Course Syllabus

18847G: *Special Topics in Computer Systems: Computing for Engineers*
Fall 2018

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Course Description: Computer systems accessible to students and engineers have become incredibly powerful. At the same time, engineering students utilize problem solving environments like Matlab or languages like Python in their research. This course covers how to scale research problems that are coded in such languages/environments from the initial concept stage usually executed on ones' laptop computer to more powerful computing systems like high end servers, GPU accelerated systems, Condor high throughput clusters, cloud computing platforms, and supercomputers. The course presents the problem as engineering trade-off: what is the minimal human effort needed to solve the problem at the needed scale, leveraging all the resources student has available. This requires understanding of algorithms, parallel machines, parallelization strategies, and many other aspects. However, this course teaches how to avoid excessive and tedious parallel programming by leveraging systems and tools that are readily available. Students will use their own research problem as case study.

Number of Units: 12

Pre-requisites: 18-213

Pre-requisite for:

Undergraduate Course Designation:

Undergraduate Course Area:

Class Lecture:

- *Tuesday and Thursday 10:30am – 11:50am TBD*

Required Textbook:
none

Suggested Reading:
none

Other Supplemental Materials:

Brief List of Topics Covered:

- Software stack and hardware for computational engineering problems
- Parallel algorithms, scalability, and numerical analysis of these algorithms
- Frameworks and execution environments for quick problem solving
- Algorithm classes for large scale computing
- Hands-on: how to get your HUGE problem solved with little programming effort

Course Canvas:
To access the course canvas from an Andrew Machine, go to the login page at: https://cmu.instructure.com/. You should check the course canvas daily for announcements and handouts.

Course Wiki:
Students are encouraged to use the ECE wiki to provide feedback about the course at: http://wiki.ece.cmu.edu/index.php.

Grading Algorithm:

30%	In-class participation
30%	Paper presentations and discussion leadership
40%	Class project (software, presentation, and final report)

Tentative Course Calendar:

Date	Day	Class Activity
August		
27	Mon.	Semester & Mini-1 Classes Begin
28	Tues.	State of computing: how big is big? parallel computing, HPC, shared memory/GPU/MPP/FPGAs

30	Thurs.	Computer architecture: 18-240 recap, what matters for your compute problem?
September		
3	Mon.	Labor Day; No Classes
4	Tues.	Software stack for computing: 18-213 recap and beyond
6	Thurs.	Algorithm analysis, scalability, complexity: How quickly do you get answers?
11	Tues.	***Cancelled. CMU TOC***
13	Thurs.	Tools: How to run larger stuff: Condor HT, PSC, ECE cluster demo
18	Tues.	Sequential vs. parallel algorithms
20	Thurs.	Principles of code optimization
25	Tues.	Student Projects: overview presentations
27	Thurs.	Numerical Analysis: how good are your answers?
October		
2	Tues.	Practical issues: how to scale up problems
4	Thurs.	Large scale frameworks: Hadoop/MapReduce, TensorFlow
9	Tues.	Frameworks: Cloud computing: Amazon EC2/Windows Azure
11	Thurs.	From desktop to big iron: large scale Matlab and Python and R
16	Tues.	Scalable algorithms: Large scale informatics/symbolic computing
18	Thurs.	Scalable algorithms: discrete and continuous optimization
19	Fri.	Mid-Semester Break; No Classes
23	Tues.	Scalable algorithms: Graph Computing
25	Thurs.	Scalable algorithms: Numerical linear algebra and FFTs
30	Tues.	Scalable algorithms: Large scale statistics: Monte Carlo and MCMC
November		
1	Thurs.	Scalable algorithms: ODE and PDE solvers
6	Tues.	Student Projects: Project check-in/status report
8	Thurs.	Getting data in and out: Data visualization, Data bases, stores, file systems,…
13	Tues.	Field trip: Pittsburgh Supercomputing Center or ECE Computing/Cyert Hall
15	Thurs.	The next step: C++, OpenMP, MPI, CUDA, Autotuning
20	Tues.	***Cancelled. One-on-one meetings.***
21-23		Thanksgiving Holiday; No Classes
27	Tues.	Guest Lecture: Nick Nystrom, Interim Director, Pittsburgh Supercomputing Center
29	Thurs.	News from SC18: Gordon Bell Finalists and noteworthy hardware and results
December		
4	Tues.	Final Student Project Presentations I
6	Thurs.	Final Student Project Presentations II
10-14		Final Examinations

Education Objectives (Relationship of Course to Program Outcomes):

(a) an ability to apply knowledge of mathematics, science, and engineering: *Implement scalable parallel algorithms, analyze scaling behavior and result accuracy*

(b) an ability to design and conduct experiments, as well as to analyze and interpret data: *Measure performance and analyze it*

(c) an ability to design a system, component, or process to meet desired needs within realistic constraints such as economic, environmental, social, political, ethical, health and safety, manufacturability, and sustainability: *Implement software that solves a large scale problem without the need of extensive programming*

(d) an ability to function on multi-disciplinary teams: *N/A*

(e) an ability to identify, formulate, and solve engineering problems: *Formulate a question that can be solved by large scale computing*

(f) an understanding of professional and ethical responsibility: *N/A*

(g) an ability to communicate effectively: *Multiple presentations of computing-related topics and the final project need to be understandable for non-experts*

(h) the broad education necessary to understand the impact of engineering solutions in a global, economic, environmental, and societal context: *N/A*

(i) a recognition of the need for, and an ability to engage in life-long learning: *N/A*

(j) a knowledge of contemporary issues: *How powerful computing has become to be the third leg of science*

(k) an ability to use the techniques, skills, and modern engineering tools necessary for engineering practice: *Large scale computing becomes another easily accessible tool for engineers*

ECE Academic Integrity Policy (http://www.ece.cmu.edu/programs-admissions/masters/academic-integrity.html**):**

The Department of Electrical and Computer Engineering adheres to the academic integrity policies set forth by Carnegie Mellon University and by the College of Engineering. ECE students should review fully and carefully Carnegie Mellon University's policies regarding Cheating and Plagiarism; Undergraduate Academic Discipline; and Graduate Academic Discipline. ECE graduate student should further review the Penalties for Graduate Student Academic Integrity Violations in CIT outlined in the CIT Policy on Graduate Student Academic Integrity Violations. In addition to the above university and college-level policies, it is ECE's policy that an ECE graduate student may not drop a course in which a disciplinary action is assessed or pending without the course instructor's explicit approval. Further, an ECE course instructor may set his/her own course-specific academic integrity policies that do not conflict with university and college-level policies; course-specific policies should be made available to the students in writing in the first week of class.

This policy applies, in all respects, to this course.

CMU Academic Integrity Policy (http://www.cmu.edu/academic-integrity/index.html**):**

In the midst of self exploration, the high demands of a challenging academic environment can create situations where some students have difficulty exercising good judgment. Academic challenges can provide many opportunities for high standards to evolve if students actively reflect on these challenges and if the community supports discussions to aid in this process. It is the responsibility of the entire community to establish and maintain the integrity of our university.

This site is offered as a comprehensive and accessible resource compiling and organizing the multitude of information pertaining to academic integrity that is available from across the university. These pages include practical information concerning policies, protocols and best practices as well as articulations of the institutional values from which the policies and protocols grew. The Carnegie Mellon Code, while not formally an honor code, serves as the foundation of these values and frames the expectations of our community with regard to personal integrity.

This policy applies, in all respects, to this course.

The Carnegie Mellon Code

Students at Carnegie Mellon, because they are members of an academic community dedicated to the achievement of excellence, are expected to meet the highest standards of personal, ethical and moral conduct possible.

These standards require personal integrity, a commitment to honesty without compromise, as well as truth without equivocation and a willingness to place the good of the community above the good of the self. Obligations once undertaken must be met, commitments kept.

As members of the Carnegie Mellon community, individuals are expected to uphold the standards of the community in addition to holding others accountable for said standards. It is rare that the life of a student in an academic community can be so private that it will not affect the community as a whole or that the above standards do not apply.

The discovery, advancement and communication of knowledge are not possible without a commitment to these standards. Creativity cannot exist without acknowledgment of the creativity of others. New knowledge cannot be developed without credit for prior knowledge. Without the ability to trust that these principles will be observed, an academic community cannot exist.

The commitment of its faculty, staff and students to these standards contributes to the high respect in which the Carnegie Mellon degree is held. Students must not destroy that respect by their failure to meet these standards. Students who cannot meet them should voluntarily withdraw from the university.

This policy applies, in all respects, to this course.

Carnegie Mellon University's Policy on Cheating
(http://www.cmu.edu/academic-integrity/cheating/index.html) states the following:

According to the University Policy on Academic Integrity, cheating "occurs when a student avails her/himself of an unfair or disallowed advantage which includes but is not limited to:

- Theft of or unauthorized access to an exam, answer key or other graded work from previous course offerings.
- Use of an alternate, stand-in or proxy during an examination.
- Copying from the examination or work of another person or source.
- Submission or use of falsified data.
- Using false statements to obtain additional time or other accommodation.
- Falsification of academic credentials."

This policy applies, in all respects, to this course.

Carnegie Mellon University's Policy on Plagiarism
(http://www.cmu.edu/academic-integrity/plagiarism/index.html) states the following:

According to the University Policy on Academic Integrity, plagiarism "is defined as the use of work or concepts contributed by other individuals without proper attribution or citation. Unique ideas or materials taken from another source for either written or oral use must be fully acknowledged in academic work to be graded. Examples of sources expected to be referenced include but are not limited to:

- Text, either written or spoken, quoted directly or paraphrased.
- Graphic elements.
- Passages of music, existing either as sound or as notation.
- Mathematical proofs.
- Scientific data.
- Concepts or material derived from the work, published or unpublished, of another person."

This policy applies, in all respects, to this course.

Carnegie Mellon University's Policy on Unauthorized Assistance
(http://www.cmu.edu/academic-integrity/collaboration/index.html) states the following:

According to the University Policy on Academic Integrity, unauthorized assistance "refers to the use of sources of support that have not been specifically authorized in this policy statement or by the course instructor(s) in the completion of academic work to be graded. Such sources of support may include but are not limited to advice or help provided by another individual, published or unpublished written sources, and electronic sources. Examples of unauthorized assistance include but are not limited to:

- Collaboration on any assignment beyond the standards authorized by this policy statement and the course instructor(s).
- Submission of work completed or edited in whole or in part by another person.

- Supplying or communicating unauthorized information or materials, including graded work and answer keys from previous course offerings, in any way to another student.
- Use of unauthorized information or materials, including graded work and answer keys from previous course offerings.
- Use of unauthorized devices.
- Submission for credit of previously completed graded work in a second course without first obtaining permission from the instructor(s) of the second course. In the case of concurrent courses, permission to submit the same work for credit in two courses must be obtained from the instructors of both courses."

This policy applies, in all respects, to this course.

Carnegie Mellon University's Policy on Research Misconduct
(http://www.cmu.edu/academic-integrity/research/index.html) states the following:

According to the University Policy For Handling Alleged Misconduct In Research, "Carnegie Mellon University is responsible for the integrity of research conducted at the university. As a community of scholars, in which truth and integrity are fundamental, the university must establish procedures for the investigation of allegations of misconduct of research with due care to protect the rights of those accused, those making the allegations, and the university. Furthermore, federal regulations require the university to have explicit procedures for addressing incidents in which there are allegations of misconduct in research."

The policy goes on to note that "misconduct means:

- fabrication, falsification, plagiarism, or other serious deviation from accepted practices in proposing, carrying out, or reporting results from research;

- material failure to comply with Federal requirements for the protection of researchers, human subjects, or the public or for ensuring the welfare of laboratory animals; or

- failure to meet other material legal requirements governing research."

"To be deemed misconduct for the purposes of this policy, a 'material failure to comply with Federal requirements' or a 'failure to meet other material legal requirements' must be intentional or grossly negligent."

To become familiar with the expectations around the responsible conduct of research, please review the guidelines for Research Ethics published by the Office of Research Integrity and Compliance.

This policy applies, in all respects, to this course.

Take care of yourself. Do your best to maintain a healthy lifestyle this semester by eating well, exercising, avoiding drugs and alcohol, getting enough sleep and taking some time to relax. This will help you achieve your goals and cope with stress.

All of us benefit from support during times of struggle. You are not alone. There are many helpful resources available on campus and an important part of the college experience is learning how to ask for help. Asking for support sooner rather than later is often helpful.

If you or anyone you know experiences any academic stress, difficult life events, or feelings like anxiety or depression, we strongly encourage you to seek support. Counseling and Psychological Services (CaPS) is here to help: call 412-268-2922 and visit their website at http://www.cmu.edu/counseling/. Consider reaching out to a friend, faculty or family member you trust for help getting connected to the support that can help.

If you have questions about this or your coursework, please let me know.