EECS 583 – Class 15
Exam Review

University of Michigan

March 18, 2024

Announcements

- Project proposal deadline – Tonight (Monday) midnight
  - Submit paragraph + reference on your project topic (Email to Aditya, Yunjie, and Scott)
- Research paper presentations
  - Each group sign up for 15 min (presentation) + 2 min (Q&A) slot on the EECS 583 calendar
  - Mon Mar 25 (next Monday) – Wed Apr 17: presentations during class (4 slots per class), signup on eecs583 calendar
- Midterm Exam
  - Wednesday, Mar 20, Hybrid format
  - In person – Send email to Aditya if you want to take the exam in class
    - 10:30am-11:50 (G906 Cooley)
    - Questions answered in the hallway
  - Virtual
    - 10:30am-11:50 + 15 mins extra time for logistics (printing, scanning, etc.)
    - Questions about exam can be posted on piazza and will be answered ASAP
  - Covers through register allocation (last lecture)

Research Paper Presentation Logistics

- Monday Mar 25 – Wednesday Apr 17
  - Signup for slot on Google calendar (just like project proposals)
  - Sign up for earliest slot available on the day you want to present → no gaps
    - Plan on attending the entire lecture on the day you present
  - Not all days will be full (max of 4 slots per lecture)
  - Will cancel class if no signups
- Each group: 15 min slot + 2 mins Q&A
  - You will be cut off if you go long!
  - Tag-team presentation – Divide up as you like but everyone must talk
  - Max of 20 slides (for the group), animations not included in count
  - Record your paper on the group sign up sheet (so we can check for conflicts!)
  - Submit paper (pdf) and slides (pptx or pdf) night before (by 9pm!)
    - Call your files groupX_paper.pdf, groupX_slides.pdf/pptx
    - Email to Aditya, Yunjie, and Scott

Research Paper Presentation Format

- Make your own slides!!!
  - Don't just lift figures from the pdf (graphs/tables ok to lift)
  - Don't have too many all text slides
  - No long sentences on slides, don't just read the slides, look at audience
  - Equations/proofs not very interesting to show, code examples are great
- Points to discuss
  - Intro/Motivation – area + problem + why is it important to solve this problem
  - How the technique works, examples are super helpful
  - Some results, but don't show 10 graphs
  - Group's commentary (last slide or 2 of your presentation)
    - What is best about the paper? Why is the idea so awesome? Don't focus on results
    - What are limitations/weaknesses of the approach (be critical!)

Research Paper Presentation – Audience Members

- Research presentations != skip class
  - You should attend or watch the Zoom video
- Grading + give comments to your peers
  - Class + Aditya, Yunjie, & I will evaluate each group's presentation and provide feedback
  - Each person will submit evaluation sheet for the day's presentations
    - Canvas quizzes
    - 3 days (72 hrs) to submit
  - Aditya/Yunjie will anonymize comments and email to each group
  - Be positive, every talk has some positives
    - What did the group do well
  - Be critical, but constructive with your criticisms
    - What could be improved, comment on slides/speaking
  - Don't try to give separate comments for each group member, just evaluate the entire team

Exam Review

Virtual Exam Logistics (see piazza for more details)

- Wednesday, Mar 20
- 10:30-11:50 + 15 minutes for logistics
- Gradescope to distribute/collect exams, accessible via canvas
- Steps
  - Download, take exam, scan & submit
    - Print out and write on exam sheets
    - Just write answers on paper
    - Use electronic method (ie tablet) to create electronic answers
  - Exam itself should take ~ 65 mins
  - Some slack time to deal with technical difficulties, but email course staff if you run into problems
- Use piazza to ask questions and get answers during the exam
  - We will answer ASAP. Be sure to read others questions before posting your own.

In-person Exam Logistics

- Wednesday, Mar 20 – G906 Cooley
- 10:30-11:50
- Printed exams available in classroom
- Steps – Normal pre-COVID exam
  - Exam itself should take ~65 mins
  - Course staff will be outside lecture room to answer questions
- Bring whatever you like (open book exam)
  - Tablet/laptop
  - Printed materials (old exams, lecture problems, etc.)
  - Books, etc.

What to Expect

- Exam format
  - Open notes, open internet
  - Apply techniques we discussed in class
  - Reason about solving compiler problems – how/why things are done
  - A couple of thinking problems
  - No LLVM code
- Honor code and cheating
  - Must sign honor code acknowledging that you have neither given no received aid on the exam
  - Please do not share answers or talk to other students during the exam
  - Graduate class, so we don't expect cheating to be an issue
    - But we will investigate any anomalies that arise

Studying

- 9 exams + answer keys (F12, F13, F18, F19, F20, F21, F22, W23, F23) are posted on the course website
  - Note – Past exams may not accurately predict future exams!!
  - Fomat will be similar
  - Work out the problems without looking at the answers!
  - **Exams vary in terms of time/length**
- Preparing yourself
  - Yes, you should study even though its open notes
    - Lots of material that you have likely forgotten from early this semester
    - Refresh your memories, especially the old topics
    - No memorization required, but you need to be familiar with the material to finish the exam
  - Go through lecture notes, especially the examples!
  - If you are confused on a topic, go through the reading
  - Go through the practice exams (Don't look at the answer) as the final step

Exam Topics

- Control flow analysis
  - Control flow graphs, Dom/pdom, Loop detection
  - Trace selection, superblocks
- Predicated execution
  - Control dependence analysis, if-conversion
- Dataflow analysis
  - Liveness, reaching defs, DU/UD chains, available defs/exprs
  - Static single assignment – Make sure you understand SSA!
- Optimizations
  - Classical: Dead code elim, constant/copy prop, CSE, LICM, induction variable strength reduction
  - ILP optimizations - unrolling, tree height reduction, induction/accumulator expansion – Just understand the concepts
  - Speculative optimization – like HW2

Exam Topics - Continued

- Acyclic scheduling
  - Dependence graphs, Estart/Lstart/Slack, list scheduling
  - Code motion across branches, speculation, exceptions
- Software pipelining
  - DSA form, ResMII, RecMII, modulo scheduling
  - Make sure you can modulo schedule a loop!
  - Execution control with LC, ESC
- Register allocation
  - Interference graph, graph coloring

Some Sample Problems

Part I: Short Questions

- Fast questions – a couple of minutes each
  - Don’t waste too much time on any single question
  - Come back later to questions you don’t know the answer
- Basic facts/trends
- Most should be obvious, but some a little thought

Question 1 – Fall 2021, Question 2 - Winter 2023

- What is the main difference between reaching definitions and available definitions?

- In liveness analysis, how would the analysis results be changed if the meet function was modified from using union of live variables (IN sets) of the successor blocks to intersection over the same sets of variables? Briefly explain your answer

Question 2 – Fall 2023

- Profile information can be used for a variety of purposes in a compiler. Name a way it can be used to optimize instruction cache performance. Briefly explain

Question 3 – Fall 2018

- When a compiler scheduler wants to speculate an instruction, name one issue that it must consider to preserve correctness of the resulting code.

Question 2 – Fall 2020

- It is often possible to improve the performance of a loop limited by RecMII by adding resources to the processor. Is the preceding statement True or False? Justify your answer

Question 3 – Fall 2021

- Is it possible to unroll a loop with a statically (compile-time) unknown number of iterations? Yes/No and briefly explain.

Part II: Medium/Long Questions

- Longer questions
  - Problems that must be worked out: ~10 mins each
  - Some questions like lecture examples
  - But, some have a little twist
- Practicing problems ahead of time will make you more comfortable and faster
  - So, practicing is strongly recommended

Question 9 – Fall 2022

Due to a corrupt disk, the original order of the instructions was lost and the instructions got randomly ordered. The student reassigns the number of each instruction and knows the corresponding partial Estart and Lstart values (see Table below). It is also known that Instruction 7 (r2 = r6*2) is the last instruction of the BB and has the largest Estart and Lstart values. Determine the original order of the instructions using the partial Estart/Lstart values and complete the missing Estart/Lstart values in the table below for the original ordering. Remember, the instruction numbers do not represent the original order.

Instruction latencies

add: 1
mul: 3
load: 2

#	Instruction	Estart	Lstart
1	r3 = r5 * r1	3	3
2	r2 = r3 + 1	6	7
3	r5 = load(r5)		
4	r6 = load(r3)		
5	r5 = r5+1	2	2
6	r1 = load(r4)		1
7	r2 = r6 * 2	8	8

Question 8 – Fall 2023

a) Compute the number of predicates required to if-convert the code.

b) To profile the code, we ran this function 100 times, we found that:

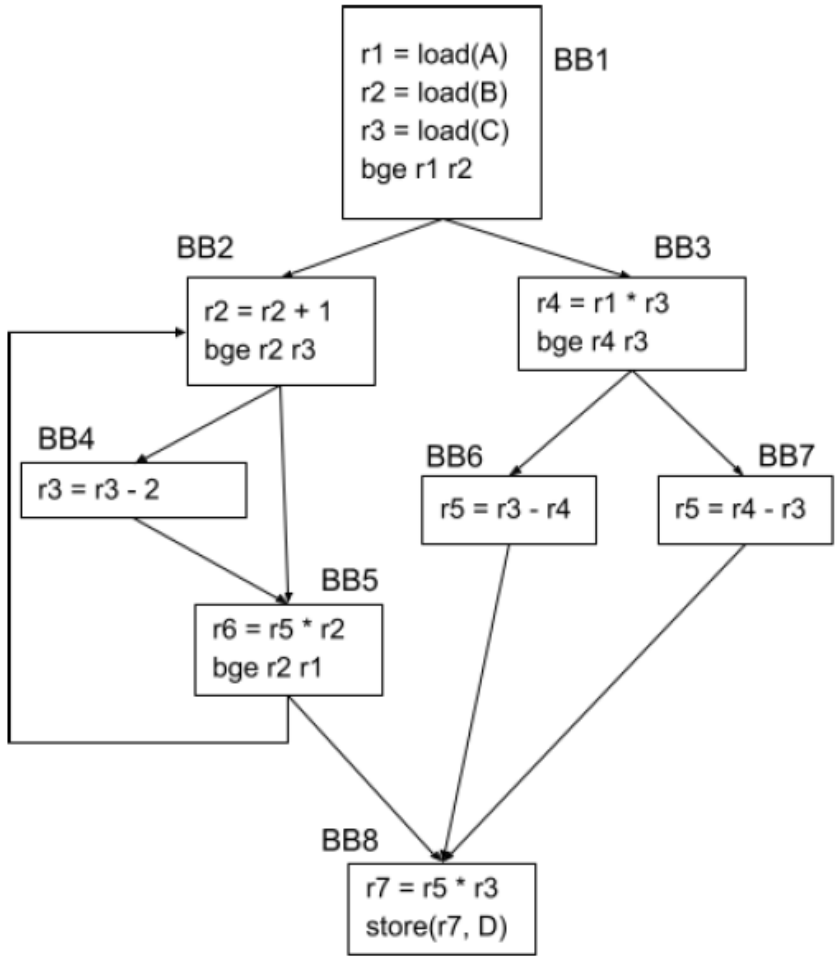
i) The loop back-edge was never taken.

ii) All other conditional branches were taken exactly 50% of the time.

iii) All branch probabilities were independent.

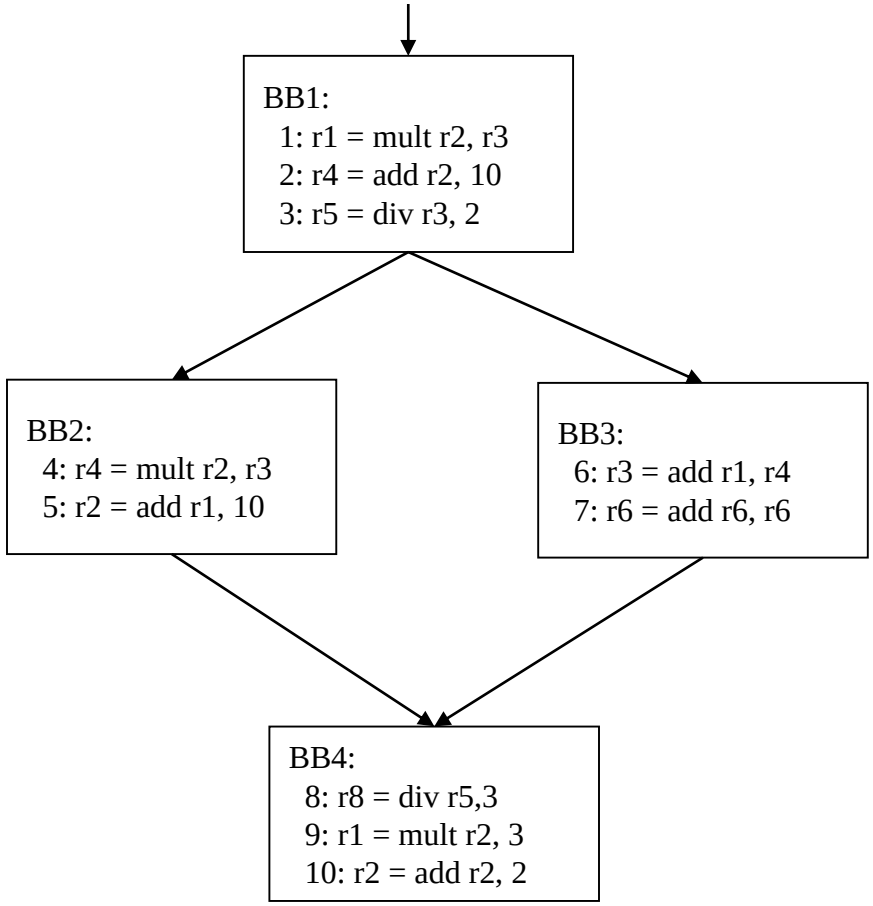
iv) Each instruction takes 1 unit of time to execute, except branches which take 3 units each.

Based on this information, will if-conversion of all eligible branches to utilize predicated execution (no other optimizations) make the code run faster on the same profile testcases?



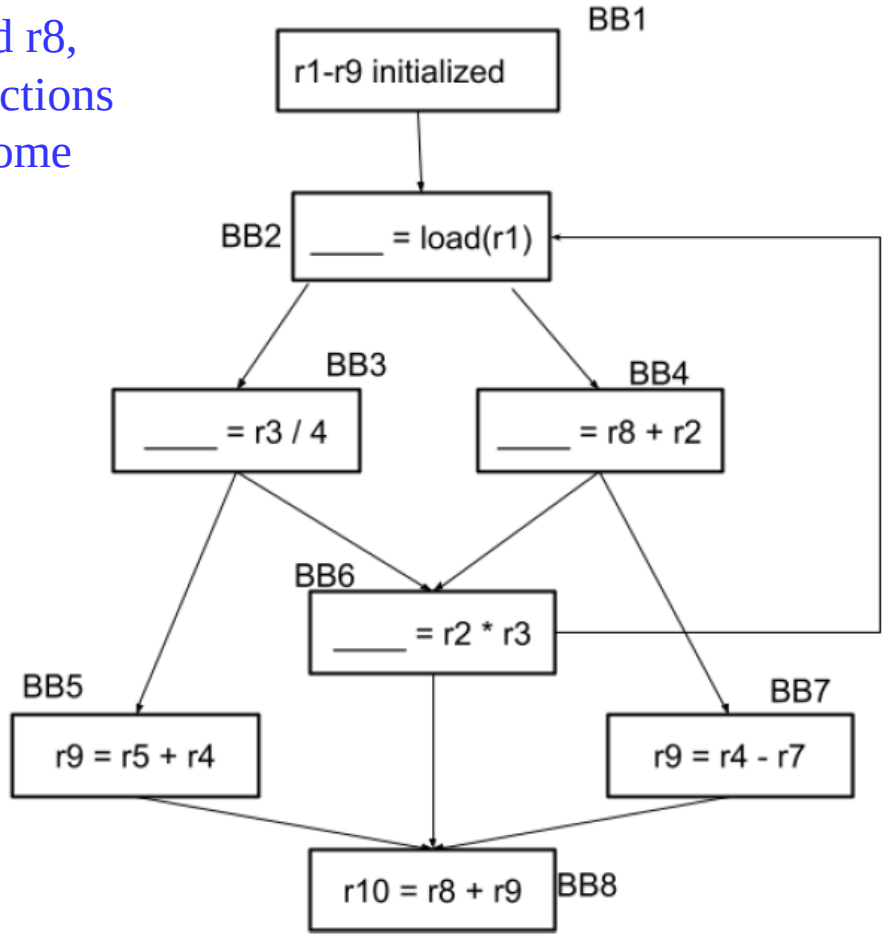
Question 7 – Fall 2020

Compute the Available Expression GEN/KILL/IN/OUT sets at BB4.
Assume r2, r3, r6 are defined before entering BB1

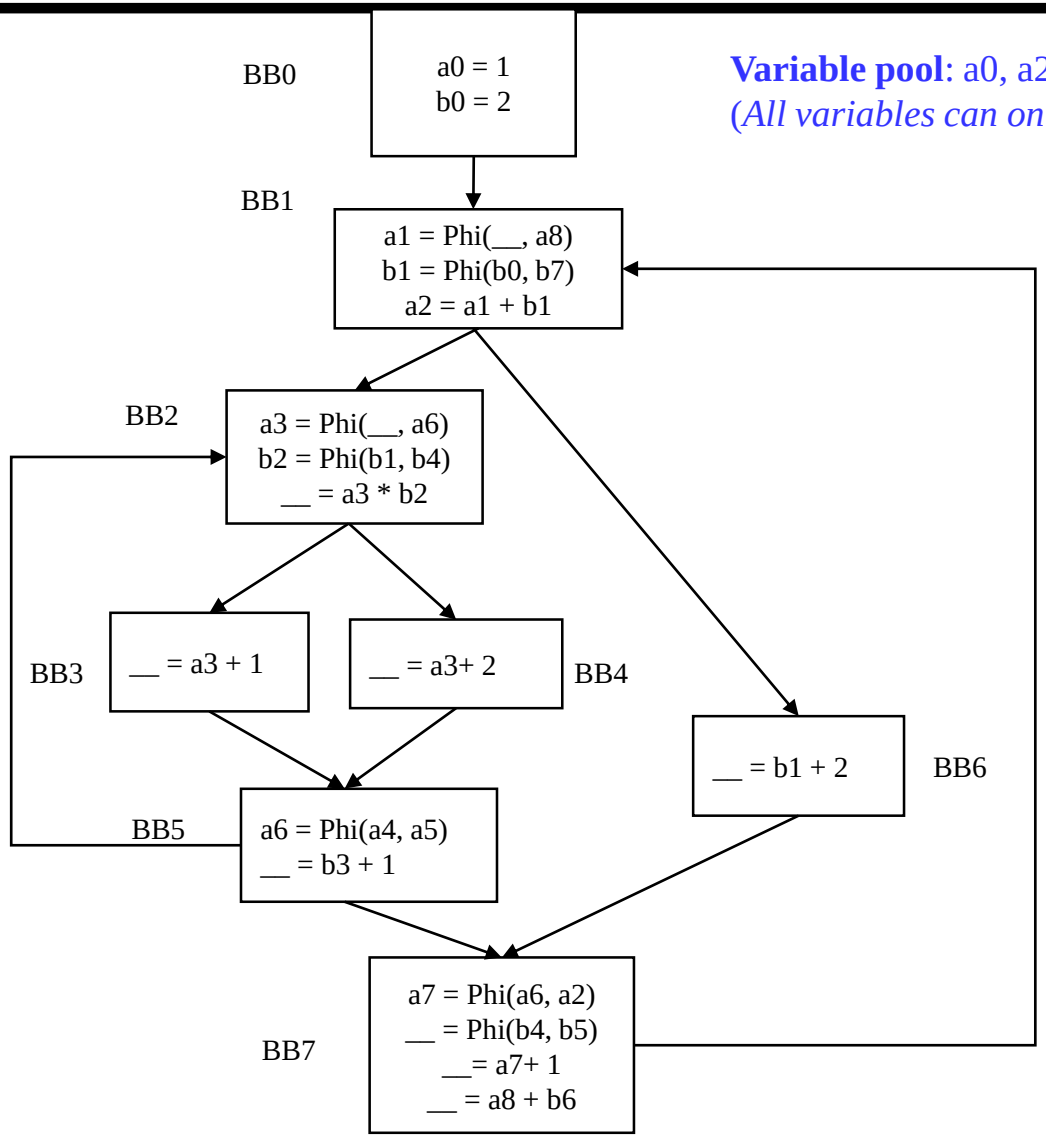


Question 8 – Fall 2023

Fill in the blanks using r4, r5, r7, and r8, so that a maximum number of instructions from BB2, BB3, BB4, and BB6 become eligible for hoisting via LICM.



Question 9 – Fall 2020



Variable pool: a0, a2, a4, a5, a8; b3, b4, b5, b6, b7
(*All variables can only be used once*)