Course Information

- ECE 66300 Compiler Code Generation, Optimization and Parallelization (a.k.a. Advanced Compilation and Automatic Programming)
- CRNs: 31192, 31780, 31240, 31781
- Wednesdays 10:30-11:20am, EE 115 (for the in-person section only)
- Course credit hours: 3
- Prerequisites: ECE-56500, CS-50200 or ECE-46800 or ECE-573000 (or equivalent); or contact the instructor.
- Course Website: https://cap.ecn.purdue.edu/ECE663

Instructor(s) Contact Information

- Xiaokang Qiu
- EE 329
- 765-494-9987
- xkqiu@purdue.edu
- Office hours: Wednesdays 11:30-12:30, via Zoom (Meeting ID: 998 5715 1883 Passcode: 663)

Course Description

This course presents the concepts needed to design and implement production quality code generators for any of the more popular languages and families of computer architecture (including various pipelined, superscalar, and macro-parallel machines). Flow analysis, concurrency detection, loop and irregular code optimization/parallelization, as well as automation of these tasks using program synthesis techniques, are covered in detail. Each student will complete a project implementing a simple optimizer/parallelizer/synthesizer.

Learning Resources, Technology & Texts

- Required texts: N/A
- Additional readings: see the course website and Brightspace.

Learning Outcomes

A student who successfully fulfills the course requirements will have demonstrated:

i. an understanding of compile-time software analysis and verification techniques
ii. an understanding of software synthesis techniques
iii. an ability to use common tools for analyze/verify/synthesize your programs

Assignments

Problem sets: There will be 3-4 problem sets covering the core techniques.

Paper presentation: You are expected to present a technique based on a research paper from a list prepared by the instructor.

Project: You are expected to learn one particular technique in detail, and use it in a concrete project, giving a theoretical or practical contribution. Projects are expected to be done either individually or in groups of two. Project will hopefully be at the level of a conference publication.
There will be four milestones for the project:

- The first milestone consists simply of informing the instructor who your teammate is, or letting us know if you plan to do an individual project.
- The second milestone is a 1-page project proposal and a short presentation where you explain what you plan to do for your project and why you think it’s a good idea. You should elaborate on the following: what are you proposing to do, why is it interesting or important, what are the expected challenges, how does it relate to the state of the art, what evidence do you have so far to suggest this may work. It is expected that for this milestone you will have already done some work towards the project, so it is advised that you seek help early on if you have questions about the suitability of your intended project.
- The third milestone will be a presentation describing your project; the exact length of the presentations will depend on the number of projects that are submitted.
- Finally, you are expected to submit a final report describing your project. The report should be at least 3 pages in length in SIGPLAN format. The report should read like a short paper, so it should make it clear what you did, why you did it, and what you learned from doing it.

Overall, projects will be judged in terms of quality of execution, originality, and scope.

**Grading Scale**
The achievement of course objectives will be assessed through a combination of problem sets, paper presentation and course project.

Grades will be assigned as follows:

- 10% — Problem sets
- 20% — Paper presentation
- 70% — Project
- 3% — Team formed by deadline
- 10% — 1-page project proposal
- 7% — Proposal presentation
- 20% — Project presentation
- 30% — Project final report

Your course grade will be determined using an absolute scale: 97–100: A+; 91–97: A; 88–91: A-; and continuing down.

**Attendance Policy during COVID-19**
Students are expected to attend all classes in-person unless they are ill or otherwise unable to attend class. If they feel ill, have any symptoms associated with COVID-19, or suspect they have been exposed to the virus, students should stay home and contact the Protect Purdue Health Center (496-INFO).

In the current context of COVID-19, in-person attendance cannot be a factor in the final grades. However, timely completion of alternative assessments can certainly be part of the final grade. Students need to inform the instructor of any conflict that can be anticipated and will affect the timely submission of an assignment or the ability to take an exam.

Classroom engagement is extremely important and associated with your overall success in the course. The importance and value of course engagement and ways in which you can engage with the course content even if you are in quarantine or isolation, will be discussed at the beginning of the semester. Student survey data from Fall 2020 emphasized students’ views of in-person course opportunities as critical to their learning, engagement with faculty, and ability to interact with peers.
Only the instructor can excuse a student from a course requirement or responsibility. When conflicts can be anticipated, such as for many University-sponsored activities and religious observations, the student should inform the instructor of the situation as far in advance as possible. For unanticipated or emergency conflicts, when advance notification to an instructor is not possible, the student should contact the instructor/instructional team as soon as possible by email, through Brightspace, or by phone. In cases of bereavement, quarantine, or isolation, the student or the student’s representative should contact the Office of the Dean of Students via email or phone at 765-494-1747. Our course Brightspace includes a link to the Dean of Students under “Campus Resources.”

**Academic Guidance in the Event a Student is Quarantined/Isolated**

If you must quarantine or isolate at any point in time during the semester, please reach out to me via email so that we can communicate about how you can continue to learn remotely. Work with the Protect Purdue Health Center (PPHC) to get documentation and support, including access to an Academic Case Manager who can provide you with general guidelines/resources around communicating with your instructors, be available for academic support, and offer suggestions for how to be successful when learning remotely. Your Academic Case Manager can be reached at acmg@purdue.edu. Importantly, if you find yourself too sick to progress in the course, notify your academic case manager and notify me via email or Brightspace. We will make arrangements based on your particular situation.

**Course Schedule**

Below is the tentative schedule of this course, and a rough estimate of how long we will spend on each.

<table>
<thead>
<tr>
<th>Component</th>
<th>Topics</th>
<th>#Week</th>
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</thead>
<tbody>
<tr>
<td>Logic Foundation</td>
<td>Intro to logic, FOL, compactness, Gödel’s theorems, decidability, RE, the Bernays-Shönfinkel-Ramsey class</td>
<td>1</td>
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<tr>
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<td>Theories, decision procedures for various theories, Nelson-Oppen theorem, quantifier elimination, SMT</td>
<td>1</td>
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<tr>
<td>Analysis and Verification</td>
<td>Floyd-Hoare verification, Hoare rules, inductive invariants, termination</td>
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<td>Abstract interpretation, Galois connections, invariant synthesis, widening and narrowing, Craig’s interpolation</td>
<td>1</td>
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<tr>
<td>Program Synthesis</td>
<td>Introduction and definitions, key dimensions, applications</td>
<td>1</td>
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<tr>
<td></td>
<td>User intent, deductive synthesis, inductive synthesis, programming by example, syntax-guided synthesis</td>
<td>1</td>
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<tr>
<td></td>
<td>Oracle-guided synthesis, enumerative search, CEGIS, stochastic search</td>
<td>1</td>
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<tr>
<td>Reactive Programs</td>
<td>Intro to automata theory, MSO, some finite model theory</td>
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<td>Infinite words, LTL, Büchi automata, Vardi-Wolper theorem</td>
<td>1</td>
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<tr>
<td></td>
<td>Reactive synthesis, Büchi games, Pnueli-Rosner theorem, GR(1) games</td>
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<tr>
<td>Project proposal</td>
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<tr>
<td>Paper presentation</td>
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<td>Project presentation</td>
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**Classroom Guidance Regarding Protect Purdue**

The Protect Purdue Plan, which includes the Protect Purdue Pledge, is campus policy and as such all members of the Purdue community must comply with the required health and safety guidelines. Required behaviors in this class include: staying home and contacting the Protect Purdue Health Center (496-INFO) if you feel ill or know you have been exposed to the virus, properly wearing a mask in classrooms and campus building, at all times (e.g., mask covers nose and mouth,
Updated Jan. 9, 2021

no eating/drinking in the classroom), disinfecting desk/workspace before and after use, maintaining appropriate social distancing with peers and instructors (including when entering/ exiting classrooms), refraining from moving furniture, avoiding shared use of personal items, maintaining robust hygiene (e.g., handwashing, disposal of tissues) prior to, during and after class, and following all safety directions from the instructor.

Students who are not engaging in these behaviors (e.g., wearing a mask) will be offered the opportunity to comply. If non-compliance continues, possible results include instructors asking the student to leave class and instructors dismissing the whole class. Students who do not comply with the required health behaviors are violating the University Code of Conduct and will be reported to the Dean of Students Office with sanctions ranging from educational requirements to dismissal from the university.

Any student who has substantial reason to believe that another person in a campus room (e.g., classroom) is threatening the safety of others by not complying (e.g., not properly wearing a mask) may leave the room without consequence. The student is encouraged to report the behavior to and discuss the next steps with their instructor. Students also have the option of reporting the behavior to the Office of the Student Rights and Responsibilities. See also Purdue University Bill of Student Rights.

**Academic Integrity**
Academic integrity is one of the highest values that Purdue University holds. Individuals are encouraged to alert university officials to potential breaches of this value by either emailing integrity@purdue.edu or by calling 765-494-8778. While information may be submitted anonymously, the more information is submitted the greater the opportunity for the university to investigate the concern. More details are available on our course Brightspace table of contents, under University Policies.

**Nondiscrimination Statement**
A hyperlink to Purdue’s full Nondiscrimination Policy Statement is included in our course Brightspace under University Policies.

**Accessibility**
Purdue University strives to make learning experiences as accessible as possible. If you anticipate or experience physical or academic barriers based on disability, you are welcome to let me know so that we can discuss options. You are also encouraged to contact the Disability Resource Center at: drc@purdue.edu or by phone: 765-494-1247.

**Mental Health/Wellness Statement**
If you find yourself beginning to feel some stress, anxiety and/or feeling slightly overwhelmed, try WellTrack. Sign in and find information and tools at your fingertips, available to you at any time.

If you need support and information about options and resources, please contact or see the Office of the Dean of Students. Call 765-494-1747. Hours of operation are M-F, 8 am- 5 pm.

If you find yourself struggling to find a healthy balance between academics, social life, stress, etc. sign up for free one-on-one virtual or in-person sessions with a Purdue Wellness Coach at RecWell. Student coaches can help you navigate through barriers and challenges toward your goals throughout the semester. Sign up is completely free and
can be done on BoilerConnect. If you have any questions, please contact Purdue Wellness at evans240@purdue.edu.

If you’re struggling and need mental health services: Purdue University is committed to advancing the mental health and well-being of its students. If you or someone you know is feeling overwhelmed, depressed, and/or in need of mental health support, services are available. For help, such individuals should contact Counseling and Psychological Services (CAPS) at 765-494-6995 during and after hours, on weekends and holidays, or by going to the CAPS office on the second floor of the Purdue University Student Health Center (PUSH) during business hours.

Emergency Preparation
In the event of a major campus emergency, course requirements, deadlines and grading percentages are subject to changes that may be necessitated by a revised semester calendar or other circumstances beyond the instructor’s control. Relevant changes to this course will be posted onto the course website or can be obtained by contacting the instructors or TAs via email or phone. You are expected to read your @purdue.edu email on a frequent basis.