CPSC 8810/ECE 8930

High-Performance Computing for Power System Modeling and Simulation

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Course Description

"High Performance Computing most generally refers to the practice of aggregating computing power in a way that delivers much higher performance than one could get out of a typical desktop computer or workstation."

With the increasing demand, scale, and data information of power systems, fast real-time modeling and simulation tools are becoming more important in power system operation and control. Improving the computational efficiency of power system applications requires parallel computing implementation of the solution methods with high-performance computing (HPC) capabilities.

This course is designed to provide instruction in the design and implementation of HPC technologies in power system modeling and simulation through extensive examples, studies, and project demonstrations, so that the students can obtain hands-on parallel programming experiences to resolve large-scale real-world complex power grid problems.

Multithreading, Open Multi-Processing (OpenMP), Massive Programming Interface (MPI), and CUDA/OpenCL will all be introduced as the parallel programming tools, and inter-operate with standard programming languages such as Matlab, C/C++, or Fortran, etc. Parallel solvers, existing power grid simulation tools, and parallel power grid computational frameworks will also be introduced.

Course Objectives

- Learn to design and implement HPC-based solutions to computationally intensive problems for power system modeling and simulation.
    - Develop computational thinking and parallel programming skills.
    - Achieve performance and scalability through understanding of hardware architecture and software mapping.
- Achieve significant hands-on parallel programming experience.
    - Develop real applications on real hardware with Pthreads, OpenMP, MPI, and CUDA/OpenCL.
    - Projects, presentations, and etc.

Course Outline

Topics covered will include (subject to change):

- Basics of HPC and its application in power grid (3 lectures)

- HPC programming interfaces (8 lectures)
    - OpenMP
    - MPI
    - Pthreads
    - CUDA/OpenCL
- Parallel Implementation of Power System Applications (8 lectures)
    - Power flow
    - Dynamic simulation
    - Contingency analysis
    - State estimation
- Introduction to scalable scientific applications, frameworks, and libraries (6 lectures)
    - Petsc
    - GridPACK
    - GridLAB-D
- Team project/presentation/midterm exam (3 lectures)

Course Materials

- No textbooks are required.
- Slides, online resources, papers, and reading materials will be made available to students during the class.

Grades

- Graded Components
    - Assignments/projects/essay: 60%
    - Exams: Midterm 30%
    - Attendance and participation: 10%
- Grading Scale
    - A: 90.0-100.0
    - B: 80.0-89.0
    - C: 70.0-79.0
    - F: 70.0 and below
- One roundup allowed
    - 84.45 -> 84.5
    - 84.60 -> 85.0

Course Policies

- Attendance: Attendance is encouraged. Substantial project information will be provided in class lectures.
- Academic Integrity: Cheating or plagiarizing on any work for this course will receive no credit for that work. Further action will also be taken if necessary.
- Late-work: An assignment submitted 24 hours of the due date will only be eligible for 80% of the maximum number of point allotted; An assignment submitted 24 to 48 hours of the due date will only be eligible for 50% of the maximum number of point allotted; Assignments submitted more than 48 hours after the due date will not be accepted.
- Re-grade: All requests for re-grades must be submitted within one week of the graded assignments being returned.
- Accommodations for students with disabilities: If you have a documented disability that requires an accommodation, please contact me so we can set up an appointment to discuss your needs. Or contact: Student Disability Services, G20 Redfern, 864-656-6848.
- Mobile Devices: Please refrain from using mobile devices during our class sessions.