# Fitting Rust YJIT into CRuby

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# Fitting Rust YJIT into CRuby

- Background
- Integration challenges
- Speaking C
- Linking

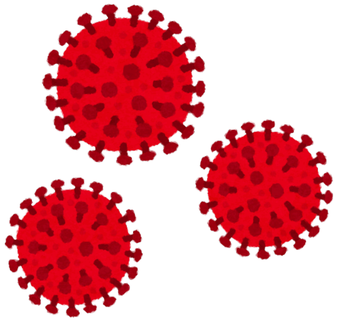
YJIT? ワイJIT? Why JIT?

the new environment

language learning

integration

2020

μJIT

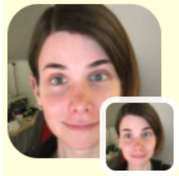
2021

YJIT

**Proposal to merge YJIT**

Added by maximecb (Maxime

2022



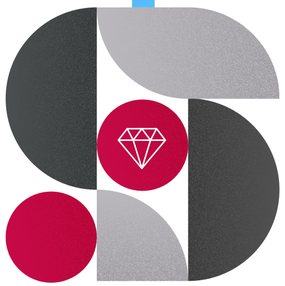
**Porting YJIT to Rust**

Added by maximecb (Maxime Chevalier-Boisvert)

Larger team

Faster and leaner

AArch64 support



# Why Rust?

- We had a lot of learning to do regardless of language choice
- Rust had/has attractive learning resources
- Borrow checker could be used to detect issues in generated code
- Contemporary conveniences
- Awesome tooling out of the box

Typical Ruby users

don't care about Rust

# Façade of magic ✨

- Flip a switch, and the program runs quicker!
- There's stuff happening inside, but I'm too busy to look
- I don't want to make *any* changes to my code/workflow
- A build of Ruby with YJIT as the side, please

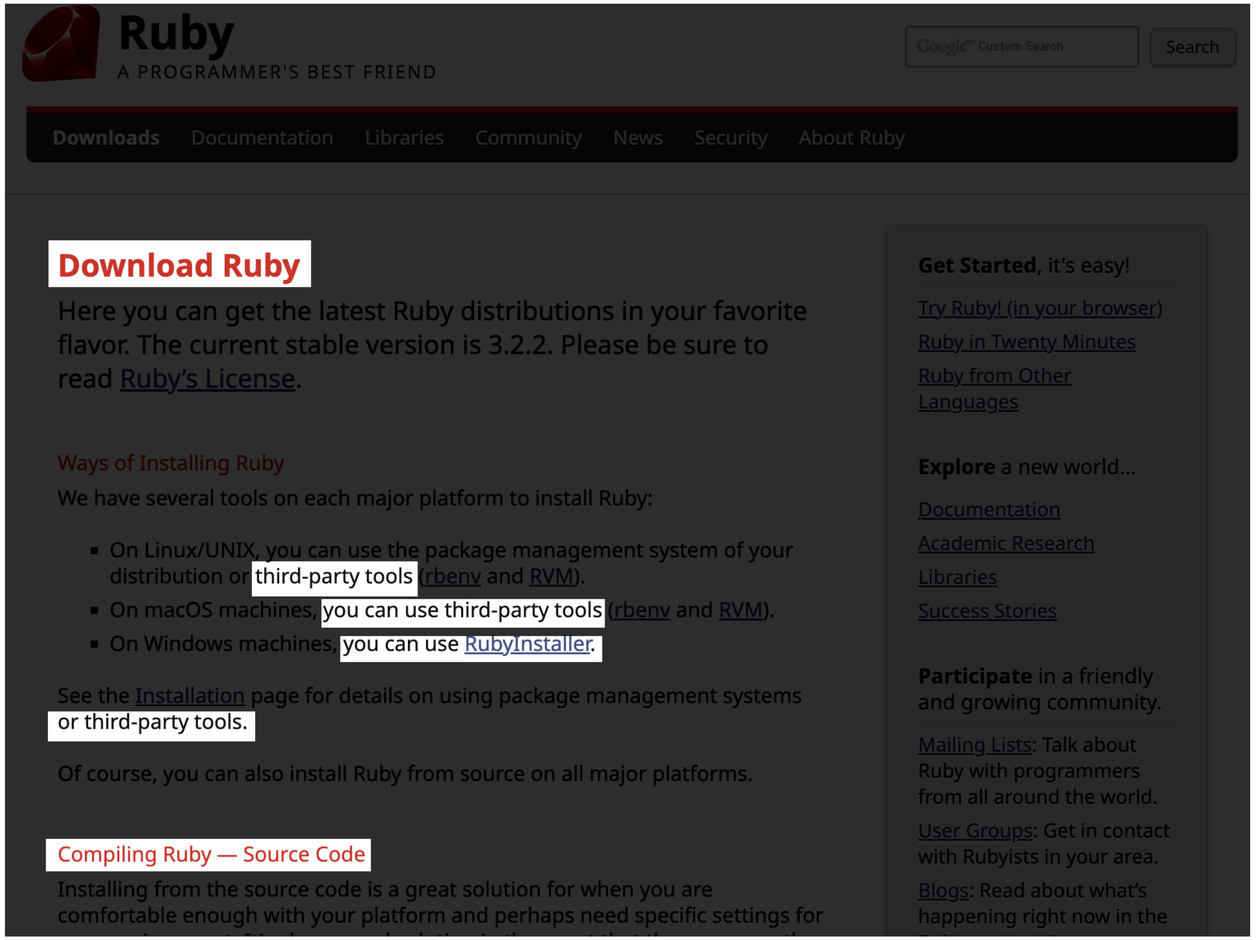
Chapter 2

# Integration Challenges

What is it like in CRuby Land

# Don't break the build...

## No official binaries on ruby-lang.org




# So many options

On Windows 10, you can also use the Windows Subsystem for Linux to install one of the supported Linux distributions and use any of the installation methods available on that system.

Here are available installation methods:

- Package Management Systems
  - Debian, Ubuntu
  - CentOS, Fedora, RHEL
  - Snap
  - Gentoo
  - Arch Linux
  - macOS
  - FreeBSD
  - OpenBSD
  - OpenIndiana
  - Windows Package Manager
  - Chocolatey package manager for Windows
  - Other Distributions
- Installers
  - ruby-build
  - ruby-install
  - RubyInstaller (Windows)
  - Ruby Stack
- Managers
  - asdf-vm
  - chruby
  - rbenv
  - RVM
  - uru
- Building from source

# Past breakages

- Trying to link with `libcapstone`
- Assuming echo "\n"
  prints a new line

# Past breakages

- Trying to link with `libcapstone`
- Assuming echo "\n" prints a new line

```
diff --git a/configure.ac b/configure.ac
index 603cbebd03..0357a7eacf 100644
--- a/configure.ac
+++ b/configure.ac
@@ -1268,15 +1268,6 @@ AC_CHECK_LIB(crypt, crypt)      # glibc (GNU/Linux, GNU/Hur
 AC_CHECK_LIB(dl, dlopen)       # Dynamic linking for SunOS/Solaris and SYSV
 AC_CHECK_LIB(socket, shutdown)  # SunOS/Solaris

-AS_IF([test -n "${PKG_CONFIG}" && ${PKG_CONFIG} --exists capstone], [
-   CAPSTONE_CFLAGS=`${PKG_CONFIG} --cflags capstone`
-   CAPSTONE_LIB_L=`${PKG_CONFIG} --libs-only-L capstone`
-   LDFLAGS="$LDFLAGS $CAPSTONE_LIB_L"
-   CFLAGS="$CFLAGS $CAPSTONE_CFLAGS"
-])
-
-AC_CHECK_LIB(capstone, cs_open) # Capstone disassembler for debugging YJIT
-
 dnl Checks for header files.
 AC_HEADER_DIRENT
 dnl AC_HEADER_STDC has been checked in AC_USE_SYSTEM_EXTENSIONS
```

```
diff --git a/configure.ac b/configure.ac
index 174e395cd6..ae560297ad 100644
--- a/configure.ac
+++ b/configure.ac
@@ -3755,7 +3755,7 @@ AS_IF([test "$RUSTC" != "no"],
     )
     dnl Fails in case rustc target doesn't match ruby target.
     dnl Can happen on Rosetta, for example.
-    AS_IF([echo "#[cfg(target_arch = \"$YJIT_TARGET_ARCH\")][-\n-] fn main() { let x = 1; format!(\"{x}\"); }" |
+    AS_IF([echo "#[cfg(target_arch = \"$YJIT_TARGET_ARCH\")][-\n-] fn main() { let x = 1; format!(\"{x}\"); }" |
             $RUSTC - --emit asm=/dev/null 2>/dev/null],
         [YJIT_RUSTC_OK=yes]
     )
```

# Minimalism

# Just make Ruby

- For incremental builds
- GNU make, bsdmake, and nmake
- Has its own language. There is a small feature set that works everywhere
- Rust's `cargo` gives incremental build out of the box
- Initial setup called `cargo` unconditionally every time

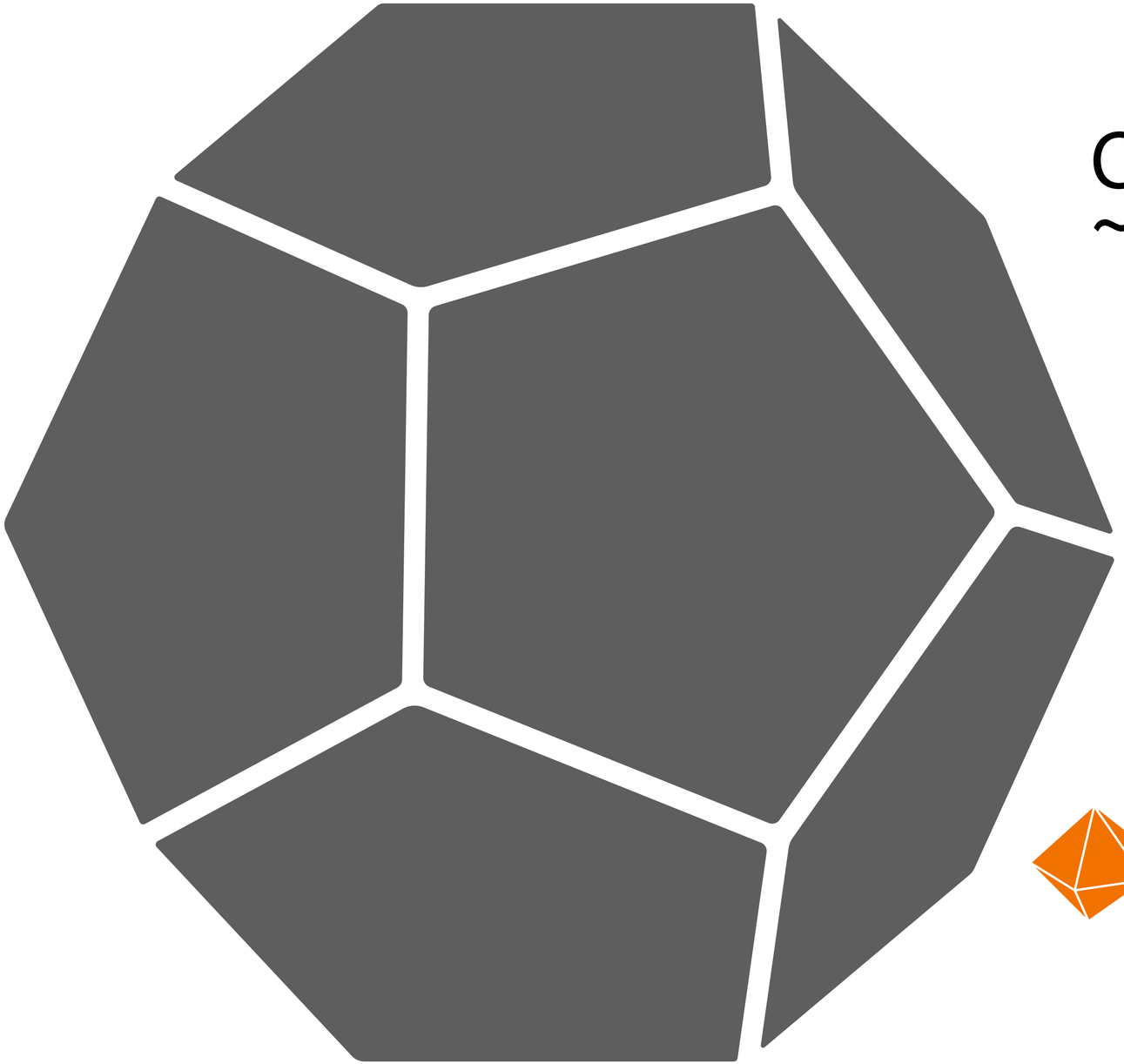
| | |
|---|---|
| not_gmake.mk | 4 months ago |
| yjit.mk | last month |

Chapter 3

# Speaking C

## using the lingua franca

```
$ tokei --compact --exclude ext --exclude spec -t=C,Rust
```



C
~220K lines



Rust
~21K lines

### 7.18.1.1 Exact-width integer types

1 The typedef name **int**_N_**_t** designates a signed integer type with width _N_, no padding bits, and a two's complement representation. Thus, **int8_t** denotes a signed integer type with a width of exactly 8 bits.

2 The typedef name **uint**_N_**_t** designates an unsigned integer type with width _N_. Thus, **uint24_t** denotes an unsigned integer type with a width of exactly 24 bits.

3 These types are optional. However, if an implementation provides integer types with widths of 8, 16, 32, or 64 bits, no padding bits, and (for the signed types) that have a two's complement representation, it shall define the corresponding typedef names.

```c
rb_define_method(rb_mKernel, "inspect", rb_obj_..., 0);
rb_define_method(rb_mKernel, "singleton_methods", rb_obj_..., -1);
```

```
Kernel.instance_method(:singleton_methods).arity
=> -1
```

```
// Copy arguments from locals
for (int32_t i = 0; i < bf->argc; i++) {
    x86opnd_t stack_opnd = ctx_stack_opnd(ctx, bf->argc - i - 1);
    x86opnd_t c_arg_reg = C_ARG_REGS[2 + i];
    mov(cb, c_arg_reg, stack_opnd);
}
```

```
error[E0277]: the type `[usize]` cannot be indexed by `i32`
 --> rust-signed-index-build-error.rs:7:37
  |
7 |         let c_arg_reg = C_ARGS_REGS[2 + i];
  |                                     ^^^^^ slice indices are of type `usize` or ranges of `usize`
  |
  = help: the trait `SliceIndex<[usize]>` is not implemented for `i32`
  = help: the trait `SliceIndex<[T]>` is implemented for `usize`
  = note: required for `[usize]` to implement `Index<i32>`

error: aborting due to previous error

For more information about this error, try `rustc --explain E0277`.
```

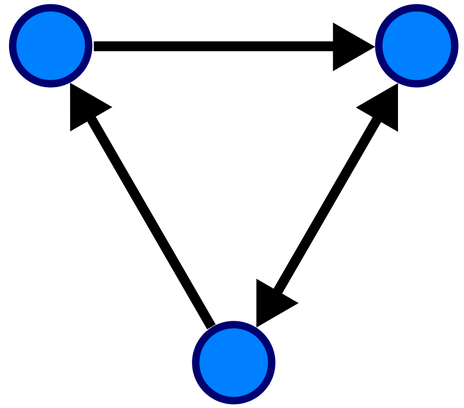
```
// Copy arguments from locals
for (int32_t i = 0; i < bf->argc; i++) {
    x86opnd_t stack_opnd = ctx_stack_opnd(ctx, bf->argc - i - 1);
    x86opnd_t c_arg_reg = C_ARG_REGS[2 + i];
    mov(cb, c_arg_reg, stack_opnd);
}
```

```
fn gen_invokebuiltin(
    jit: &mut JITState,
    asm: &mut Assembler,
    _ocb: &mut OutlinedCb,
) -> Option<CodegenStatus> {
    let bf: *const rb_builtin_function = jit.get_arg(0).as_ptr();
    let bf_argc: usize = unsafe { (*bf).argc }.try_into().expect("non negative argc");
```

# References

| | |
|---|---|
| `T *restrict` | `const T *` |
| `&mut T` | `&T` |

# Dealing with restrictions



- We have graphs in YJIT
- Tried RefCell. It ate memory and added crash risks
- Studied the semantics of `&mut` and `&` through communications from T-opsem (Team Operational Semantics)
- Currently using `unsafe` (hopefully correctly!)

| | |
|---|---|
| `T *restrict` | `const T *` |
| `&mut T` | `&T` |

# When the rules are muddy

- Find first party (or close to first party) sources
- Read discussions
- Ask questions!
  - It does take effort to formulate good questions
  - But trust that there are people willing to help if you ask nicely 🤗

Chapter 4

# Linking

connecting machine code

# ~~Linking~~ "link-editing"

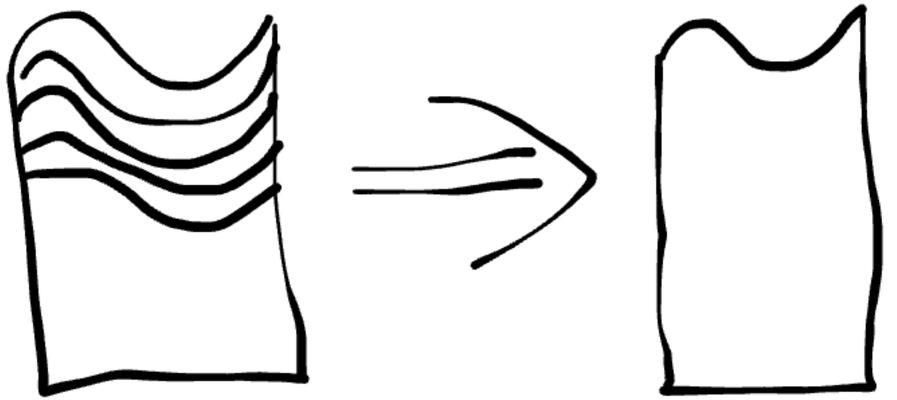
From the first edition of Unix Programmer's Manual

```
11/3/71                                                    LD (I)

NAME                ld -- link editor

SYNOPSIS            ld [ -usaol ] name1 ]

DESCRIPTION         ld combines several object programs into one; resolves
                    external references; and searches libraries. In the
                    simplest case the names of several object programs are
                    given, and ld combines them, producing an object module
                    which can be either executed or become the input for a
                    further ld run.
```

https://www.bell-labs.com/usr/dmr/www/1stEdman.html

# The link editing operation

- Serval files in, a single file out
- Connect code compiled across spacetime
- Why link at all?
  - Enables incremental builds
  - A way to distribute librariesLinkers and object file format



# x64 CALL

```
e8 00 00 00 00
```

instruction identifier

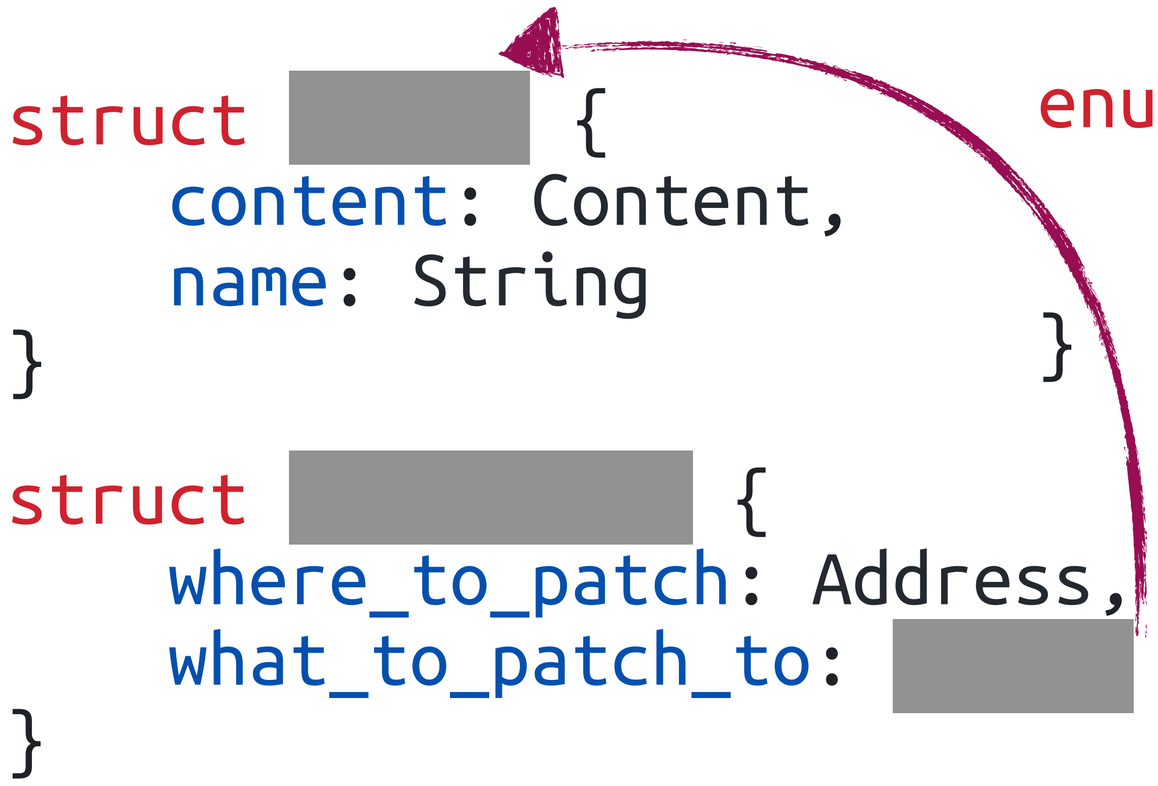
call target address (relative)

```
struct [redacted] {
    content: Content,
    [redacted]
}
```

```
enum Content {
    Undefined,
    Defined(Address)
}
```

```
struct [redacted] {
    content: Content,
    name: String
}
```

```
enum Content {
    Undefined,
    Defined(Address)
}
```


struct {
content: Content,
name: String
}
struct {
where_to_patch: Address,
what_to_patch_to:
}
enum Content {
Undefined,
Defined(Address)
}

```
struct Symbol {
    content: Content,
    name: String
}

struct Relocation {
    where_to_patch: Address,
    what_to_patch_to: Symbol
}
```

```
enum Content {
    Undefined,
    Defined(Address)
}
```

1839 C. A. HARRIS *Dental Art* xxi. 348 The obtaining of a model of the alveolar ridge, or ridges, when one for each jaw is required, though apparently very easy, is nevertheless often attended with some difficulty. 1857 *Brit. Jrnl. Dental Sci.* I. 579/1 Mr. Saunders thought that the plan of bending down the front part of the model could be fatal to a correct impression. 1917 F. A. PEESO *Crown & Bridge-Work* vii. 140 When the plaster for the impression has been tinted, the impression and model are easily distinguished by the difference in coloring. 1938 *Dental Rec.* LVIII. 14, I think, from a study of the original models, that there had probably been pyorrhœa for some years. 1940 [see IMPRESSION *sb.* 2 e]. 1973 D. H. ROBERTS *Fixed Bridge Prostheses* v. 66 Only one model can be poured from each impression.

**e. A simplified or idealized description or conception of a particular system, situation, or process (often in mathematical terms: so *mathematical model*) that is put forward as a basis for calculations, predictions, or further investigation.**

Cf. sense 1 c.

1913 N. BOHR in *Phil. Mag.* XXVI. 1 To explain the results of experiments on scattering of α rays by matter Prof. Rutherford has given a theory of the structure of atoms. According to this theory, the atoms consist of a positively charged nucleus surrounded by a system of electrons [etc.].

Great interest is to be attributed to this atom-model.

```
struct Symbol {
    content: Content,
    name: String
}
```

```
enum Content {
    Undefined,
    Defined(Address)
}
```

- >0 Undefined, 0 Defined => "undefined symbol error"
- >1 Defined with the same name => "duplicate symbol error"
- Disassembly for calls seem to go nowhere => use `objdump -r` to see relocations

```
struct Symbol {
    content: Content,
    name: String
}

struct Relocation {
    where_to_patch: Address,
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```
enum Content {
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# Closing

- Fitting in is a continuous process
- Fitting in is a collaborative process
  - Thanks to nobu, k0kubun, ko1, mame, Maxime, Ralf Jung, and everyone who helped directly or indirectly!
- First party resources such as `man` pages and the C standard are surprisingly intelligible
- Asking questions takes efforts and can be scary, but people want to help
- Build understanding by building small mental models and refining them

# Thanks!