Enabling cross-library optimization and compile-time error checking in the presence of procedural macros

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Library Groups

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Goals

- Cross-library optimizations
- Type checking across library boundaries
- Single binary for multiple libraries
- Unchanged development process

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Library Groups

- Explicitly combine libraries
- Optionally add a top-level program
- A new form: `library-group`

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Example

```
(library (tree)
(export make-tree ---)
(import (rnrs))
(define make-tree ---)
---)
```


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Example

```
(library (tree constants)
  (export quote-tree t0 ---)
  (import (rnrs) (tree))
  (define-syntax quote-tree
    --- (make-tree ---) ---)
  (define t0 (quote-tree))
  ---)
```


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Example

```
(import (rnrs) (tree) (tree constants))
(define tree->list ---)
(tree->list t0)
(tree-value (tree-children t2))
(tree->list (quote-tree 5 (7 9)))
```


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Example

```
(library-group
  (library (tree)
    (export make-tree ---)
    (import (rnrs))
    (define make-tree ---)
    ---)
  (library (tree constants)
    (export quote-tree t0 ---)
    (import (rnrs) (tree))
    (define-syntax quote-tree
      --- (make-tree ---) ---)
    (define t0 (quote-tree))
    ---)
(import (rnrs) (tree) (tree constants))
(define tree->list ---)
(tree->list t0)
(tree-value (tree-children t2))
(tree->list (quote-tree 5 (7 9))))
```


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Example

```
(library-group
  (include “tree.sls”)
  (include “tree/constants.sls”)
  (include “app.sps”))
```


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Library Group Syntax

```
library-group -> (library-group lglib* lgprog)
                 | (library-group lglib*)
lglib         -> library | (include filename)
lgprog        -> program | (include filename)
```


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Challenges

- Achieving proper phasing
- Handling cyclic dependencies
- Enabling cross-library optimization/checking

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Implementation: Libraries

- Visit code, invoke code, metadata
- Import dependencies form a DAG
- Invoke code body uses `letrec*` semantics

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Example

```
(letrec* ([make-tree ---]
          ---)
 (set-top-level! $make-tree make-tree)
 ---)
```


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Example

```
(letrec* ([t0 tree-constant]
          ---)
 (set-top-level! $t0 t0)
 ---)
```


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Example

```
(letrec* ([tree->list ---])
  (tree->list $t0)
  ($tree-value ($tree-children $t2))
  (tree->list tree-constant))
```


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Implementation: Library Groups

- Combine `letrec*` expressions
- Preserve existing library exports
- Invoke libraries needed during expansion

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Library Group 1

```
(lambda (uid)
  (case uid
    [(tree) (letrec* ([make-tree —]
                      ---)
                ---)]
    [(constants) (letrec* ([t0 ---] ---)
                   ---)]
    [else (letrec* ([tree->list ---])
            (tree->list $t0)
            ($tree-value
              (car ($tree-children $t2)))
            (tree->list ---))])))
```


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Library Group 1

- Advantages:
  - Single output binary
    - Matches existing library semantics
- Disadvantages:
  - Hinders cross-library optimizations

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Library Group 2

```
(letrec* ([make-tree ---] ---)
  (set-top-level! $make-tree make-tree)
  ---
  (letrec* ([t0 tree-constant] ---)
    (set-top-level! $t0 t0)
    ---
    (letrec* ([tree->list ---])
      (tree->list $t0)
      ($tree-value
        (car ($tree-children $t2))))
      (tree->list tree-constant)))
```


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Library Group 2

- Advantages:
  - Creates a single invoke code
    - Allows optimizations and checking
- Disadvantage:
  - Causes dependency problems

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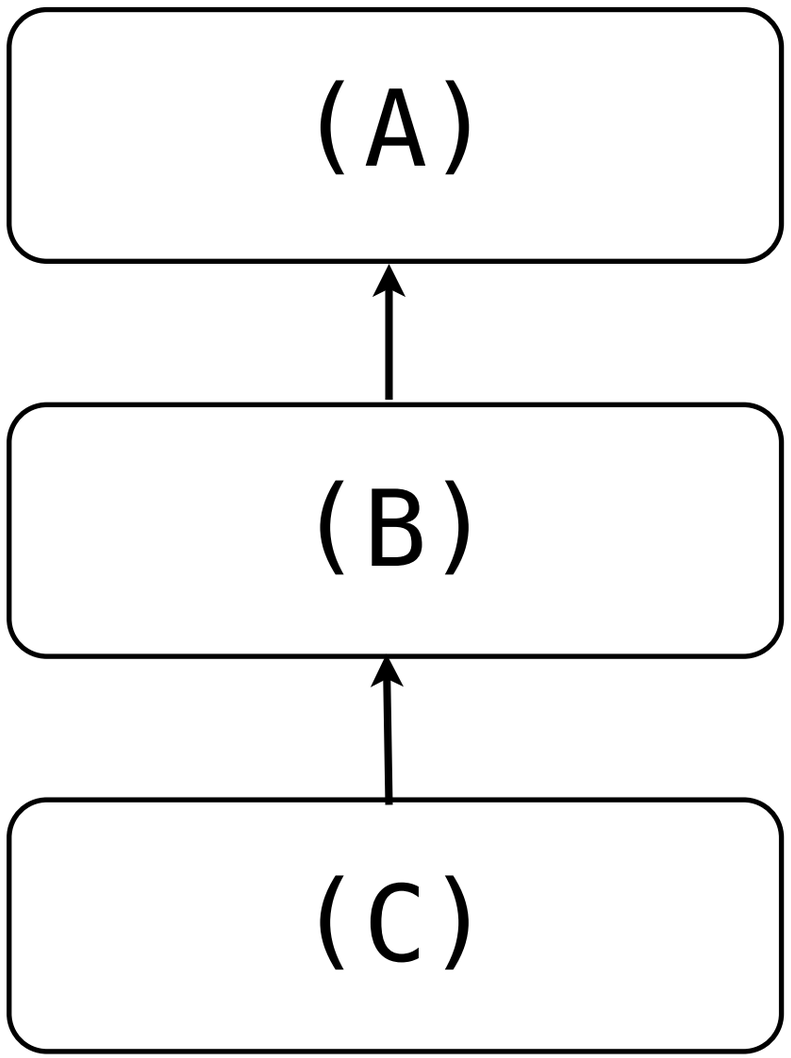
Dependency Problems



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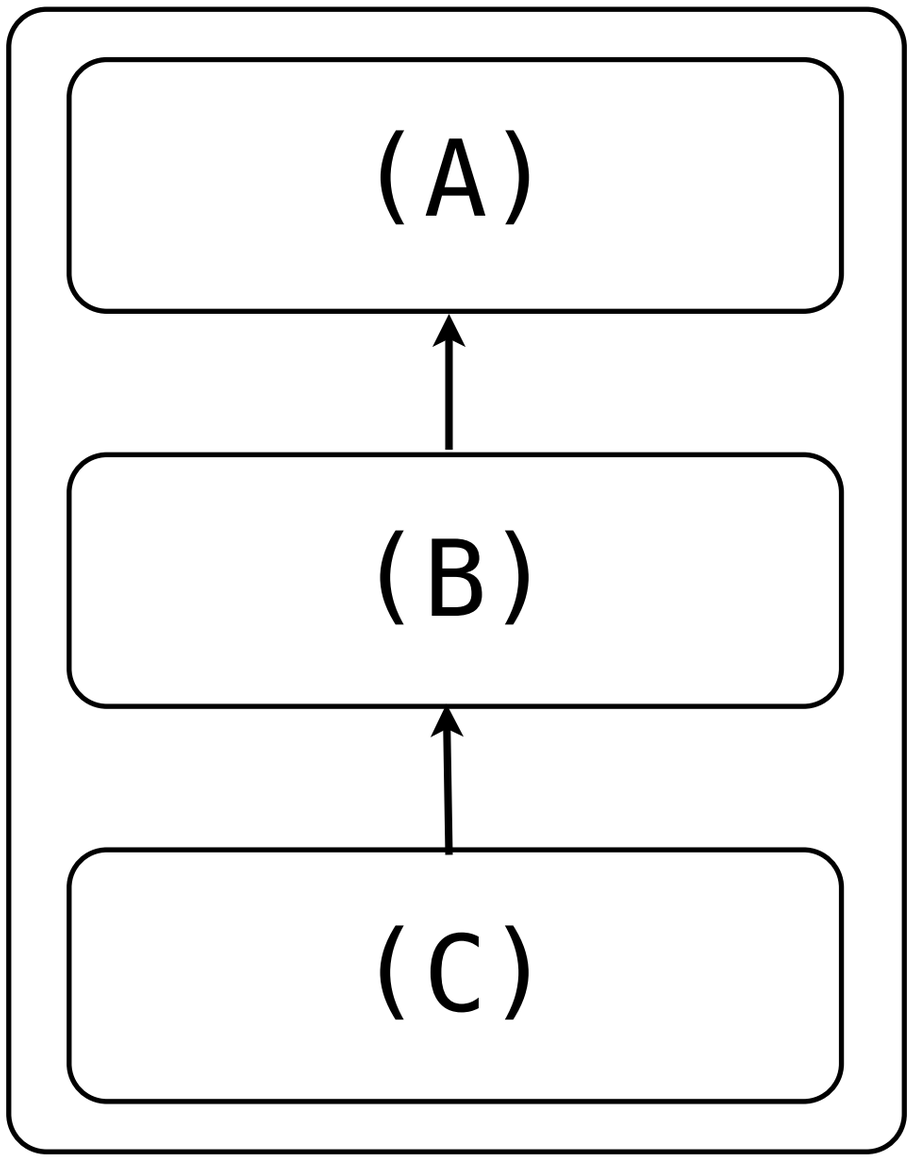
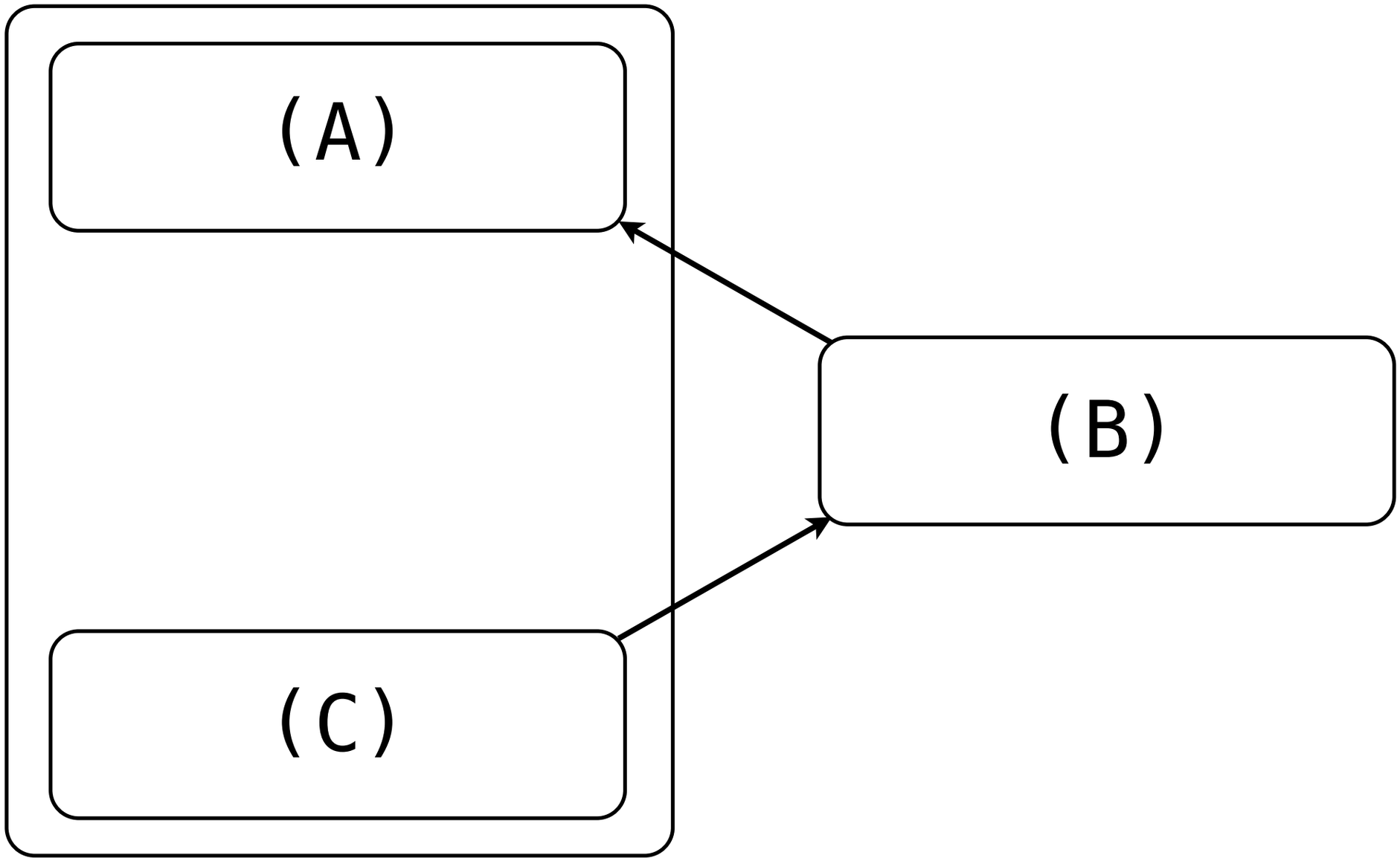
Dependency Problems



21

Dependency Problems



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Library Group 3

```
(lambda (uid)
  (letrec* ([make-tree ---] ---)
    ---
    (mark-invoked! 'tree)
    (let ([nested-lib
           (lambda (uid)
             (letrec* ([t0 ---] ---)
               ---
               (mark-invoked! 'constants)
               (let ([nested-lib program code])
                 (if (eq? uid 'constants)
                     nested-lib
                     (nested-lib uid))))))])
      (if (eq? uid 'tree)
          nested-lib
          (nested-lib uid)))))
```


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Library Group 3

- Advantages:
  - Avoids synthetic cycles
  - Allows optimization and checking
  - Single output binary

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Caveat: Dynamic Dependencies

- Arises from use of `eval` in init expressions
- Library groups allow explicit ordering
- Work arounds
  - Transform into import dependency
  - Move into initialization function

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Fixing Dynamic Dependencies

- Start with `case`-based `library-group`
- Lift "simple" `letrec*` bindings
- Requires `letrec*` style optimization

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Library Phasing

- Retain phasing between libraries in group
- Cannot simply recompile from source
- Relatively straightforward solution

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Summary

- Library groups meet our goals:
  - Cross-library optimization
    - Type checking across library boundaries
    - Single output binary
- Maintains proper phasing order
- Avoids synthetic import dependency cycles

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Thanks

Questions?

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