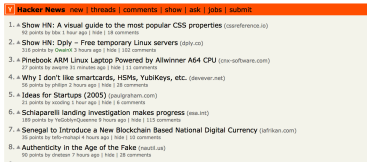
# The Racket Virtual Machine

as an application of CS 4400

# Some Racket Applications




Hacker News

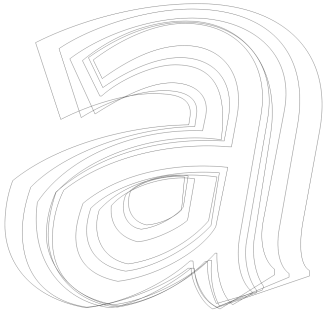
Arc

Racket


Game Content

DC

Racket



*Practical Typography*

Pollen

Racket

Telescope Controller

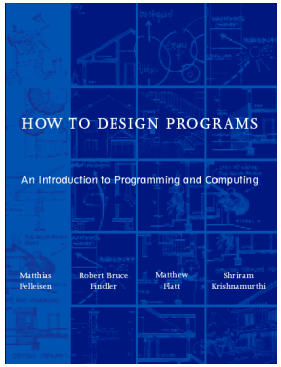
DrRacket

Racket

Synthesized Program

Rosette

Racket

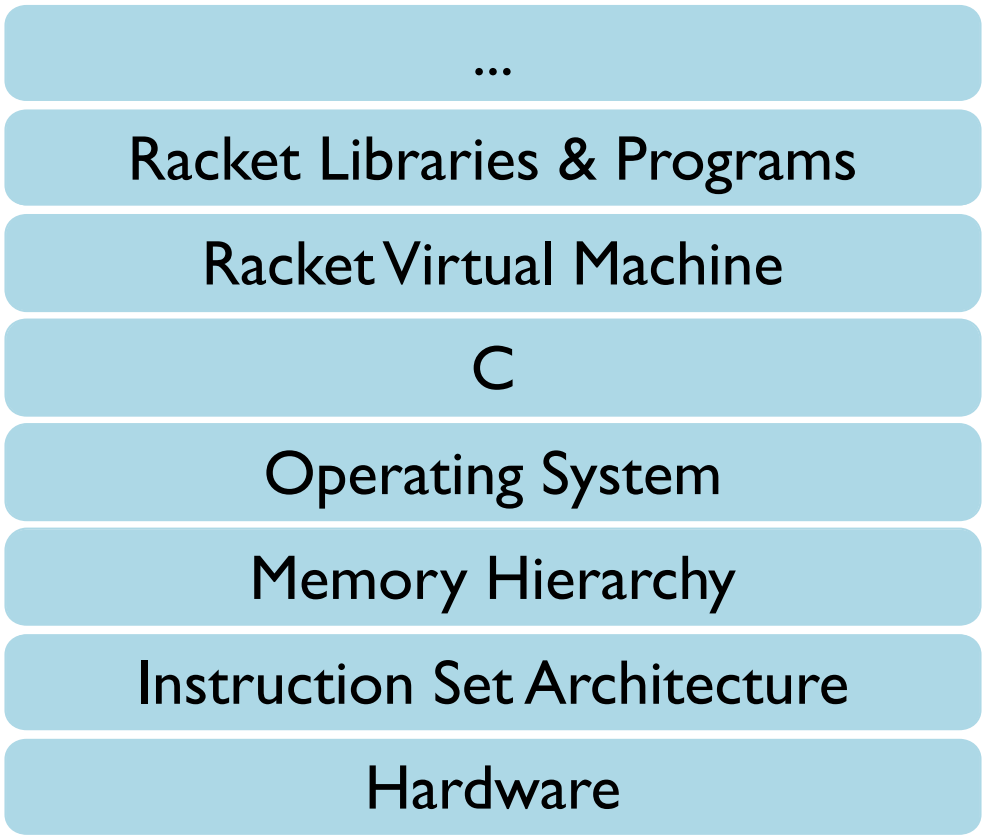



Homework

Beginner Student

Racket

# Virtual Machines



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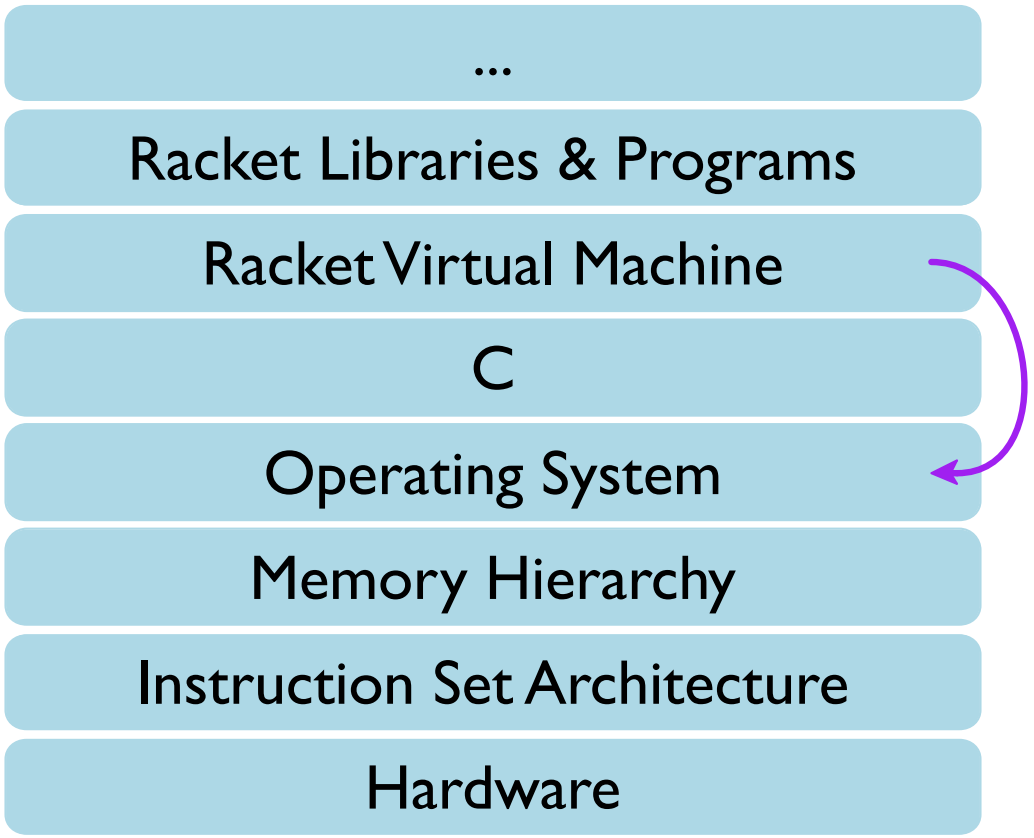

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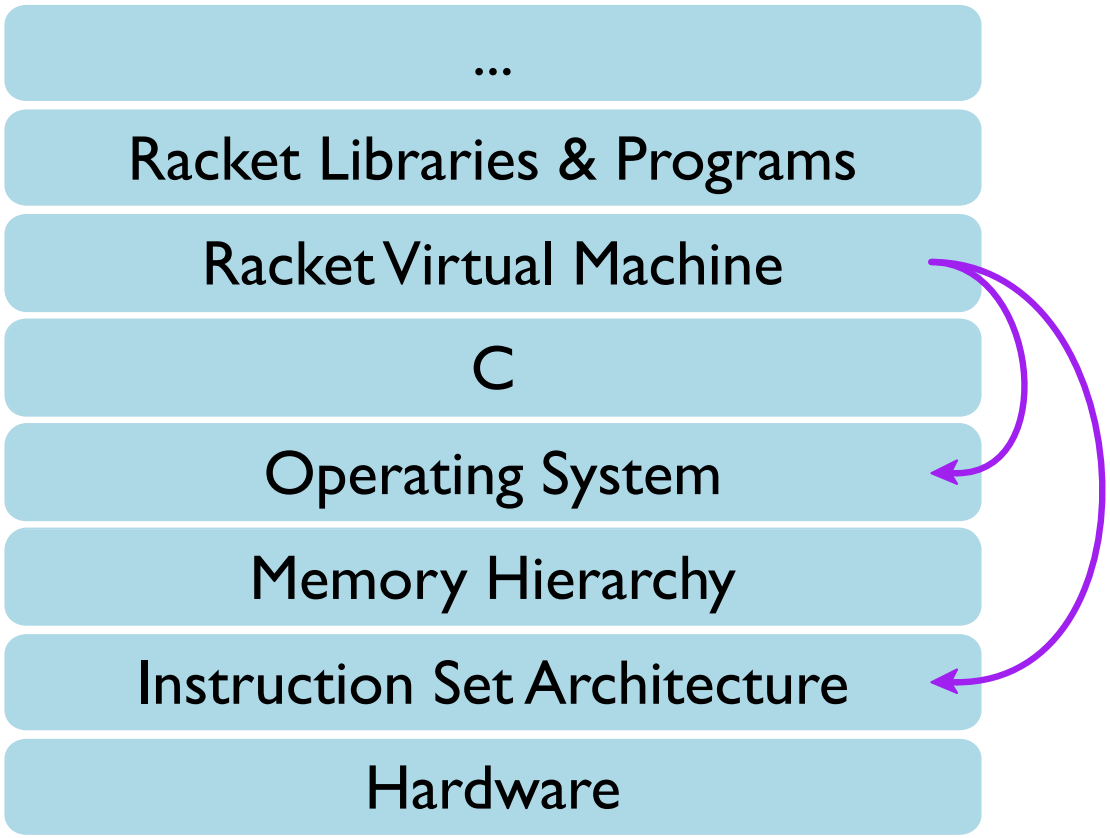

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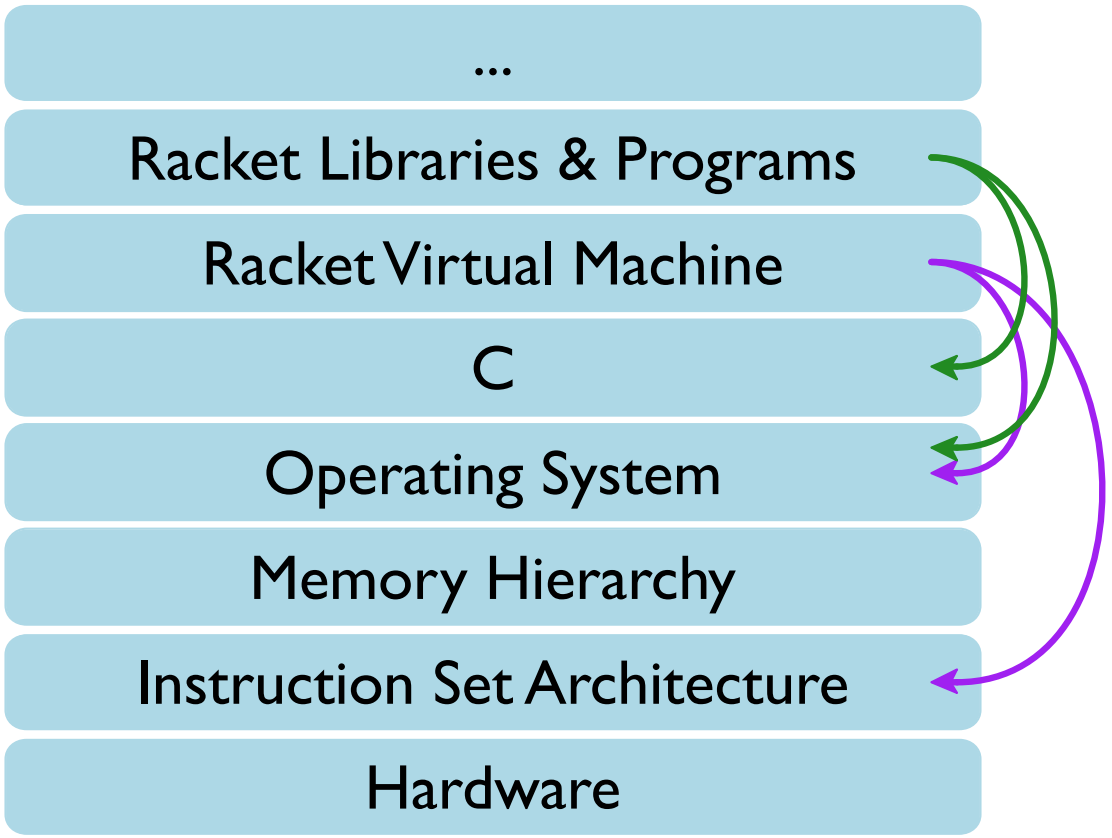
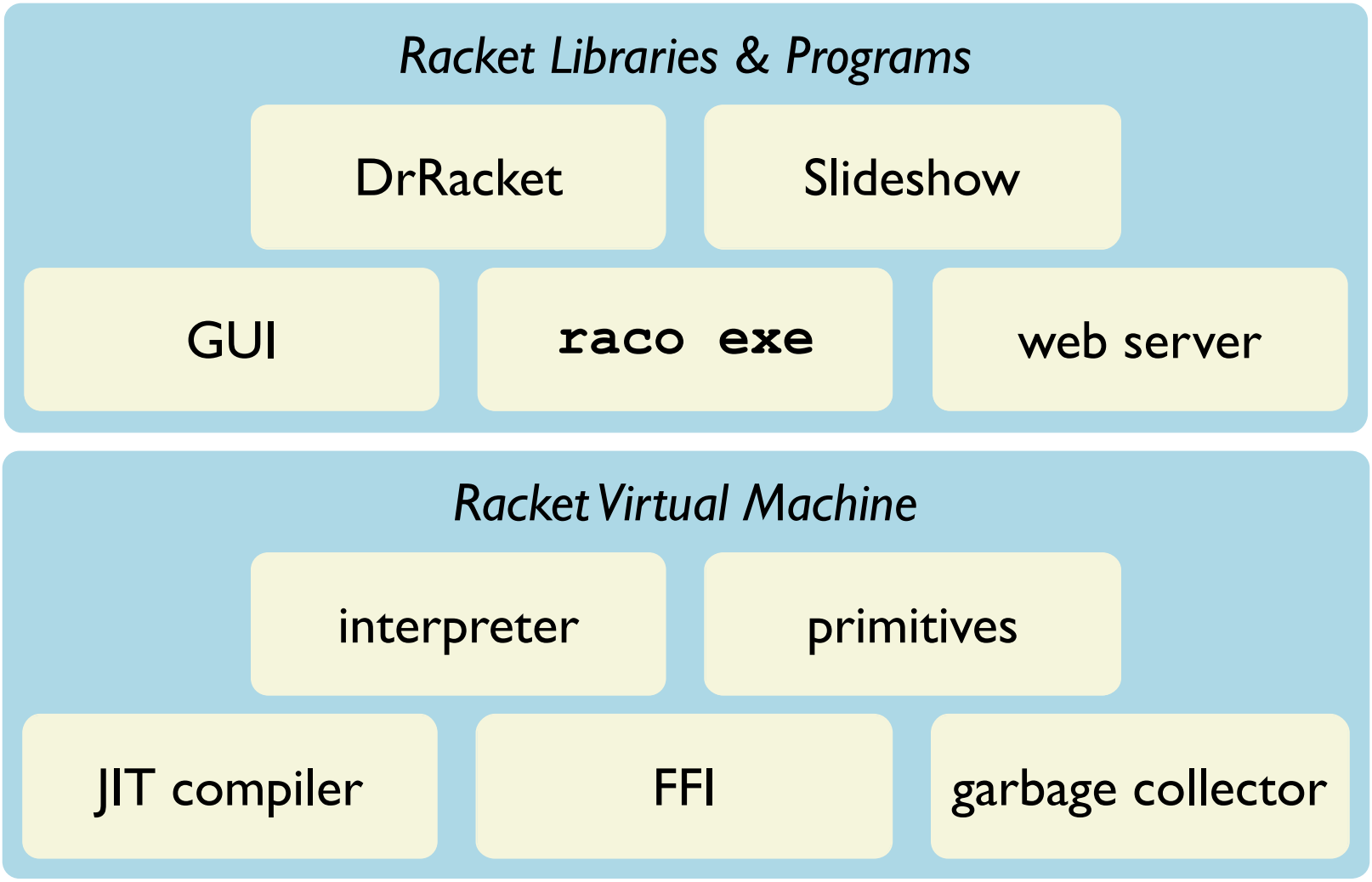


# Racket Virtual Machine



# C

The Racket runtime system is implemented in C

`src/racket`

# Representing Numbers

- Representing fixnums: **`SCHEME_INTP`** and **`SCHEME_TYPE`** — `scheme.h`
- **`ADD`** for fixnums — `numarith.c`
- **`SCHEME_RATIONAL_FROM_FLOAT`** for `inexact->exact` — `ratfloat.inc`

# x86-64 Machine Model

Just-in-Time (JIT) compiler:

- **`ARITH_ADD`** `jitarith.c`

# Representing Control Flow

Just-in-Time (JIT) compiler:

- `"unbox"` implementation — `jitinline.c`
- `list_ref_code` implementation — `jitcommon.c`

See also `github.com/mflatt/jit-demo`

# Representing Procedures

- `unsafe/ffi`

```
(define atoi
  (get-ffi-obj "atoi"
               #f
               (fun string -> int)))
```

- backtrace

- continuations

# Arrays

- **`array-ref`** **`ffi/unsafe.rkt`**

# Structures

- **`Scheme_Object`** — `scheme.h`
- **`Scheme_Bignum`** — `schpriv.h`
- **`Scheme_Small_Bignum`** — `schpriv.h`

- **`Scheme_IR_Local`** — `schpriv.h`

# Optimization

- **`scheme_application_type`** case in **`scheme_do_eval`** — **`eval.c`**
- **`XFORM_ASSERT_NO_CONVERSION`** and **`fd_write_string`** vs. **`fd_write_string_slow`** — **`port.c`**

# More on Optimization

- Branch-prediction interaction in **`scheme_generate_non_tail_call`** `jitcall.c`

# Memory Hierarchy, Locality, Caches

- **`repair_heap`**'s fused loops for the **`SIZE_CLASS_SMALL_PAGE`** case

`newgc.c`

# Linking

The **`unsafe/ffi`** functions work by dynamically loading shared libraries

- **`ffi-lib`** uses **`dlopen`**
- **`get-ffi-obj`** uses **`dlsym`**

**`foreign.c`**

# ELF and Relocation

**`raco exe`** creates an executable by

- copying a stub binary that links to the Racket runtime system
- adding a new ELF section to hold bytecode for the Racket source

`collects/compiler/private/elf.rkt`

# Processes

Racket runs **`/bin/uname`** to get the result of

```
(system-type 'machine)
```

**`string.c`**

# More on Processes

The **`subprocess`** execs an arbitrary program

Implementation uses **`fork`** and **`execve`**, and **`waitpid`**

**`port.c`**

**`place.c`**

# File Descriptors

Racket's I/O uses file descriptors directly

- **`fd_get_string_slow`** `port.c`

# Signals

- **`SIGINT`** handler in **`main`** `main.c`
- **`SIGCHLD`** handler related to `subprocess` `port.c`

# Virtual Memory

Garbage collector allocates pages using **`mmap`**

Write permission is disabled to implement a ***write barrier*** for generational collection

Handler calls **`designate_modified_gc`**

**`newgc.c`**

# Dynamic Memory Allocation

- **`allocate`**

`newgc.c`

# More on Memory Allocation

- **`do_malloc`** uses a free list **`sgc.c`**
- Segmented allocation **`sgc.c`**

# Garbage Collection

- Bootstrap with conservative collector `sgc.c`
- Convert C code to cooperate with precise GC
- Production GC is fairly complex `newgc.c`

See also `github.com/mflatt/jit-demo`

# Network Programming

- DNS `net/dns.rkt`

# More Network Programming

- Web server
- **`raco pkg`**
- Git checkout **`net/git-checkout.rkt`**

# Concurrency

- File and network reads are multiplexed internally
- **`MZ_GETADDRINFO`**, which calls **`getaddrinfo`** in a thread

`network.c`

# Synchronization

- Mutex at Racket-thread level protects hash tables (e.g., **`hash_table_count`**) `list.c`

- GC keeps a list of threads for cooperation on macOS

`gc2/vm_osx.c`

# ...And More

What topics crucial to Racket *weren't* covered in CS 4400?

- Programming and data structures
- Interpreters and compilers
- Databases
- GUIs and graphics
- Rules and strategies for portability