects (e.g. RoboCup) in which the associated undergraduates played minor roles. I am much more impressed by John's publishable one-on-one work with me than the judges were.

Most recently, I have worked with undergraduate Ruth Brown to evaluate "Boost" template library as a potential software basis for a complete redesign of the *LINK* software system. This template library is a serious candidate for incorporation into C++'s Standard Template Library, yet it makes no allowance for hypergraphs (graphs in which relationships are not limited to those between exactly two vertices – three or more vertices can be related in one "hyperedge"), and seems vastly overcomplicated.

In the near term, I have several definite research plans. In particular, I have been accepted to spend a sabbatical year at Sandia National Laboratories in the massively parallel computing group. Although my upcoming switch in institutions is going to mean that I will not be able to spend the year there as I had planned, I still hope to work at Sandia in shorter blocks of time. I plan to use my skills in both experimental algorithmics and software design to help them design and run massive experiments with discrete algorithms.

I have also been selected to be a site leader for another instance of DIMACS's Reconnect program in the summer of 2004. The proposal has been submitted to the NSF by DIMACS, listing myself as a site director at Elon. My switch in institution may make the new institution one of the Reconnect sites, though I am not sure about the portability of this NSF grant.

In the long term, my plans are somewhat contingent upon the environment in which I am to work. At Elon, I have always had at least six distinct course preparations per year, so I have had to content myself with sporadic work on graph partitioning during the academic year followed by flurries of very focused effort in the summers. In an environment with a lighter teaching load and stronger research expectations, I plan to expand my interests and activities to include:

- considering the new models of partitioning problems recently proposed by Bruce Hendrickson at Sandia,
- addressing other discrete optimization problems,
- using my experiences with software and educational users to design a successor to *LINK*,
- a study of algorithms for computational biology, which was one of the subjects of Reconnect '98, and on which I have worked with Elon Science Fellow students, and
- a study of algorithms for quantum computing.

It goes without saying that I intend to involve students in all of my scholarly activities.

2 Statement of Teaching Philosophy

In my five years of experience as an assistant professor at an institution with a strong liberal arts tradition, I have had many opportunities to observe teaching excellence. It has been a long-term project of mine to capitalize on these opportunities and adapt accordingly. However, the primary reason that I enjoy teaching comes from within: it gives me daily opportunities to be creative. Great teaching is every bit as much fun, and often as challenging as research.

The Carnegie Foundation tries to formalize this idea with their definition of a "Scholarship of Teaching," but I have never found their definitions of four different types of scholarship to be very compelling. Their attempt to elevate educational publication to the same plane as pure research publication doesn't serve the practice of teaching well. Neither should scholars be apologetic for a love of discipline that transcends the setting in which they study it, nor should they feel incomplete for not publishing their advances in teaching in the literature. Rather, they should use their natural curiosity and creativity to attract students to beautiful ideas because that is an enjoyable thing to do.

Pedagogical seminars are rejuvenating events and good opportunities to interact with respected colleagues. I have attended many, but never has a one or two hour period influenced me to make a significant change in the way I teach. It has been much more valuable to join a class and participate in it while observing a master teacher. Through extended observation, I have seen how to make meaningful improvements, and have made them.

Therein lies my chosen program for teaching excellence. I am a great observer, and I have a creative mind. Over the past four years, I have sat through five complete courses in addition to my full teaching load. Two of these courses were taught be recipients of the "Daniels-Danieley Award" for the institution-wide teacher of the year. One of the things I admire greatly about Elon is that this award is truly the most prestigious honor on campus. It typically goes to a long-term faculty member who is reduced to tears by the roaring, standing ovation given by the entire institution. Like all Elon faculty, I would be honored by that award more than just about any other.

Neither of these Daniels-Danieley teachers of mine were computer scientists. I sat in on their instances of our freshman "Global Experience" course, as I was learning to teach it myself. I saw them try to apply collaborative learning, with mixed results, and I saw the way they respected, listened patiently to, and demonstrated caring for their students, with fantastic results. I learned from them that small, seemingly unimportant changes in my style could dramatically improve the motivation level of my students. For example, I saw small talk used to such wonderful advantage in creating a trusting atmosphere that I now make an extra effort in that regard. I always try to participate in whatever conversation the students are having when I walk into a room. This was not natural for me at first, as I was always anxious to dive into the material, but I am a believer now. The experience has reinforced the obvious, but sometimes overlooked message that great teachers talk *with* their students, not *to* their students.

The other courses in which I have participated as a "student" are the first three calculus-based physics courses. I have done this partially to fill holes in my education, partially to gain the respect and confidence of some of my students in an equal relationship (I have taken all of the tests), partially to see how natural science is currently taught, and partially to prepare myself for a study of quantum computers. The experience has made me a more interesting professor. The physics faculty have the advantage of textbooks that are *much* better than ours, and they organize their courses so cleanly and beautifully that I was influenced to change mine.

In my five years at Elon, I have compiled a written record of summaries of all of the courses I have taught, along with all of the teaching experiments I have tried. Some of the most successful of these involve taking advantage of the small class sizes inherent to a liberal arts environment. For example, I have had great success using playing cards and charades to teach data structures and algorithms. Ann Wooten, one of my Daniels-Danieley teachers, refers to this technique in her enclosed letter.

Other experiments have involved simple logistics. For example, I have shown instances in which a straightforward organizational change has coincided with dramatically improved retention. The change is simply to ensure that graded first projects have been returned to CS1 students *before* they take the first examination. It takes some curricular gymnastics and creative project design to implement this idea, but the results have been positive.

I hope that you will have the following questions about me with respect to teaching: Does he really love computer science? Can he communicate clearly? Does he make his courses fun without sacrificing challenge? Does he interact with students all of the time? Does he enjoy working with students on undergraduate research? Has he had success with that? The answer to all of these questions is "yes," and you will not be making a mistake if you hire me.

My objective is simple: I want to be a computer science professor in a stimulating liberal arts environment in which computer science is a first class scientific discipline, and in which science takes clear precedence over application.