CS 485: Compilers

Martin Kellogg

Agenda

- Administrivia
  - course policies, webpage, Martin, TAs, etc.
- What is this class about?
  - brief history lesson
  - compiler structure
- Discussion of course difficulty + workload (“is this a hard class?”)
  - and why you should or shouldn’t take the course

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  - Let's try it now! **Suggested questions**:
    - Why would you do that?
    - Are you just bribing us to pay attention?
    - Does that actually work?
    - Do even silly questions count?

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  - Hamdi Korreshi
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- Their OH (all in GITC 4324)
  - Tom: M 1-2, F 1-2
  - Hamdi: M 12-1, R 12-1

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We will also make heavy use of the course forum (**Discord** this semester)

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  - when I **make claims** like this one, you're encouraged to **ask me to justify** why I'm making the claim

Aside: on taking notes

“…students who took notes on laptops performed worse on conceptual questions than students who took notes longhand. We show that whereas taking more notes can be beneficial, laptop note takers’ tendency to transcribe lectures verbatim rather than processing information and reframing it in their own words is detrimental to learning.”

[Pam Mueller, Daniel Oppenheimer. The pen is mightier than the keyboard: advantages of longhand over laptop note taking. Psychol. Sci. 2014 Jun; 25(6):Epub 2014 Apr 23.]

Aside: red-bordered slides

- Did you notice the **red border** on the previous slide (and this one)?

Aside: red-bordered slides

- Did you notice the **red border** on the previous slide (and this one)?
- The border indicates material that is **not** fair game for exam questions
  - I often include asides or tangents into lecture material, like the one on taking notes on the previous slides
  - You'll also see this border "mid-class break" slides later :)

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This class is heavily inspired (with permission) from a course I took as an undergrad! So, I too have done the assignments (many moons ago).

Course staff: me: style

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  - difficulty level is very high
  - students have to put in a lot of work to succeed
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Course staff: me: the bad

- (all quotes are about CS 490)

"the midterm was **very difficult** and the project was **difficult** as well"

"I think there is a bit **too much content** … this class takes **way more time** than most other classes."

"very straight forward but **very difficult exam**"

"He's **devilish with his intense assignments**, but has the dignity to be upfront about it."

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"I like his teaching style quite a lot and find his **lectures to be quite interesting**."

"how the professor **engages the class to participate** is great"

"**ability to explain complex concepts** in an easy to understand way is a plus….in some cases he does **move a little to fast**."

"capable of **actually explaining** complex and abstract concepts in a non-judgemental way to people unfamiliar to them"

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- This course, unlike CS 490, is an **elective**

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  - but I hope you'll get even more out of the course!

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  - so I'm excited to try my hand at introducing it to you :)
    - that said, this is the first time I'm teaching this course. So, please be **patient** when (not if) I make some mistakes…

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Note that “higher-level” here is in the eye of the beholder. Sometimes, a compiler whose source and target languages are similarly abstract is called a ***transpiler*** instead.

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  - but cut development time dramatically (2 weeks -> 2 hours)

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- By 1958, >50% of all software is in FORTRAN
  - Compilers can **save as much programmer time** as an interpreter, but produce **much faster code**

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  - enable code to be **shared between different machines**

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Implication for this class: writing a compiler itself is still **relatively machine-dependent**, even in the modern era. You'll need to use the same OS version etc. as our grading server!

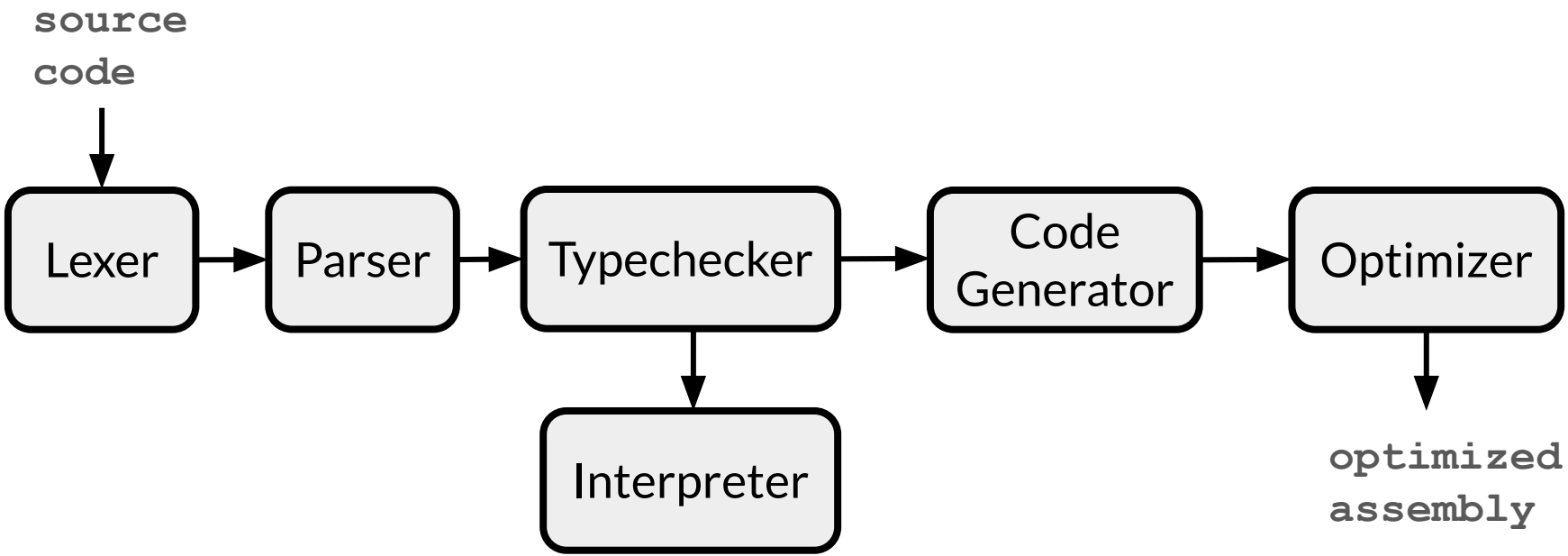
Trivia Break: Computer Science

This notation is used to describe the syntax of both programming languages and other formal languages. It can be described as a metasyntax for context-free grammars. It is typically used whenever an exact language description is needed, such as in official language specifications, in manuals, or in textbooks on programming language theory. It is named after its co-creators, who are also famous for leading the development of the early programming languages FORTRAN and Algol, respectively.

Trivia Break: Real-life Languages

46% (3.2 billion people) of the world's population speaks a language from this language family as their native language - by far the highest of any language family. It is divided into 17 branches, of which 9 are extinct and 8 contain one or more living languages: Albanian, Armenian, Balto-Slavic, Celtic, Germanic, Hellenic, Indo-Iranian, and Italic. The languages from this family with the most native speakers today are English, Spanish, Portuguese, Russian, Hindustani, Bengali, French, and German.

Traditional compiler/interpreter structure



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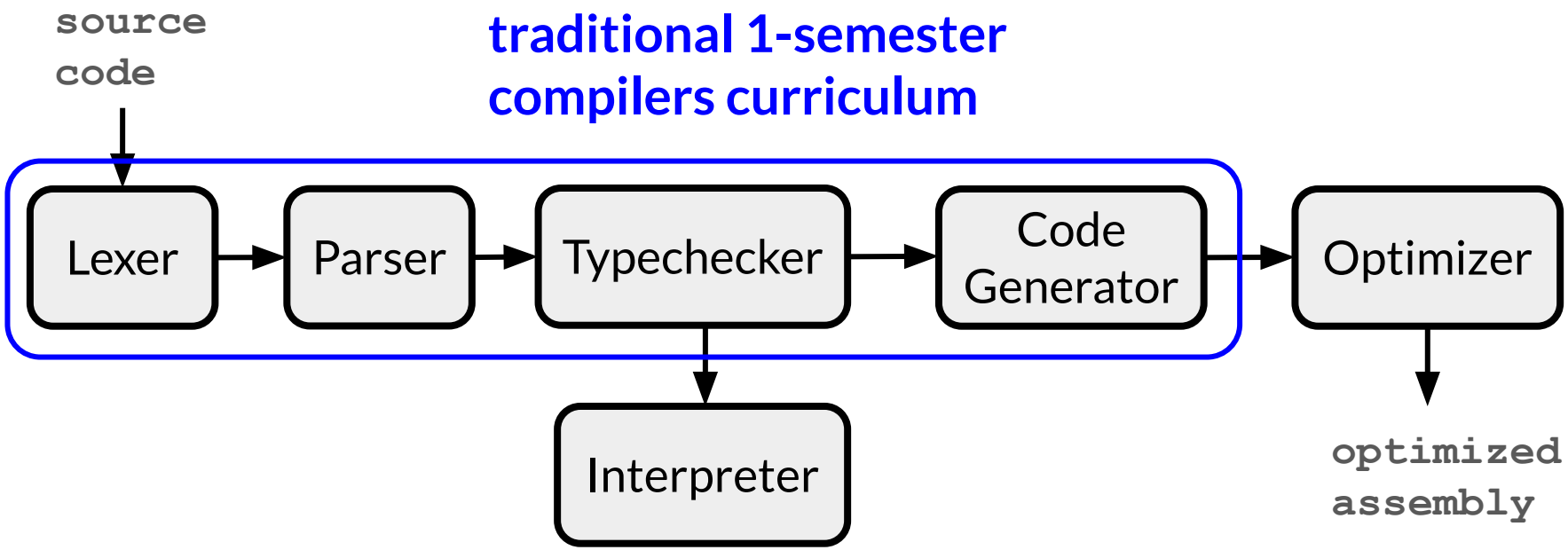

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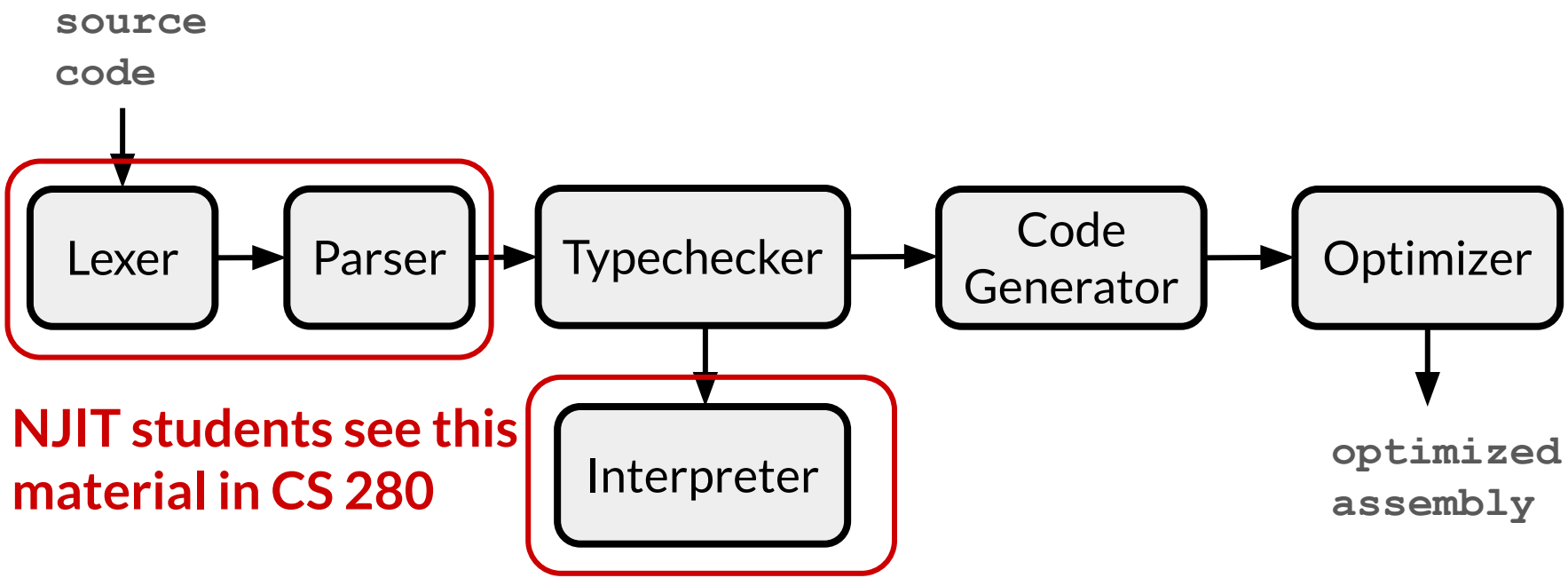

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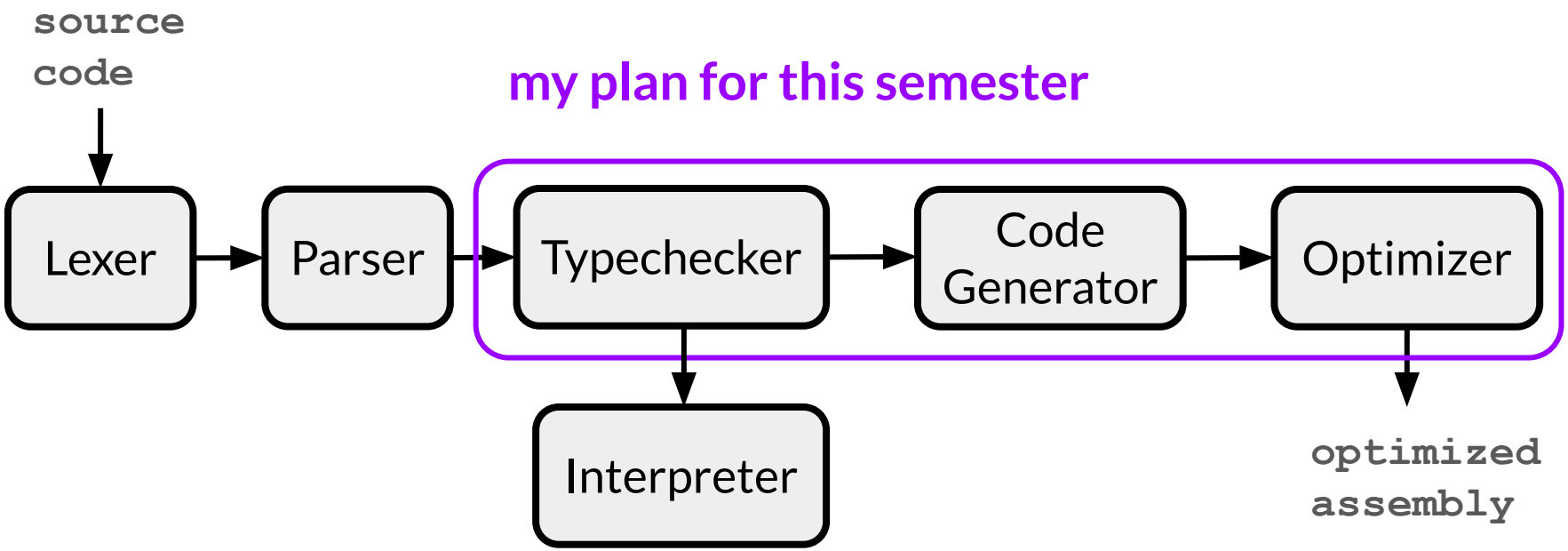

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    - compilers instead generate code that itself will execute the parsed code
- Not all modern languages are compiled (e.g., Python!)

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The first 3, at least, can be understood by analogy to how humans comprehend natural languages like English.

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- Note the:
  - Capital letter "**T**" (symbol for **start** of a sentence)
  - Spaces between words (symbol for **word separator**)
  - Period at the end (symbol for **end** of sentence)

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- Lexical analysis is not trivial. Consider:

  How d'you break "this" up?

Lexical analysis

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  How d'you break "this" up?

- Plus, programming languages are typically ***more cryptic*** than English:

  ***p->f += -.12345e-6**

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- For example, consider:

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- A lexer would break this up into:

  if, x, ==, y, then, z, =, 1, ;, else, z, =, 2, ;

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- ***Parsing*** is like **diagramming sentences**
  - the diagram is a tree
  - often annotated with additional information

Sentence Diagramming

This line is a longer sentence

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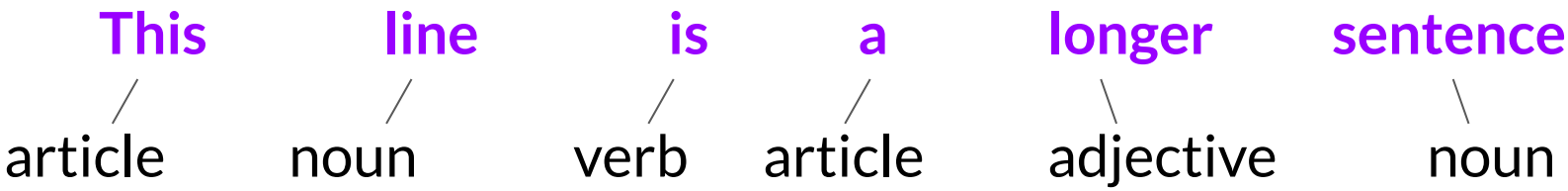

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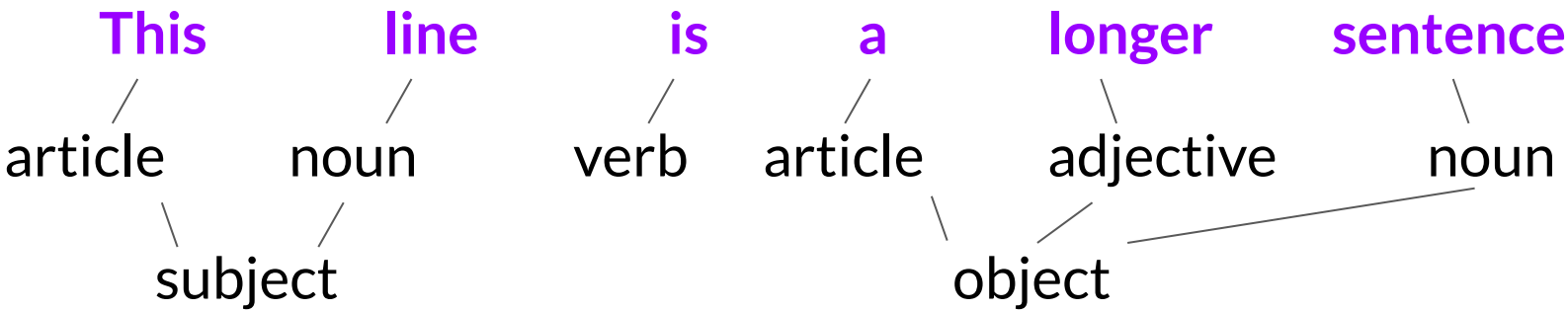

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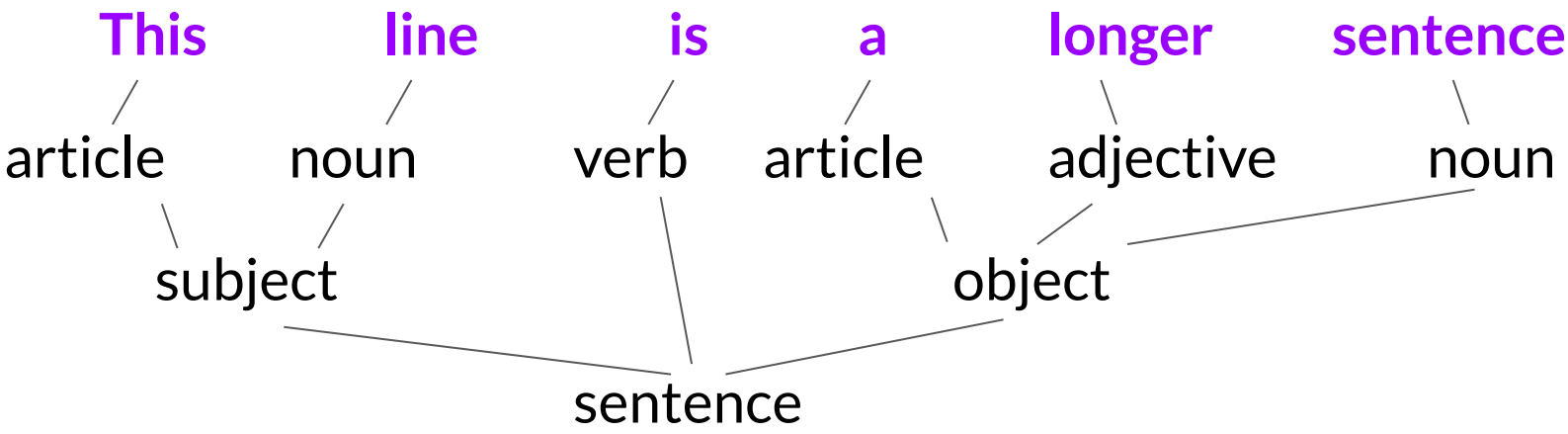

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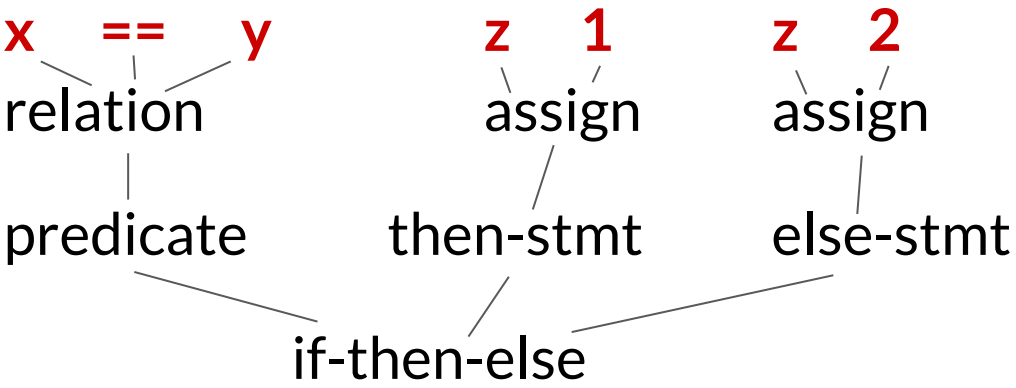
- Diagrammed:



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It’s **context-sensitive**!

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We’ll discuss this kind of ***scoping*** issue in a later lecture.

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  - ensures that methods being called actually exist on the relevant object
  - etc.

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  - In general, conserve some resource

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  - Course theme: **trade-offs** in language design

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This boils down to studying how to build compilers that generate **correct and fast** programs!

Agenda

- Administrivia
  - course policies, webpage, Martin, TAs, etc.
- What is this class about?
  - brief history lesson
  - compiler structure
- **Discussion of course difficulty + workload (“is this a hard class?”)**
  - and why you should or shouldn’t take the course

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    - so, it'll be a slog but if you put in the effort you'll be rewarded

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- Increase capacity of expression
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- Improve understanding of program behavior
  - Know how things work "under the hood"
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  - but they will always be **imprecise**, unlike a real PL

Compilers Todos

- **Most important**: start PA1 (“Rosetta Stone”)

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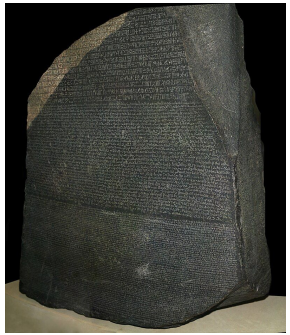

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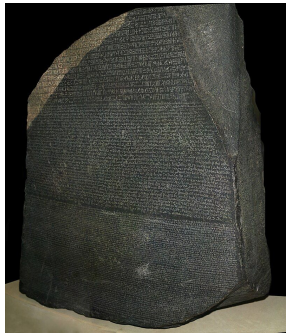

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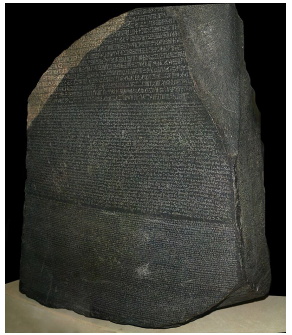

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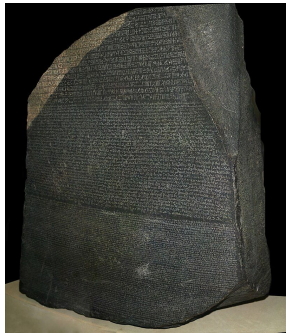

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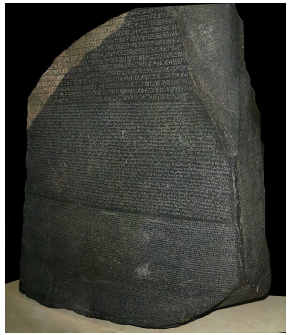

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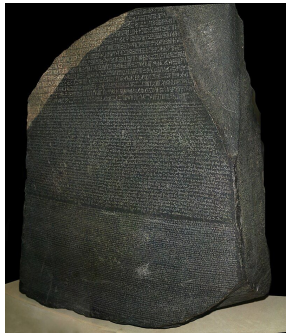

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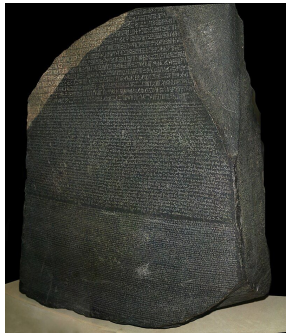

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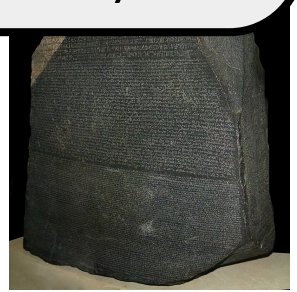
Rest due soon:
- one more due next Thursday
- other 2 due Monday 2/3



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  - There **will** be a quiz on Cool next week
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