Lecture 27 – Course Review

COSE212: Programming Languages

Jihyeok Park

2025 Fall

Goal of This Course

PLRG

To learn **essential concepts** of **programming languages**

- Why? After this course, you will be able to:
  - **learn new programming languages** quickly.
  - **evaluate** and pick the best language for a given task.
  - **design** your own **specialized languages** for specific tasks.
- How? You will learn how to:
  - **design** programming languages in a **mathematical** way.
  - **implement** their **interpreters** using **Scala**.

Summary

(Part 1) Untyped Languages	(Part 2) Typed Languages
Arithmetic Expressions **AE** (Lecture 2 & 3)	

Summary

(Part 1) Untyped Languages	(Part 2) Typed Languages

Arithmetic Expressions

AE

(Lecture 2 & 3)

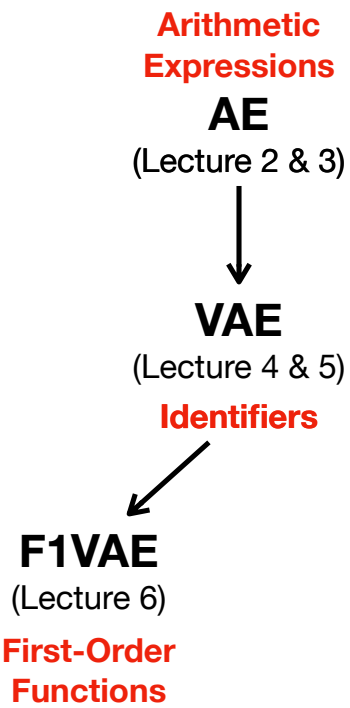
VAE

(Lecture 4 & 5)

Identifiers

Summary

(Part 1) Untyped Languages	(Part 2) Typed Languages



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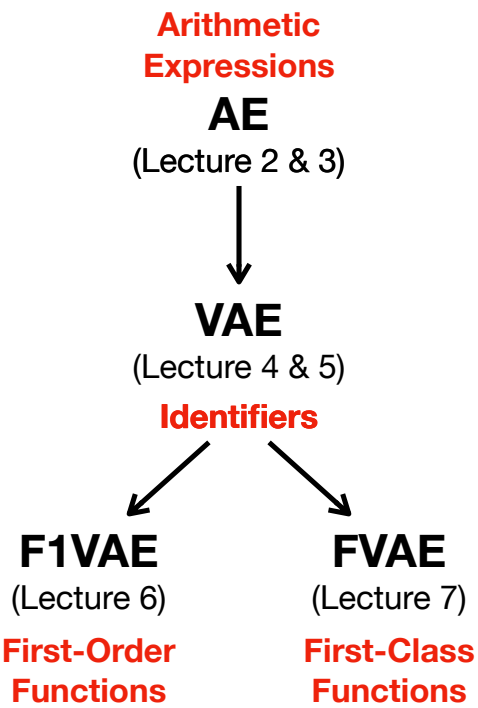
(Part 1) Untyped Languages	(Part 2) Typed Languages



Summary

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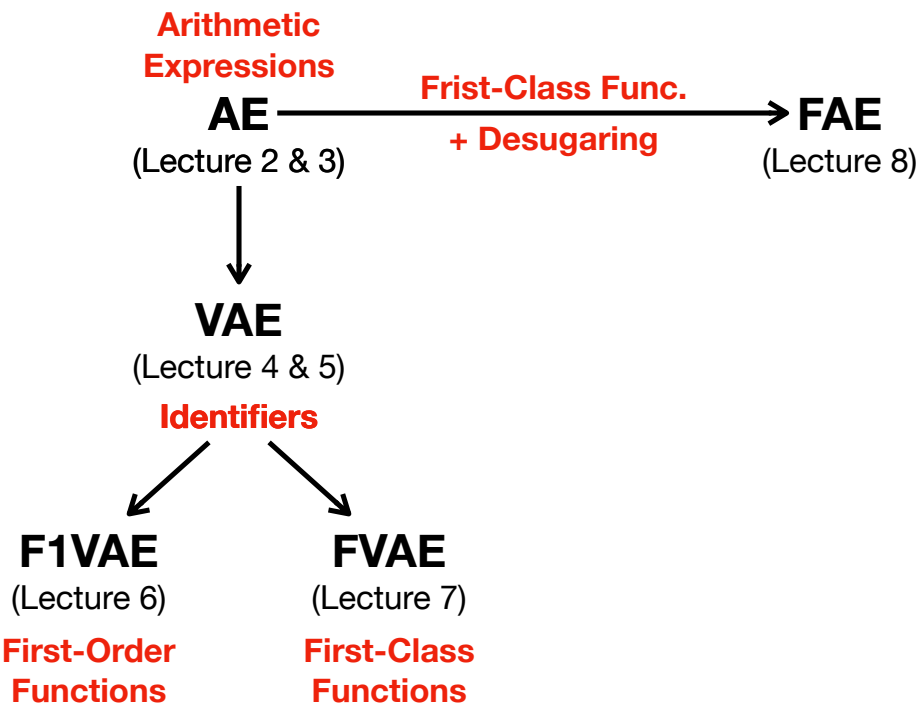
Untyped Languages



(Part 2)
Typed Languages

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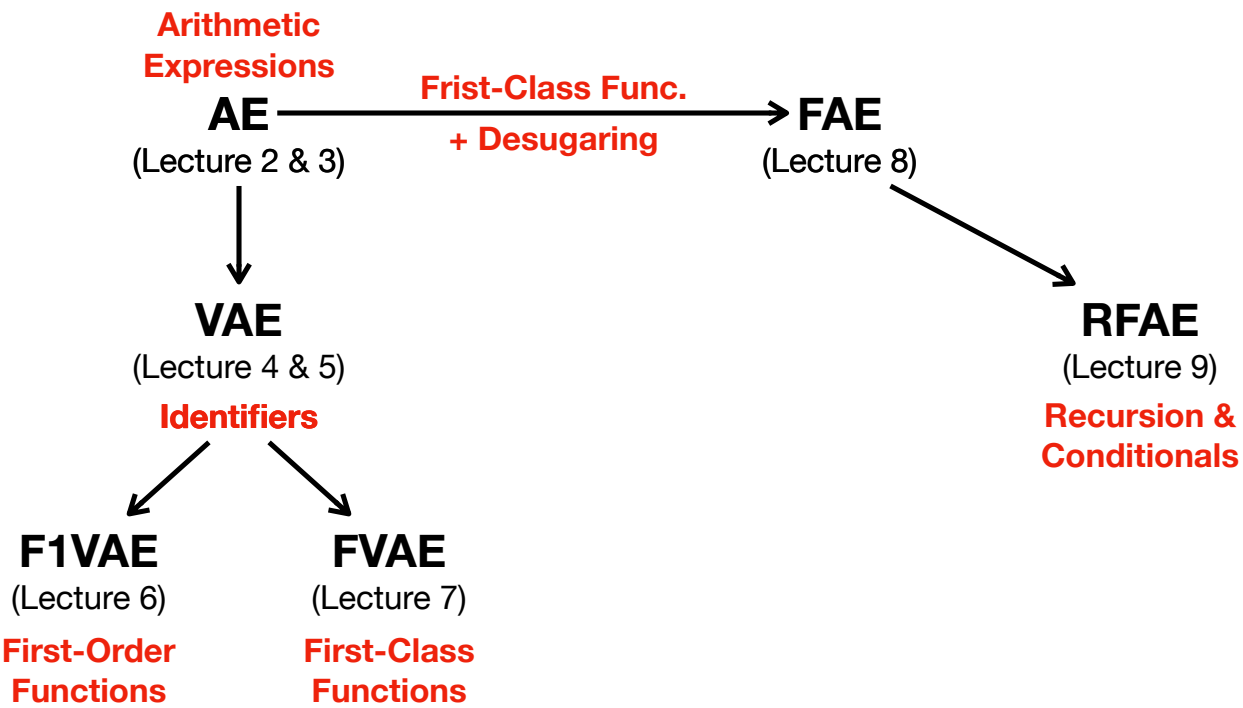
(Part 2)
Typed Languages



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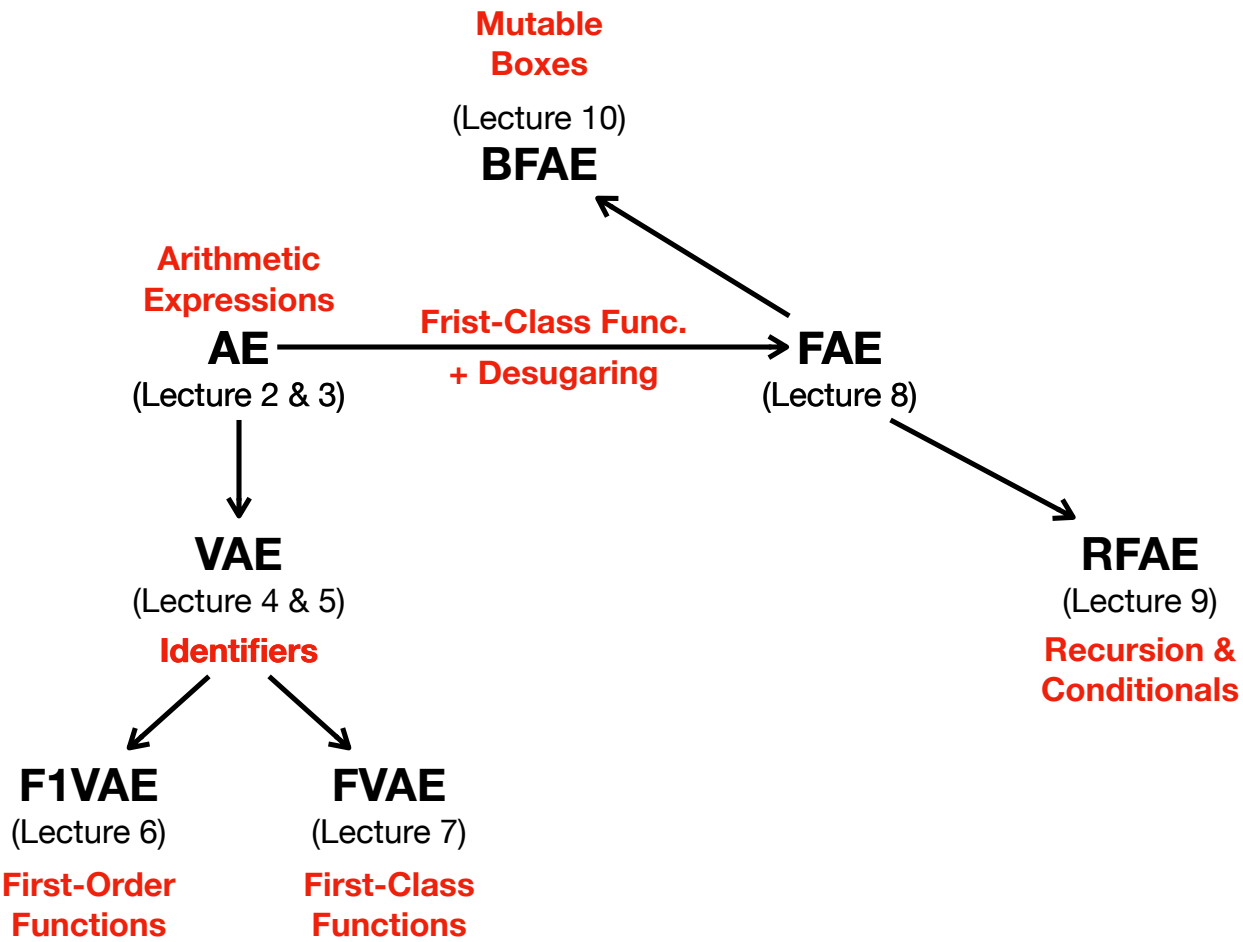
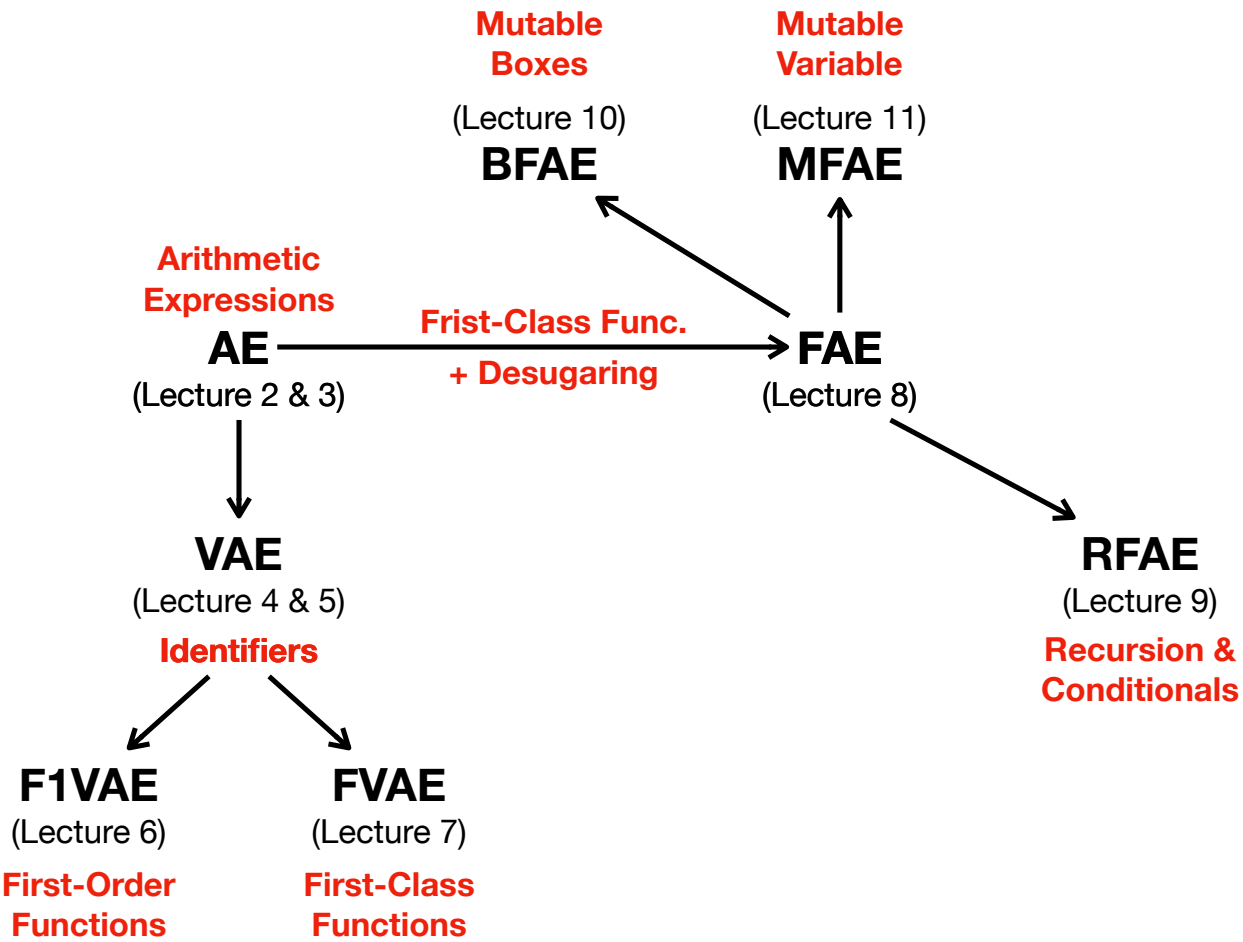


Summary

PLRG

(Part 1)
Untyped Languages

(Part 2)
Typed Languages



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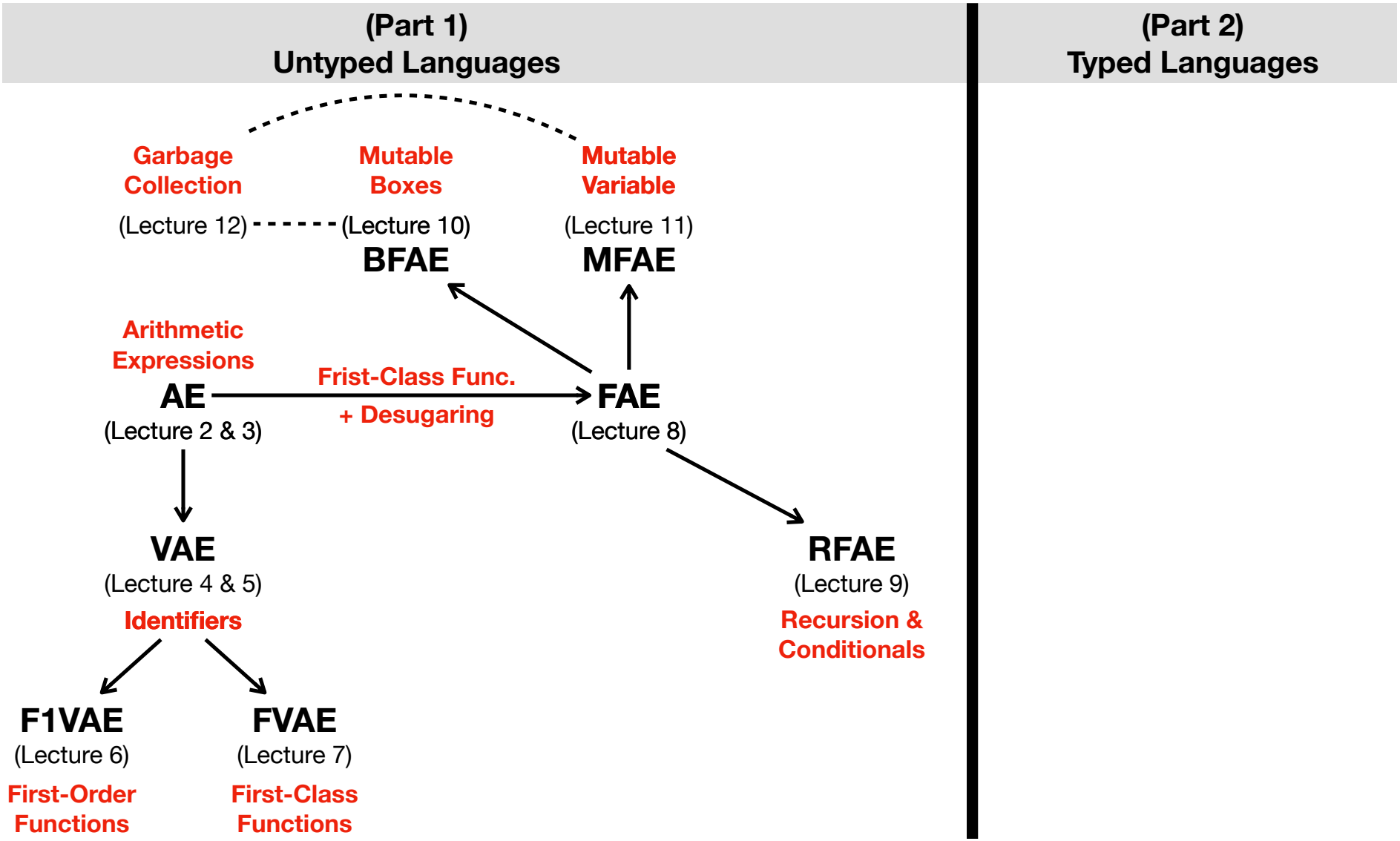
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MFAE
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+ Desugaring
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FVAE
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First-Class Functions

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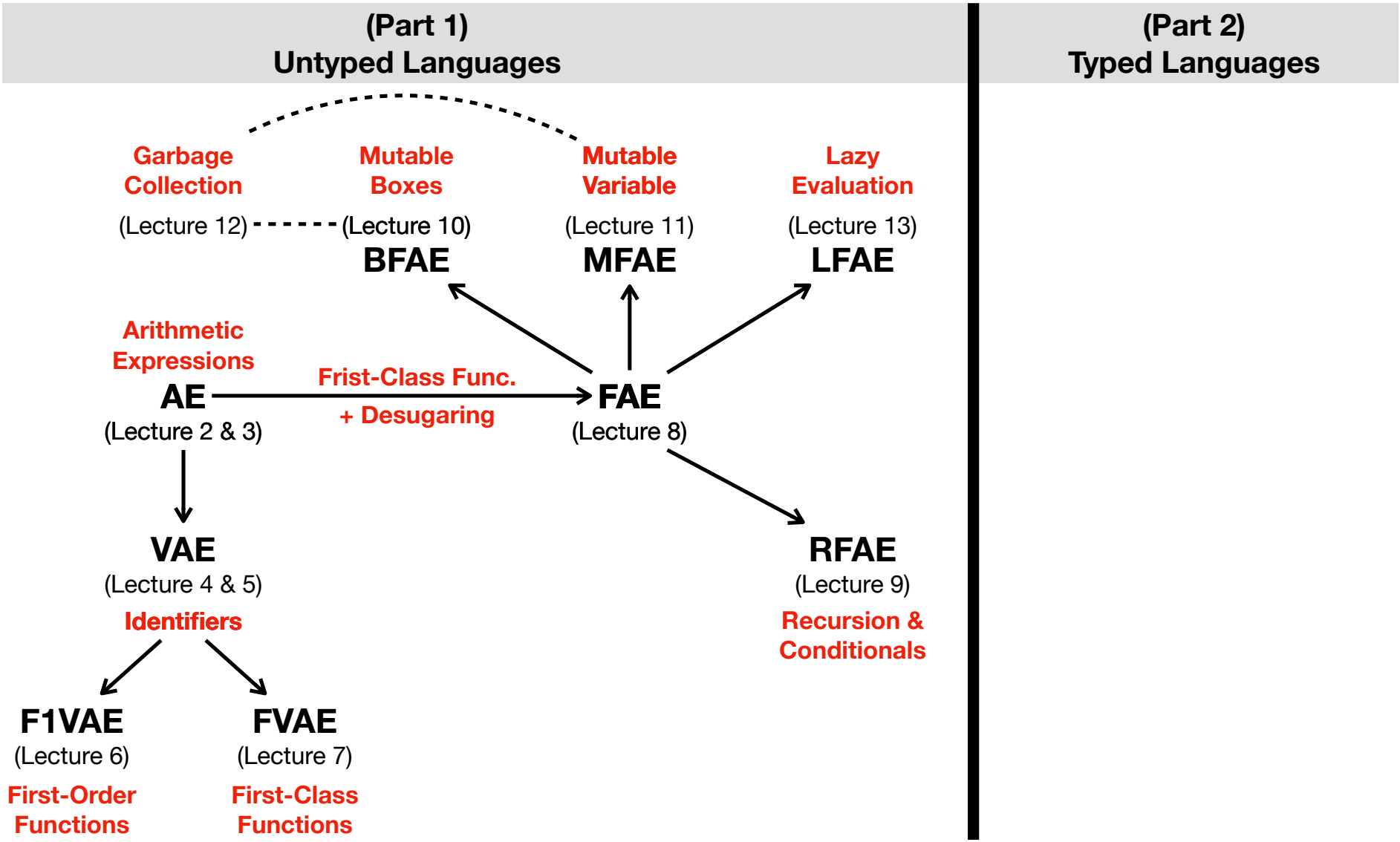
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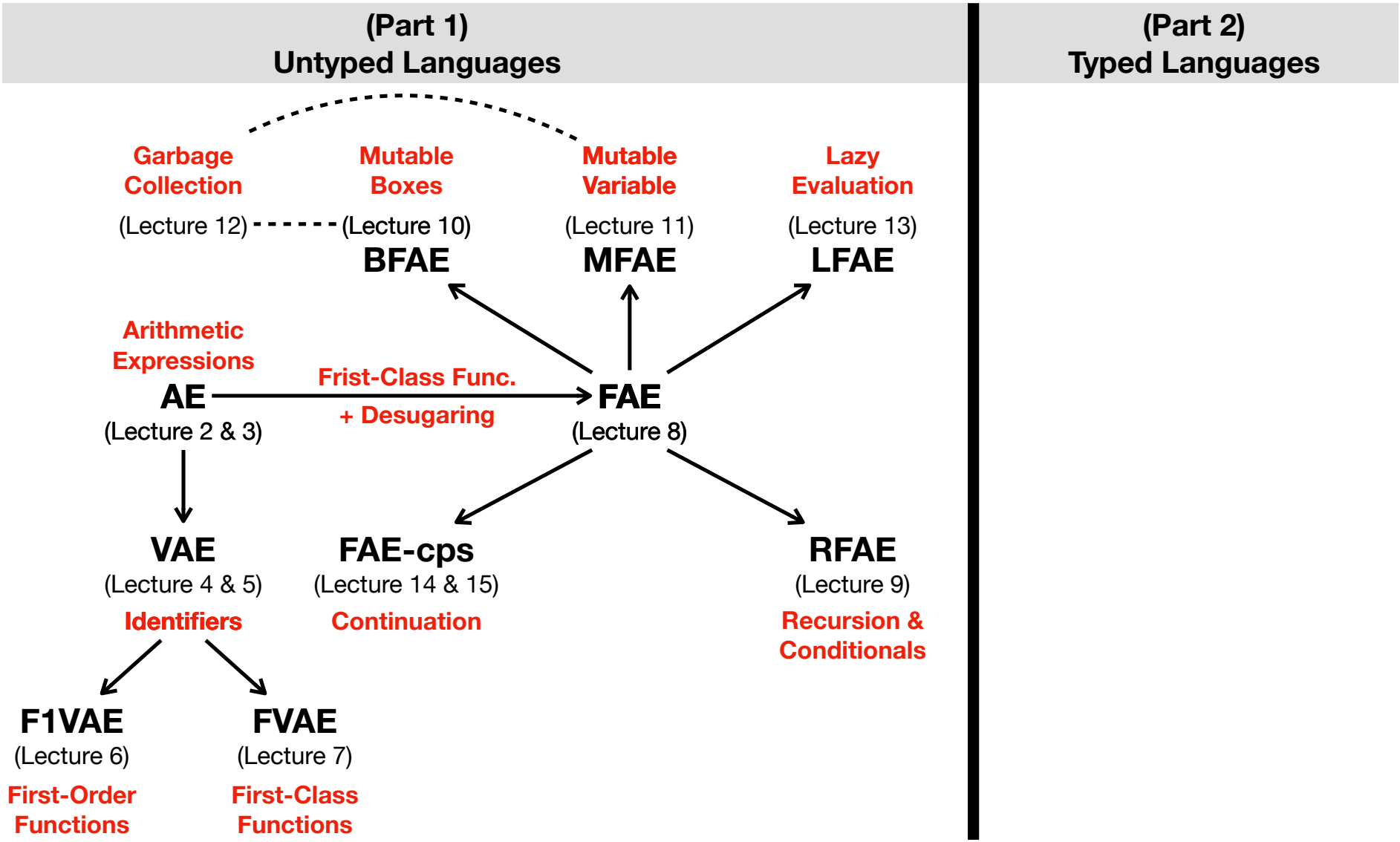
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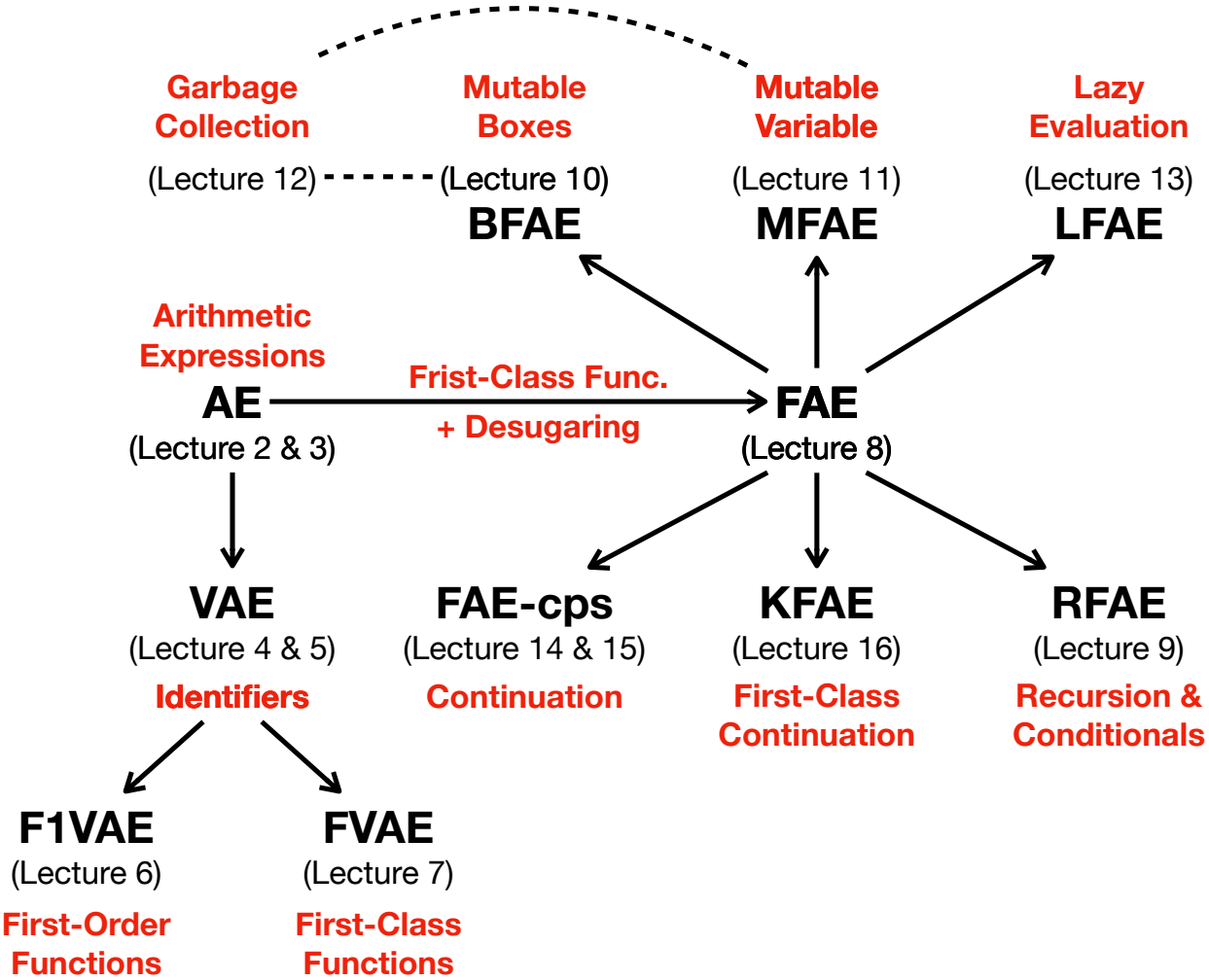

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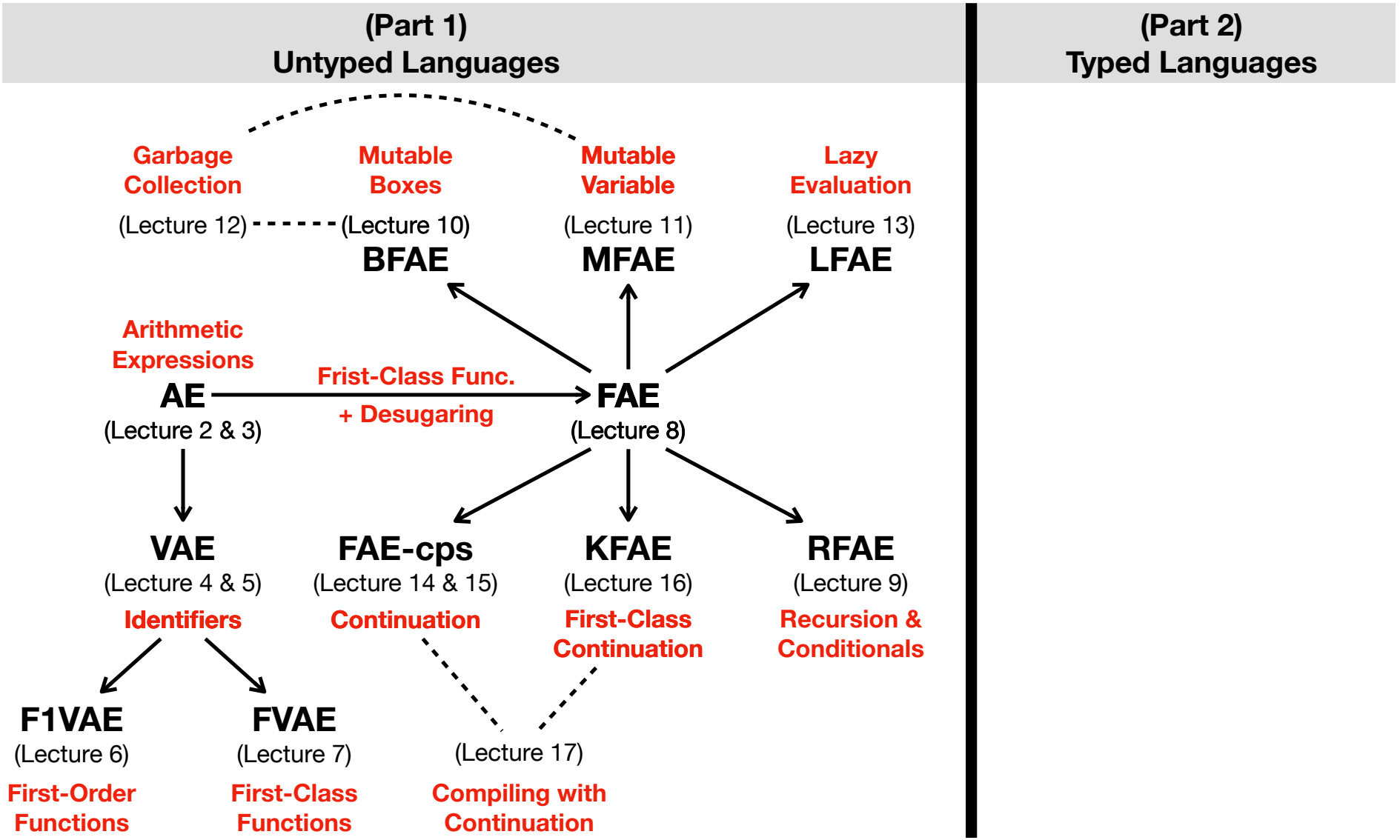
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Compiling with Continuation

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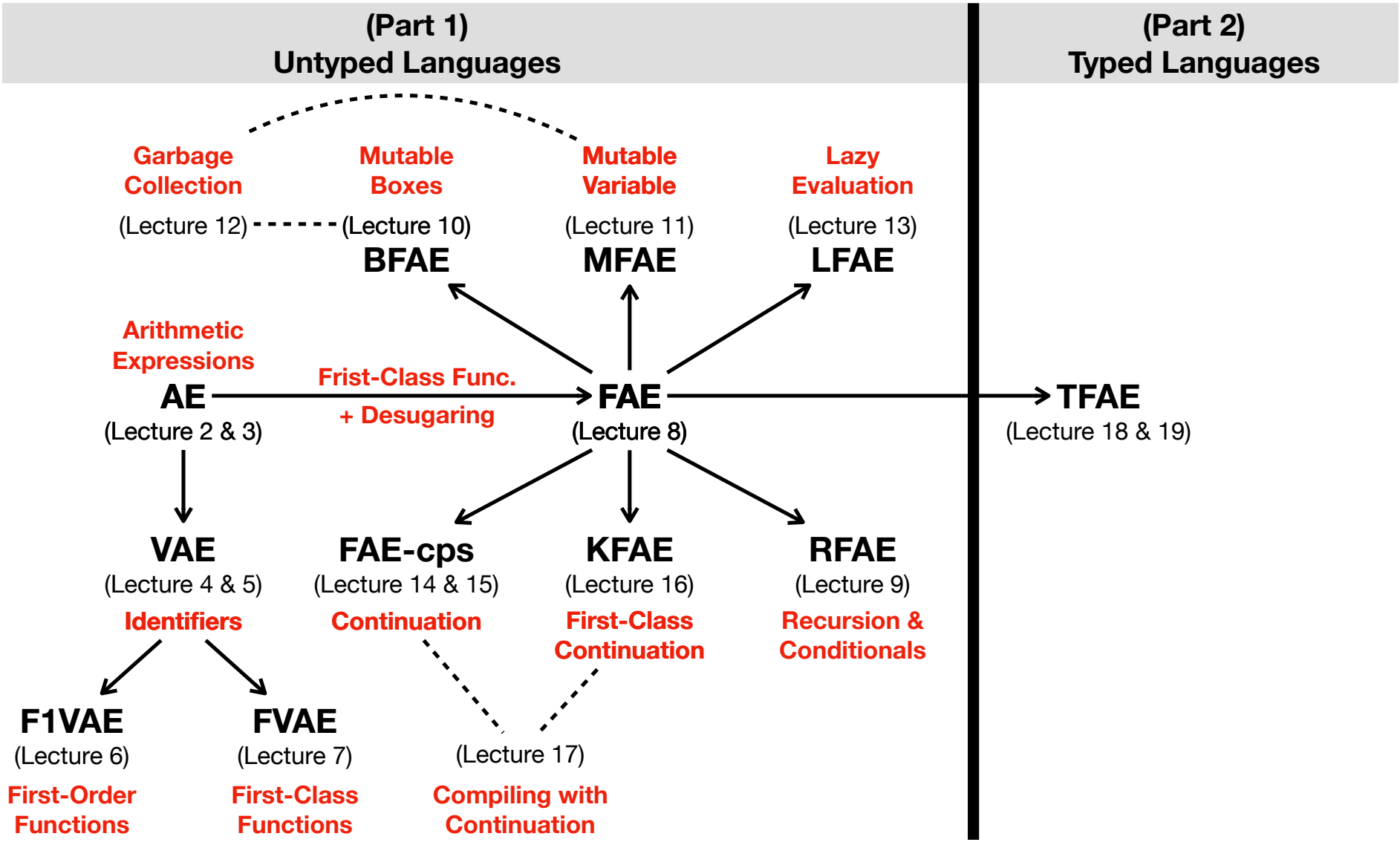
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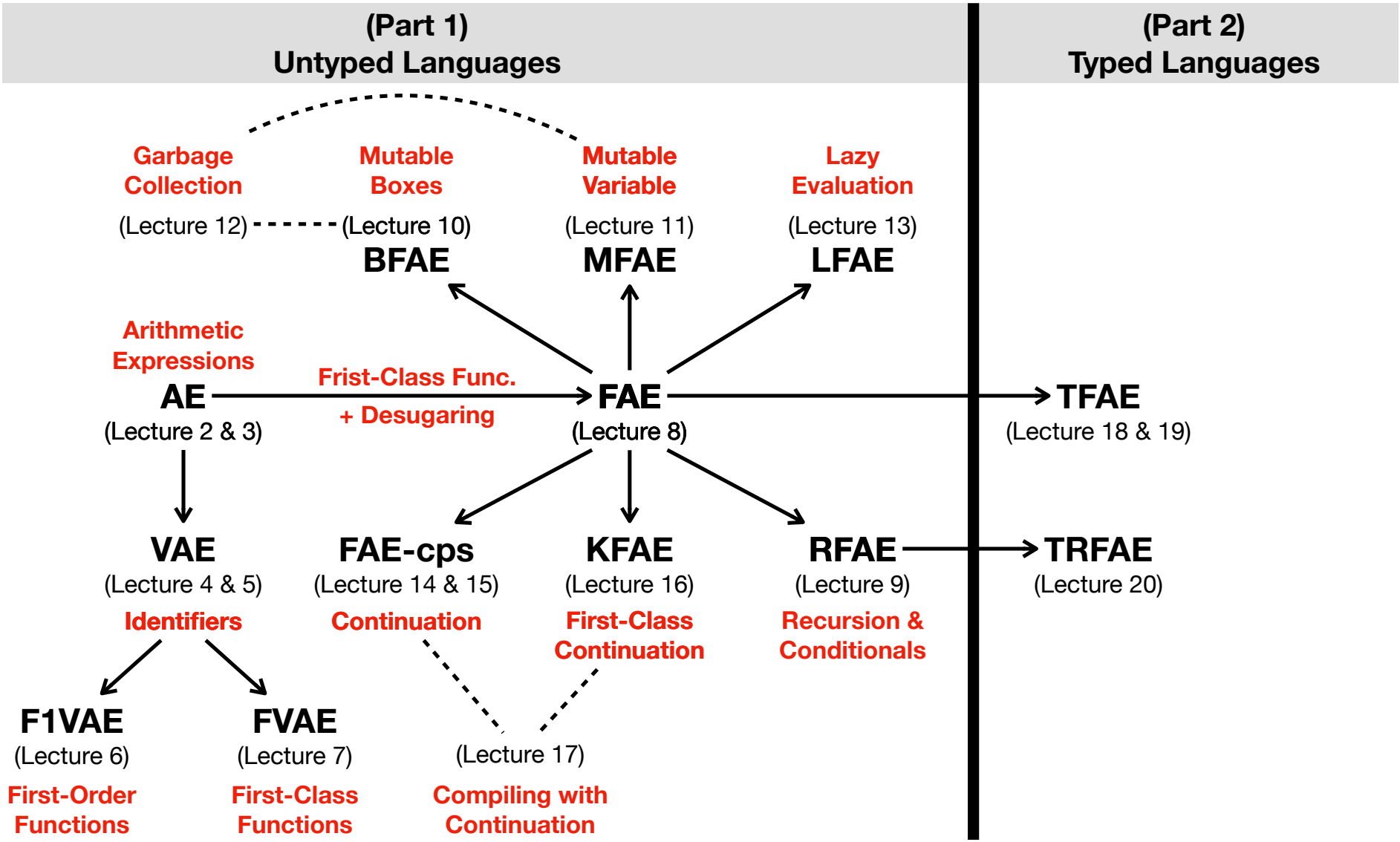
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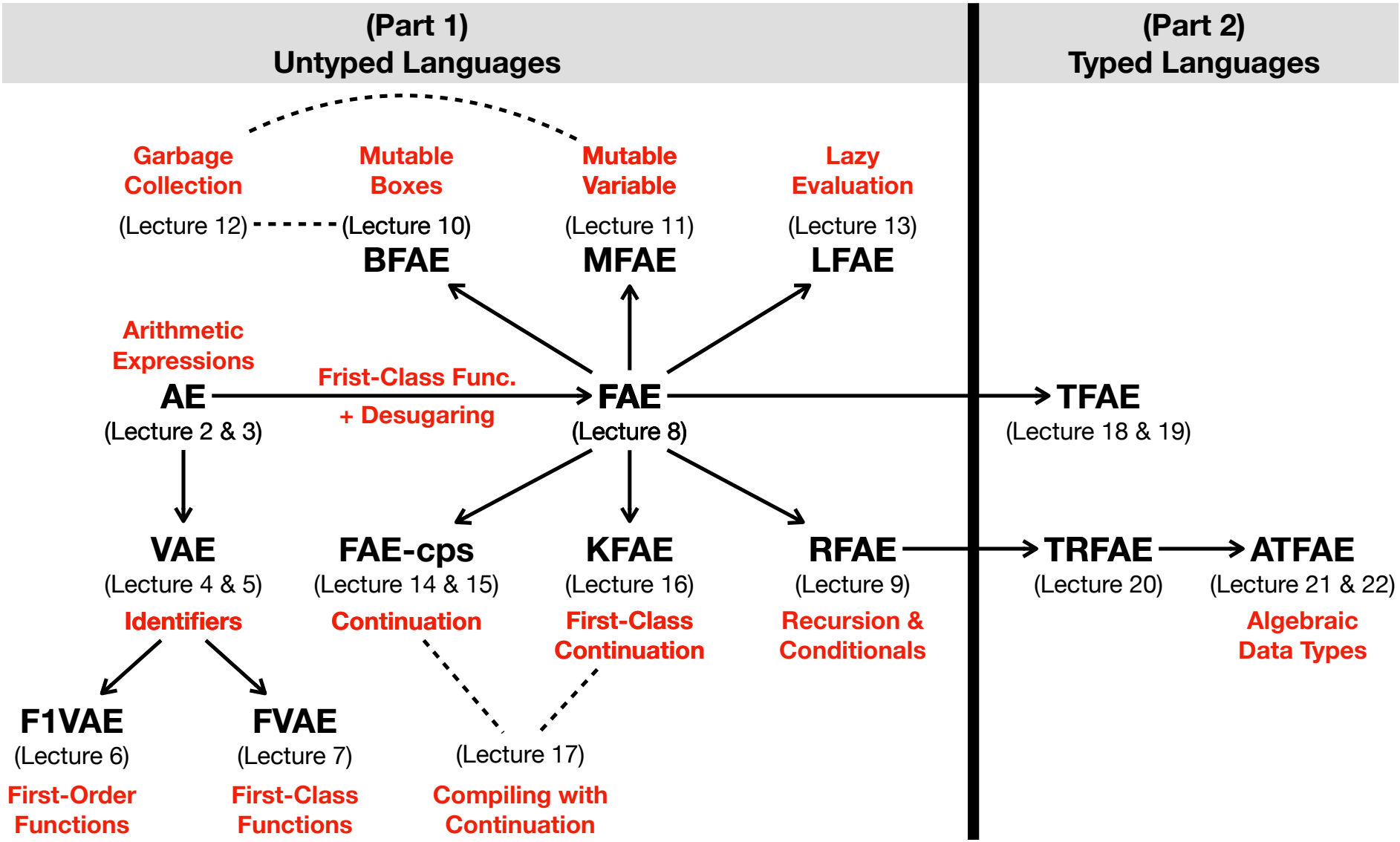
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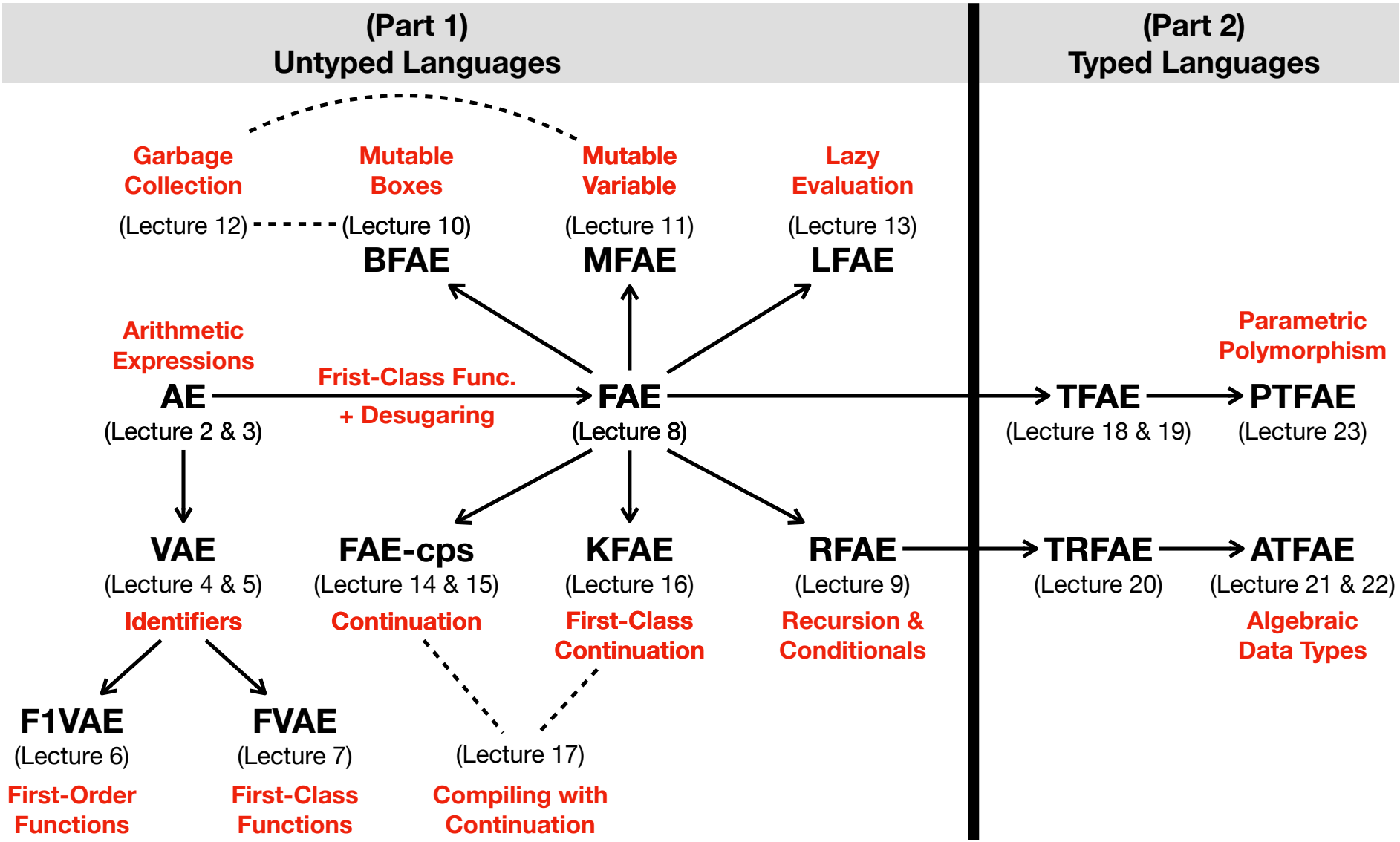
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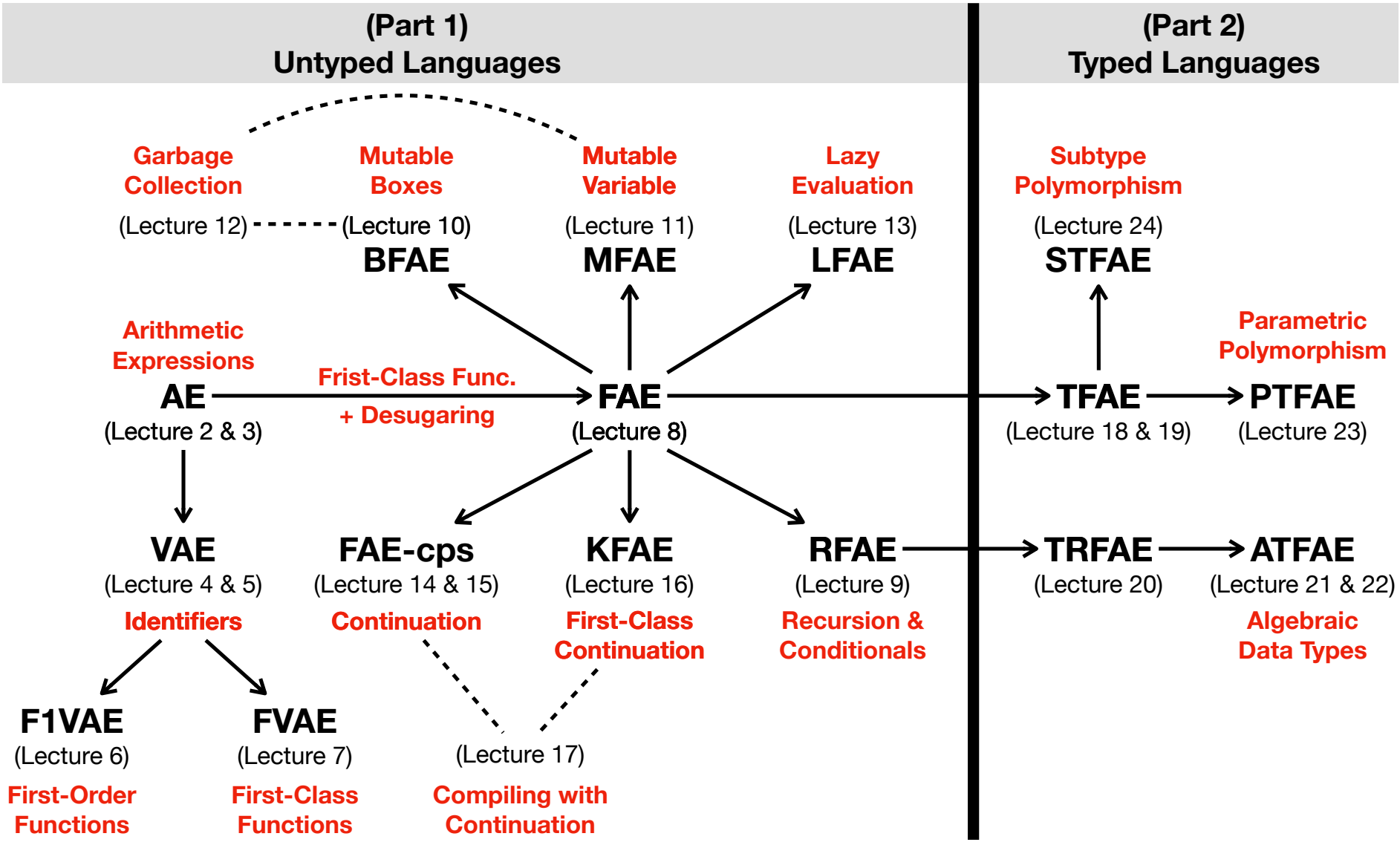
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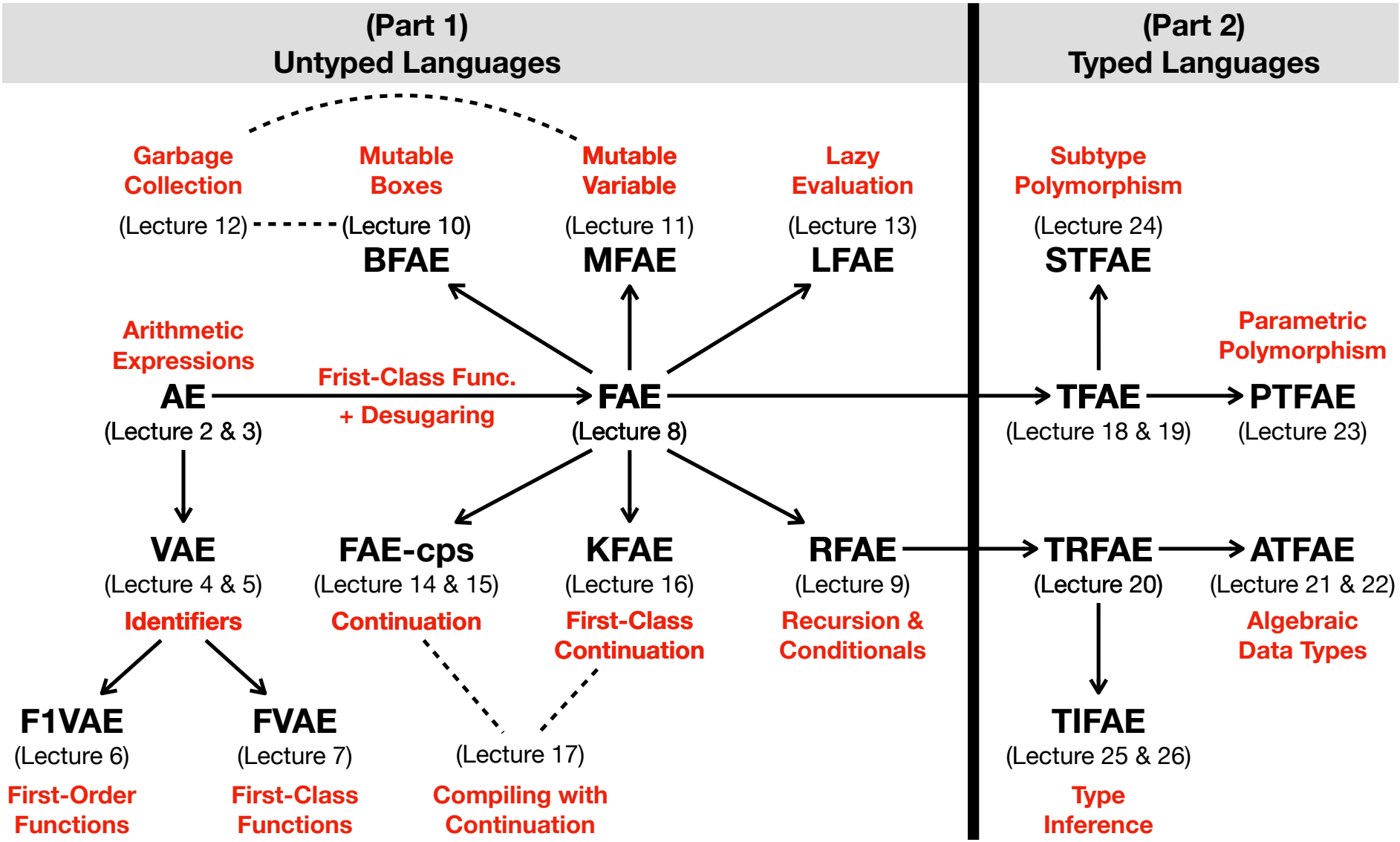
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TIFAE
(Lecture 25 & 26)
Type Inference

Applications of PL Foundations

PLRG

A deeper understanding of programming languages can help you in:

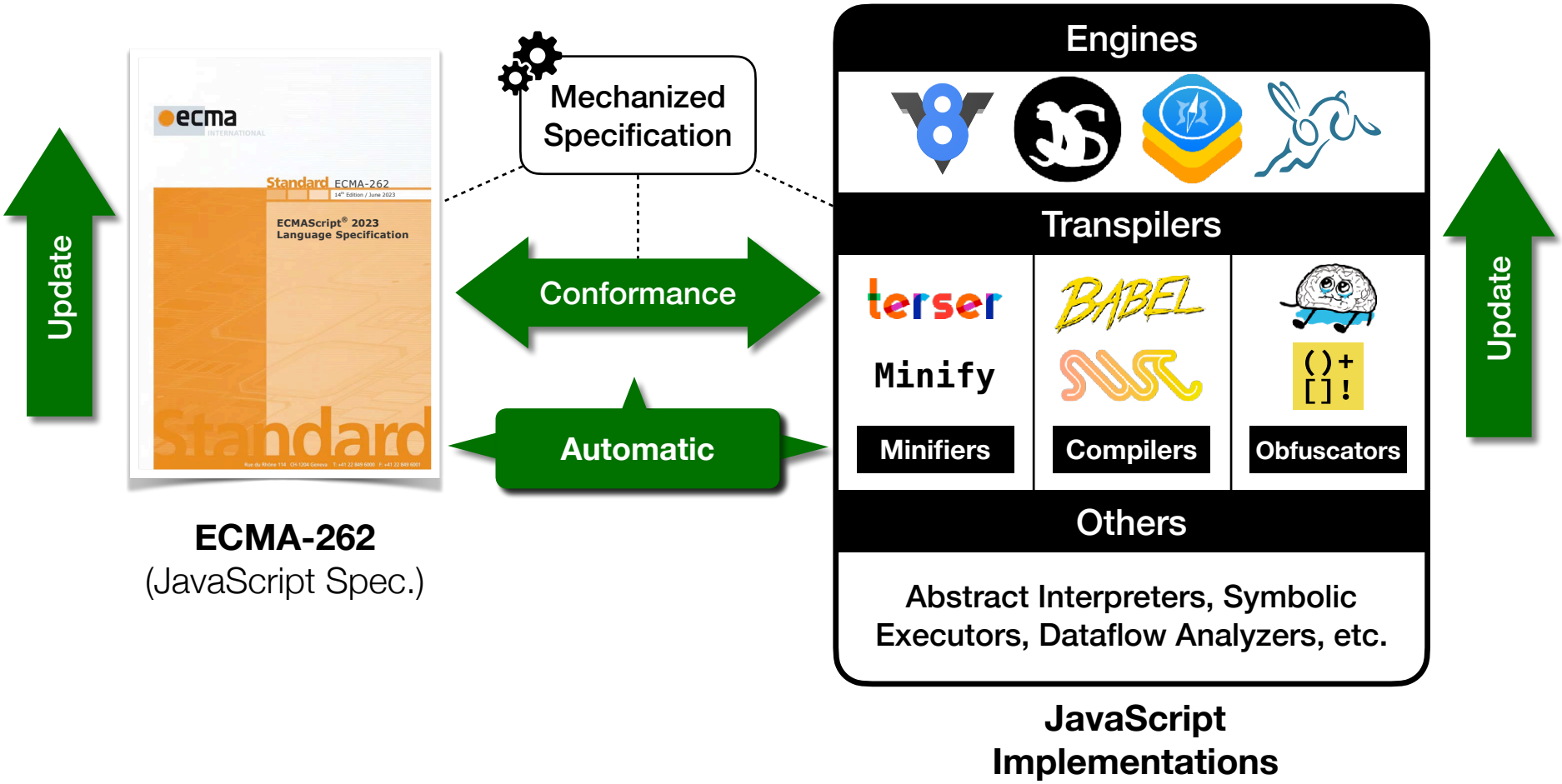
- Static/Dynamic Analysis
- Vulnerability Detection
- Automated Testing
- Program Synthesis
- Explainable AI
- etc.

In the rest of this lecture, I will introduce some of the applications developed in our **programming languages research group (PLRG)**:

https://plrg.korea.ac.kr

Application 1 – Mechanized Specification

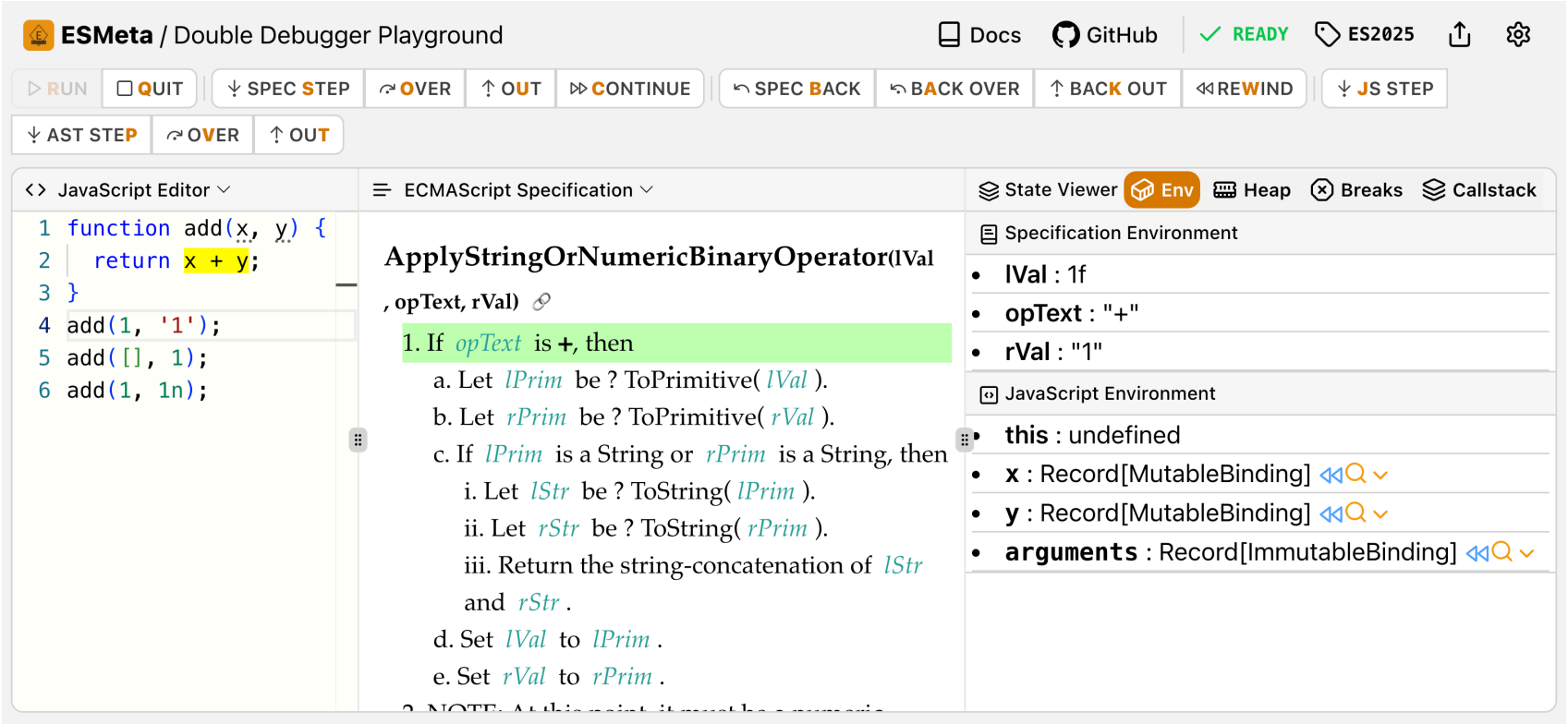
ECMA-262 is the official specification of JavaScript written in English.[1]
ESMeta is a **mechanized** version of ECMA-262 developed by our lab.[2]



[1] https://tc39.es/ecma262/2025/multipage/
[2] https://github.com/es-meta/esmeta

Application 2 – Double Debugger

We can **visualize** the execution of JavaScript programs based on the mechanized specification to help **understand/debug** complex features.[3]

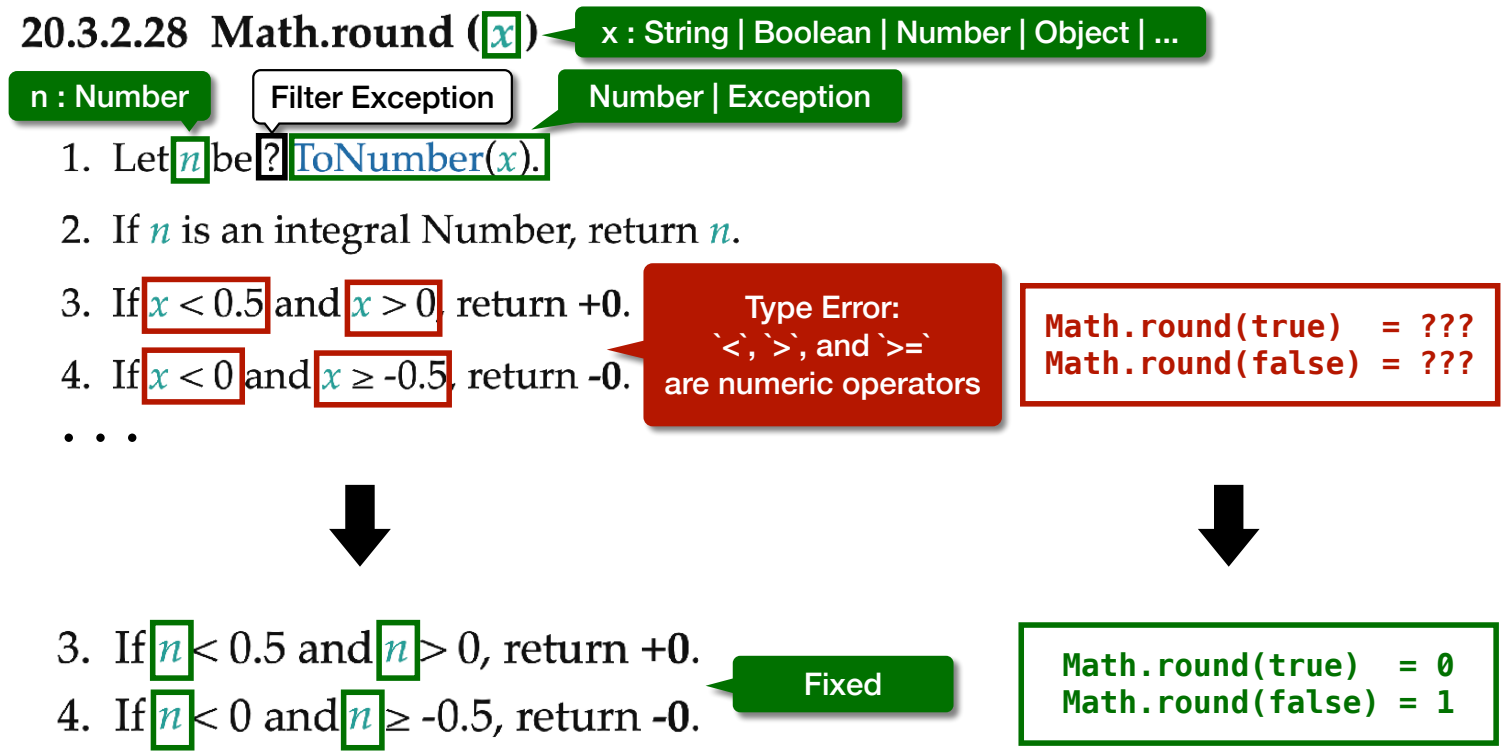


[FSE'25 Demo] M. Choe*, K.Song*, H. Kim, and **J. Park**, "JSSpecVis: A JavaScript Language Specification Visualization Tool"

[3] https://es-meta.github.io/playground/

Application 3 – Type Analysis

We can detect **specification errors** using **type analysis** based on the mechanized specification. It is officially used in language design process.[4]

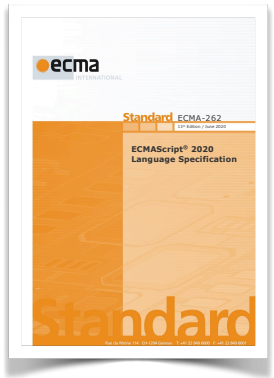


[ASE'21] **J. Park**, S. An, W. Shin, Y. Sim, and S. Ryu, "JSTAR: JavaScript Specification Type Analyzer using Refinement"

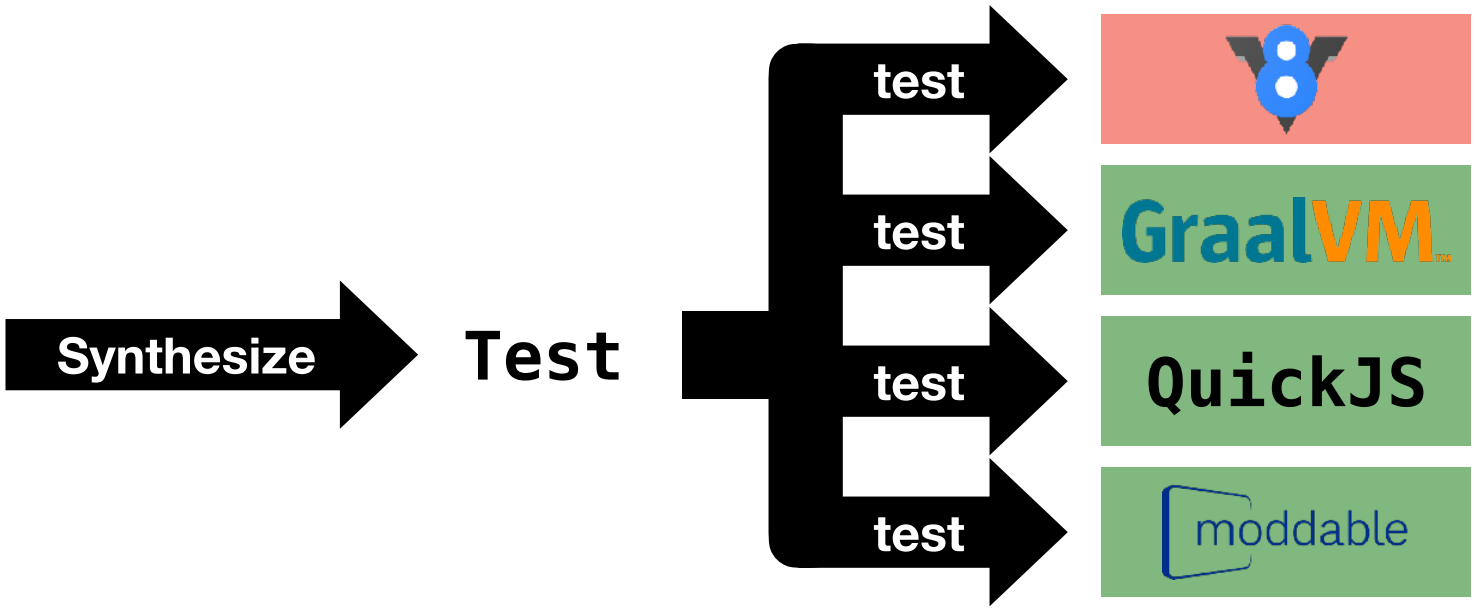
[4] https://github.com/tc39/ecma262/actions/workflows/esmeta-typecheck.yml

Application 4 – Program Synthesis

We can **synthesize JS programs** with assertions from the mechanized specification to **test real-world JS interpreters** (e.g., V8 for Chrome).



ECMA-262
(JavaScript Spec.)



JavaScript Engines

[PLDI'23] **J. Park**, D. Youn, K. Lee, and S. Ryu, "Feature-Sensitive Coverage for Conformance Testing of Programming Language Implementations"

Application 4 – Program Synthesis

PLRG

For example, we found a bug in the SpiderMonkey JavaScript engine (v107.0b4) used in Firefox.[5]

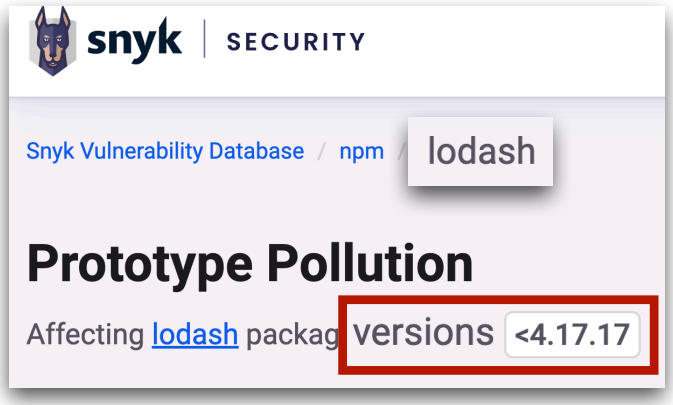
```
var x = (async function ([]) {})();
// Assertions
...
$assert.sameValue(Object.getPrototypeOf(x), Promise.prototype);
$assert.sameValue(Object.isExtensible(x), true);
$assert.notCallable(x);
$assert.notConstructable(x);
...
```

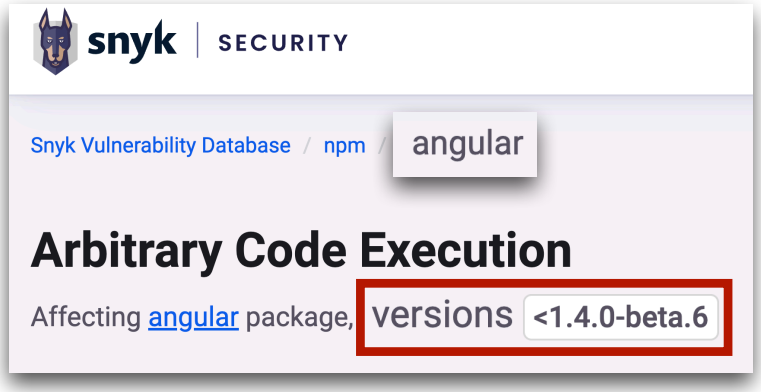
While it should be terminated normally, SpiderMonkey engine throws a run-time `TypeError` when executing this program.

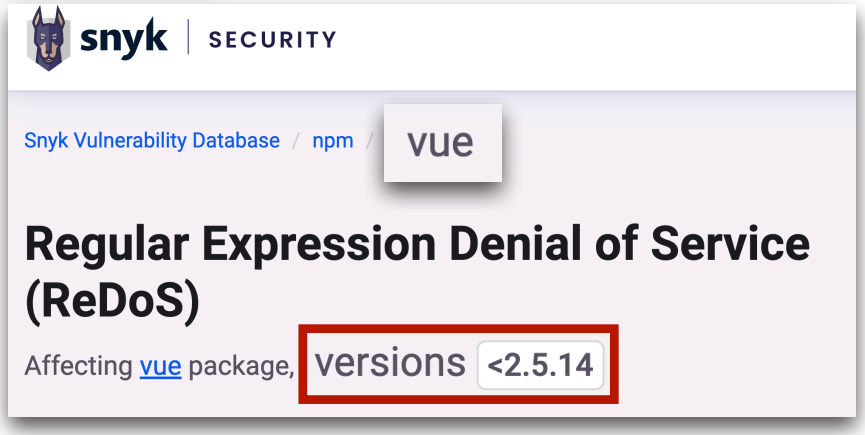
[5] https://bugzilla.mozilla.org/show_bug.cgi?id=1799288

Application 5 – Vulnerability Detection

Detecting vulnerable JS libraries on the web is important for web security.







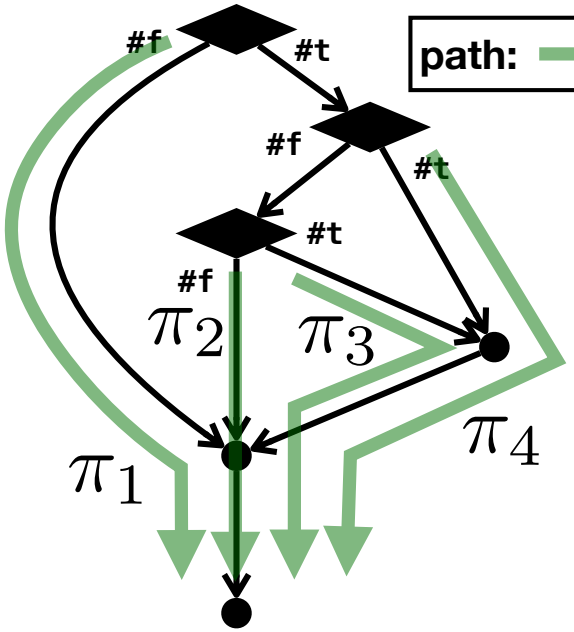
Application 5 – Vulnerability Detection

However, it is challenging to detect JS libraries accurately because:

- Bundlers ***modify*** and ***compress*** **user code** and **libraries** together using diverse **transpilers**
- It makes **difficult to detect libraries** in transpiled code in web applications

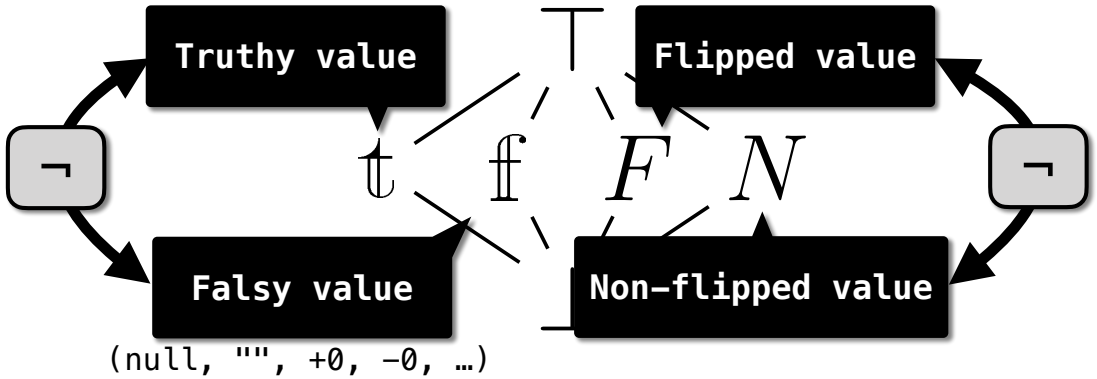
Application 5 – Vulnerability Detection

We can accurately detect vulnerable JS libraries on web using property-order graphs extracted through **static analysis** techniques.



path:

Track truthiness of variables along execution paths!
(Path = Control flow from each branch)



Abstract domain

We are recruiting motivated students who are interested in this topic!

[ASE'25] S. Kim*, S. Park*, and **J. Park**, "Debun: Detecting Bundled JavaScript Libraries on Web using Property-Order Graphs"

Final Exam

- **Date:** 18:30 – 21:00 (150 min.), December 17 (Wed.).
- **Location:** B102, IT & General Education Center (정운오IT교양관)
- **Coverage:** Lectures 14 – 26
- **Format:** closed book and closed notes
  - Fill-in-the-blank questions about the PL concepts.
  - Write the evaluation results of given expressions.
  - Draw derivation trees of given expressions.
  - Define the syntax or semantics of extended language features.
  - Define typing rules for the given language features.
  - etc.
- Note that there is **no class** on **December 15 (Mon.)**.

- I hope you enjoyed the class!

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https://plrg.korea.ac.kr