Control-Based Program Analysis

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Outline

- CBA Overview
- CBA by Example
- Properties of CBA
- Comparison to Related Analyses
- Implementation
- Conclusions

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  - All values looked up relative to point in CFG
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- CFG is the only data structure
  - No abstract environment or store
  - So, variable lookup **only** needs CFG

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A Very Simple Example

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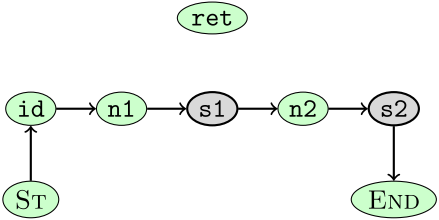
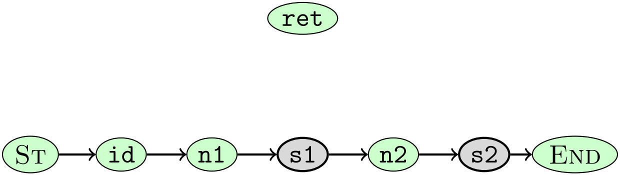
Initial graph:



A Very Simple Example
Graph closure

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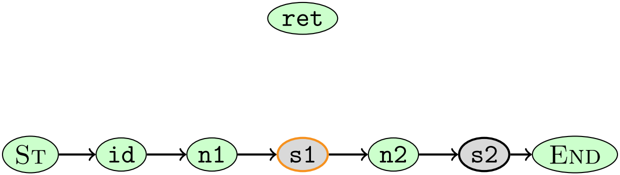
Graph closure for call site `s1`

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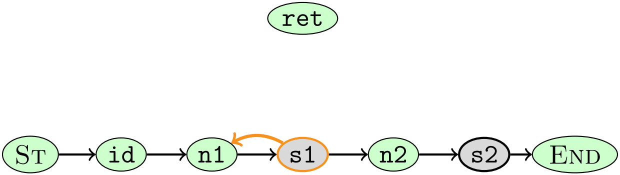


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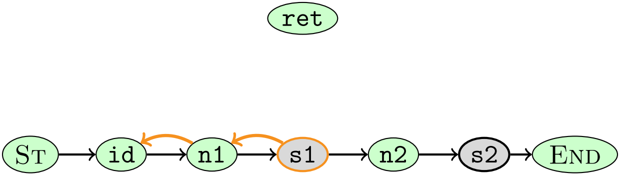


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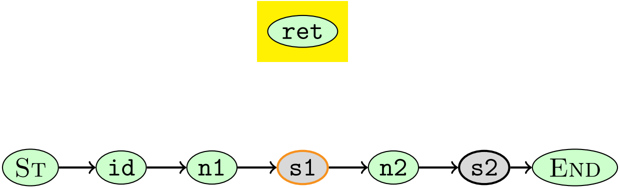


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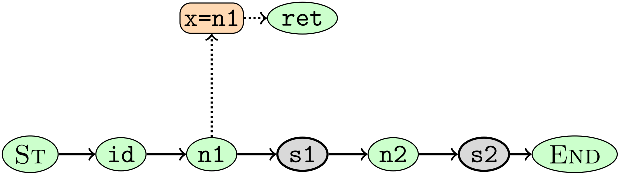
Graph closure for call site `s1`

Bind argument `n1` to parameter `x`

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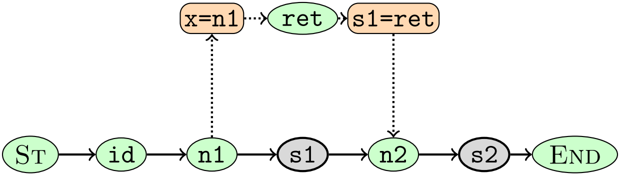
Graph closure for call site `s1`

Assign result `ret` to call site `z1`

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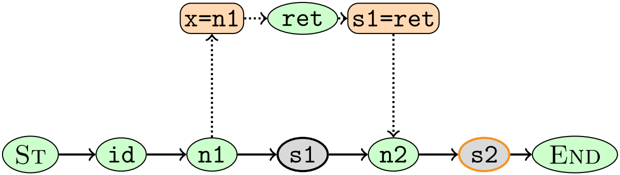
Graph closure for call site s2

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Graph closure for call site `s2`

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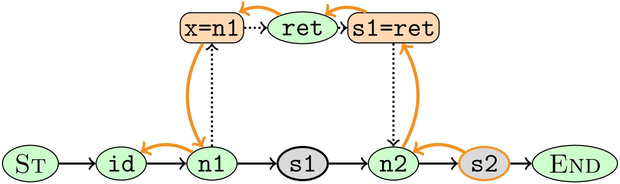


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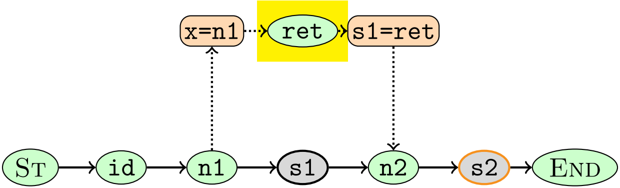


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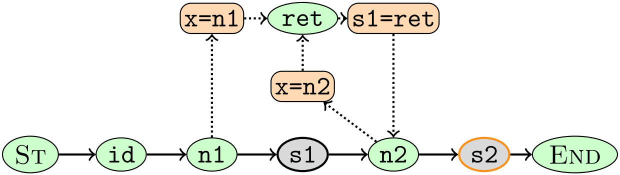


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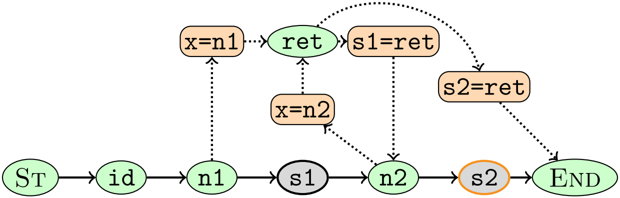


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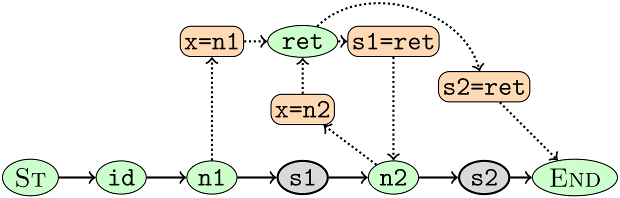
Closure complete!

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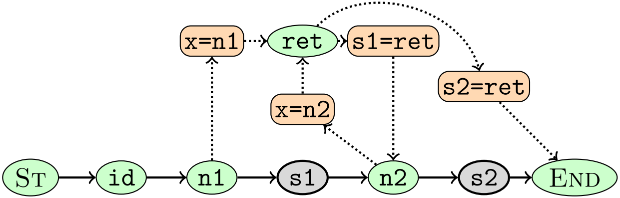
  - Non-local variables

Call Stack Alignment
Goal: polymorphism

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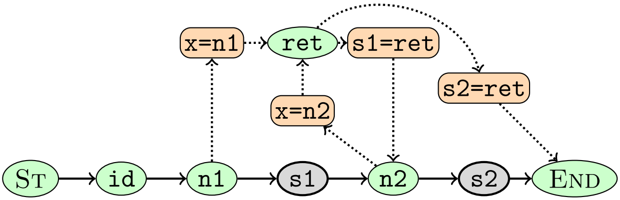


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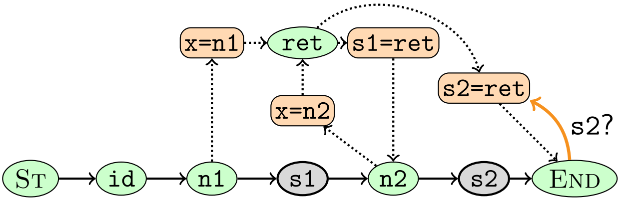


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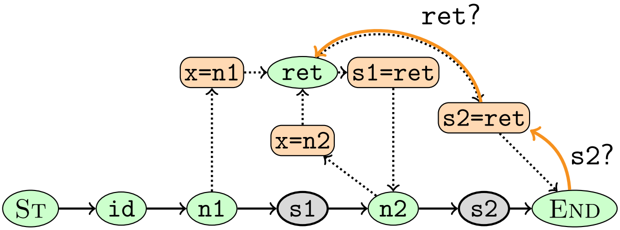


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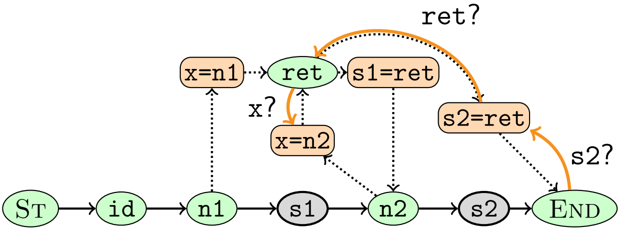


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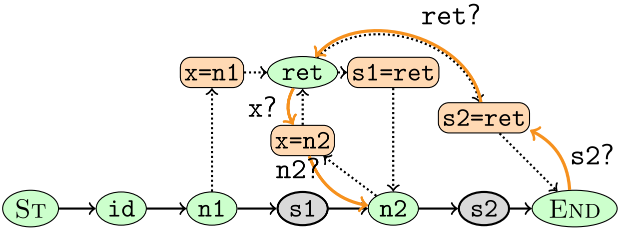


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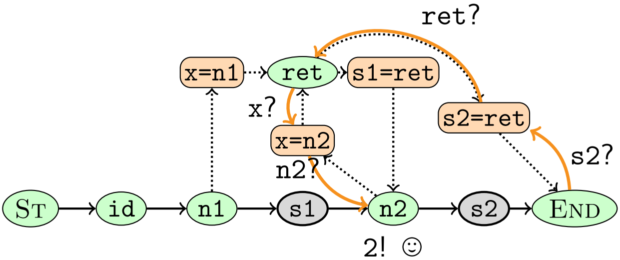


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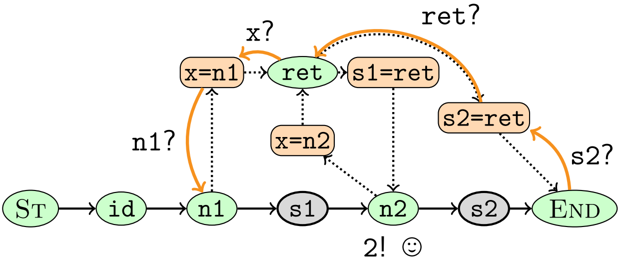


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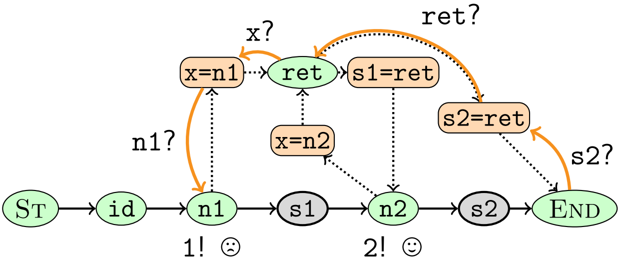


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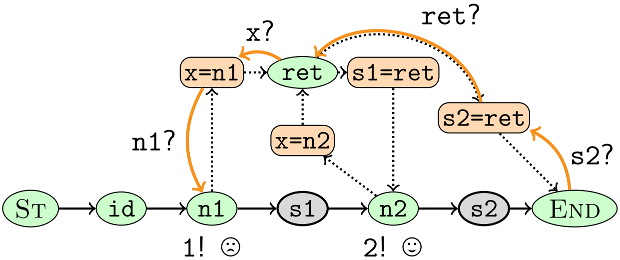


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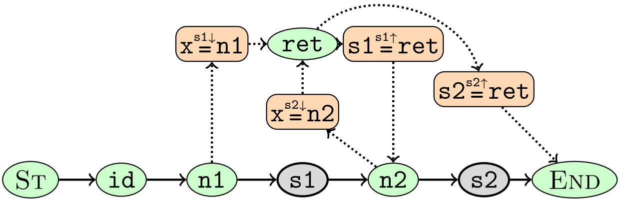
Annotate wiring nodes with call sites

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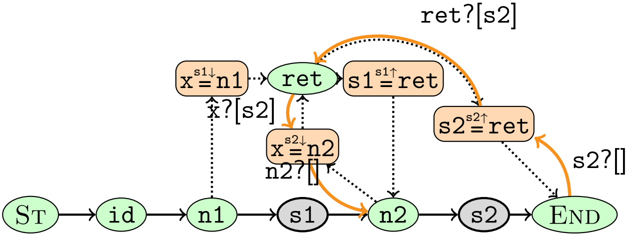


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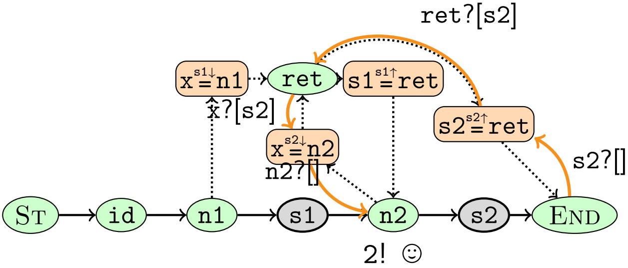


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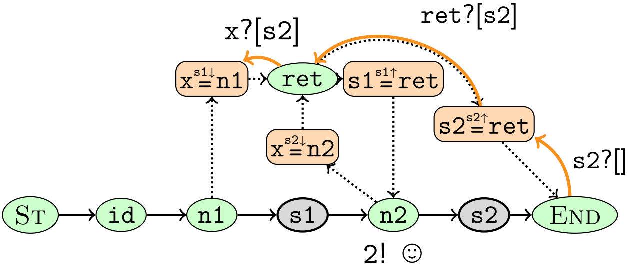


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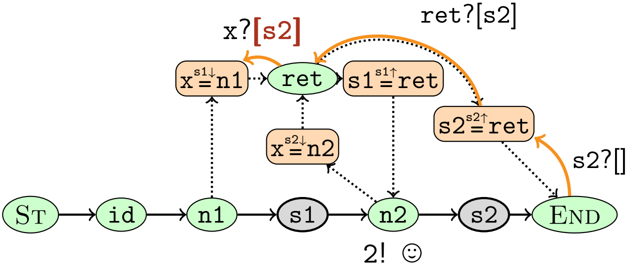


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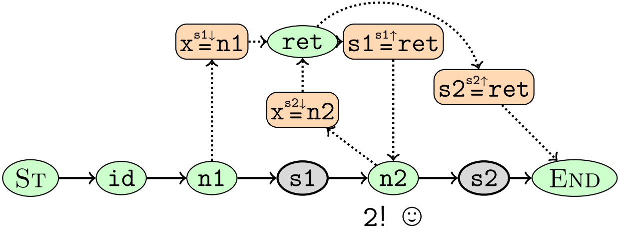
Here, 1 is eliminated

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Call Stack Alignment: Related Work

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  - CFL-reachability analyses: calls and returns modeled as CFL
- CFA2 [VS-ESOP10] and PDCFA [MSV-PLDI10]: align calls and returns via PDA
  - PDA is precisely an abstract interpreter

Handling Non-Local Variables

Non-local example: K-combinator

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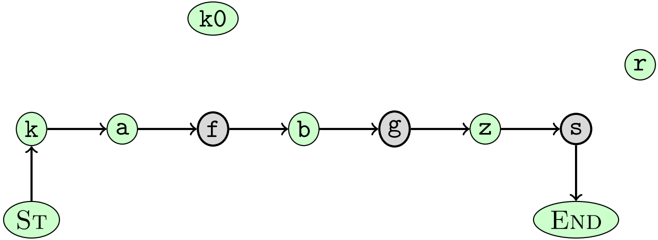


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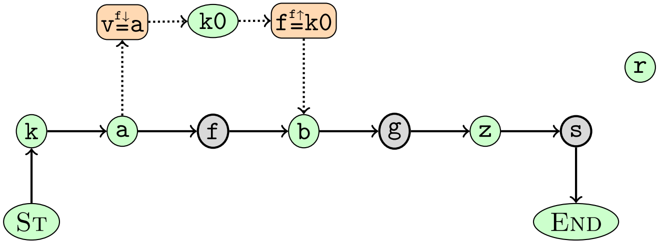


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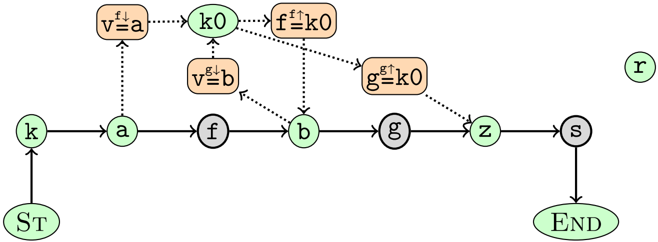


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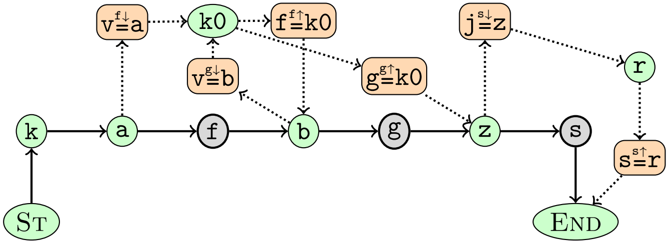


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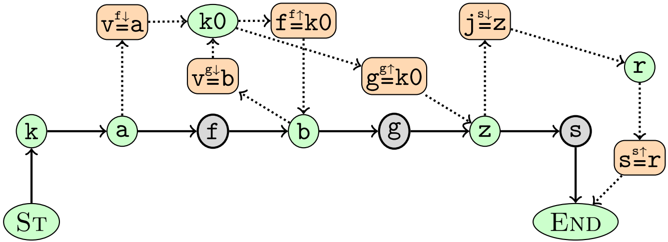


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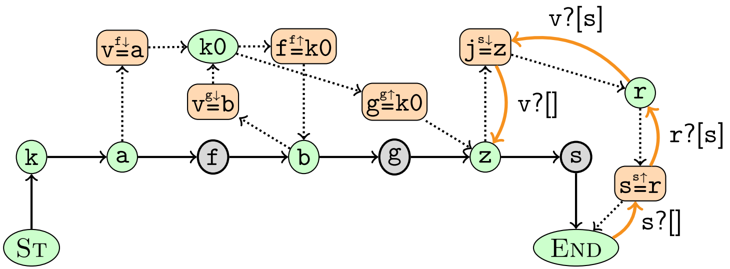


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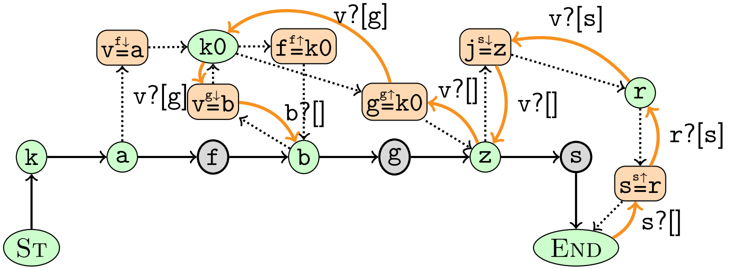


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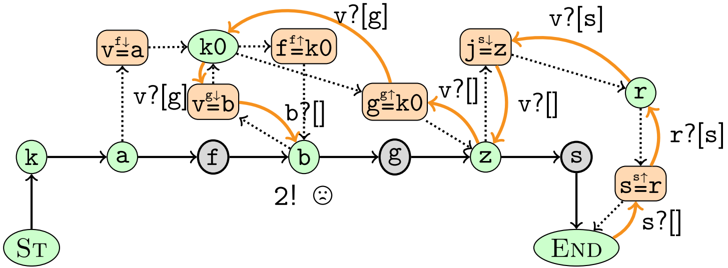


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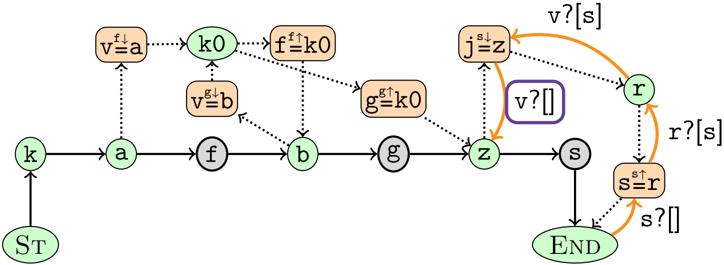


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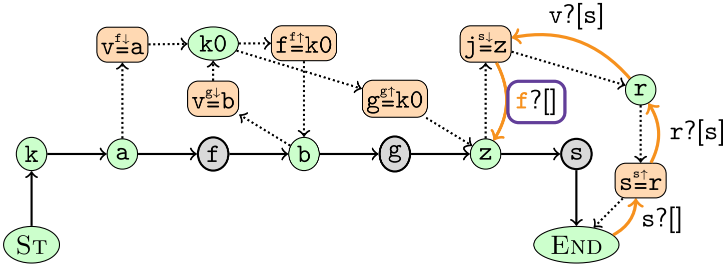


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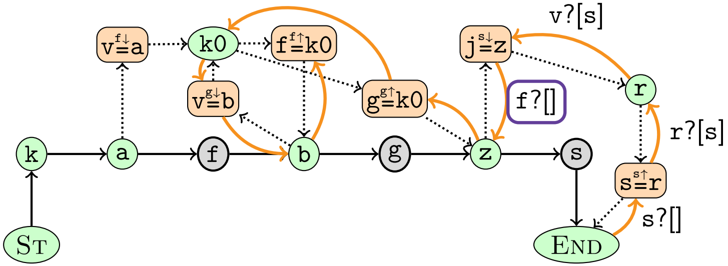


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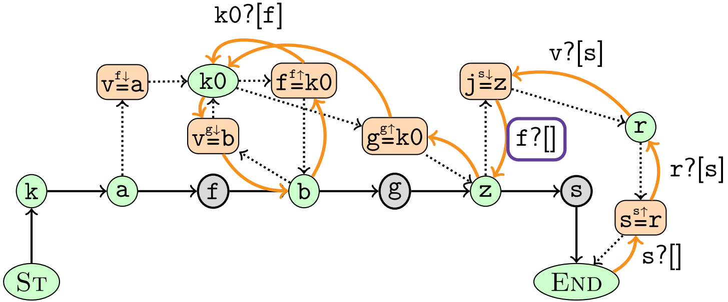


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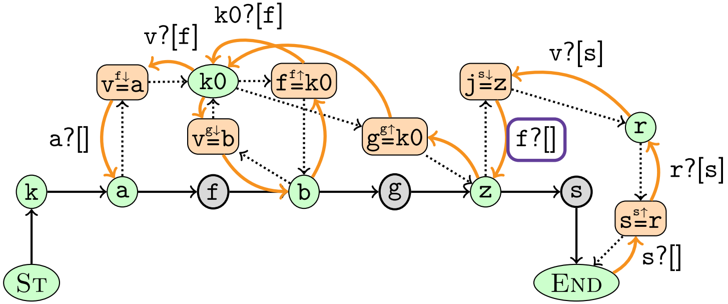


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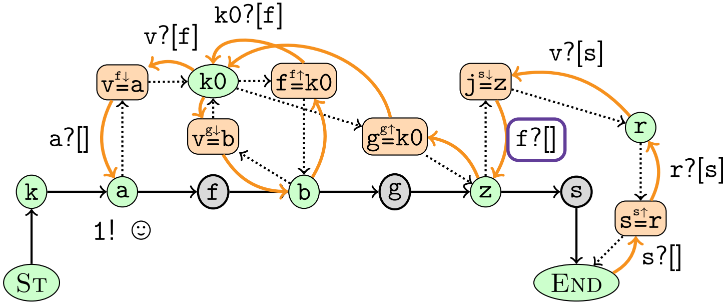


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- **Polyvariance**
  - PDCFA: classic CFA-like graph copying
  - CBA: via call stack alignment and non-local lookup

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  - Path-sensitivity model: possible theorem-proving applications

Questions?

- Code: `https://github.com/JHU-PL-Lab/odefa-proof-of-concept`
- Paper: `http://pl.cs.jhu.edu/projects/big-bang/papers/control-based-program-analysis.pdf`

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