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CSCI 5451: Introduction to Parallel Computing

University of Minnesota

3 credits, Fall 2021

Table of Contents

- 1. Basic Information
  - 1.1. Catalog Description
  - 1.2. Prerequisites
  - 1.3. Couse Goals
  - 1.4. Staff
  - 1.5. Meetings
  - 1.6. Course Materials
  - 1.7. Office Hours
  - 1.8. Communication
- 2. Coursework and Grading
  - 2.1. Graded Components
  - 2.2. Final Grade Determination
  - 2.3. Assignments
  - 2.4. Late Assignment Submission
  - 2.5. Exams
  - 2.6. Regrade Requests
  - 2.7. Textbook Readings
- 3. Academic Integrity
  - 3.1. Thou Shalt Not
  - 3.2. Penalties
  - 3.3. Fair Collaboration
- 4. General Policies
  - 4.1. Masking During Class Meetings
  - 4.2. Online Behavior
  - 4.3. Use of Recordings

1 Basic Information

1.1 Catalog Description

Parallel architectures design, embeddings, routing. Examples of parallel computers. Fundamental communication operations. Performance metrics. Parallel algorithms for sorting. Matrix problems, graph problems, dynamic load balancing, types of parallelisms. Parallel programming paradigms. Message passing programming in MPI. Shared-address space programming in OpenMP or threads.

1.2 Prerequisites

Grade of C or better in CSCI 4041 or instructor consent.

Students are presumed to have significant experience writing and debugging programs along with some background in basic computer systems architecture such as what is offered through CSCI 2021 and CSCI 4061. Programming assignments will be in the C programming language and students without prior experience working with C programs will be at a major disadvantage.

1.3 Couse Goals

This course focuses on parallel computing, the art of using multiple processing units to solve computational problems. The primary goal of this effort is either to solve a problem in a shorter time than is possible with a single computer or use the same amount of time

to solve a larger problem. The course will primarily focus on tightly coupled parallel computers which have a relatively low overhead to communicate in contrast to networked computers in which communication time is high.

Typical topics covered in the course include the following:

- Basic parallel computing architecture
- Shared and distributed memory computers
- POSIX Threads and OpenMP for shared memory computers
- MPI: Message Passing Interface for distributed memory computers
- CUDA for GPU/Co-processor programming
- Common communication patterns in parallel programs
- Parallel algorithms for matrix operations, sorting, graphs, and discrete optimization
- Evaluation metrics for parallel computing including speedup, efficiency, and isoefficiency
- Emerging technologies such as parallel programming languages and supercomputing architectures

By the end of the semester, a passing student will be able to carry out the following types of activities:

- Describe the differences, advantages, and limitations of various parallel computer hardware architectures.
- Convert an existing serial program into a parallel version accounting for coordination, load balancing, and efficient communication.
- Identify common communication patterns that arise in parallel programming and how several programming platforms make them possible.
- Implement a parallel programs using distributed memory, shared memory, and GPU/Co-processor paradigms.
- Evaluate the theoretical and actual efficiency of parallel programs using standard metrics.

1.4 Staff

Instructor

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Teaching Assistants

Name	James Mooney
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1.5 Meetings

Meeting	Day / Time	Location
Lec 01	MW 09:45 AM-11:00 AM	Akerman 319

1.6 Course Materials

Textbooks

There is no required textbook for the course. However, we will utilize parts of the following texts which may be found via online search.

Introduction to Parallel Computing, 2nd Edition by Grama, Gupta, Karypis, and Kumar. Addison Wesley 2003.
(Optional) This text covers 90% of the material in the course and is a classic despite its >15 year age. It will not be available at the bookstore but excerpts can be located through internet search.

GPU parallel program development using CUDA by Tolga Soyata. CRC Press 2018

(Optional) UMN Library Link. A good introduction to GPU programming as well as PThreads. It includes a very accessible history of GPU development based on the authors personal experience. This text is available online through the UMN library for UMN students.

Additional online resources associated with C programming and parallel architecture will be posted online.

Computing

It is assumed you will have access to a computer with the ability to edit, compile, and run Unix programs. Some university labs provide this ability; the first week of the course will cover how to set up your personal environment as well. If you have difficulty accessing a suitable environment, contact the course staff.

You will need to create a CSE Labs account for use on assignments and during Discussion. Accounts can be created here: https://wwws.cs.umn.edu/account-management/

Environments to compile and run all parallel programs will be through the CSE Labs system so it is imperative that students set up their CSE Labs account and know how to remotely access CSE Labs systems. Some tactics to do so are described here:

https://www-users.cse.umn.edu/~kauffman/tutorials/unix-environment

1.7 Office Hours

Office Hours for staff will be posted on the course Canvas site. Office hours for all staff are open to all students in any section of the course governed by this syllabus. No appointments are necessary but usually students receive help on a first-come / first-serve basis.

Students are strongly encouraged to visit the professor and teaching assistant(s) during office hours to further their understanding of the material: **we are here to help you learn**.

Special Note for Online Offerings: Office hours will be held online using Zoom as be described in the first week of the course.

1.8 Communication

This offering of the course will be administered Online which means you should acquaint yourself with the following resources / policies on communication in the class.

- Canvas (Course Management): used to provide links to other resources and for Overall grade dissemination
- Gradescope (Assignments/Exams): used to submit most graded work, receive grades on that work, and make requests for regrades.
- Piazza (Announcements/Async Q&A): used to ask questions on course material outside of synchronous meetings and for staff to make announcements to students.
- Zoom (Video Conferencing): used to present audio/video synchronously such for individual online appointments and Office Hours.

How should I contact staff?

Here are common situations for students and the best method to use to contact staff.

- I want to get some real-time assistance with some coursework.

  Stop by office online. Locations and times for office hours are listed on the course Canvas site. Keep in mind that **office hours get busy** around project deadlines so there may be a queue to wait in to get help.

- I have a question on an assignment or course content and there aren't any office hours coming up soon.

  Post your question on **Piazza**; staff members check several times a day and answer questions there. Make sure to post an **answerable question** as described in the Etiquette Piazza post and **avoid publicly posting large portions of your code**.

  You might also try **searching Piazza first** to see if someone already asked your question and received an answer.

- I have a logistics questions such as when something is due, when something will happen, etc.

Also use **Piazza** for most of these. If a staff member isn't sure how to answer the question, they'll give you they're best guess sooner and ask the Professor to confirm later.

Staff will often use **Piazza for Announcements** such as upcoming deadlines or canceled office hours. These announcements will go to student email so check your UMN account regularly.

- I think some of my work was graded wrong and I want someone to look at it again.

  Gradescope has a "Request Regrade" feature which will be open for students to use after grades are posted. Using this feature will notify whoever graded your work to have another look. If you cannot resolve the issue, your grader will involve the professor. There are some exceptions to this:

  - Homework Quizzes allow you to retake the Quiz to improve your score. No online Regrade Requests will be available, just retake the quiz up to the deadline.
  - Lab Quizzes can only be regraded in Labs/Office Hours up to the next lab. No online Regrade Requests will be available, visit your lab or office hours to talk to a staff member about your mistakes.

- I need help some one-on-one help and I can't make it to office hours to talk to a staff about it.

  Email one or two of your favorite staff members to see if they can meet outside of their normal office hours. If you don't have luck in the first go, try contacting a different staff member including Prof Kauffman.

- I had a major life event (got sick / family problem / mental health problem) and I'm wondering how to cope with it and this class.

  Email Prof Kauffman as soon as you can. Explain the situation and we'll work out a plan for how to proceed such as rescheduling exams, extending deadlines, or providing some additional help

- I'm going to miss a lecture / lab meeting. What should I do?

  No special action is required: all course meetings will be recorded and will be viewable within a day or two of them happening to support the inevitable conflicts that arise.

2 Coursework and Grading

2.1 Graded Components

Final grades will be determined by scores obtained on the components below according to their associated weight.

Component	Weight	Notes
Assignments (5 x 10%)	50%	Combinations of written work and coding
Mini-Exams (4 x 10%)	40%	30-minutes during lecture on posted dates
Final Exam	10%	Comprehensive

2.2 Final Grade Determination

Final grades will be assigned **without rounding** according to the following criteria.

Percent	Grade	Percent	Grade	Percent	Grade	Percent	Grade
>= 93	A	87-89	B+	77-79	C+	65-69	D+
90-92	A-	83-86	B	73-76	C	60-64	D
		80-82	B-	70-72	C-	<60	F

If circumstances require it, the grading scale may be adjusted, generally in the students' favor.

2.3 Assignments

Students will receive a number of assignments during the semester. Each will involve combine writing programs, answering theoretical questions, and demonstrating knowledge of the recent course topics. Assignments are usually large and require a significant amount of work to complete.

Specific assignments may allow collaboration between pairs of students or require individual work. Pay careful attention to the guidelines for each assignment.

2.4 Late Assignment Submission

Late assignment submission will be penalized as follows.

- On-time submissions receive no penalties
- Submitting 1-24 hours will result in the loss of 10% absolute credit
- Submitting 25-48 hours late will result in the loss 20% absolute credit
- **No submissions will be accepted more than 48 hours after a deadline**
- Late penalties may be assessed later in the semester after the initial round of grading.

Example: Villanelle is running short on time and so takes an extra night to finish HW2. She submits it 16 hours after the deadline. Her grader gives her a 85% but **later in the semester her score is lowered to 75%** due to her late submission incurring a 10% penalty

2.5 Exams

There will be a series of 30-minute Mini-Exams through the semester. These will occur at the end of the lecture on the dates they occur. Dates for the Mini-exams appear in the schedule.

There will also be a comprehensive Final Exam at the end semester. Refer to the schedule for dates of the exams.

At the time of this writing, Exams will take place during lecture meetings in the normal lecture location. Any changes to this will be posted in advance of the exams.

All exams are **Open Resource Exams:** unless otherwise specified you may use any course content during exams including lecture slides, your notes, the textbook, editors/compilers/shells, and any code the you have written or received from course staff. No communication is allowed during the exam (no email/texting/chat), and no Internet searches are allowed (do not "google for answers"). In addition, you may only use exams from previous versions of this course if you personally took those exams. If in doubt, ask about specifics before or during the exam.

Missing an exam results in a zero score and make-up exams will be considered only in situations involving significant life events. Proof of such circumstances will be required for a make-up to be considered.

2.6 Regrade Requests

Most coursework will be graded via **Gradescope** which features a **Request Regrade Button** associated with specific problems and criteria. This will notify the specific individual responsible grading about the dispute. Raise regrade requests respectfully and specifically: mention what you think a grader missed in your answer or why you feel a deduction was unfair. Keep in mind that graders assign credit based on what appears on the project and exams, not post-hoc explanations of answers.

If a Student and Grader are not able to resolve a grading issue to the satisfaction of both, the student can **ask the grader to consult the Professor** who will review the dispute and resolve it. Students should ask their grader to do this, not email the Professor directly.

When grades are published, there will generally be a **1 week window** in which disputes are considered. Failing to request a regrade in that time will forfeit further opportunity to contest the grade.

2.7 Textbook Readings

Readings from the textbook relevant to each lecture are listed in the schedule. You will increase your understanding of lectures by reading associated textbook sections ahead of time, though this is not assumed. We may provide additional reading material to supplement the textbook which will be posted on the course web page.

3 Academic Integrity

PRIME DIRECTIVE: Be able to explain your own work including assignment answers, program code, and exam solutions. The work you submit should be the product of your own effort and reflect your personal understanding.

Nearly all cheating in programming can be averted by adhering to the PRIME DIRECTIVE. Students may be asked at any time to explain code or exam solutions they submit. Inability to do so will be construed as evidence of misconduct. More specific guidelines are given below.

3.1 Thou Shalt Not

Some coursework is to be done individually, usually programming Projects and Exams. For this individual work, the following actions constitute scholastic misconduct (cheating) and will be reported.

- Directly copying someone else's solution to an assessment problem, including student solutions from a previous semester
- Directly copying an answer from some outside source such as the Internet or friend for a homework problem.
- Making use of an Instructor Solution manual to complete problems.
- Submitting someone else's work as your own.
- Using or sharing Exam materials from another student from past offerings of this course; you may view your own past copies of exams but not share them with others.
- Paying someone for a solutions to assignments/exams.
- Posting solutions to any web site including public posts to our course web site.
- Collaborating or copying the work of others during an exam.
- Taking another student's code with or without their consent.
- Giving another student one's own code on assignments or exams
- Aiding or abetting any of the above.
- Witnessing any of the above and failing to report it to an instructor immediately.

REMEMBER: Once you give away your code/work, you lose control of it. This may lead to pain in the following non-obvious cases

- Using a public Github repository to track your code allows anyone to copy it and submit it as their own.
- Sharing code with a classmate "just to help them" may lead to them submitting it as their own, sharing it with others, or selling it for profit
- Giving someone access to your accounts or devices to help them may mean that they use your account to steal your work subsequently.
- Leaving your work open in a public space may allow someone to take snapshots of your screen and use it as their own.

All Of This Has Happened Before And Will Happen Again. Don't become one of your Professor's stories.

Refer to the following links for additional information.

- UMN Student Conduct Code
- Computer Science Department policies on scholastic dishonesty
- Office of Community Standards

3.2 Penalties

Any instance of misconduct that is detected will be referred to the Office of Community Standards and will likely result in failing the course. Be advised that the teaching team will be employing **electronic means to detect plagiarism**. This is extremely easy with computer code so keep your nose clean.

3.3 Fair Collaboration

The purpose of this course is to learn about programming and learning from one another is a great help. To that end, the following actions **will NOT be considered cheating in this course.**

- Collaborating with a partner on Assignments that allow it is perfectly acceptable. Limit your collaborations to within your partnership to avoid trouble.
- Discussing code at a high level with students other than a partner is fair so long as no code is shared. Take great care at the point of directly showing your work to others as your answers are subsequently out of your own control.
- Asking public questions on the course discussion board so long as limited information about your own solution is included. To convey details of your solution, use private posts.
- Asking any course staff member questions in person or online is acceptable and encouraged. Staff members may initiate small group discussions in which collaboration is fine.

- Making use of your own code or exam materials which you accumulated from past semesters of this class is fine. If you are retaking the course, make sure staff know this so that no misunderstandings occur.
- If you are unsure whether a given collaboration is fair or not, stop the activity and clear it with your instructor.

At all times keep the PRIME DIRECTIVE in mind when studying with other students. The above collaborations should be limited to getting someone over a hurdle, not carrying them across the finish line.

4 General Policies

General university policies which apply to our course are listed here: https://policy.umn.edu/education/syllabusrequirements-appa

Summaries of those policies are below.

Students are expected to maintain a high level of civility for all participants in and out of class meetings. This includes respecting participants of all genders, ethnicities, and social backgrounds. Harassment of any type will not be tolerated and failure to behave in a respectful manner will be reported to the University.

Observance of religious events will be accommodated for students of any faith. All possible accommodations will be made for students with disabilities. Please contact the Disability Resource Center and the instructor for further information.

Some special policies in effect for the semester are below.

4.1 Masking During Class Meetings

All students and staff will be required to wear protective masks during class meetings. This directive comes from the University and is intended to stop the spread of disease during the pandemic. No eating/drinking will be allowed during class meetings so masks will stay on everyone throughout each meeting. If students feel they merit an exception to the policy should contact the Professor via email before attending class.

Full details of the University Mask policy are here: https://safe-campus.umn.edu/return-campus/face-coverings

4.2 Online Behavior

This course will have a number of online interactions and the following additional policies on student/staff behavior and Academic Integrity also apply: https://communitystandards.umn.edu/know-code/online-learning-expectations

The gist of the behavior policies are "Don't be a troll" and the Academic Integrity portion reflects our PRIME DIRECTIVE.

4.3 Use of Recordings

This course will include video and audio recordings of class lectures and classroom activities. These recordings will be used for educational purposes and the instructor will make these available to students currently enrolled in this course. Students must seek instructor permission in order to share either course recordings or course content/materials. Similarly, instructors who wish to share zoom recordings with other sections or classes must seek and document permission from students whose image or voice are in these recordings.

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