Static Analysis and LLMs

CS 485/698: AI-Assisted SE

Today’s Agenda

- Team meeting (~10 minutes)
  - Show us your deployed app, now that P6 is finished
- Lecture on static analysis: linters, bug-finders, static types
- In-class activity: improve your team project’s static analysis posture

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  - **key idea**: the abstraction will have fewer states to explore
    - hopefully, many fewer!

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- static **type systems**
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Next, we're going to look at each of these categories in a little more detail

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  - Consequence: linters can only find shallow mistakes
- Best practice: always use the best linter(s) for your language
  - And always fix all of their complaints (no harm in doing so)

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"**interesting**" in this context means "not trivial", i.e., not uniformly true or false for all programs

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Rice's theorem caveats:

- only applies to **semantic** properties (syntactic properties are decidable)
- "programs" only includes programs **with loops** (*logical* loops - recursion counts!)

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- Some work via pattern matching, but most are backed by some form of ***dataflow analysis***

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- Analysis designer abstracts what we want to learn (e.g., to help developers) down to a small set of ***abstract values***
- Analysis uses **rules** to compute a fixpoint of those abstract values
  - Dataflow analyses take programs as input and produce a set of "dataflow facts" (=abstract values at locations) as output
    - Heuristics in bug-finders convert facts to warnings

Dataflow analysis example: null-pointers

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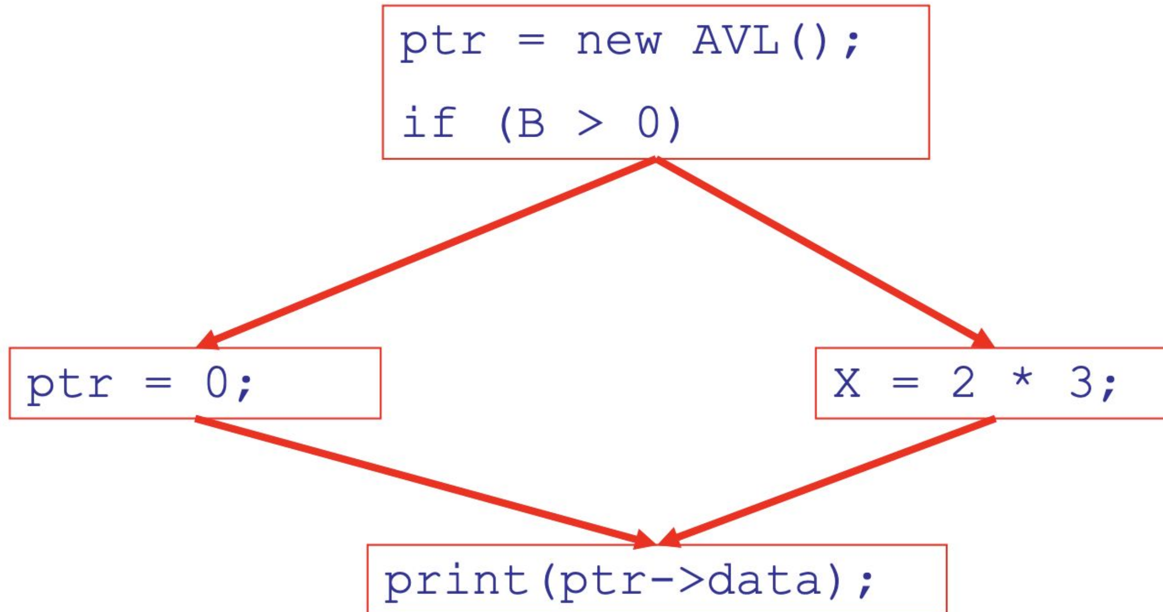
Question: is `ptr` ***always*** null when it is dereferenced?



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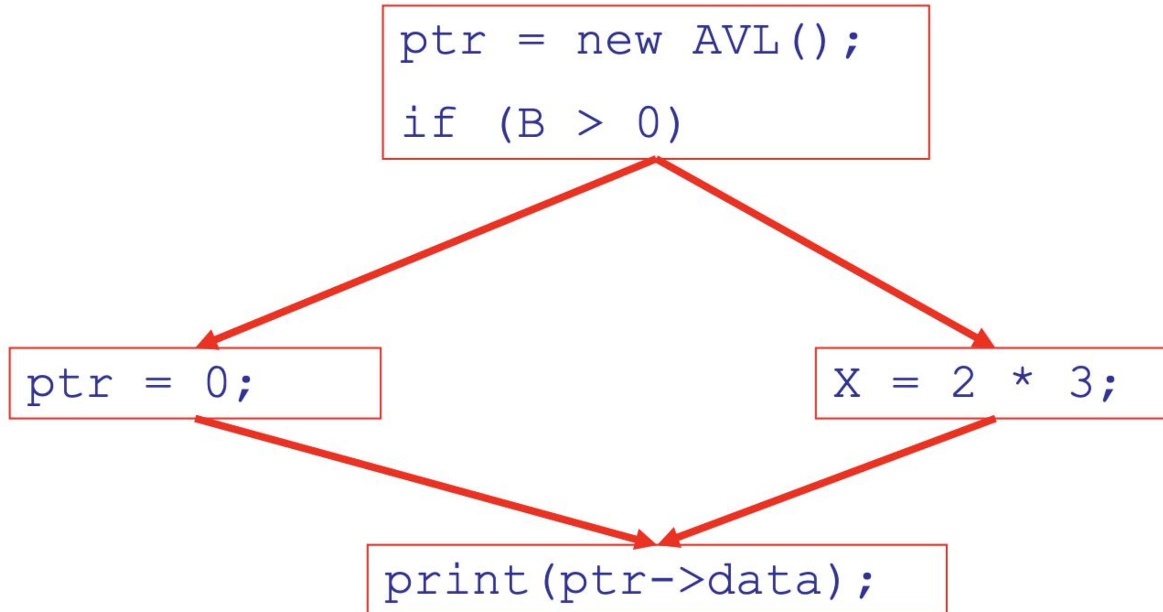

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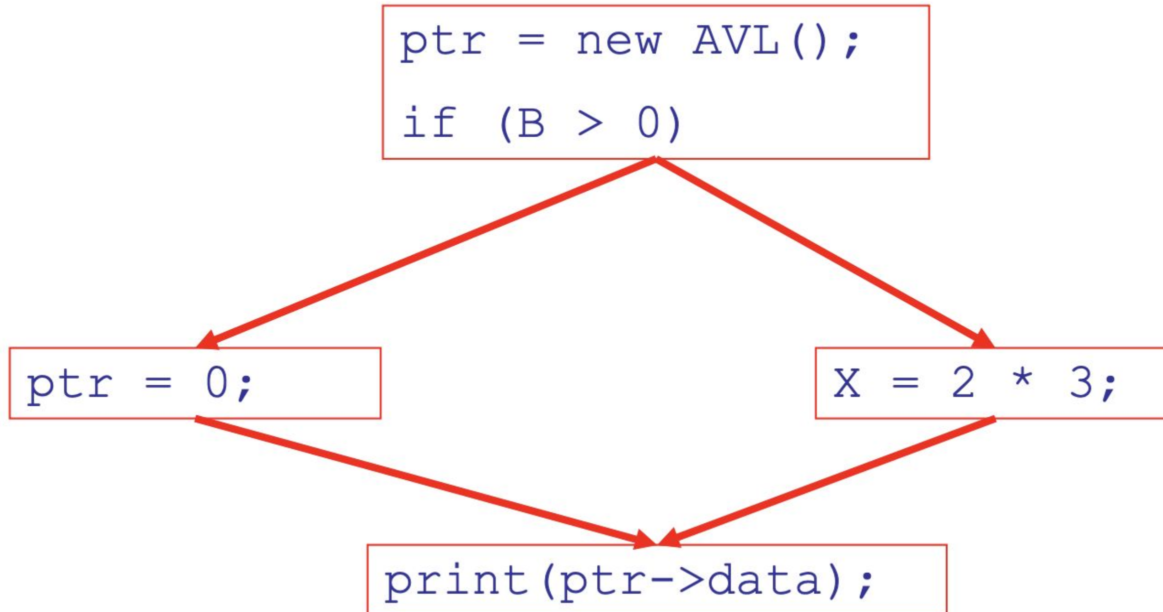

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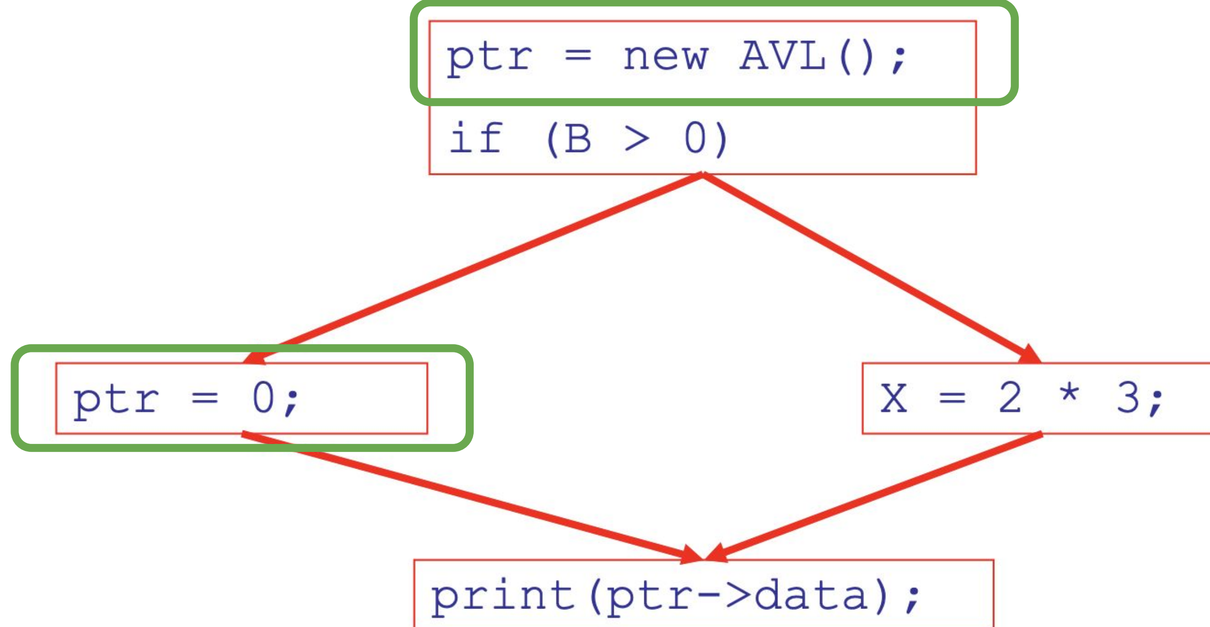

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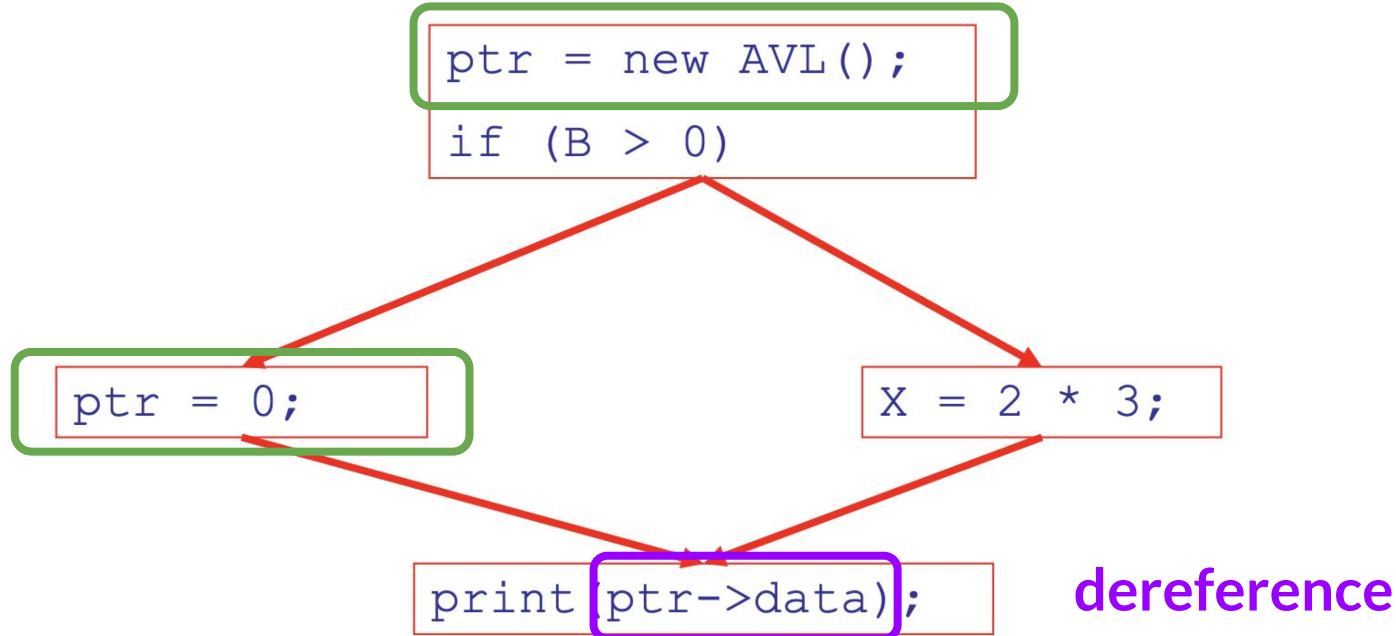

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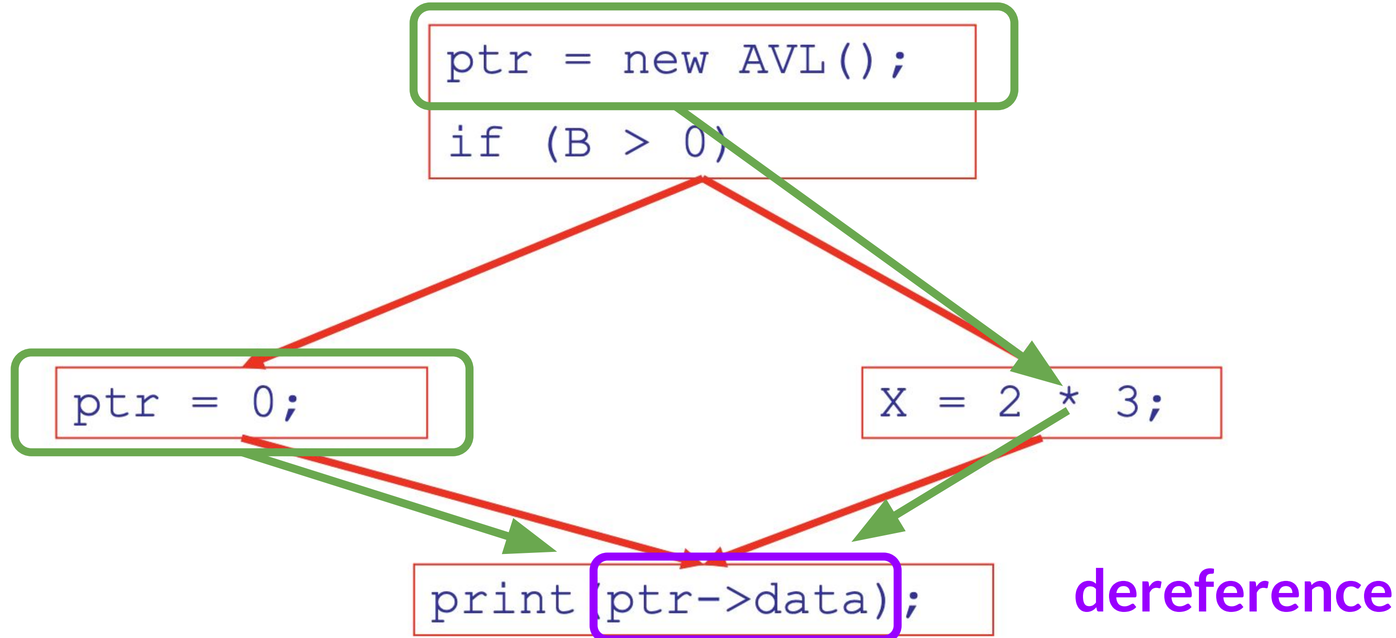

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Key idea: make it **impossible** to mix things that shouldn't be mixed

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- goal of a type system: **prevent errors** at run time due to unexpected values
- **type theory** is the discipline of math (yes!) that studies the formal properties of type systems
- most programming languages include some kind of type system
  - exceptions: assembly, Lisp, a few others

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- Most static type systems are ***sound***: "well typed programs don't go wrong"
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If you already have a static type system, you can extend it with a ***pluggable type system*** to prevent more bugs

- e.g., nullness in Java

LLMs and Static Analysis

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- So, when using a coding agent, my advice: **always use the best static analyses available**

In-class activity: statically analyze your project

- Each project team should have one **blue letter**
    - If your team has a "static analysis expert", give them the blue letter (swapping if necessary)
    - If you're on a team by yourself, make sure your letter is blue
- If you have a **red letter**, you should find the person with the corresponding blue letter (note there are duplicate red letters)

In-class activity: statically analyze your project

- Today’s goal: get an LLM to fully enroll the **blue team member**’s course project into a new static analysis and add it to CI
  - by the end of the class, every team project should have a new open PR that adds a new static analysis tool + resolves warnings
- Fun rule to make it more exciting: **only red team members can type**
  - blue team member’s role is advisory only
  - your choice of whose computer/LLM to use
- Suggestions for static analyzers on the following slides, by language
  - Frontend or backend is ok (but we suggest you pick one)
- Challenge problem: JavaScript -> TypeScript

JavaScript/TypeScript Static Analyzers

- Linters:
  - ESLint
  - Standard JS
  - JSHint
- Bug-finders:
  - Insider
  - SemGrep
  - SonarJS
- Static Types:
  - TypeScript
  - Closure
  - Flow
  - Hegel

Python Static Analyzers

- Linters:
  - ruff
  - Pylint
  - Flake8
- Bug-finders:
  - SemGrep
  - CodeQL
  - Bandit
  - Pysa
- Static Types:
  - Mypy
  - Pyright
  - Pyre

Java Static Analyzers

- Linters:
  - Checkstyle
  - SpotBugs
  - ErrorProne
- Bug-finders:
  - Infer
  - SemGrep
  - CodeQL
- (More) Static Types:
  - Checker Framework
  - NullAway

Go Static Analyzers

- Linters:
  - just run `go vet` (if you're not already)
  - golangci-lint
  - staticcheck
- Bug-finders:
  - gosec
  - govulncheck
  - errcheck
- Static Types:
  - I don't know of any extensions to the type system, so focus on linters and bug-finders.

Dart Static Analysis

- I'm not particularly familiar with Dart, so if you're the one group working in the language you're going to have to figure it out for yourself (sorry). Here are some links to get you started:
  - https://dart.dev/tools/analysis
  - https://dart.dev/tools/linter-rules/all

Wrapup and Reminders

- For grad students: don’t forget about A7
  - remember that you have to prepare to lead a discussion on your chosen paper
  - undergrads: it is not too late to sign up for an A7 topic, for extra credit
- Only 6 of you have filled out the course evaluation form so far
  - It doesn’t close until May 7, so you have time
  - *Especially* for a special topics course, I care a lot about your feedback! Please do actually do it.