Course Syllabus

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University of Oklahoma

CS 4473/5473

Parallel, Distributed, and Network (PDN) Programming

Spring 2025

Instructor: Dr. Chongle Pan, Professor of Computer Science and Biomedical Engineering

Email: cpan@ou.edu (mailto:cpan@ou.edu)

Teaching Assistants:

- Justin Reynolds, Ph.D. student of Computer Science, Email: justinreynolds@ou.edu (mailto:justinreynolds@ou.edu)
- Averi Bates, Ph.D. student of Computer Science, Email: Averi.J.Bates-1@ou.edu (mailto:Averi.J.Bates-1@ou.edu)

Class Schedule: 4:30 pm - 5:45 pm on Tuesdays and Thursdays

Classroom: Sarkeys Energy Ctr A0235 (http://www.google.com/maps/search/Sarkeys%20Energy%20Center%20University%20of%20

Calendar Invitation: PDN_Lectures_Zoom_Calendar_Invite_2025.ics (https://canvas.ou.edu/courses/387316/files/120047573?wrap=1) (https://canvas.ou.edu/courses/387316/files/120047573/download?download_frd=1)

Zoom Classroom ID: 916 2090 1039; Passcode: 35736071

https://oklahoma.zoom.us/j/91620901039?pwd=KelSlmKP2rdRyHzCn6AxhV0mgRJahb.1 (https://oklahoma.zoom.us/j/91620901039?

pwd=KelSlmKP2rdRyHzCn6AxhV0mgRJahb.1)

Office Hours:

- **Office Hours with TA Justin Reynolds**:

  Every Monday from 10:30 AM to 11:30 AM and by Appointment

  Zoom Meeting Room ID: 945 8327 2439; Passcode: 46235308

  https://oklahoma.zoom.us/j/94583272439?pwd=NUbvtZb2baz1ixNrkyZaTclsghuQkA.1 (https://oklahoma.zoom.us/j/94583272439?pwd=NUbvtZb2baz1ixNrkyZaTclsghuQkA.1)
- **Office Hours with TA Averi Bates**:

  Every Wednesday from 3:00 PM to 4:00 PM and by Appointment

  Zoom Meeting Room ID: 944 5451 8908; Passcode: 85246561

  https://oklahoma.zoom.us/j/94454518908?pwd=xxpqCC3Lyid0Zgnyv0BCcHnH80zcuA.1 (https://oklahoma.zoom.us/j/94454518908?pwd=xxpqCC3Lyid0Zgnyv0BCcHnH80zcuA.1)
- **Office Hours with Dr. Chongle Pan**:

  After every lecture on Tuesdays and Thursday and By Appointment

Discord Server: https://discord.gg/sfkTVKugWv (https://discord.gg/sfkTVKugWv)

You may ask questions and exchange information about the course and the projects on Discord. The two TAs will monitor the discussion and respond to questions.

OSCER Support for Schooner

Website: **https://www.ou.edu/oscer (https://www.ou.edu/oscer)**

Email: **support@oscer.ou.edu (mailto:support@oscer.ou.edu)**

Zoom help session: 1:00 pm – 3:00 pm on Thursdays and Fridays

https://oklahoma.zoom.us/j/94533999288?pwd=dEtGaFl0dTNMZXA5b005dmloZDRFUT09 (https://oklahoma.zoom.us/j/94533999288?pwd=dEtGaFl0dTNMZXA5b005dmloZDRFUT09)

Course Description

Parallel and distributed computer architectures, algorithms, and programming paradigms. Topics include distributed and shared memory systems, network programming, GPU architectures, load balancing, message passing interface (MPI), multithreaded programming, and distributed and cloud computing. Students will learn to program using MPI, OpenMP, and CUDA.

Course Prerequisites

CS 3113 Operating Systems, CS 4413 Algorithm Analysis

Communication Plan

All the announcements and project assignments will be released in Canvas. You are expected to read the announcements and assignments within a day of their release. The announcements may contain important time-sensitive information, including clarification and correction to the project assignments. If you have questions, please contact the instructor or the TA by email with a subject line that begins with "PDN: ". If you do not receive a reply within 2 days, please send a reminder.

Recommended Textbooks

- **OpenMP and MPI Programming Modules**

  An Introduction to Parallel Programming

  Peter S. Pacheco, Matthew Malensek; 2021, Morgan Kaufmann, 2nd edition, ISBN-10: 0128046058

https://www.elsevier.com/books/an-introduction-to-parallel-programming/pacheco/978-0-12-804605-0 **(https://www.elsevier.com/books/an-introduction-to-parallel-programming/pacheco/978-0-12-804605-0)**

- **GPU Programming Module**

  Programming Massively Parallel Processors: A Hands-on Approach,

  Wen-mei Hwu, David Kirk, Izzat El Hajj; 2022, Morgan Kaufmann, 4th edition, ISBN-10: 0323912311

  (https://www.elsevier.com/books/programming-massively-parallel-processors/hwu/978-0-323-91231-0) https://www.elsevier.com/books/programming-massively-parallel-processors/hwu/978-0-323-91231-0 (https://www.elsevier.com/books/programming-massively-parallel-processors/hwu/978-0-323-91231-0)

- **Network Programming Module**

  Computer Networking: A Top-Down Approach,

  James Kurose, Keith Ross; 2020, Pearson, 8th edition, ISBN-10: 9356061319

  https://www.pearson.com/en-us/subject-catalog/p/computer-networking/P200000003334/9780135928615 (https://www.pearson.com/en-us/subject-catalog/p/computer-networking/P200000003334/9780135928615)

Grades

Assignments and Grade break-down

Assignment	Description	Weight

Exercises	You have two attempts. You are expected to submit an initial solution in class in the first attempt and then re-submit a revised solution based on the instructor's solution in the second attempt. You will receive the full points if your initial solution is non-trivial and your revised solution is generally correct.	15%
Projects	You are expected to answer essay questions, solve programming problems, benchmark performance, and write project reports. You will be graded based on correct implementations of the programs and correct answers in the project reports. Your programs will be tested using auto-grading scripts on the designated computing systems. Partial credits will be given to the code that fails the auto-graders but correctly implements some required functionalities that are well commented. Clear explanation of your code in the comments is essential for us to know your level of knowledge and give partial credits accordingly. You will provide benchmarking results and discuss parallel performance of your program in the report. If your program does not run successfully, you will not be able to provide the actual performance of your program in the report. But you can still discuss the expected results or the range of possible outcomes and provide your rationale. We will give your partial credits for such theoretical discussion in the report. You must complete all the projects independently.	70%

Final Exam	You are expected to complete a take-home exam composed of both theory questions and programming problems. You must complete the final exam independently.	15%
	Total	100%

Graduate students taking this course as CS5473 will have additional assignments in the projects and the final exam (beyond those required for CS4473). Graduate students enrolled in CS4473 will not get graduate credit for the class.

Project Submission and Auto-Grading:

Before submitting your project, you should test your program using the provided test datasets through our auto-grader. If your program can pass our auto-grader, your program is considered to be able to generate the correct output for the grading purpose. The primary objective of these projects is to develop a scalable program that generate the correct output in the shortest amount of time by using parallel computing. You should focus on achieving the best parallel performance in terms of speed-up and efficiency.

Here are some important considerations for auto-grading:

- File Structure: Please ensure that your submissions adhere to the correct file structure. Correct file submission and file names are crucial for the auto-grader to function properly.
- Output CSV Files: Please verify that your output in the CSV files follows the specified convention. You can cross-check by reviewing the test data on Schooner and ensuring that your output matches the provided output files there. The auto-grader may fail to parse your results if the formatting in your output file is incorrect.
- Library Accessibility: Please confirm that all the libraries included in your code do not require additional installations. This prevents any issues related to missing or inaccessible libraries during auto-grading.
- Make file: When you have to edit a Makefile, please make sure that the 'make all' rule works correctly when calling your code, because the auto-grader invokes 'make all' when testing your code. Please also remove the starter code from any make rules,

because the auto-grader will report a compilation error when the actual starter code is not in the submission.
- Mac Users: Please avoid including an extra "/_MACOSX/" folder in your submission if you use MacOS.

Grading Scale

Grade	Points
A	90 ~ 100
B	80 ~ 89
C	70 ~ 79
D	60 ~ 69
F	0 ~ 59

The letter grade thresholds will be no higher than above; they may be lowered at the discretion of the instructors.

Bug Bounty Program

All the problems in the six projects contain complex instructions, autograders, and test datasets. To identify and fix potential errors in the projects, we will institute a bug bounty program to award bonus points to the students who help us validate the projects as early testers. The bonus points will be used to offset any deducted point in a project, but the bonus points will not push your grade above the maximum of 100 points on a project. The bug bounty program is designed to encourage both positive bug reports and negative bug reports on the Canvas Discussions board. We will open a thread for each project in the Canvas Discussion board.

Positive bug reports: If you find any bug or error in the autograders, the test datasets, or the instructions of a project, please report them on the Canvas Discussions board and propose a fix for the bug/error. If you are the first reporter of a bug/error and your fix

works, we will give you 10 bonus points per bug/error for that project. It's important that you can provide a working fix for the identified bug. You can earn up to 30 bonus points in a project. Before you report, please check the Discussion board to make sure this bug has not been reported before.

Negative bug report: We will also give 10 bonus points to each of the first 3 students who have submitted their projects and reported on the Canvas Discussion board that everything works for them in that project. You may also report any tip or trick that you found relevant for the fellow students to know when testing the code.

If you find a bug in any project, please report it to the corresponding Project discussion thread in the discussion session.

Late Policies

- **Late policy for projects:**
  - 1-day late: 5% penalty
  - 2-day late: 10% penalty
  - 3-day late: 15% penalty
  - Beyond 3 days: 0 point for the project

  Every project has a due date and an available date on Canvas. The available date is set to be 3 days later than the due date in order to accommodate late submissions. You need to submit by the due date to avoid the late penalty. You are allowed to submit past the due date and before the available date, but the late penalty will apply as described above. After the available date, Canvas will close the submission and you will get 0 point for this project.

  Some students may need penalty-free extension of the due dates on their projects due to illnesses or some other unexpected events. To give the extension to those who really needs it in rare occasions and to be fair to everyone at the same time, we will give everyone one and only one penalty-free due date extension for the projects in this semester. This penalty-free extension only applies to the due date and the late penalty past the due date. There is no extension on the available date. We do not

accept any submission past the available date. If you fail to submit a project to Canvas before the available date, you will receive 0 point on this project.

We will still apply the late penalty to every project that is submitted past the due date. At the end of the semester, if you have late penalty on one project, we will revise the points for that project to waive the late penalty. If you have late penalties on multiple projects, we will waive the late penalty on the project with the highest late penalty. Since everyone has one penalty-free due date extension, we will reject all requests for extension of project due dates except for a true medical emergency with a written note from a doctor. Please be careful about using this one extension, because your semester will become busier towards the final exam.

- **Late policy for exercises:**

  You have two attempts for every exercise. You should submit the first attempt in class and submit the second attempt within the same week (before the mid-night of the coming Sunday) of the first attempt. The due date and available date of an exercise will be both set when we work on the exercises in class. We will grade the exercises in the following week based on your last attempt. You will lose any un-used attempt after the exercises are graded.

  If you see a muted exercise after the first attempt, which prevents you from viewing the solution after the first attempt, please clear the cache on your computer to fix this. You should be able to view the solution after you finish the last question of an exercise and before you submit the first attempt. You can save the solution pdf file just in case.

Academic Integrity

You must independently complete the projects and the final exam without any help from another human being. You may use other references and online resources, but you cannot verbatim-copy any code without proper acknowledgement and citation. You may use artificial intelligence coding tools (e.g., ChatGPT and Github Copilot), but you must clearly describe in your report how you have used these tools . For example, if some of your code is based on the output from ChatGPT, you must provide the prompt that you have used to ask ChatGPT to generate the code. Basically, the two simple rules are (1) no help in any shape or form from any other human; and (2) proper documentation and acknowledgement of any non-human assistance.

All code submissions in this class will be compared with each other and with all code submissions from previous classes and all code examples that can be found on the internet using anti-plagiarism software. We will check the code plagiarism at the end of the semester for all project assignments and the final exam in a single batch processing. Any suspected academic misconduct will be reported by the instructor and be investigated by OU through the due process.

Thus, if you cheat on a project, you may receive a good score at the time, but you should be worried for the rest of the semester that you can be caught at the end of the semester and you will receive an email directly from the OU Office of Academic Integrity for a formal investigation.

Tentative Schedule (Subject to Change):

Date	Week	Module	Lecture Topics	Projects
01/14	Week 1	Module 0	Introduction to PDN Programming	Project 1
01/21	Week 2	Module 1	OpenMP Programming	
01/28	Week 3	Module 1	OpenMP Parallelization	Project 2
02/04	Week 4	Module 1	OpenMP Shared Memory	Project 3
02/11	Week 5	Module 2	GPU: Data Parallel Programming	
02/18	Week 6	Module 2	GPU: Scalable Parallel Execution	
02/25	Week 7	Module 2	GPU: Memory and Data Locality	Project 4
03/04	Week 8	Module 3	MPI: Introduction to High-Performance Computing	
03/11	Week 9	Module 3	MPI Point-to-Point and Collective Communication	

03/18	Week 10		Spring Vacation	
03/25	Week 11	Module 3	MPI: Parallel Performance	Project 5
04/01	Week 12	Module 4	Distributed Programming: Cloud Computing and Hadoop	
04/08	Week 13	Module 4	Distributed Programming: MapReduce	
04/15	Week 14	Module 5	Network Programming: Computer Networks	Project 6
04/22	Week 15	Module 5	Network Programming: Socket Programming	
04/29	Week 16		Final Exam Preparation Week	
05/06	Week 17		Final Exam Week	Final Exam

University Policies

Academic Misconduct

In addition to the course conduct policies outlined by your professor in the Course Syllabus in the online classroom, please review the Graduate Student Handbook.

It is the responsibility of each student to be familiar with the definitions, policies, and procedures concerning academic misconduct. The Student Code is available from the Office of the Vice President for Student Affairs, and is contained in the **Student's Guide to Academic Integrity (http://integrity.ou.edu/students_guide.html%C2%A0)** .

This site also defines misconduct, provides examples of prohibited conduct, and explains the sanctions available for those found guilty of misconduct.

Plagiarism

Plagiarism is the most common form of academic misconduct at OU. There is basically no college-level assignment that can be satisfactorily completed by copying. OU's basic assumption about writing is that all written assignments show the student's own understanding in the student's own words. That means

all writing assignments, in class or out, are assumed to be composed entirely of words generated (not simply found) by the student, except where words written by someone else are specifically marked as such with proper citation. Including other people's words in your paper is helpful when you do it honestly and correctly. When you don't, it's plagiarism.

For more information about plagiarism, watch this **video (https://libraries.ou.edu/content/academic-integrity-tutorial)** and then take this **short course (https://canvas.ou.edu/courses/129766)** offered by University Libraries.

Reasonable Accommodation for Disabilities

The University of Oklahoma is committed to providing reasonable accommodation for all students with disabilities. Students with disabilities who require accommodations in this course should contact their professor as early in the semester as possible. Students with disabilities must be registered with the Disability Resource Center prior to receiving accommodations in this course.

If you have a disability and you would like to make a request for reasonable accommodation, please see the Graduate Student Handbook or get in touch with the **Accessibility and Disability Resource Center (http://drc.ou.edu/)**.

Adjustments for Pregnancy/Childbirth Related Issues

Should you need modifications or adjustments to your course requirements because of documented pregnancy-related or childbirth-related issues, please contact me as soon as possible to discuss your options. Generally, modifications will be made where medically necessary and similar in scope to accommodations based on temporary disability. Learn more about the rights of pregnant and parenting students by consulting the **FAQ sheets (http://www.ou.edu/eoo/faqs/pregnancy-faqs)** provided by the **Institutional Equity Office (http://www.ou.edu/eoo)**.

Title IX Resources

For any concerns regarding gender-based discrimination, sexual harassment, sexual misconduct, stalking, or intimate partner violence, the University offers a variety of resources, including advocates on-call 24/7, counseling services, mutual no contact orders, scheduling adjustments, and disciplinary sanctions against the perpetrator. Please contact the **Sexual Misconduct Office (https://www.ou.edu/eoo/about/sexual-misconduct-policies)** at 405-325-2215 (8-5, M-F) or **OU Advocates (https://ou.edu/gec/gender-based-violence/advocates)** at 405-615-0013 (24/7) to learn more or to report an incident.

Religious Holidays

It is the policy of the University to excuse absences of students that result from religious observances and to provide for the rescheduling of examinations and additional required classwork that may fall on religious holidays without penalty. It is the responsibility of the student to make alternate arrangements with the instructor at least one week prior to the actual date of the religious holiday.

Copyright Policy

It is illegal to download, upload, reproduce, or distribute any copyrighted material, in any form and in any fashion, without permission from the copyright holder or his/her authorized agent. The University of Oklahoma expects all members of its community to comply fully with federal copyright laws. If such laws appear to have been violated by any user, the university reserves the right (1) to terminate that user's access to some or all of the university's computer systems and information resources and (2) to take additional disciplinary actions as deemed necessary or appropriate. Repeat offenders will be sanctioned and their privileges terminated.

Registration and Withdrawal

If you choose to withdraw from this course, you must complete the appropriate University form and turn the form in before the deadline. If you stop attending the course and doing the coursework without doing the required paperwork, your grade will be calculated with missed homework and examination grades entered as zero. This could result in receiving a grade of F in the course. Deadlines are shown in the **Academic Calendar (http://www.ou.edu/registrar/academic-calendars)** , which is available from the Office of the Registrar.

Final Exam Preparation Period

Pre-finals week will be defined as the seven calendar days before the first day of finals. Faculty may cover new course material throughout this week. For specific provisions of the policy please refer to OU's **Final Exam Preparation Period policy (https://apps.hr.ou.edu/FacultyHandbook#4.10)** .

Mental Health Support Services

If you are experiencing any mental health issues that are impacting your academic performance, counseling is available at the University Counseling Center (UCC). The Center is located on the second floor of the Goddard Health Center, at 620 Elm Rm. 201, Norman, OK 73019. To schedule an appointment call (405) 325-2911. For more information, please visit **University Counseling Center (https://www.ou.edu/ucc)** .

Emergency Protocols

During an emergency, there are official university **procedures (https://www.ou.edu/campussafety/emergency-management-department/procedures)** that will maximize your safety.

Severe Weather:

If you receive an OU Alert to seek refuge or hear a tornado siren that signals severe weather.

1. *Look* for severe weather refuge location maps located inside most OU buildings near the entrances

2. *Seek* refuge inside a building. Do not leave one building to seek shelter in another building that you deem safer. If outside, get into the nearest building.
3. *Go* to the building's severe weather refuge location. If you do not know where that is, go to the lowest level possible and seek refuge in an innermost room. Avoid outside doors and windows.
4. *Get in, Get Down, Cover Up*
5. *Wait* for official notice to resume normal activities.

For more information, visit **Weather Safety Information (https://www.ou.edu/campussafety/university-meteorologist/weather)** .

Armed Subject/Campus Intruder:

If you receive an OU Alert to shelter-in-place due to an active shooter or armed intruder situation or you hear what you perceive to be gunshots:

1. *Avoid*: If you believe you can get out of the area WITHOUT encountering the armed individual, move quickly towards the nearest building exit, move away from the building, and call 911.
2. *Deny*: If you cannot flee, move to an area that can be locked or barricaded, turn off lights, silence devices, spread out, and formulate a plan of attack if the shooter enters the room.
3. *Defend*: As a last resort fight to defend yourself.

For more information, visit **OU Emergency Preparedness site (https://www.ou.edu/campussafety/emergency-management-department/procedures)** .

Fire Alarm/General Emergency:

If you receive an OU Alert that there is danger inside or near the building, or the fire alarm inside the building activates:

1. *Leave* the building. Do not use the elevators.
2. *Know* at least two building exits
3. *Assist* those that may need help
4. *Proceed* to the emergency assembly area
5. *Once safely outside, Notify first responders of anyone that may still be inside building due to mobility issues.*
6. *Wait* for official notice before attempting to re-enter the building.

Course Summary:

Date	Details	Due
Sun Jan 19, 2025	**Exercise 0.1.0 (https://canvas.ou.edu/courses/387316/assignments/2913391)**	due by 11:59pm

Date	Details	Due
	Exercise 0.1.1 (https://canvas.ou.edu/courses/387316/assignments/2913390)	due by 11:59pm
Fri Jan 24, 2025	Project 1 (https://canvas.ou.edu/courses/387316/assignments/2913398)	due by 11:59pm
Sun Jan 26, 2025	Exercise 0.1.2 (https://canvas.ou.edu/courses/387316/assignments/2913392)	due by 11:59pm
	Exercise 1.1.1 (https://canvas.ou.edu/courses/387316/assignments/2913349)	due by 11:59pm
	Exercise 1.1.2 (https://canvas.ou.edu/courses/387316/assignments/2913396)	due by 11:59pm
Sun Feb 2, 2025	Exercise 1.1.3 (https://canvas.ou.edu/courses/387316/assignments/2913378)	due by 11:59pm
	Exercise 1.2.1 (https://canvas.ou.edu/courses/387316/assignments/2913389)	due by 11:59pm
Tue Feb 4, 2025	Exercise 1.1.3 (https://canvas.ou.edu/courses/387316/assignments/2913378) (1 student)	due by 11:59pm
	Exercise 1.2.1 (https://canvas.ou.edu/courses/387316/assignments/2913389) (1 student)	due by 11:59pm
Fri Feb 7, 2025	Project 2 (https://canvas.ou.edu/courses/387316/assignments/2913399)	due by 11:59pm
Sun Feb 9, 2025	Exercise 1.3.1 (https://canvas.ou.edu/courses/387316/assignments/2913357)	due by 11:59pm
Sun Feb 16, 2025	Exercise 2.1.1 (https://canvas.ou.edu/courses/387316/assignments/2913369)	due by 11:59pm
Mon Feb 24, 2025	Project 3 (https://canvas.ou.edu/courses/387316/assignments/2913400)	due by 11:59pm

Date	Details	Due
Sun Mar 30, 2025	**Project 4** (https://canvas.ou.edu/courses/387316/assignments/2913401)	due by 11:59pm
Tue Apr 15, 2025	**Project 5** (https://canvas.ou.edu/courses/387316/assignments/2913402)	due by 11:59pm
Mon Apr 28, 2025	**Project 6** (https://canvas.ou.edu/courses/387316/assignments/2913403)	due by 11:59pm
Sun May 4, 2025	**Project 7** (https://canvas.ou.edu/courses/387316/assignments/2913404)	due by 11:59pm
Wed May 7, 2025	**Final Exam** (https://canvas.ou.edu/courses/387316/assignments/2913397)	due by 11:59pm
	Exercise 2.2.1 (https://canvas.ou.edu/courses/387316/assignments/2913394)	
	Exercise 2.2.2 (https://canvas.ou.edu/courses/387316/assignments/2913351)	
	Exercise 2.3.1 (https://canvas.ou.edu/courses/387316/assignments/2913365)	
	Exercise 2.3.2 (https://canvas.ou.edu/courses/387316/assignments/2913393)	
	Exercise 3.1.1 (https://canvas.ou.edu/courses/387316/assignments/2913388)	
	Exercise 3.2.1 (https://canvas.ou.edu/courses/387316/assignments/2913386)	
	Exercise 3.2.2 (https://canvas.ou.edu/courses/387316/assignments/2913382)	
	Exercise 3.3.1 (https://canvas.ou.edu/courses/387316/assignments/2913361)	
	Exercise 3.3.2 (https://canvas.ou.edu/courses/387316/assignments/2913346)	

Date	Details	Due
	Exercise 4.1.1 (https://canvas.ou.edu/courses/387316/assignments/2913375)	
	Exercise 4.2.1 (https://canvas.ou.edu/courses/387316/assignments/2913387)	
	Exercise 4.2.2 (https://canvas.ou.edu/courses/387316/assignments/2913350)	
	Exercise 5.1.1 (https://canvas.ou.edu/courses/387316/assignments/2913372)	
	Exercise 5.2.1 (https://canvas.ou.edu/courses/387316/assignments/2913353)	
	Exercise 5.2.2 (https://canvas.ou.edu/courses/387316/assignments/2913395)	