Mini Workshop on GCC Internals

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Part 1

Outline

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- Open Source Vs. Free Software
- GCC Internals
- Major Research Initiatives
- Conclusions

Part 2

Open Source Vs. Free Software

Open Source Vs. Free Software

- The open source initiative: (http://www.opensource.org/)
  Emphasis on development methodology
- The Free Software Foundation: (http://www.fsf.org/)
  Emphasis on freedom of the user
- In some cases, open source software has restricted user freedom

Open Source and Free Software Development Model

- The Cathedral and the Bazaar

  Eric S Raymond, 1999.
- Cathedral: Total Centralized Control

  Design, implement, test, release
- Bazaar: Total Decentralization

  Release early, release often, let users fix bugs

The Bazaar Approach

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- "Given enough eyeballs, all bugs are shallow".

  Code errors, logical errors, and architectural errors.

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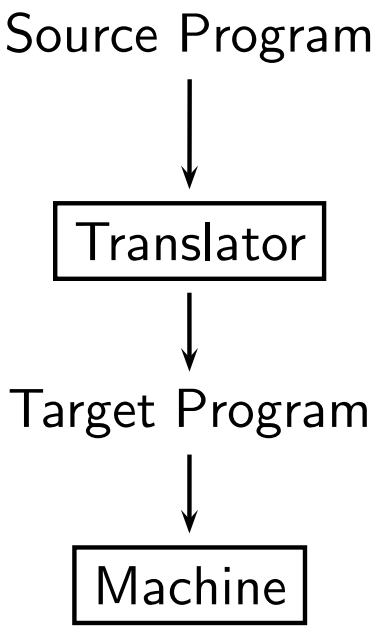
A combination of the two seems more sensible

Part 3

Introduction to Compilation

Implementation Mechanisms



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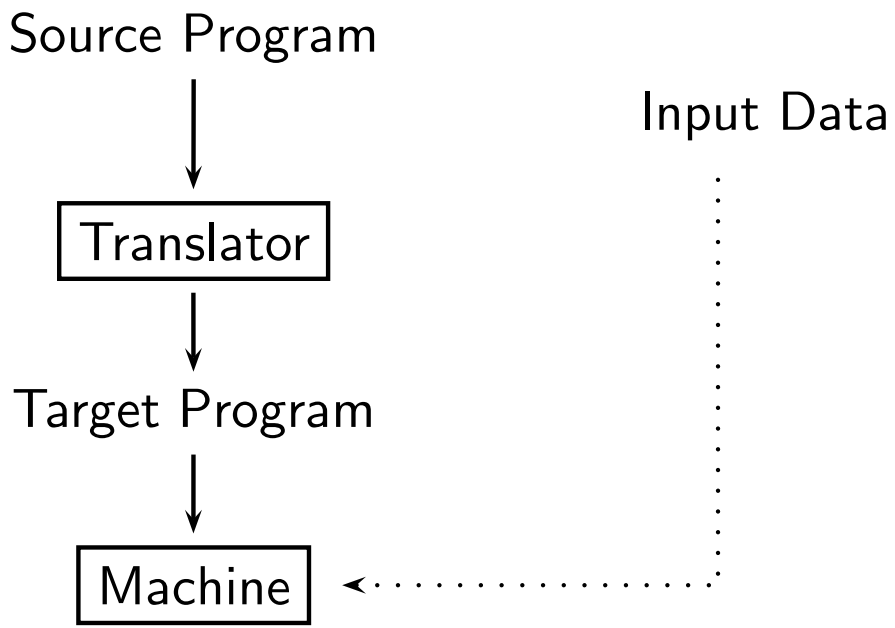

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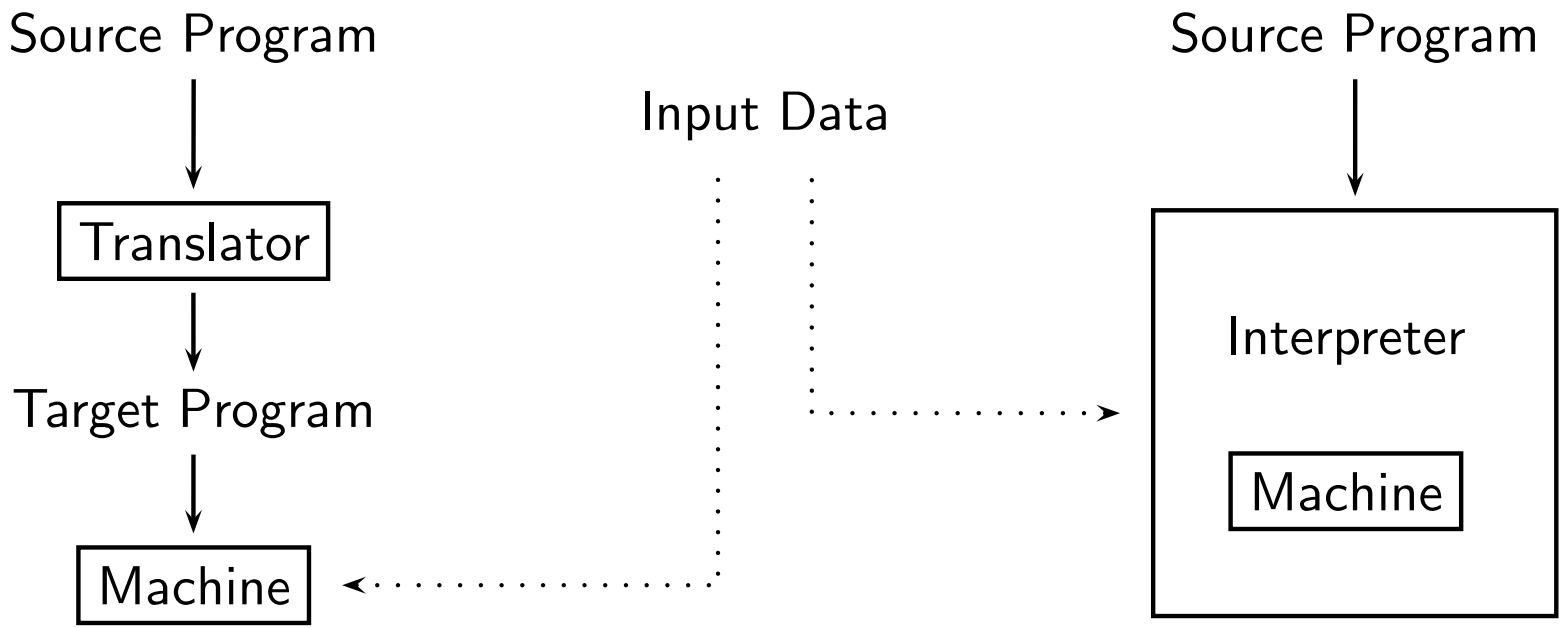
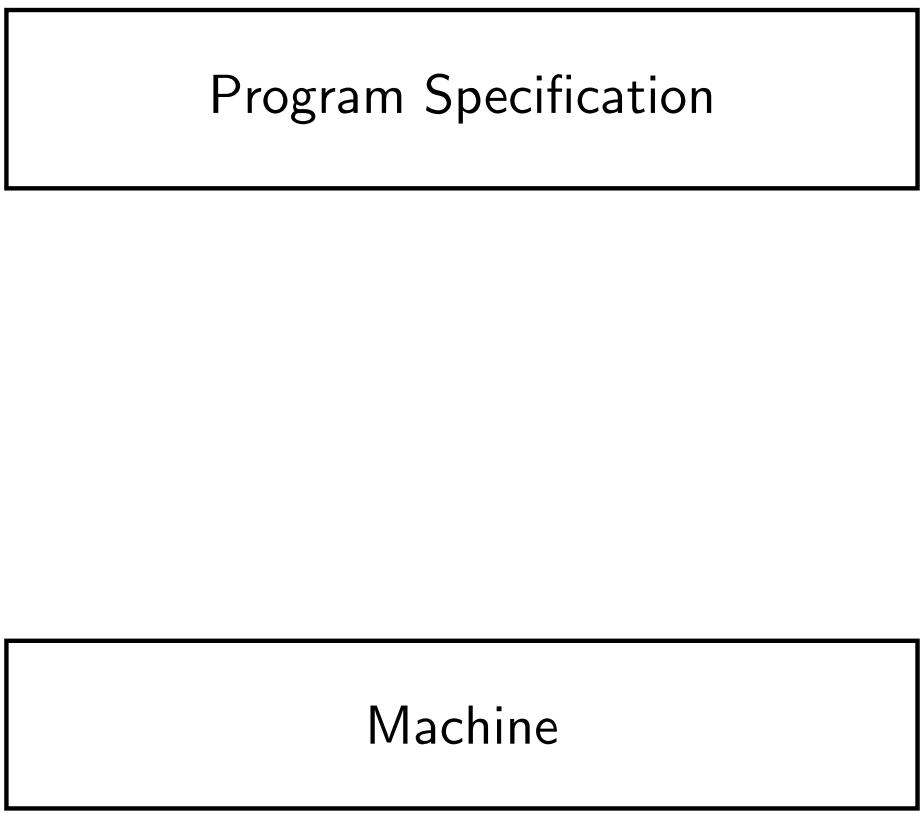


Implementation Mechanisms as "Bridges"

- "Gap" between the "levels" of program specification and execution



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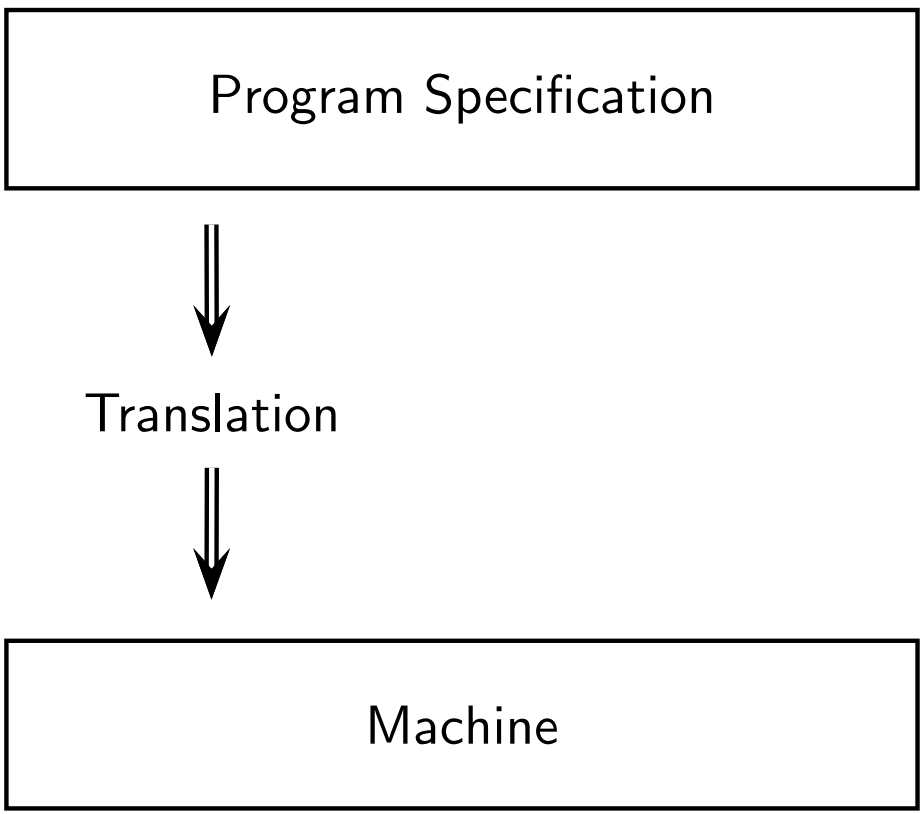

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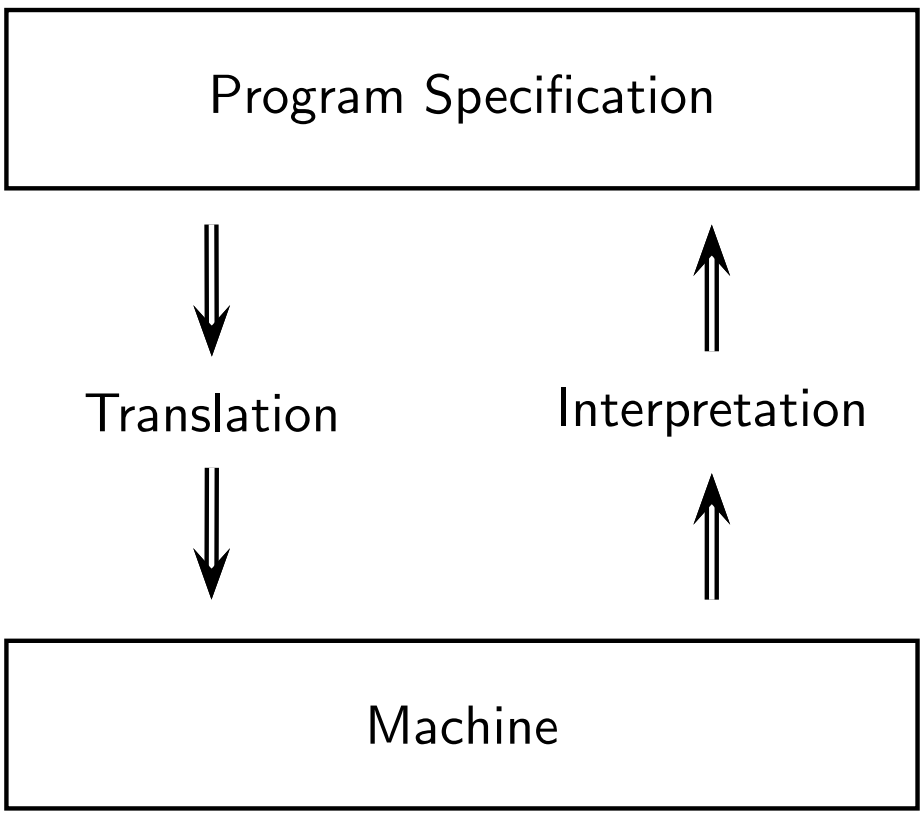

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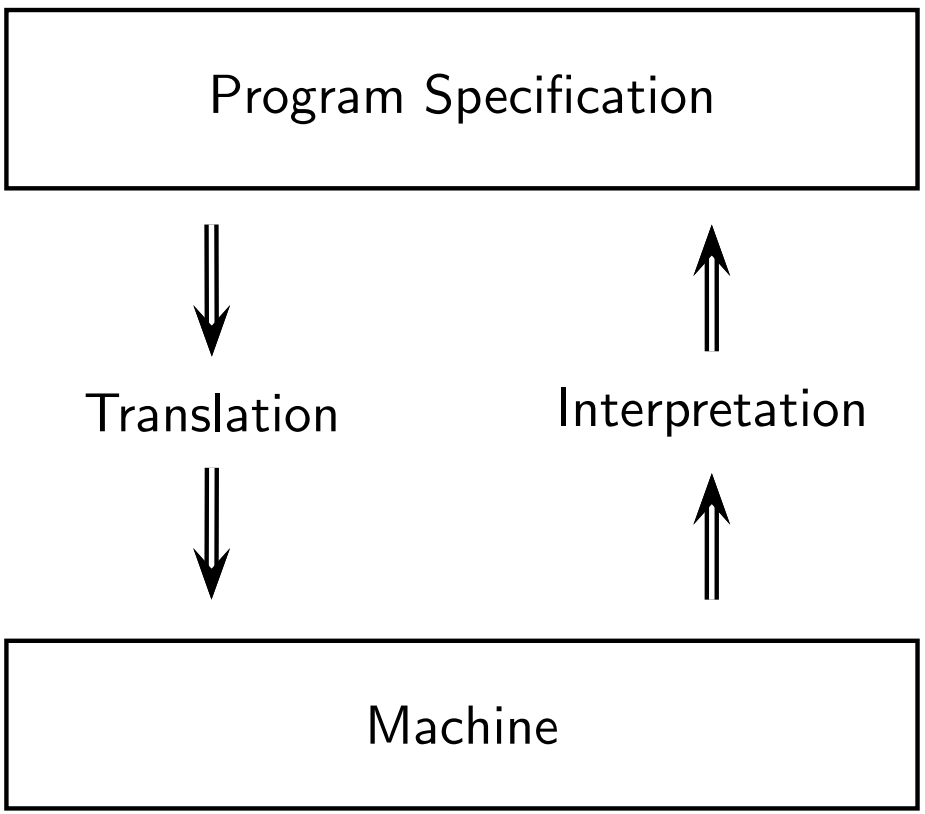

State : Variables
Operations: Expressions, Control Flow

State : Memory, Registers
Operations: Machine Instructions

High and Low Level Abstractions

- A source statement

```
a = b < 10 ? b : c;
```

- Spim assembly equivalent

```
        lw   $t0, 4($fp)    #       $t0 <- b
        slti $t0, $t0, 10   #       $t0 <- $t0 < b
        not  $t0, $t0       #       $t0 <- ! $t0
        bgtz $t0, L0:       #       if $t0 >=  0 goto L0:
        lw   $t0, 4($fp)    #       $t0 <- b
        b    L1:            #       goto L1:
L0:     lw   $t0, 8($fp)    # L0:   $t0 <- c
L1:     sw   0($fp), $t0    # L1:   a <- $t0
```


Implementation Mechanisms

- Translation = Analysis + Synthesis

  Interpretation = Analysis + Execution

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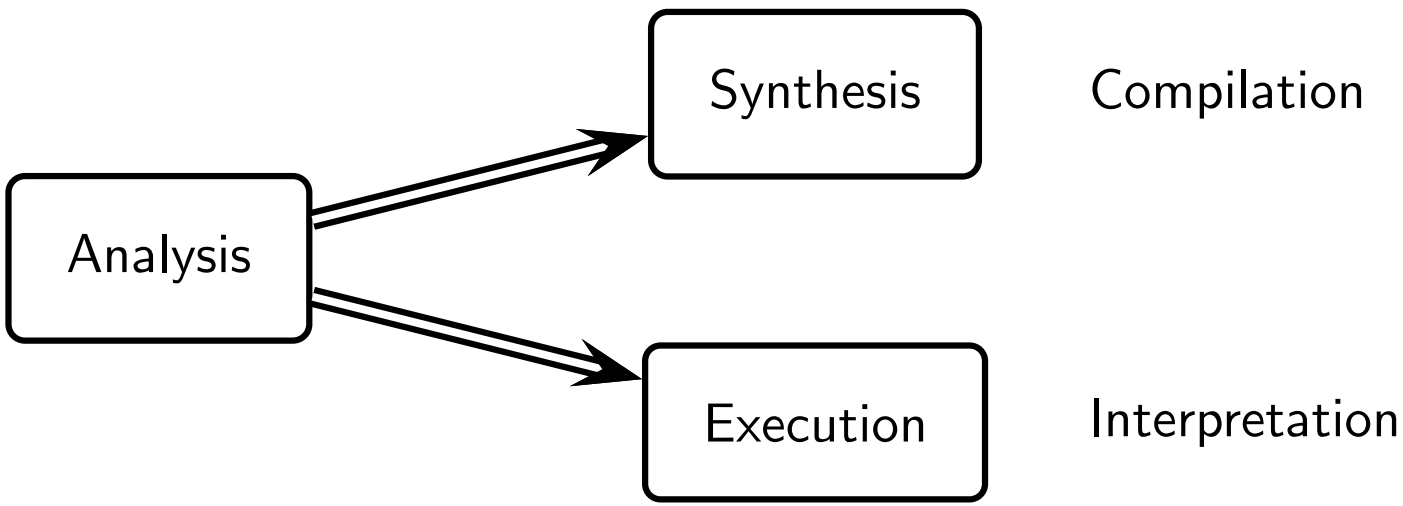
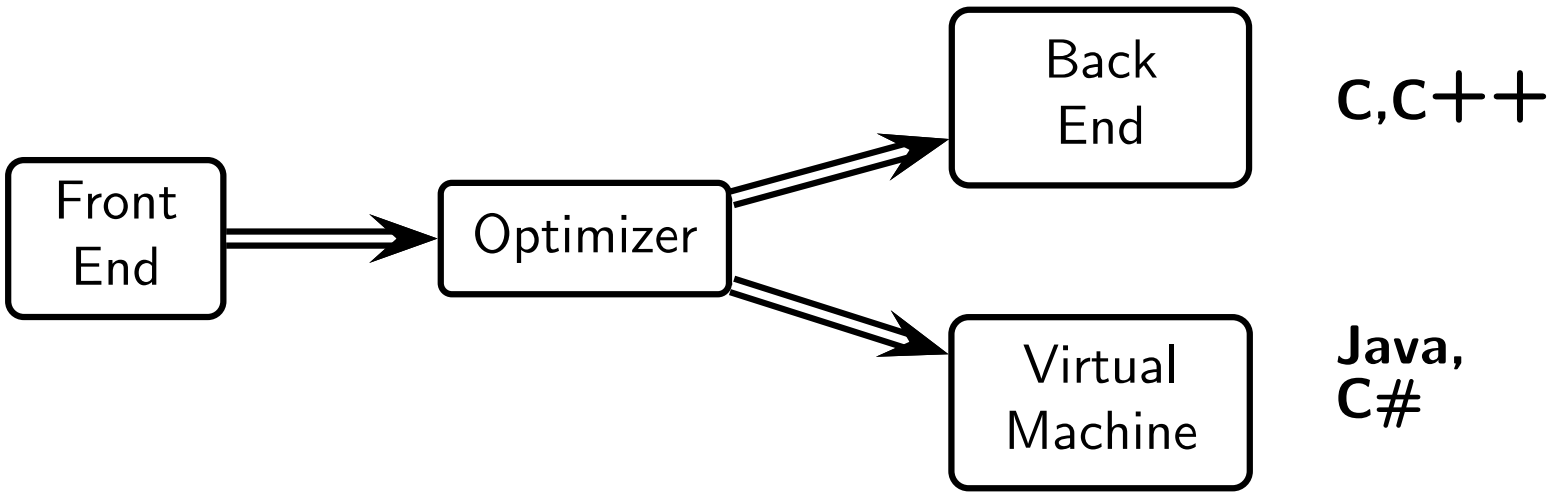
  Interpretation Instructions $\Longrightarrow$ Actions Implied by Instructions

Language Implementation Models



Language Processor Models



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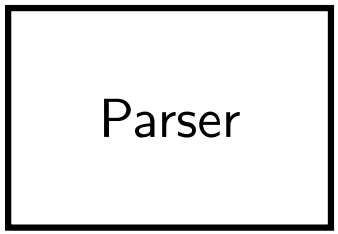

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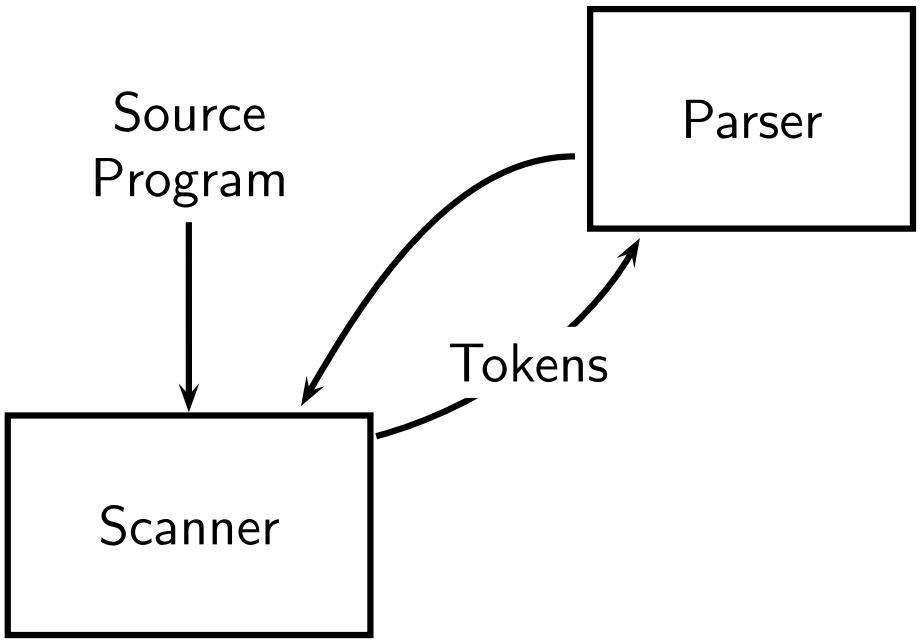

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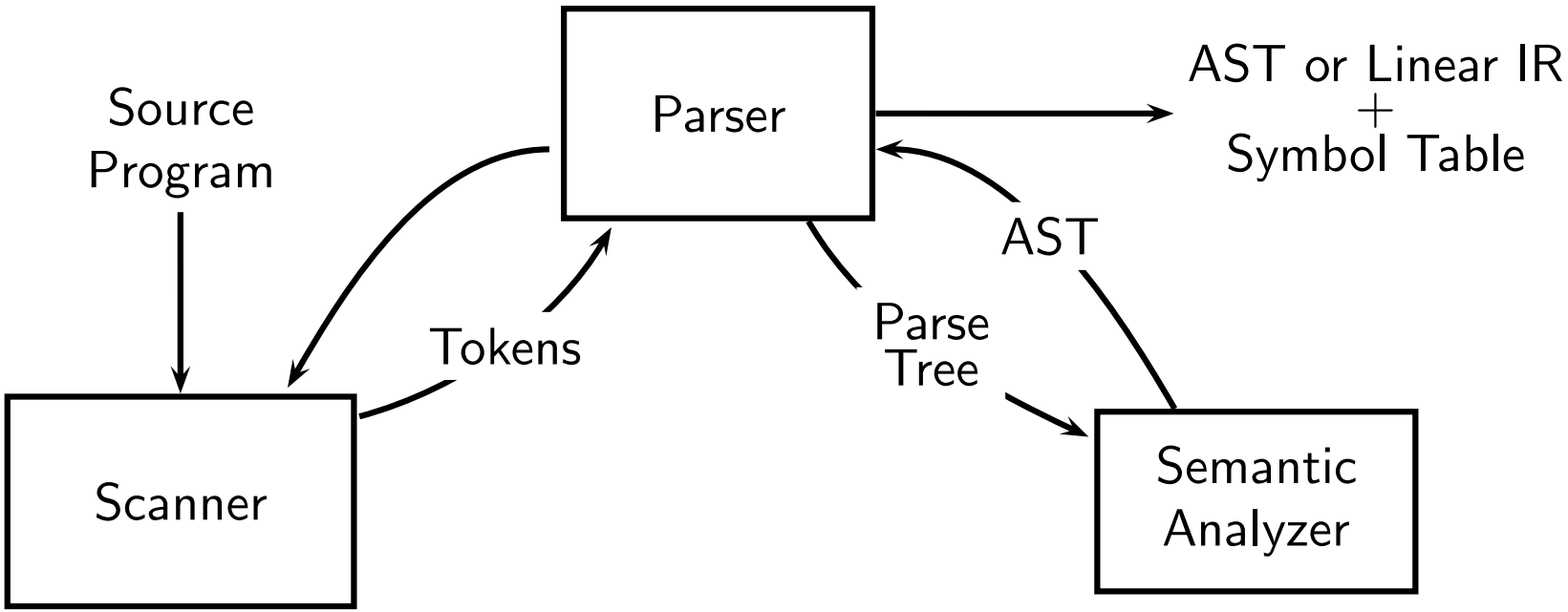

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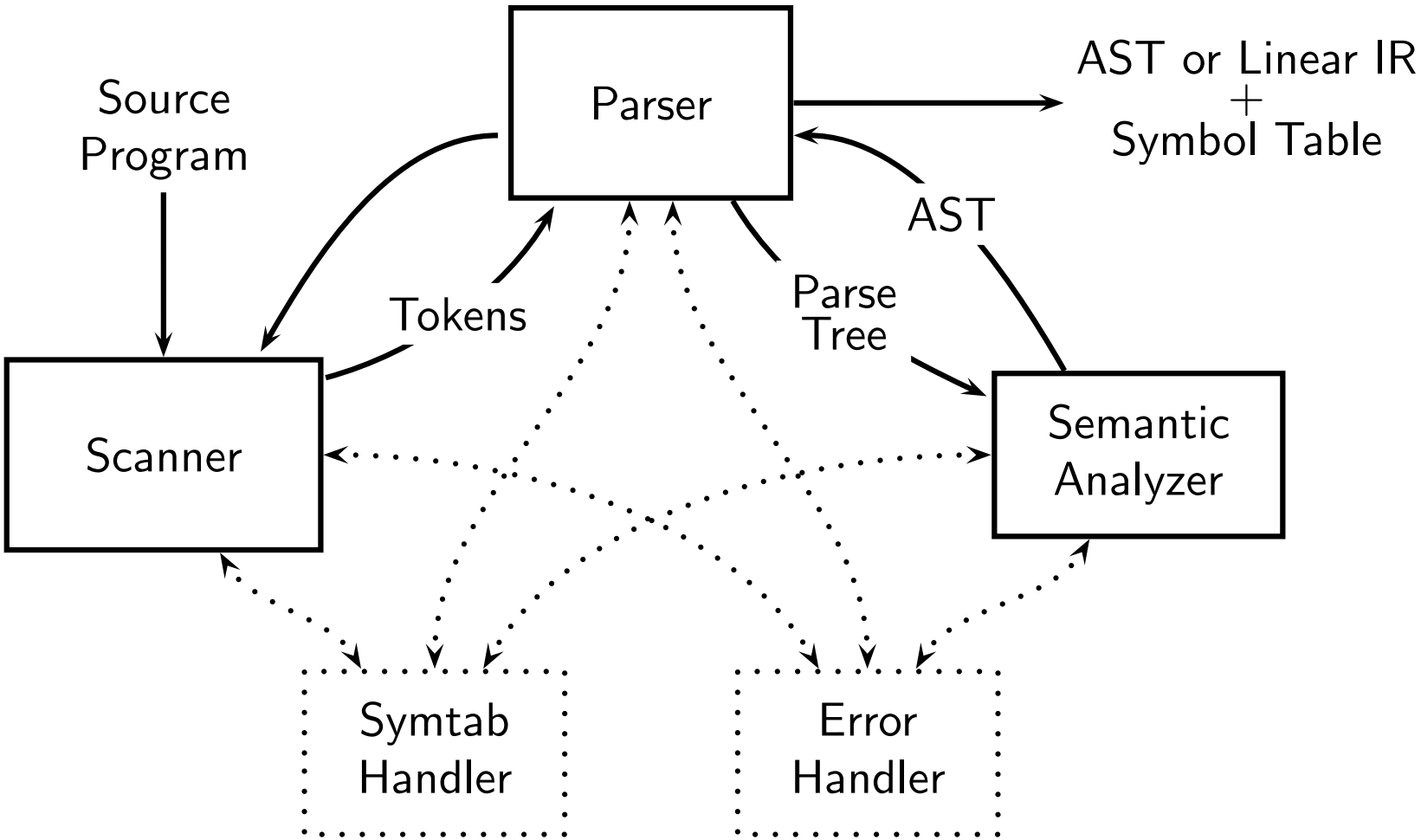

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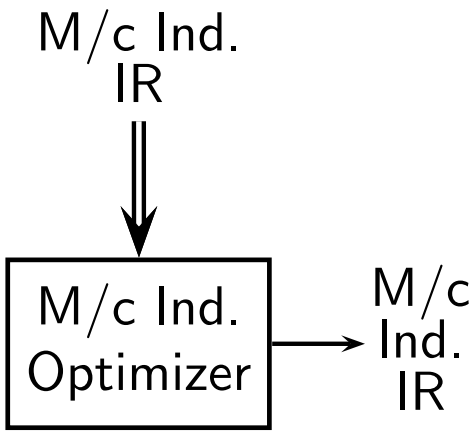

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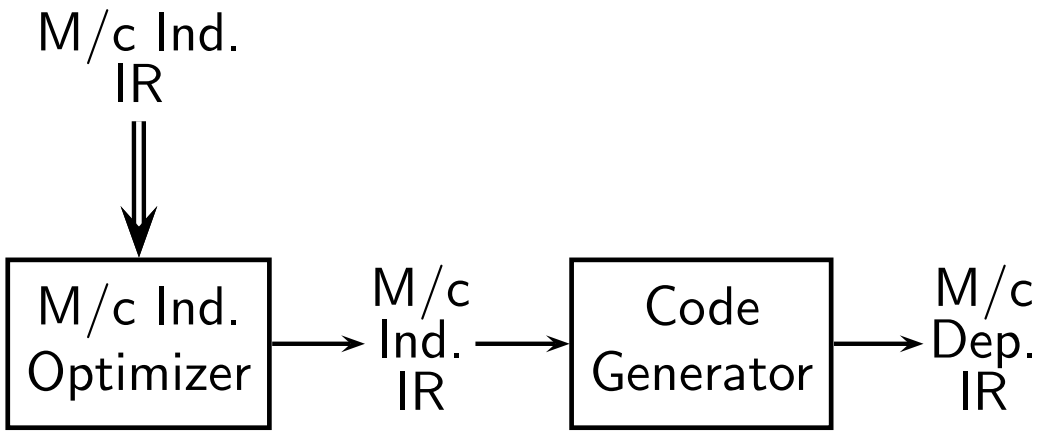

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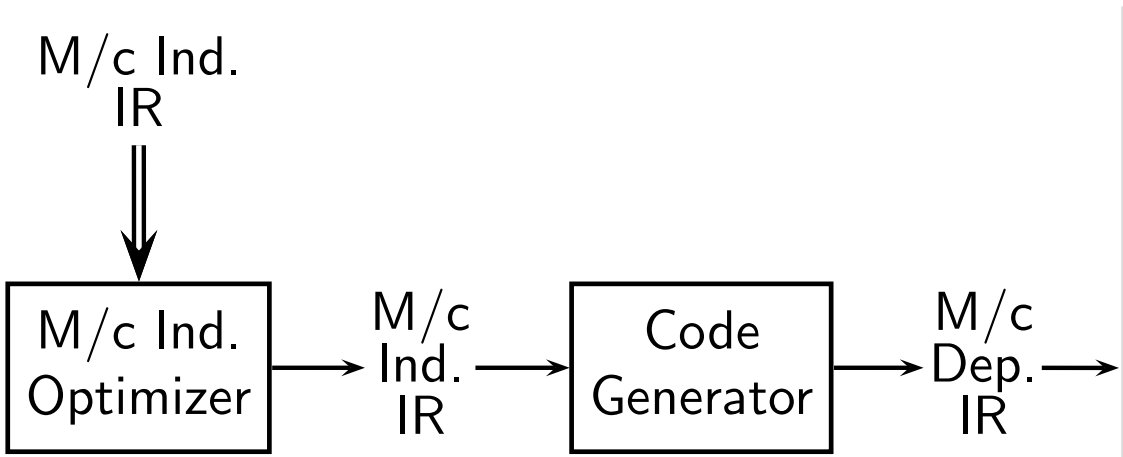

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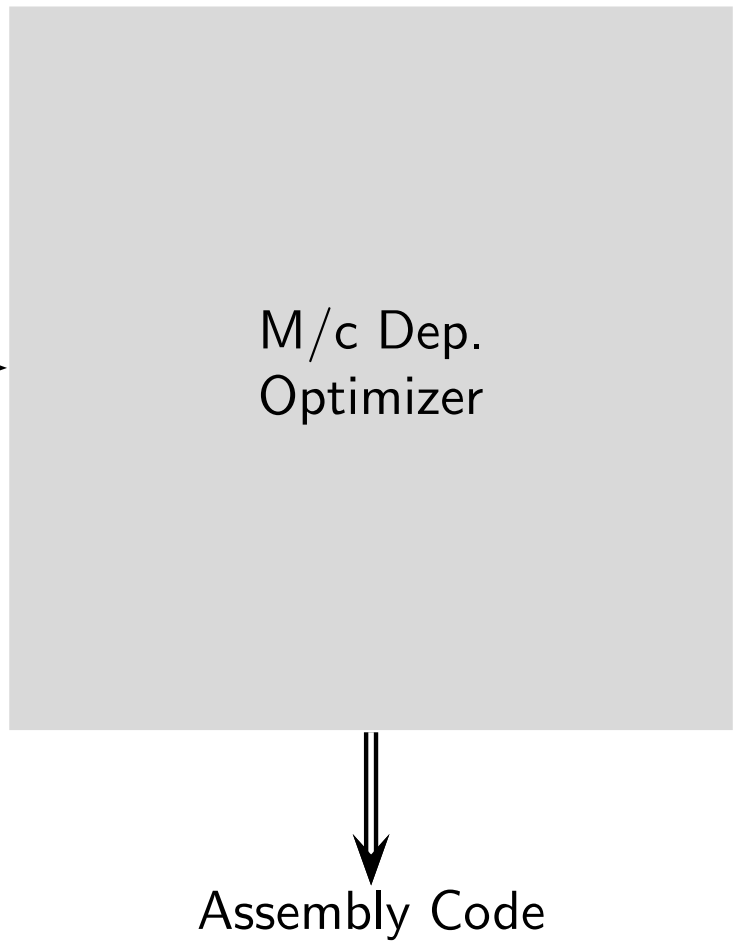

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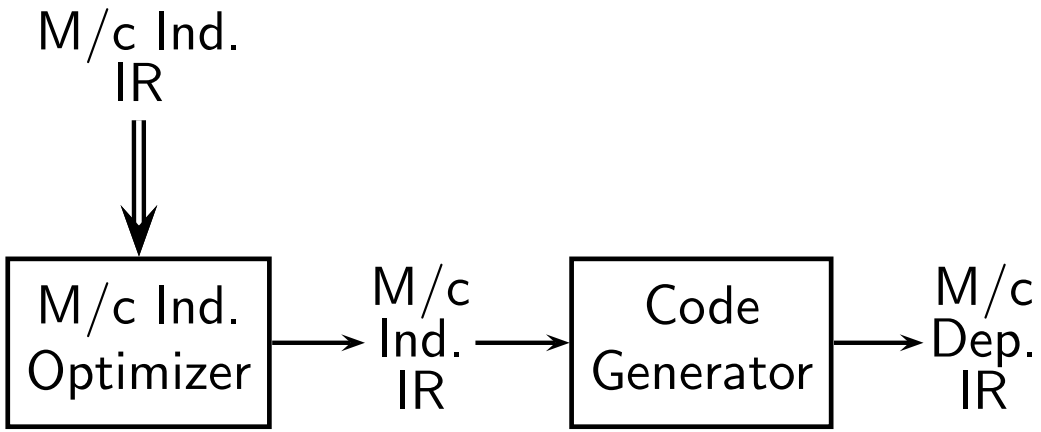

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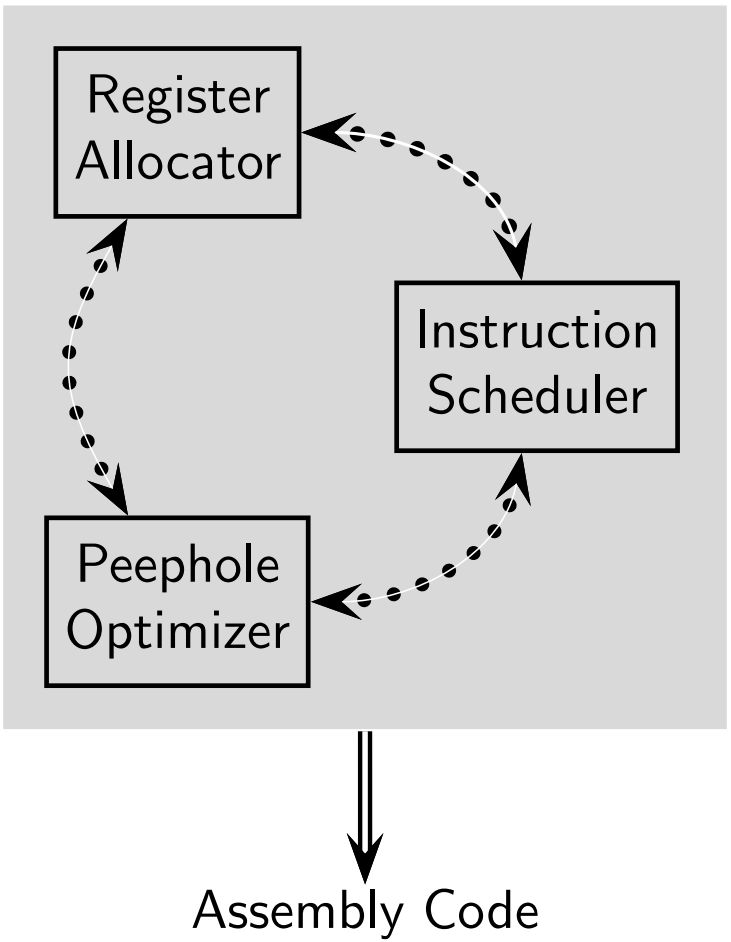

Part 4

Major R&D Initiatives

Improving Retargetability and Instruction Selection

- The Problem:
- The Consequences:

Improving Retargetability and Instruction Selection

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- The Consequences:
  - A compiler developer needs to visualize and specify meaningful combinations of instructions for generating good quality code.
  - The machine descriptions are difficult to construct, understand, maintain, and enhance.
  - GCC has become a hacker's paradise instead of a clean, production quality compiler generation framework.

Improving Retargetability and Instruction Selection

- Our Goals:

- Current Status:

Improving Retargetability and Instruction Selection

- Our Goals:
  - Discover the abstractions required in machine descriptions and develop a systematic methodology of constructing them.

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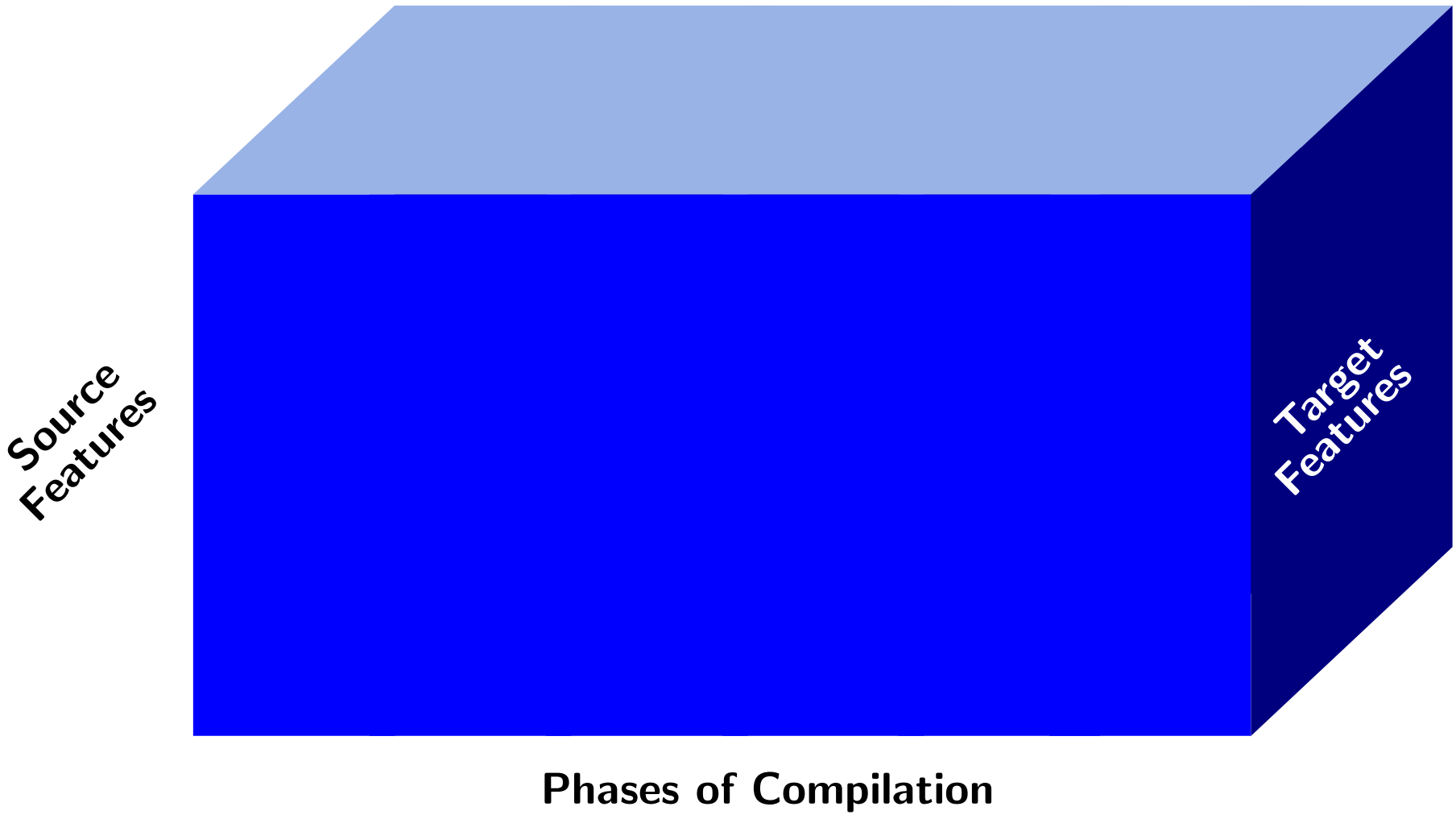
  - Preliminary investigations in using `iburg` seem very promising. (Only 200 rules required for `i386` instead of over a 1000!)

In Search of Modularity in Retargetable Compilation



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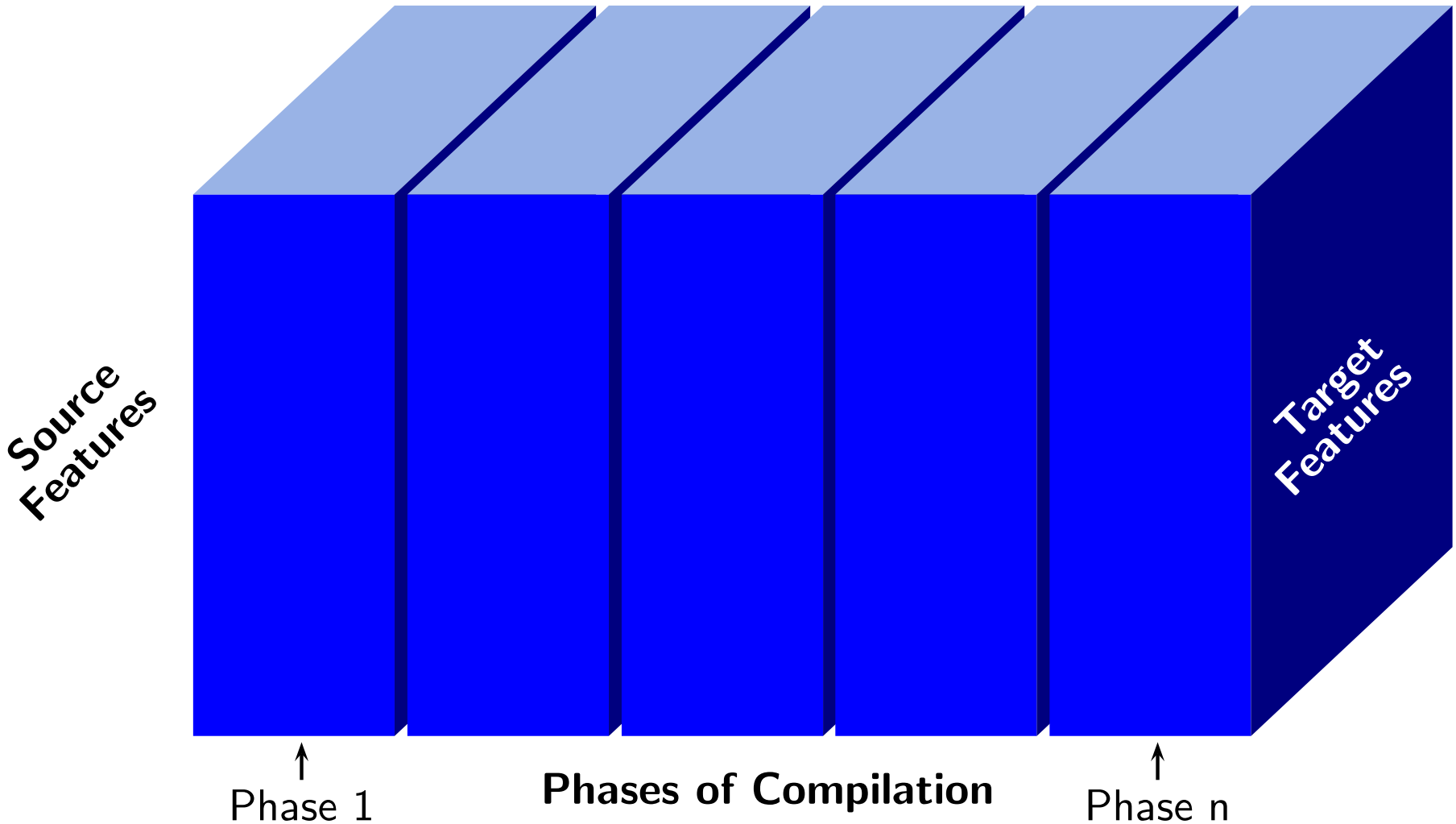

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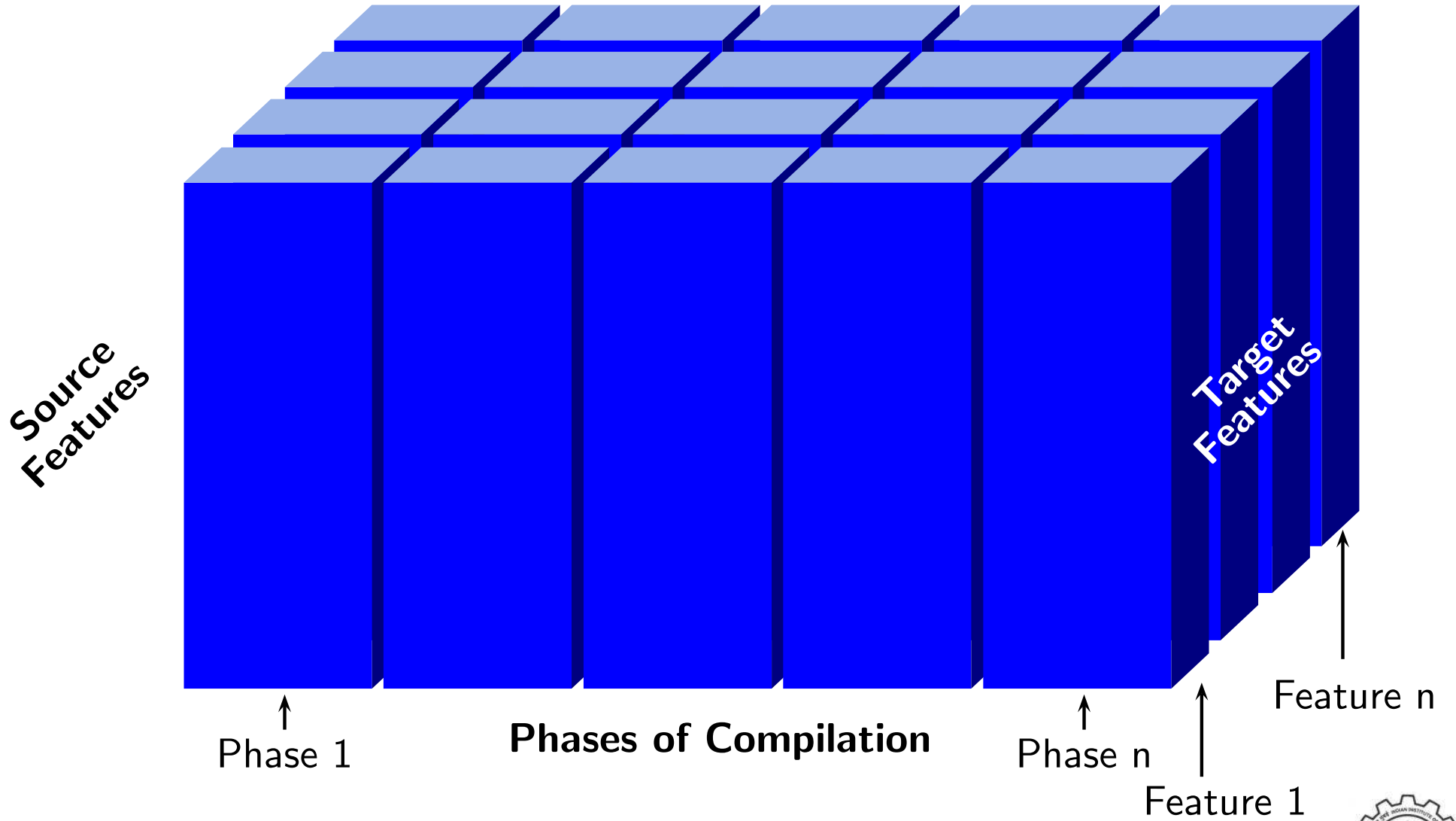

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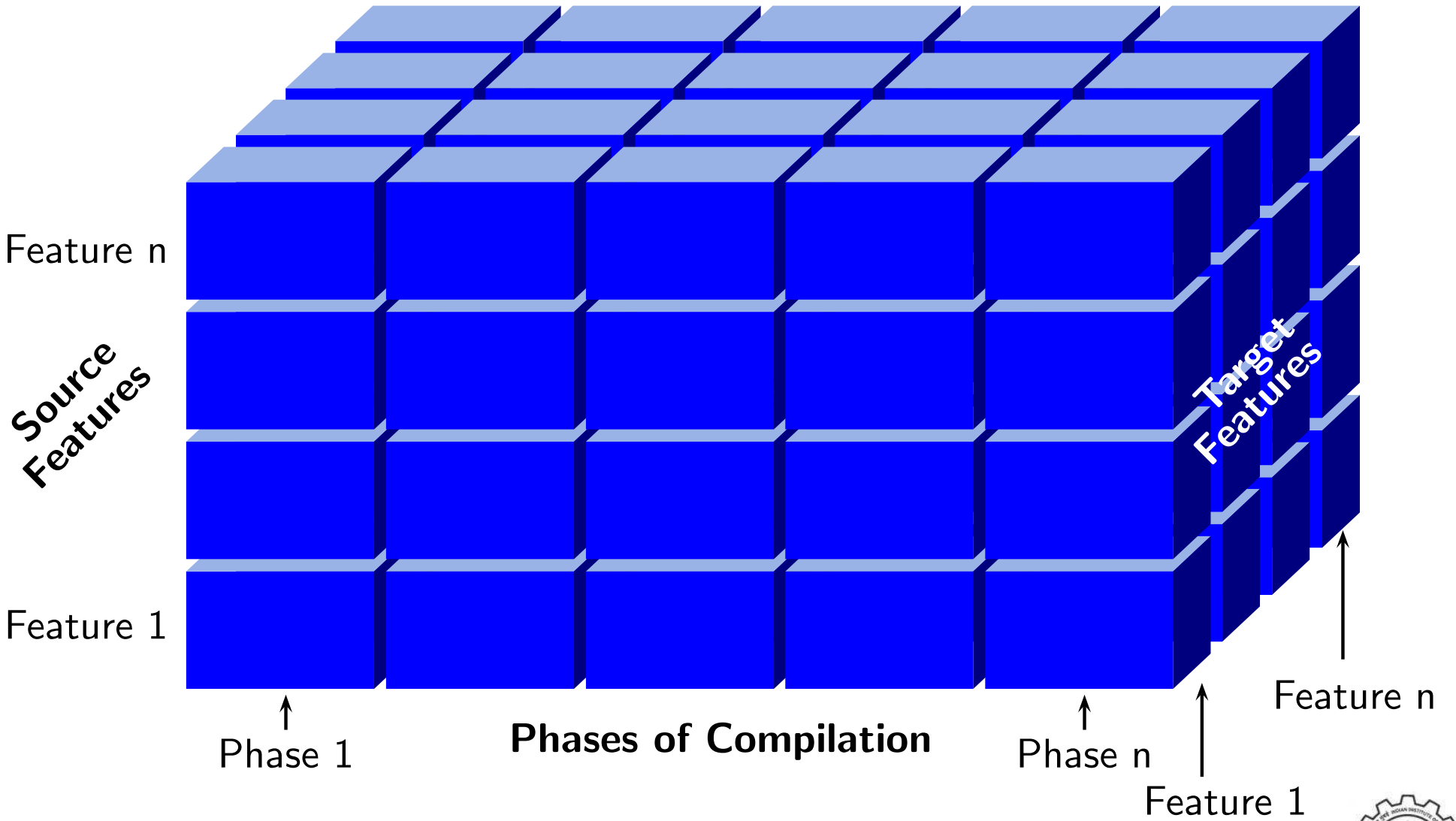

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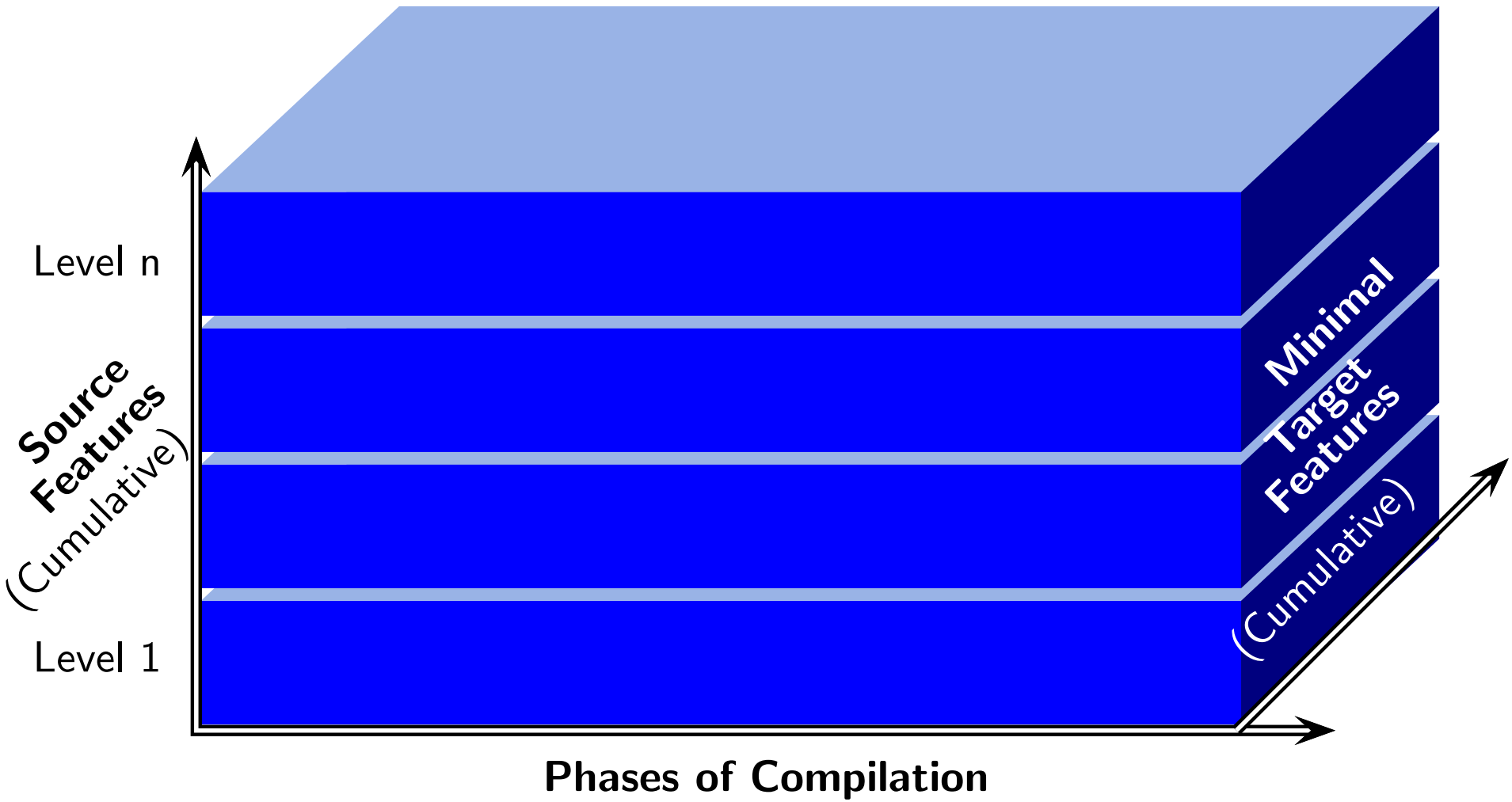
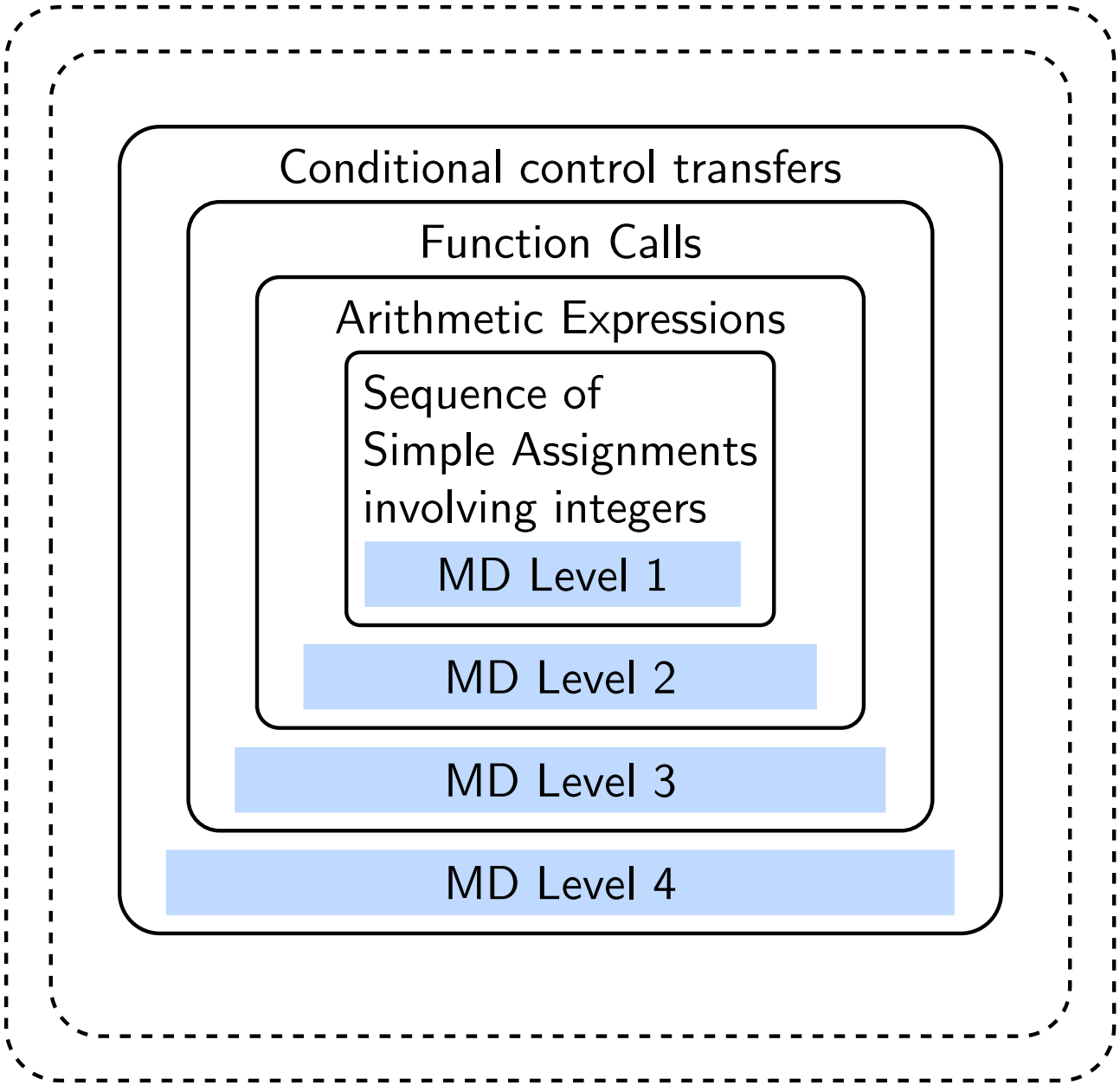


Systematic Development of Machine Descriptions



Improving Machine Independent Optimizations in GCC

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  - The results of proof of concept implementations are very encouraging.

Translation Validation of GCC

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- Our Objectives:
- Our approach:
- Current Status:
- Future work:

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  - Cleaning up the theory to systematize the termination criteria.
  - Extending the approach to include more optimizations.

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- Current Status:
  - Problem definition has to be made more precise.

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  - Variants of linearity have been identified.

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  - Significant imprecision in analysis
  - The scope of optimizations is significantly reduced.
  - Parallelization and Vectorization becomes difficult.
  - Synchronization and correctness problems in threads.
- Our Goals:
  - Use linear types to prohibit aliasing.
  - Allow reasonable limited relaxations of linearity constraints.
  - Define appropriate type system and enforce it.
- Current Status:
  - Linearity aspects in C have been studied in details.
  - Variants of linearity have been identified.
  - An initial draft of the type system is in place.

Part 5

Conclusions

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- Our group on GCC at IIT Bombay
  - Synergy from group activities
  - Long term commitment to challenging research problems
  - A desire to explore real issues in real compilers
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    A dream to improve GCC
- *Would you like to be a part of this dream?*

Last but not the least ...

Thank You!