Physics Department Senior Design Project Proposal

Project Mentor: Prof. Mark Coffey, 303-273-3818, mcoffey@mines.edu
(Name, phone, email)

Project Title Quantum algorithms for logistics and scheduling problems

Project Type: [x] Team; Number of students__1-3___ [ ] Honors

Objective
(What is the science and/or engineering in this project?)
Logistical and scheduling problems are very important in practice, yet very computationally challenging. These problems arise in operations research, computer science, and elsewhere, and commonly require beyond polynomial resources for solution. An open problem is how best to apply quantum resources to the solution of these types of problems. The objectives of this project are to investigate and apply generalized quantum search and other quantum algorithms to this family of problems. Honors option available for this project.

Prior Background
(What is the history of your involvement with this topic, including previous student projects?)
The PI participates in regional, national, and international meetings on quantum information. The PI is funded to investigate this area. Numerous previous student projects in quantum information science have been supervised.

Student Expectations
(What do you anticipate the student(s) will be able to accomplish during the academic year?)
Initially, to gain an understanding of qubits, quantum logic gates, elementary quantum circuits, and quantum search algorithms. The students will apply concepts of matrix decompositions, the properties of tensor products, and controlled logic operations. Both analytic and symbolic computing analyses are anticipated. If a team effort, the team should assign roles and responsibilities and a working timeline (schedule). The student (team) is expected to formulate one or more algorithms to solve a specified logistical or scheduling problem. Especially if a team project, a simulation should be performed. Documentation of the algorithm and any simulation performed is expected. The regular completion of theoretical and/or computational exercises is expected.

Supervision Plan
(Who will be directly interacting with the student(s), you, a post-doc, grad students, or others?)
I will initially directly work with the student(s), and there will likely be meetings where another research student(s) will join the discussion. Weekly meetings will provide status and an opportunity to discuss difficulties and possible approaches for their resolution.

Resources
(What equipment, algorithms, and facilities are available, and what will be assembled as part of the project?)
Student computer labs suffice for computing facilities. Mathematica suffices for symbolic computing software. A quantum computing textbook will be provided, as well as research papers.

Technical References
(Identify a few key starting points for the student(s); journal citations, prior reports, instruction manuals, etc.)

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A standard textbook is Quantum Computation and Quantum Information by M. A. Nielsen and I. L. Chuang (Cambridge, 2000).
F. Lu and D. C. Marinescu, Quant. Info. Proc. **6**, 159 (2007).
Various papers by L. Grover and others on quantum search are available through PROLA (prola.aps.org) and elsewhere, including arxiv.org.