R Melts Brains: An IR for First-Class Environments and Lazy Effectful Arguments

Doctoral Research Days at FIT 2019

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Study info summary

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Student: Jan Ječmen

Supervisor: Jan Vitek

Year of studies: 3

Dissertation thesis topic: Dynamic deoptimization for the R language

R

R

Ecosystem: Users, CRAN, Bioconductor, books, SO

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Almost no support from the PL community

Optimizing R...

...is hard!

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- Imperative

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- Imperative
- Functional
- Object oriented
- Vectorized
- Lazy – with side effects

Optimizing R...

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...is hard!

- Imperative
- Functional
- Object oriented
- Vectorized
- Lazy – with side effects
- Reflective

Consider:

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```
f <- function() {
    a <- "Hi!"
    g()
    print(a)
}
```

Consider:


```
f <- function() {
    a <- "Hi!"
    g()
    print(a)
}

g <- function() 42
f()
## [1] "Hi!"
```

Consider:


```
f <- function() {
    a <- "Hi!"
    g()
    print(a)
}

g <- function() 42
f()
## [1] "Hi!"

g <- function() {
    e <- parent.frame()
    rm("a", envir = e)
}
f()
## Error in print(a) : object 'a' not found
```

Consider:

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```
f <- function(x) {
    e <<- environment()
    a <- "Hi!"
    x
    print(a)
}
```

Consider:


```
f <- function(x) {
    e <<- environment()
    a <- "Hi!"
    x
    print(a)
}

f(42)
## [1] "Hi!"
```

Consider:


```
f <- function(x) {
    e <<- environment()
    a <- "Hi!"
    x
    print(a)
}

f(42)
## [1] "Hi!"

a <- "Surprise!"
f(rm("a", envir = e))
## [1] "Surprise!"
```

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Research VM

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Research VM

PIR – IR tailored for optimizing R code

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PIR – IR tailored for optimizing R code

Static analysis

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Research VM

PIR – IR tailored for optimizing R code

Static analysis... and speculation

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Research VM

PIR – IR tailored for optimizing R code

Static analysis... and speculation... and deoptimization

PIR

Goal: enable classical compiler optimizations

PIR

Goal: enable classical compiler optimizations
Obstacle: need to resolve variables and scopes

PIR

Model environments explicitly:

```
instr ::=
        |  MkEnv((x = a)* : env)   create environment
        |  LdVar(x, env)           load variable
        |  StVar(x, a, env)        store variable
```

PIR

Model environments explicitly:

```
instr ::=
        |  MkEnv((x = a)* : env)   create environment
        |  LdVar(x, env)           load variable
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```

Scope resolution

1. Find reaching stores
2. Lower loads to PIR variables

PIR

Model promises explicitly:

```
instr ::=
        |  MkArg(id, env)          create promise
        |  Force(a), env           force promise
```

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        |  MkArg(id, env)          create promise
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Promise inlining

1. Find dominating *Force* instruction
2. Inline the promise code

Publications

1. Olivier Flückiger, Guido Chari, Jan Ječmen, Ming-Ho Yee, Jakob Hain, Jan Vitek: *R Melts Brains: An IR for First-class Environments and Lazy Effectful Arguments*, proceedings of the 15th ACM SIGPLAN International Symposium on Dynamic Languages, pp. 55–66, 2019. ISBN 978-1-4503-6996-1.

Thank you!

github.com/reactorlabs/rir

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