# Running R Faster

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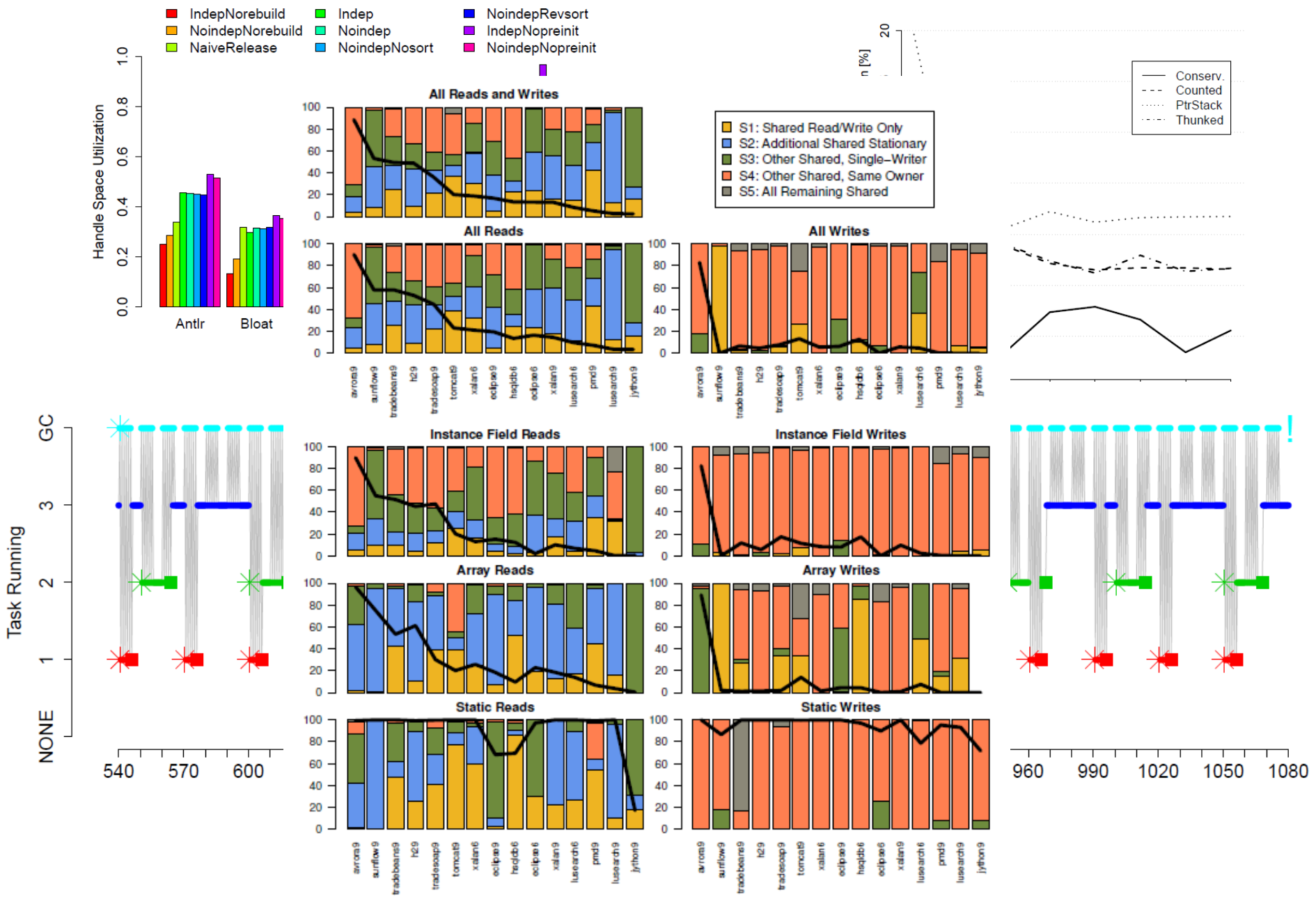
# My background: computer scientist, R user.



# My FastR experience: Implementing a new R VM in Java.

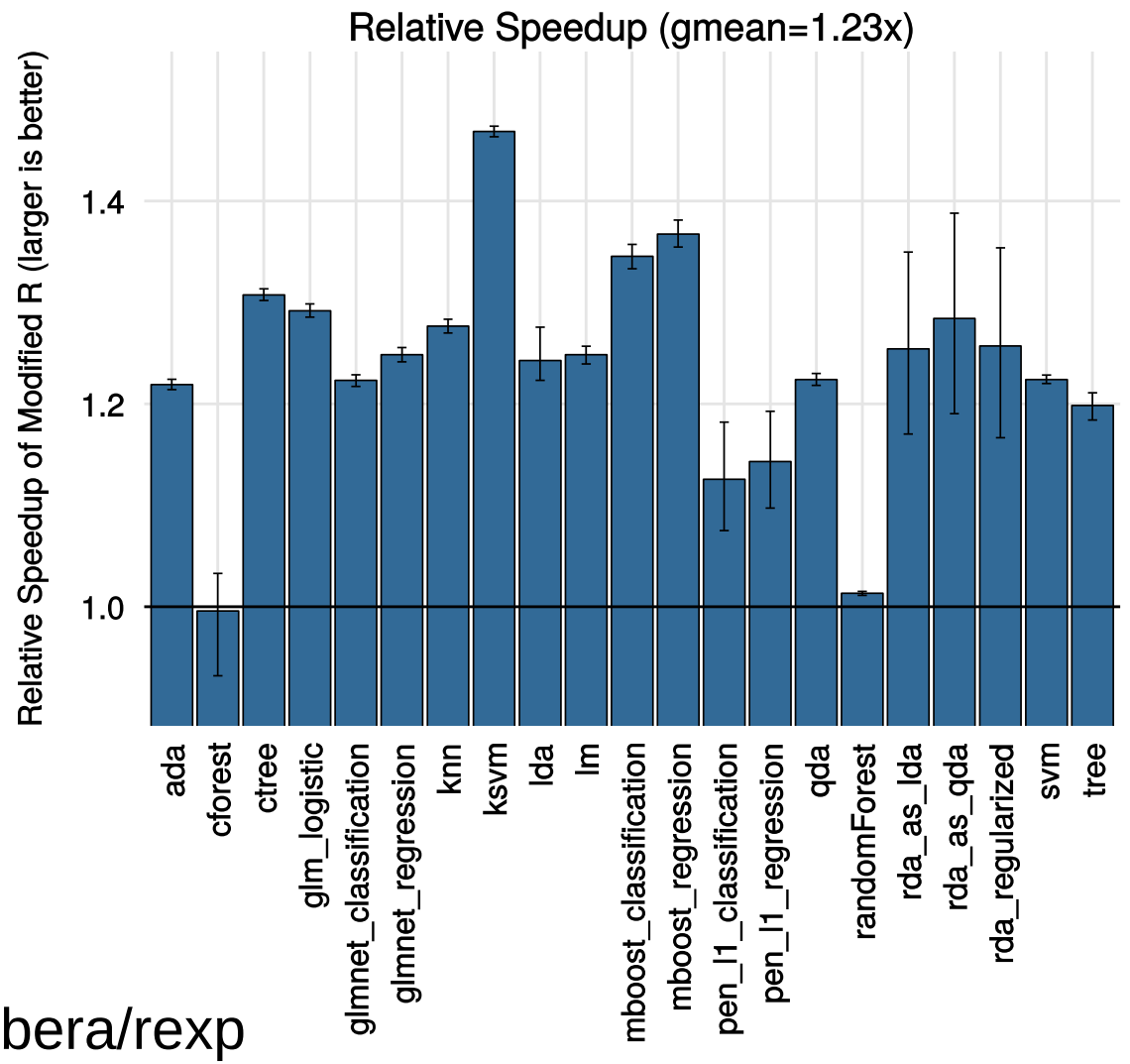
- New algorithms, optimizations help
  - Frame representation, variable lookup
  - Function calls and argument matching
  - Specialized data types
  - Code specialization
  - Lazy arithmetics with profiling views
- Implementing a new R VM is hard
  - Specification
  - Tightly coupled packages and the VM

VEE'14: A fast abstract syntax tree interpreter for R

# My current work: speeding-up GNU-R.

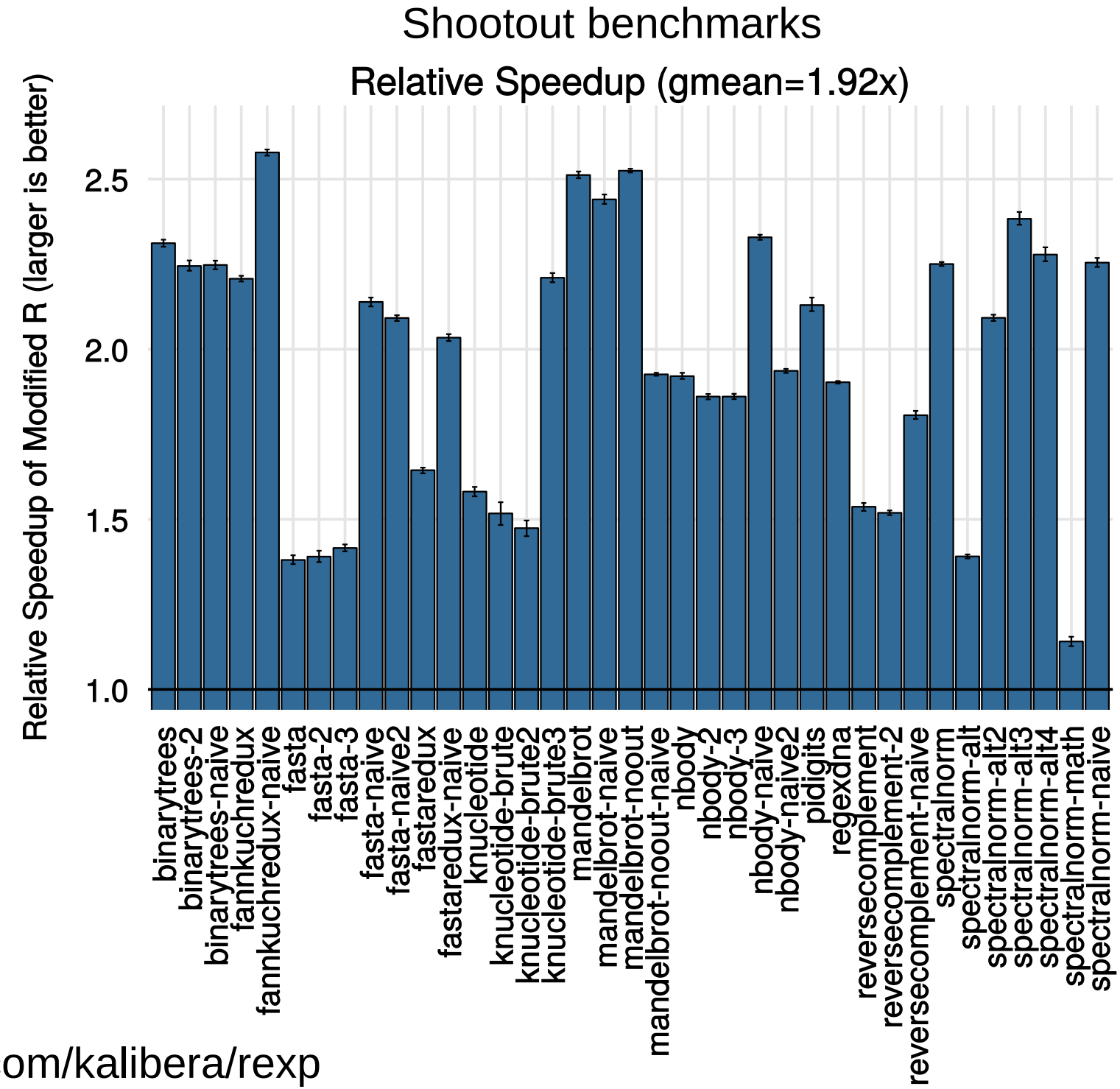
With Luke Tierney, Jan Vitek

ML benchmarks from TU Dortmund




github.com/kalibera/rexp

Based on R-dev 65969 (June 18), check-all passes.

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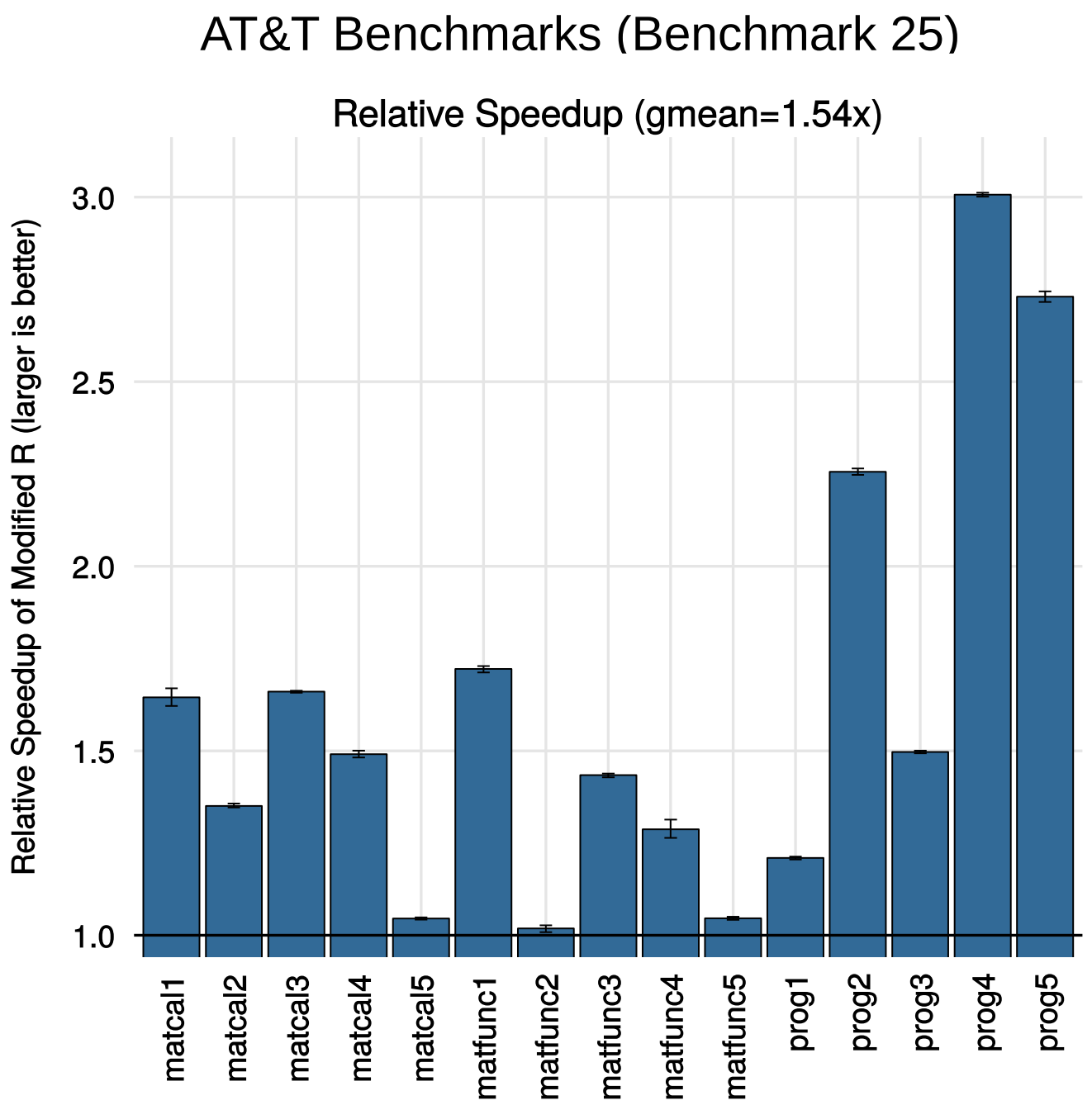


github.com/kalibera/rexp

# Compiler bytecode-optimizations.

- Inlining constants into bytecode
- Inlining labels into bytecode

```
function(x) {
    for(i in 1:10) { x <- x + 1 }
    x
}
```

```
    LDCONST.OP, 1L,
    STARTFOR.OP, 3L, 2L, 16L,
 7: GETVAR.OP, 4L,
    LDCONST.OP, 5L,
    ADD.OP, 6L,
    SETVAR.OP, 4L,
    POP.OP,
16: STEPFOR.OP, 7L,
    ENDFOR.OP,
    POP.OP,
    GETVAR.OP, 4L,
    RETURN.OP
```

```
1: 1:10,
2: i,
3: for (i in 1:10) { x <- x + 1 },
4: x,
5: 1,
6: x + 1
```

# Compiler optimizations – variable access.

- Special instruction for creating a promise that just reads a variable
  - Faster variable access for builtins (uses cache)
- Constant-pool re-ordering
  - Variable are first, which reduces memory overhead of the binding cache and improves locality

```
Frames in R are implemented using linked lists.
A binding cache stores, for each constant in the constant pool,
a reference to the corresponding element of the linked list.
```

# Stack-allocation of call arguments. (primarily in the compiler)

- Call arguments passed as linked-list
- Special stack-based memory region
  - Growable, shrinkable stack for fixed-size call argument cells
  - Special treatment by the GC
- Support for long-jumps via contexts
- Better locality, faster reclamation

```
In R, the list of function arguments (promises) passed to a function are kept
around for the duration of the function call, because they'll become needed
in the case of object dispatch.
```

# Explicit argument passing (no linked lists).

- For (many) builtins and internals
- For closures called positionally
  - Lists are only created lazily if needed

```
get(x, envir, mode, inherits)
```

```
SEXP attribute_hidden do_get(SEXP call, SEXP op, SEXP args, SEXP rho)

    if (!isValidStringF(CAR(args)))
    if (TYPEOF(CADR(args)) == REALSXP)
    if (isString(CADDR(args)))
    ginherits = asLogical(CADDDR(args));
```

```
do_earg_get(SEXP call, SEXP op,
     SEXP arg_x, SEXP arg_envir, SEXP arg_mode, SEXP arg_inherits, SEXP rho)
```

# Inlining wrappers to foreign calls.

```
rnorm <- function (n, mean = 0, sd = 1)
             .External(C_rnorm, n, mean, sd)
```

- Inlining avoids overhead of promise creation, argument matching, environment creation
- Explicit passing of arguments to .Call foreign calls (avoiding linked list)
- Updating external pointer at load time

C_rnorm in the example is a variable in the `stats` namespace, which is automatically created when `stats` package is loaded and it points to a registered native symbol (R object). This object contains an external pointer (R structure), which contains a physical pointer to the `rnorm` routine implemented in the C code of the `stats` package.

# Object dispatch (S3/S4) optimizations.

```
method.class
method#class1#class2#class3
```

- Faster signature creation
  - Avoid name allocation
  - Re-use hashcode of first term “method”
  - Comparison using == (instead of strcmp)
- Fast-path optimizations

```
During method dispatch, one needs an R symbol for a signature (S3 or S4).
A symbol has to be looked up in a hash table, based on its string name.
Strings in R are however also interned (STRSXPs), and remember their
hashes.
```

# Summary

- GNU-R performance for real applications can be improved without changing current semantics
  - Avoiding linked lists for function arguments
  - Optimizing dispatch of stats functions, S3/S4 dispatch
  - Optimizing string operations
  - Smaller clean-ups (symbol, charsxp shortcuts, etc)
- I'm working with Luke Tierney on merging some of these improvements