



accu
conference
2025

Duck-Tape Chronicles

Rust C++ Interop

Victor Ciura

Abstract

C++/Rust is not a zero-sum game. We need to learn to play nice together... for a looong time! That applies equally to people, but also to code. Rust code everywhere is increasing at an accelerated rate, but so does C++ (and that's on top of gazillion lines already out there). So, hybrid codebases are quickly becoming the norm.

Having seamless interop between the C++ and Rust components is essential for the success of this symbiosis. There are many challenges in this process, but people found various ways to make things "work" - from dealing with ABI compatibility and platform/toolchain guarantees, to going down to C and FFI, to various techniques and tools for generating glue-code between the two languages.

Alas, general-purpose interoperability (not tied to a specific toolchain/IR) without loss of performance has yet to be achieved. Just "making things work" is not enough in the domain space of C++ and Rust; as such, many of the explored solutions so far by the community fail to deliver on all the needed requirements, swinging the wide range between performant and ergonomic.

This presentation aims to highlight all of the interop challenges, some of the explored solutions out there, and tease out the avenues at the forefront of this pursuit.

Who thinks **interop** is about... **C FFI**



Who thinks **interop** is about... **C FFI**

glue code



Who thinks **interop** is about...

C FFI

glue code

coge generators



Who thinks **interop** is about...

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fat compilers



Who thinks **interop** is about...



C FFI

glue code

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linkers

Who thinks **interop** is about...



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ABI compat

When you ask about Rust interop

C ffi, autocxx, bindgen, cbindgen, diplomat, cxx, etc.



When you ask about Rust interop

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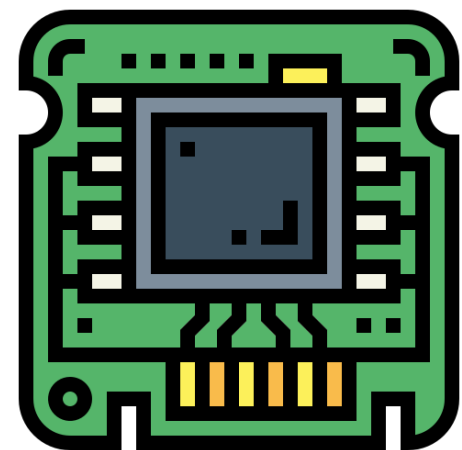
boilerplate
source annotations
code generators
IDLs
mapping language constructs



NO, I'm not going to dazzle you
with **boilerplate** code
that an **LLM assistant**
can spit out anytime, on demand

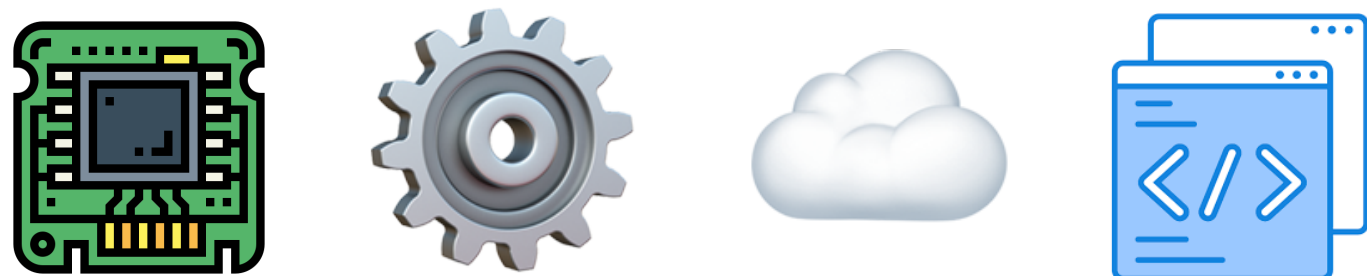
Higher Level Concerns

Rust extreme **range** of operation



Rust @Microsoft

- Project Mu
- Pluton security processor
- SymCrypt - rustls
- Azure Integrated HSM
- Azure Boost Agents
- Open VMM / Open HCL
- Hyper-V
- Azure SDK for Rust
- Azure Data Explorer
- Drasi
- MIMIR
- Caliptra
- Hyperlight / WASM
- ... 🤔



TBD:

- ⚙️ Windows core components
- ☁️ Microservices

More oxidation 🦀 efforts in progress...

C++ → Rust ← C#

- Assist developers making the *transition* from C, C++, C# to Rust
- Investing in Rust [developer tooling](#)

Rust in Production

Learn by doing: **Exploration** → **Flighting** → **Production**

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- Direct impact: improve security & reduce operation cost

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- **Performance** targets, **x-language** LTO
- Costs of maintaining a **hybrid C++/Rust** codebase?

Rust ❤️ **C++**

They need to play nice together... for a looong time!

 Choose... ~~some~~ some?

- No need for excessive `unsafe` keyword

 Choose... none some?

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- Easily `automated`
- Hybrid `build systems` (CMake, cargo, MSBuild, bazel, buck2...)



Compiler



Linker



ABI guarantees



Interop Library



Duck-Tape Chronicles

Rust/C++ Interop

Episode 1 – The ABI Menace

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Victor Ciura

~~Principal Engineer~~

Rambling Idiot

Rust Tooling @ Microsoft

About me



Advanced Installer



Clang Power Tools



Oxidizer SDK



Visual C++



**Rust Tooling
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Disclaimer

I'm just an engineer, with some opinions on stuff...



Let me start
with a ~~sad story~~ cautionary tale

ABI - Now or Never

In Feb 2020, in Prague, the ISO C++ committee took a series of polls on [whether to break ABI](#), and decided [not to](#)... sort of.

There was no applause 🙄

"I'm not sure we fully understood what we did and the consequences it could have."

-- not so anonymous C++ committee member

- wg21.link/P2028
- wg21.link/P1863

C++ ABI - Now or Never

February 24, 2020

The Day The Standard Library Died



cor3ntin.github.io/posts/abi/

Design or Implementation Detail?

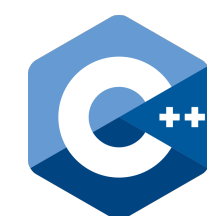
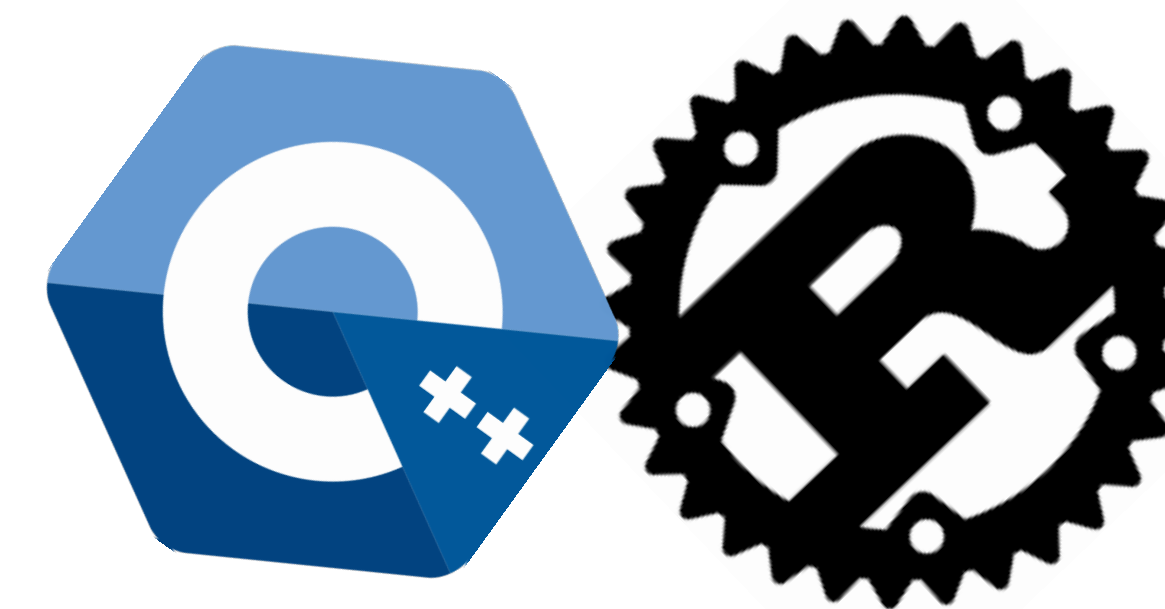
No, this is not an “ABI - Now or Never” talk 😊

Is ABI merely an artifact of **implementation** in native programming languages or should it be considered part of their **design**?

Some programming languages avoid this commitment, while others are still trying to figure out a path forward.

Design or Implementation Detail?

- ABI stability: benefits & risks
- Dynamic linking
- Rust/C++ interop
- Designing for ABI resilience
- Resilience in library evolution
- Performance costs and (opt-out) strategy



How does C++ navigate on this journey?



What can we learn from Swift's ABI resilience?



Can Rust be liberated from the ABI conundrum?

What is ABI, anyway?

ABI can mean a lot of different things to different people.

Is it platform, hardware, calling conv, language, compilers, std library, your code?

At the end of the day it's a *catch-all* term for "implementation details" that at least two things need to **agree** on for everything to work.

What is ABI, anyway?

ABI stability isn't technically a property of a programming *language*.

It's really a property of a *system* and its *toolchain*.

ABI is something defined by the *platform*.

The *platform owner* can just require you to use a particular compiler toolchain that happens to implement their "stable" ABI.

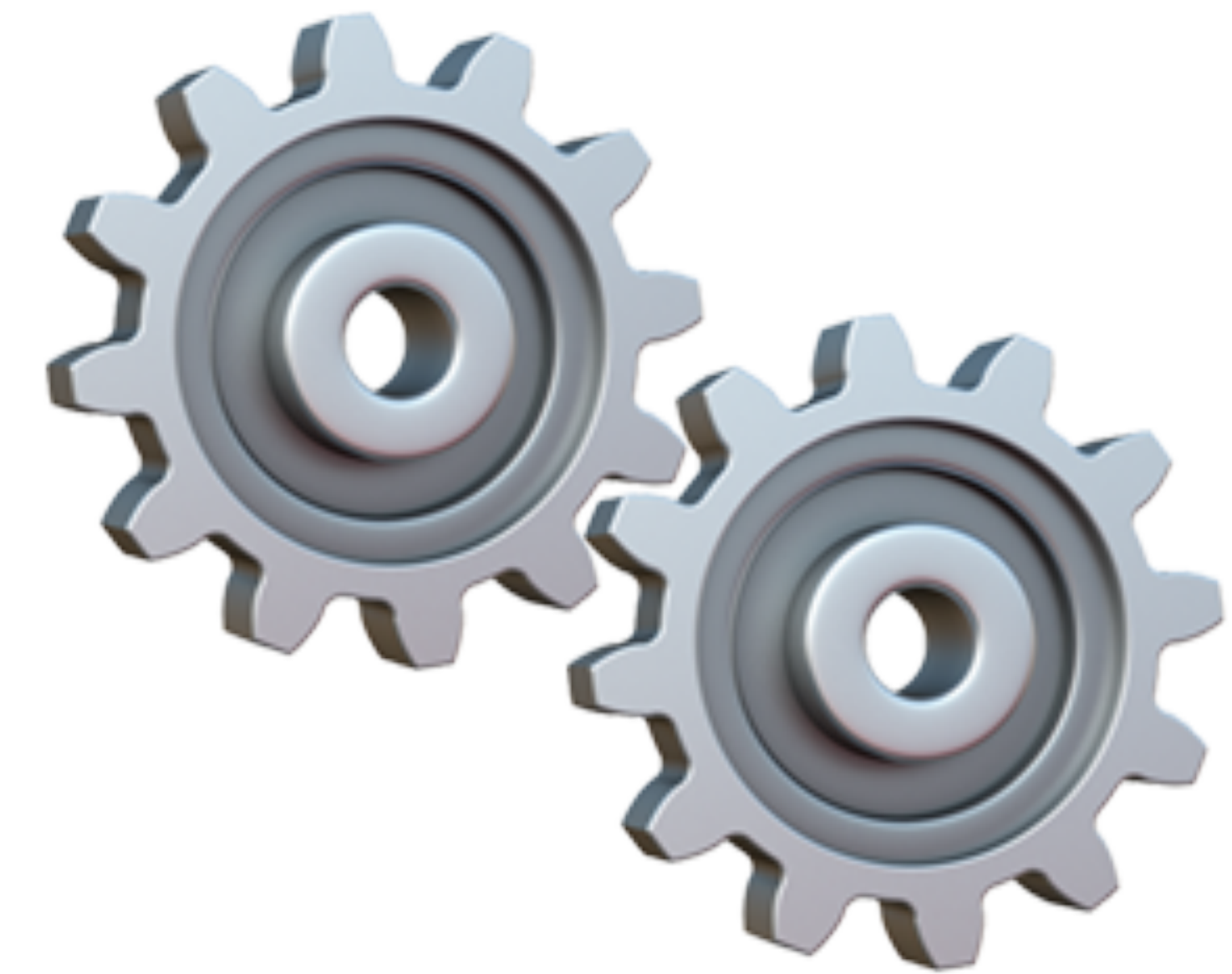
If you care about *dynamic linking* (shared libraries).

What is ABI, anyway?

- Layout of types
 - size & alignment (stride)
 - offsets & types of fields
 - v-table entries
 - closures
- Calling conventions
- Name mangling (symbols)
- Metadata (if applicable)

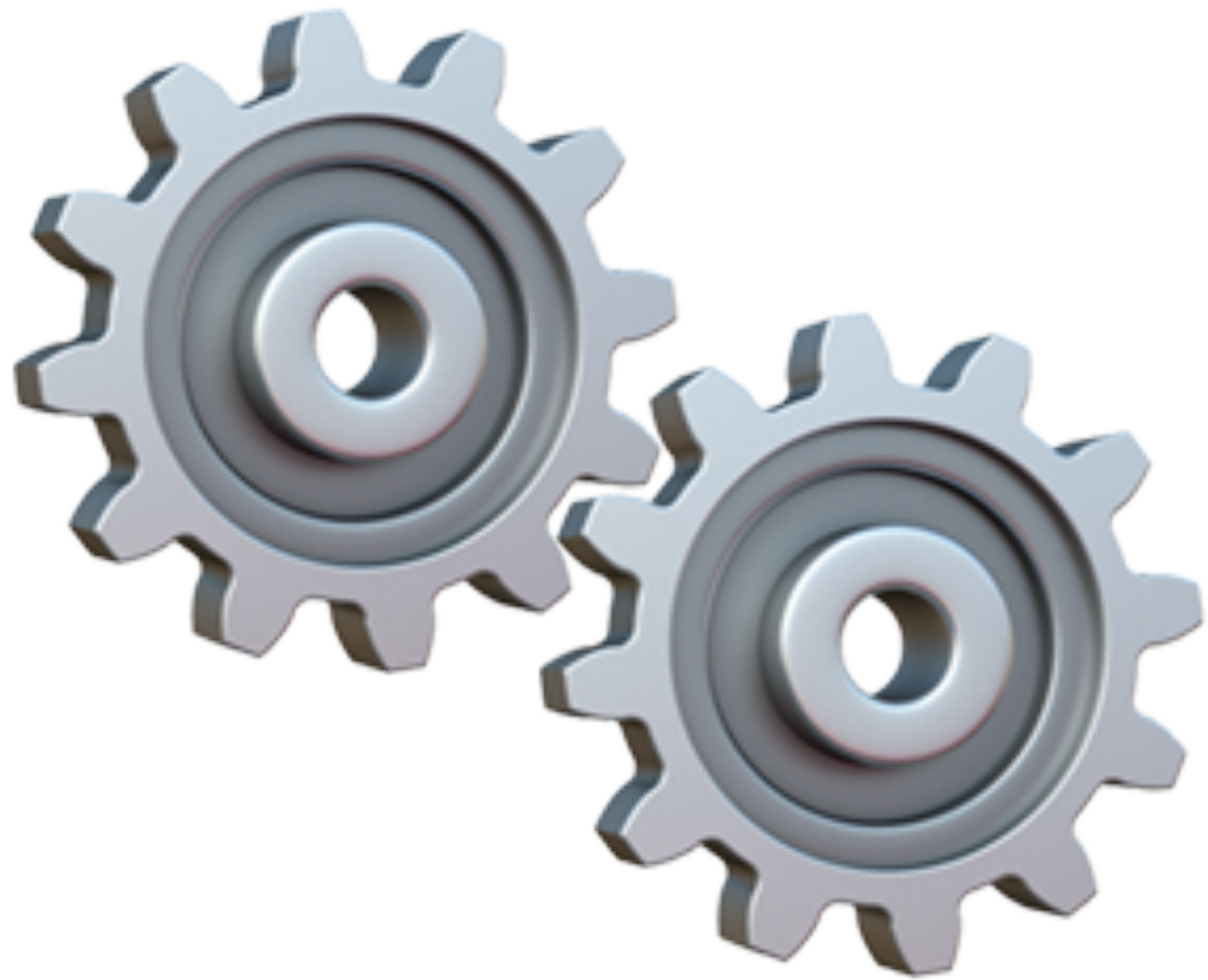


ABI Stability - Why?



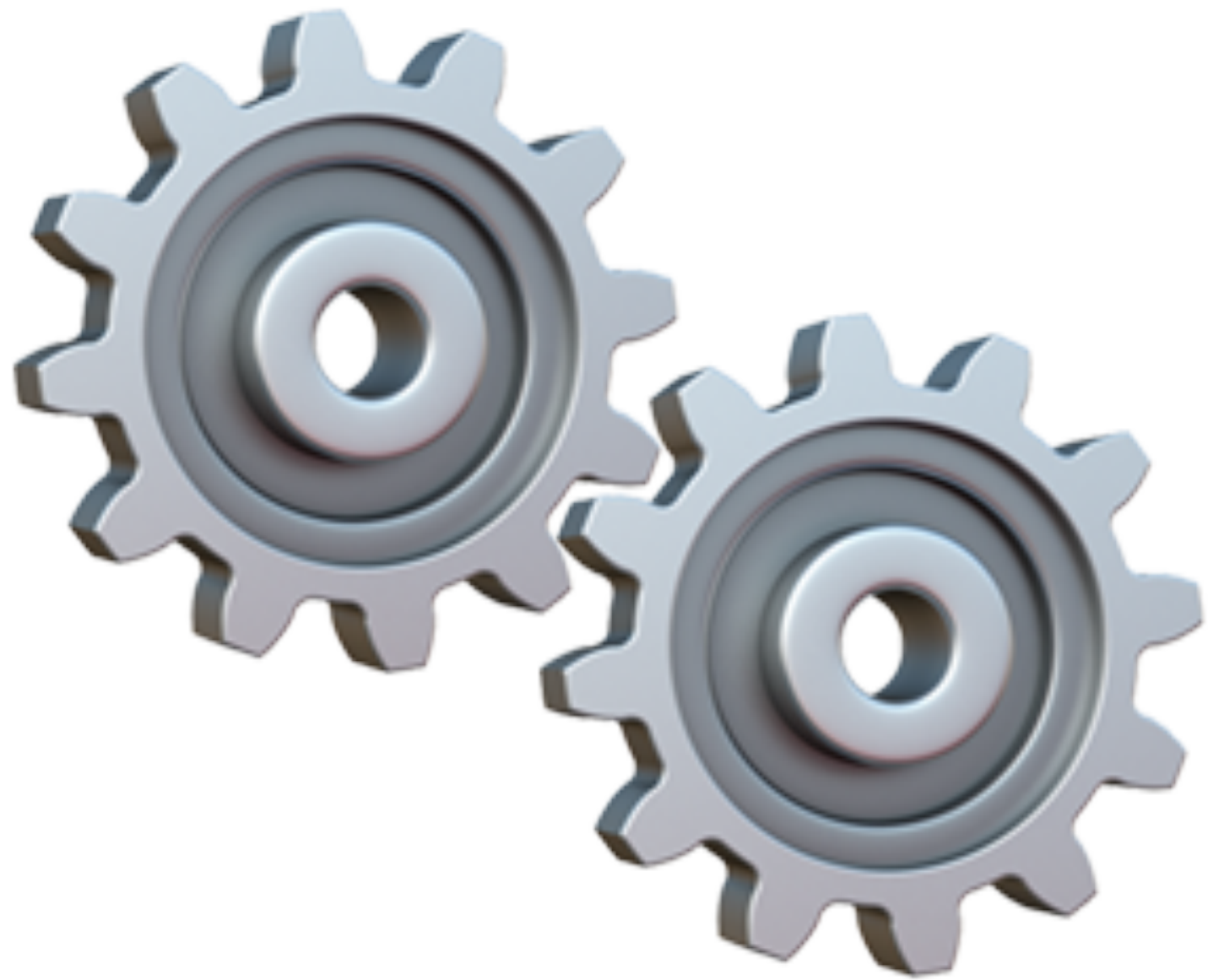
ABI Stability - Why?

- You don't have to share the **source code** of your library



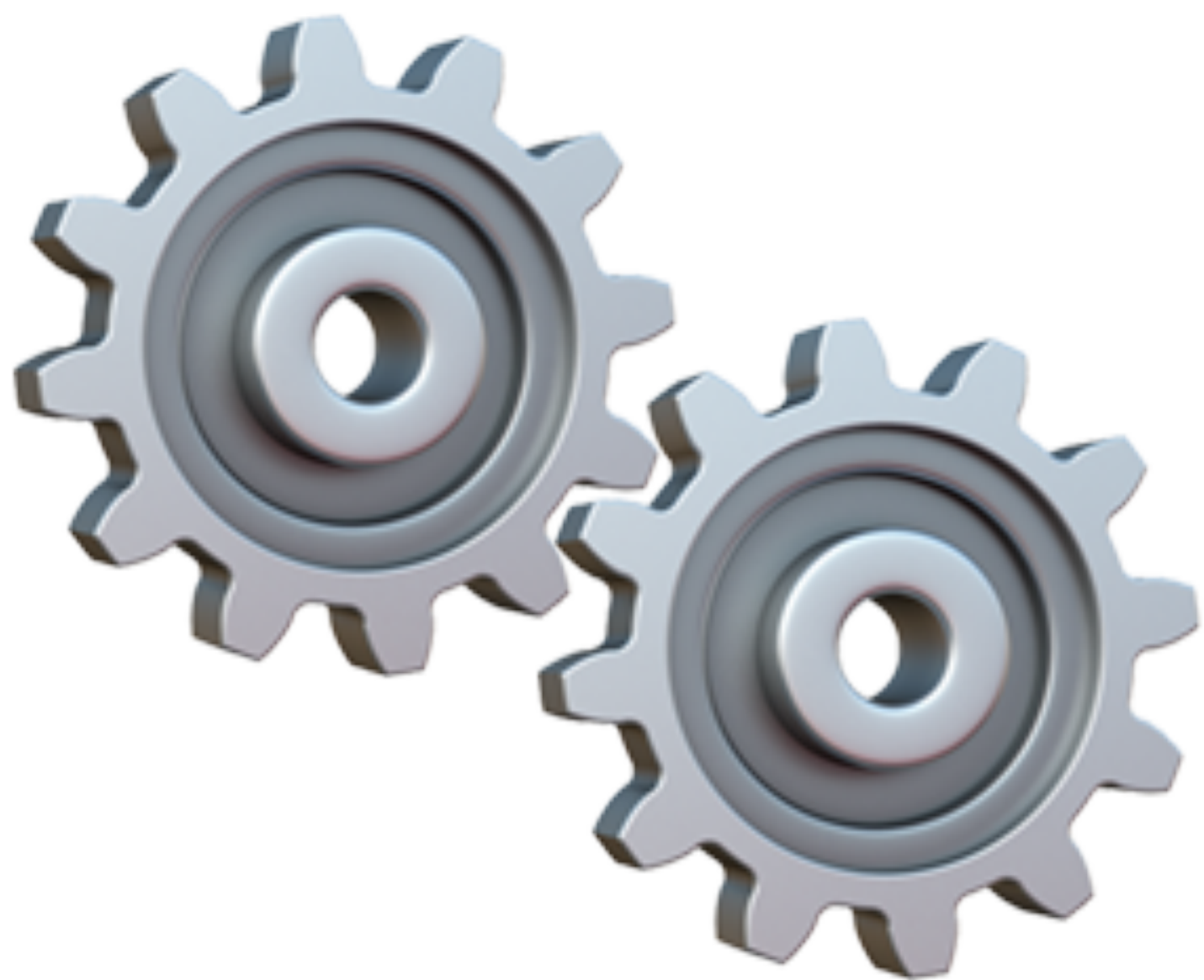
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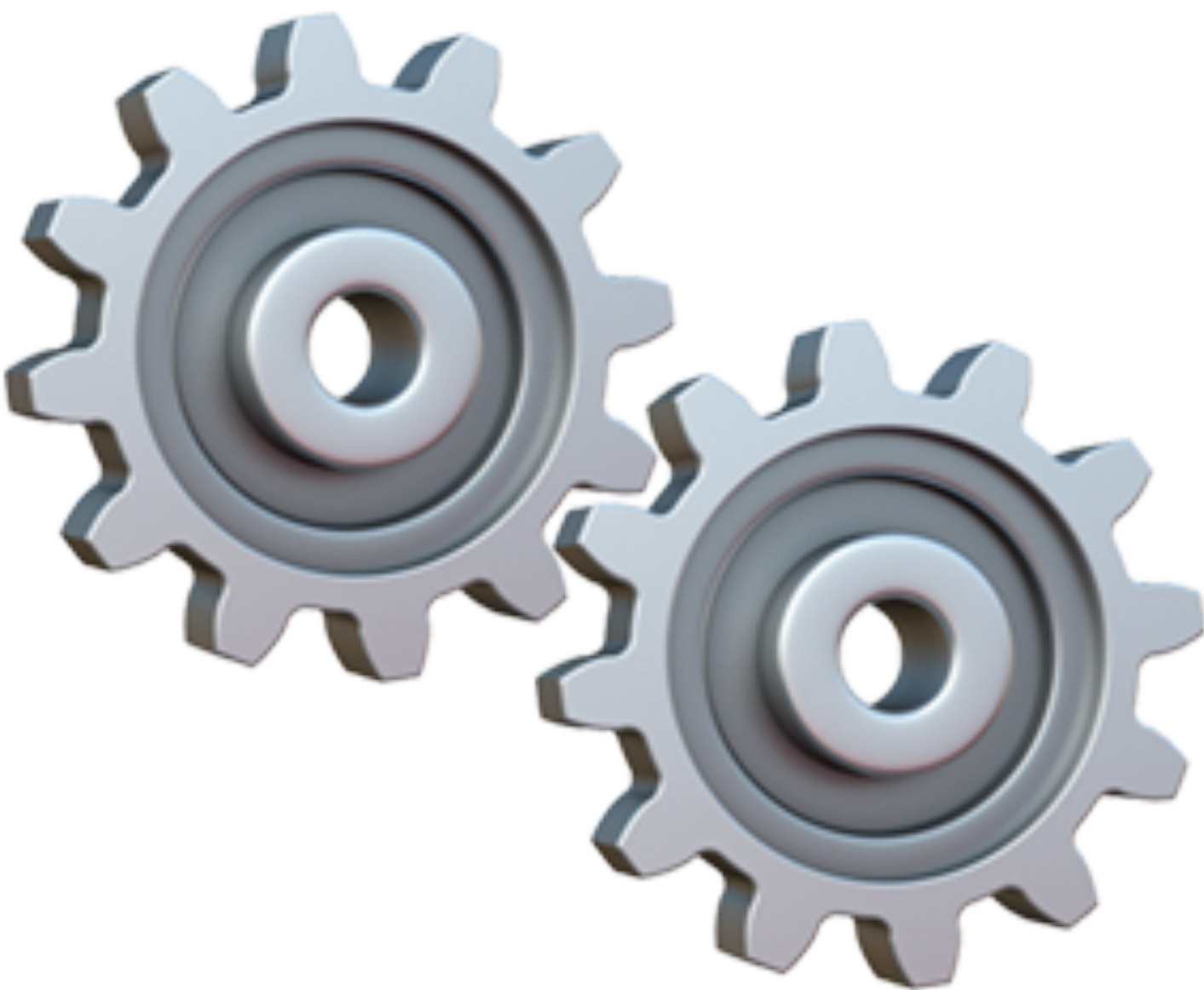


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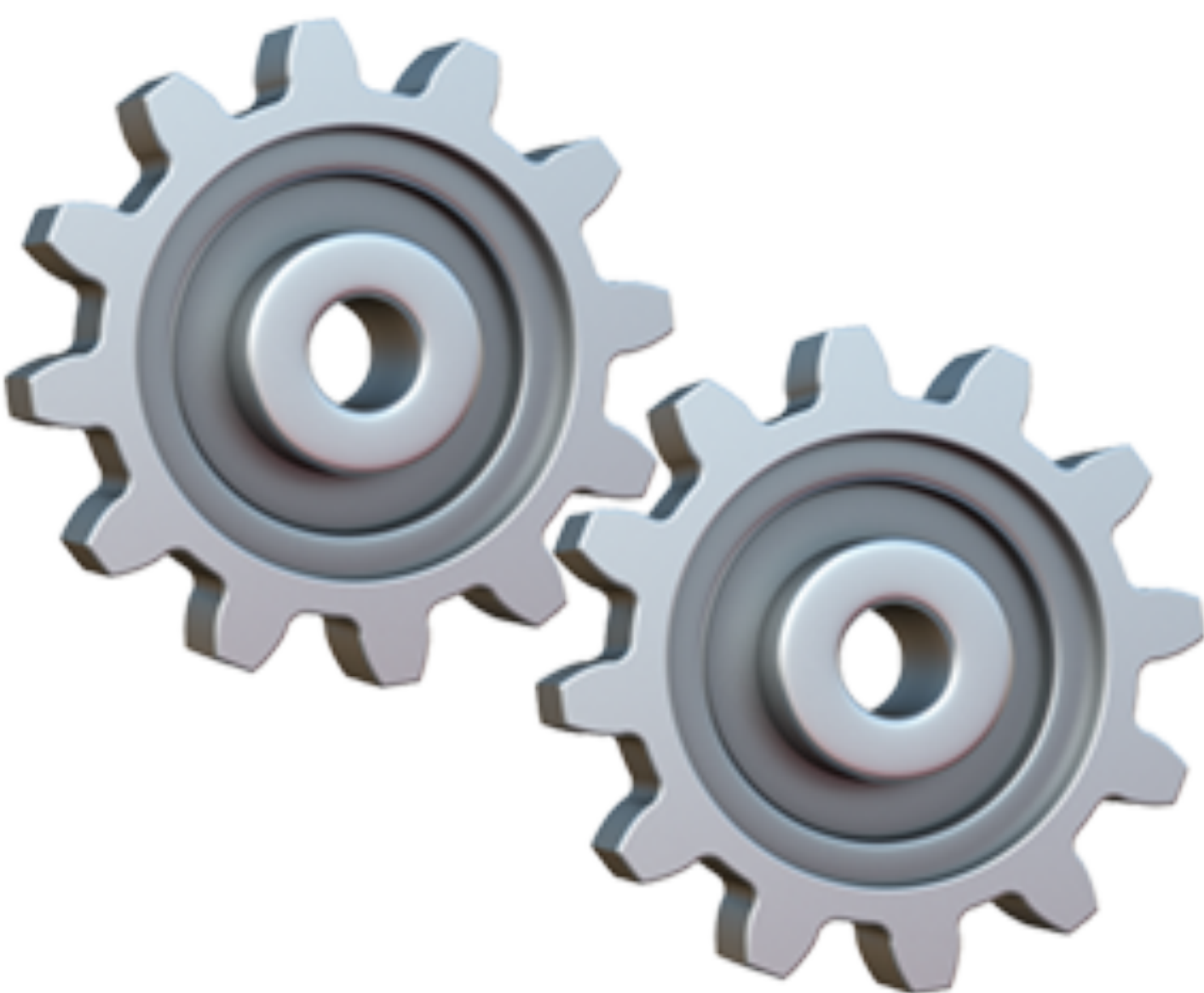


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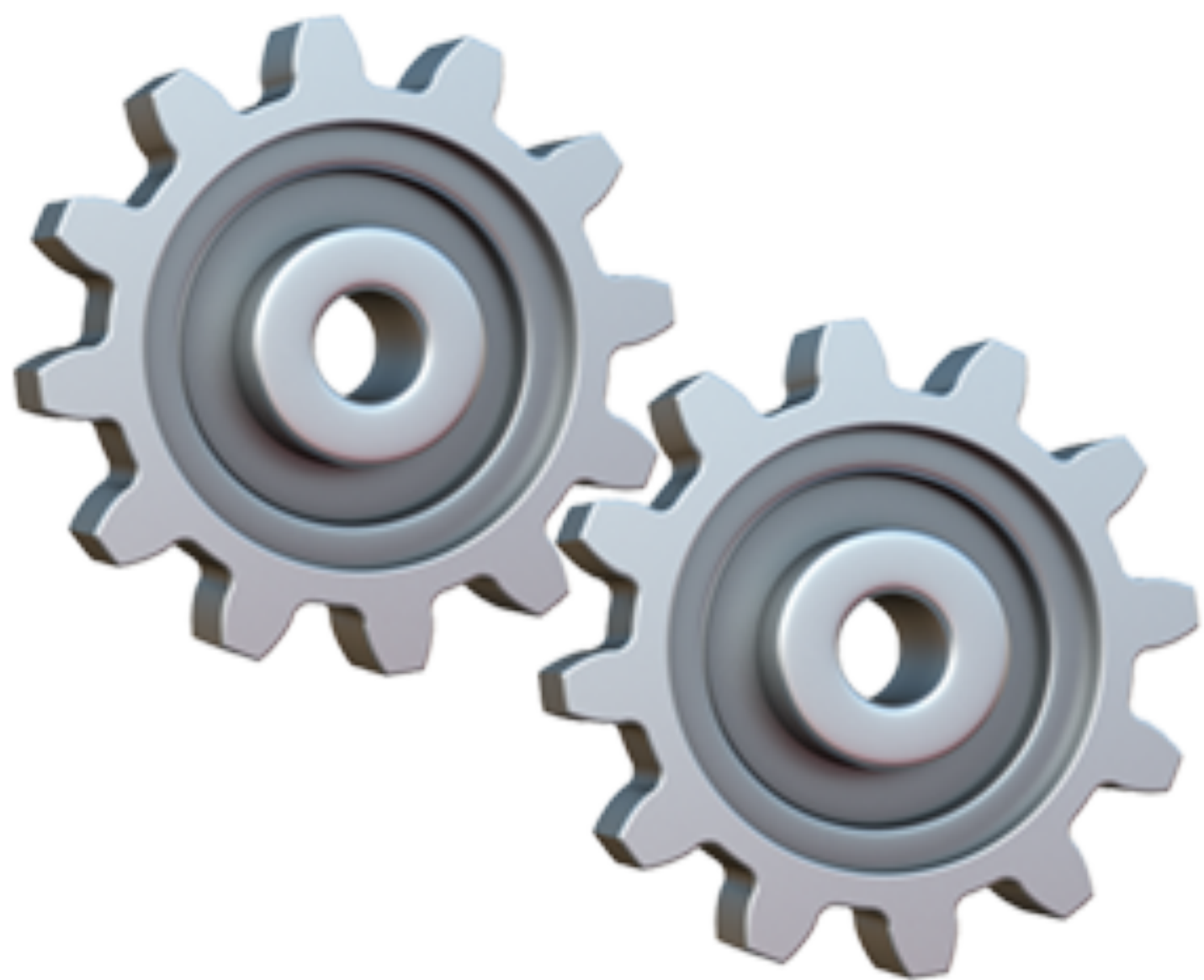
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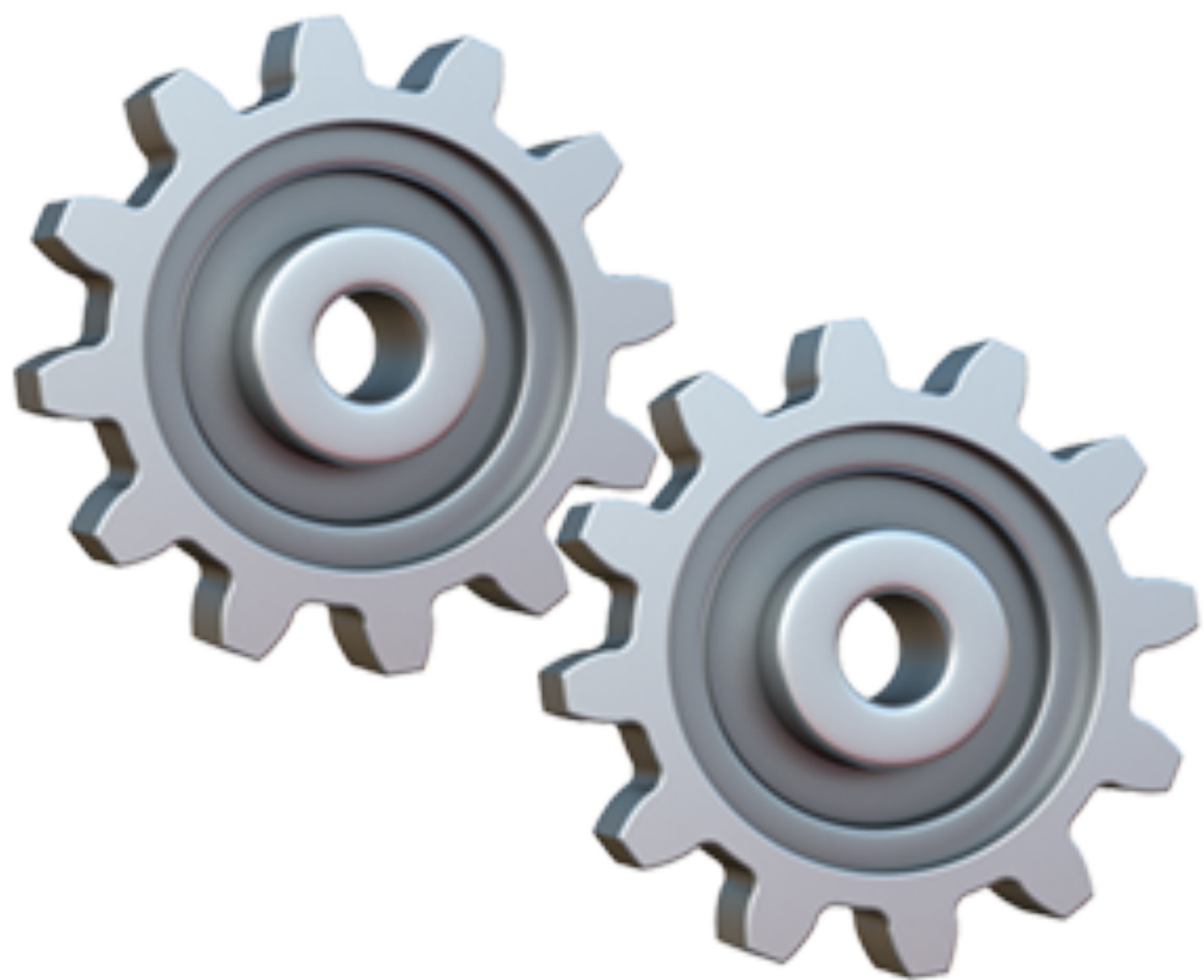
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- **Plugins**/extensions (dynamically loaded)

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- **Plugins**/extensions (dynamically loaded)
- Language **interop** (hybrid projects)

ABI Stability - When?

- Don't shut the door on **future** compiler & library improvements
- **Stabilizing** the ABI (**too early**)™ might miss optimization opportunities
 - implement a faster custom calling convention
 - implement optimal structure layout
 - improve the way a std utility works
- **NB. These are not impossible things!**
 - They are just tough engineering problems
 - We need to invest a lot of time and brain power to solve them

ABI Stability - Evolution of Software Libraries

- Developers want to evolve their software libraries without breaking ABI
 - add new functionality
 - fix bugs
 - improve performance
- A lot of these activities can break ABI
 - add a field to a class
 - make changes affecting v-table
 - (re)use existing padding for a new field?

ABI Stability Scorecard

Can we have stable ABI, pretty please?

- **Go:** NO
- **Rust:** NO
- **Carbon:** NO
- **Zig:** NO
- **C++:** <always has been meme> 🙄 ... but don't tell anyone!
- **Swift:** YES, since v5.0 (most important thing ever!)

Rust has never had a stable ABI

Rust was not designed with a stable ABI as a primary goal

Still an unsolved problem 10 years after v1.0

Some people refuse to acknowledge this is an important problem

Zig natively supports C ABIs for *extern* things; which C ABI is used depends on the target you are compiling for (e.g. CPU architecture, operating system).

This allows for near-seamless interoperation with code that was not written in Zig; the usage of C ABIs is standard amongst programming languages.

Zig internally **does not use an ABI**, meaning code should explicitly conform to a C ABI where reproducible and defined binary-level behavior is needed.

Go ABI specification

- Go's ABI defines the layout of data in memory and the conventions for calling between Go functions
- This ABI is **unstable** and will change between Go versions
- If you're writing assembly code, please instead refer to Go's assembly documentation, which describes Go's stable ABI, known as **ABI0**
- Go uses a **common** ABI design across all architectures (instead of the **platform** ABI)
- All functions defined in Go source follow **ABIInternal**
 - however, **ABIInternal** and **ABI0** functions are able to call each other through **transparent** ABI wrappers

Carbon / non-goals 😊

github.com/carbon-language/carbon-lang#language-goals

“ We also have explicit **non-goals** for Carbon, notably including:

- a stable ABI for the entire language and library
- perfect backwards or forwards compatibility

The greatest champion of ABI stability and dynamic linking:

C

That's plain old **C**, not [Carbon](#), by the way :)

Many software ecosystems require both long-term ABI **stability** and the ability to constantly **evolve**.

These systems tend to use **C** as the stable ABI

Evolving software components with a C ABI requires to **manually** and **proactively** introduce extra levels of indirection, to account for potential future changes.

pimpl



* one more level of indirection solves every problem, right? 😊

The (early) 90s are calling...

- COM interfaces

- change API to hide implementation changes (break ABI)
 - `IWidgetSomething`, `IWidgetSomething2`, `IWidgetSomething3`
- `MIDL` for interop
- metadata

- Objective-C `msg-send`

- ~unstructured data
- type erasure / everything dynamic / indirections
- swizzling, isa





Consistency



Jonathan Müller @foonathan · Feb 3, 2020

What's the point of standard library containers if they can't give the best performance?

2



9



Titus Winters @TitusWinters · Feb 3, 2020

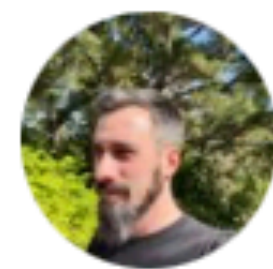
They're common and readily available? (Which does have some value.)

Committing to ABI is like admitting that the standard library is aiming to be McDonald's - It's everywhere, it's consistent, and it technically solves the problem.

5

3

18



JF Bastien @jfbastien@mastodon.social @jfbastien · Feb 3, 2020

The rumors of STL pink slime are wildly overblown 🤪

1



5



May I have some ABI?



Sean Parent @SeanParent · Feb 4, 2020



A stable ABI means you can link against the platform API, shared library APIs including the standard, evolve your product without breaking plugins. C++ needs a strategy on how to specify and maintain ABI compatibility - not some "one time break" for efficiency. See [@SwiftLang](#)



Chandler Carruth
@chandlerc1024



You could have an independent mechanism for accessing platform libraries. We (almost) have that on Linux with their C APIs & ABIs.

Pinning all of C++ (and its standard library) down with a stable ABI for the entire thing largely blocks evolving any of them for performance.

May I have some ABI?



Doug Gregor @dgregor79 · Feb 4, 2020



A stable C++ ABI is useless for platform APIs if it doesn't encompass the standard library. That said, you could have a compilation mode choose between resilience (library impl can change without breaking you) or fragility (performance without ABI stability)



Sean Parent @SeanParent · Feb 4, 2020



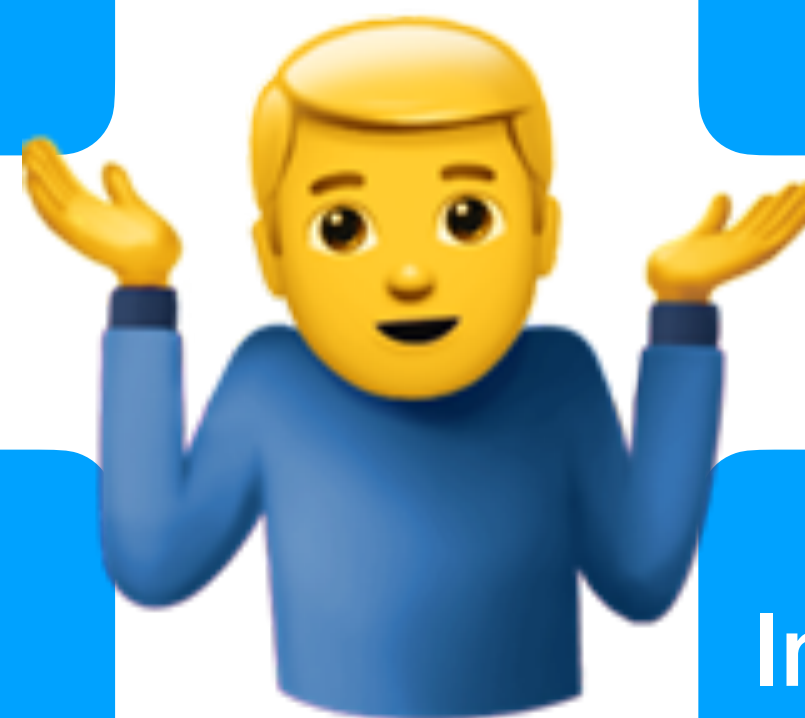
I didn't say lock everything. Define what can be used in an ABI stable interface, and how it is versioned. A single app needs to be able to link against multiple versions of the same lib without an ODR violation. C++ currently is `_not_` ABI stable.

twitter.com/TitusWinters/status/1224351257479077889?s=20

C++ the king of mix signals and ambivalent behavior

C++ does not have an ABI resilience model (it's not stable)

The committee will reject any proposal that could cause ABI breaks in existing STL components



C++ will not officially commit to guaranteeing ABI stability

Implementors* will not change/improve library components if it would cause an ABI break for clients

- wg21.link/P2028
- wg21.link/P1863

The king of mix signals and ambivalent behavior

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- WG21 will not promise stability forever
- WG21 wants to keep [prioritizing performance over stability](#)

The king of mix signals and ambivalent behavior



Quick recap: A “**lost decade**” pattern

MSVC 6

~12 years

Shipped in **1998**

“10 is the new 6” fanfare in **2010**

C99 `_Complex` and VLAs

~12 years

Added in **1999**

Walked them back to “optional” in **2011**

 C++11 `std::string`

~11 years

Banned RC for `std::string` in **2008/2010**

Major Linux distro enabled it in **2019**

Python 3

~12 years

Shipped 3.0 in **2008**

10% still using 2.x as of early **2020**

If you don't build a strong backward compatibility bridge, expect to slow your adoption down by

~10 years

(absent other forces)

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- `std::span`, `std::string_view`, `std::unique_ptr` need to be spilled into registers for function calls (language changes needed => zero-overhead for x64 call conv.)
- improving `std::shared_ptr`, eg. `lock_exclusive()`

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- making `std::unordered_map` faster or swap the hash algorithm
- better conformance: some implementations are intentionally not conforming for the sake of stability
- tweaks to string, vector, and other container layouts
- `std::span`, `std::string_view`, `std::unique_ptr` need to be spilled into registers for function calls (language changes needed => zero-overhead for x64 call conv.)
- improving `std::shared_ptr`, eg. `lock_exclusive()`
- improving perf of `std::mutex` (`std::shared_mutex` is faster!)

Clang libc++ ABI stability

There is [a path](#) forward:

- libc++ aims to preserve a stable ABI to avoid subtle bugs
(when code built under the old ABI is linked with code built under the new ABI)
- libc++ wants to make ABI-breaking improvements/fixes (user opt-in)
- libc++ allows specifying an ABI version at build time:
 - `LIBCXX_ABI_VERSION=`
 - `1` (stable/default); `2` (unstable/next); `3` (when 2 will be frozen)...
- always use the most cutting-edge, most unstable ABI: `LIBCXX_ABI_UNSTABLE`
- [All or nothing!](#) solution 😞

📖 Clang docs:

libcxx.llvm.org/DesignDocs/ABIVersioning.html

Design Choices

C++ / Rust / Carbon / ...	Swift
Fast code	Favor small* code
Heavy inlining	Outlining
CPU utilization/saturation	CPU power usage
Mostly* static linking (with occasional DLL madness)	Dynamic linking (shared libraries)

Outlining

LLVM Outliner

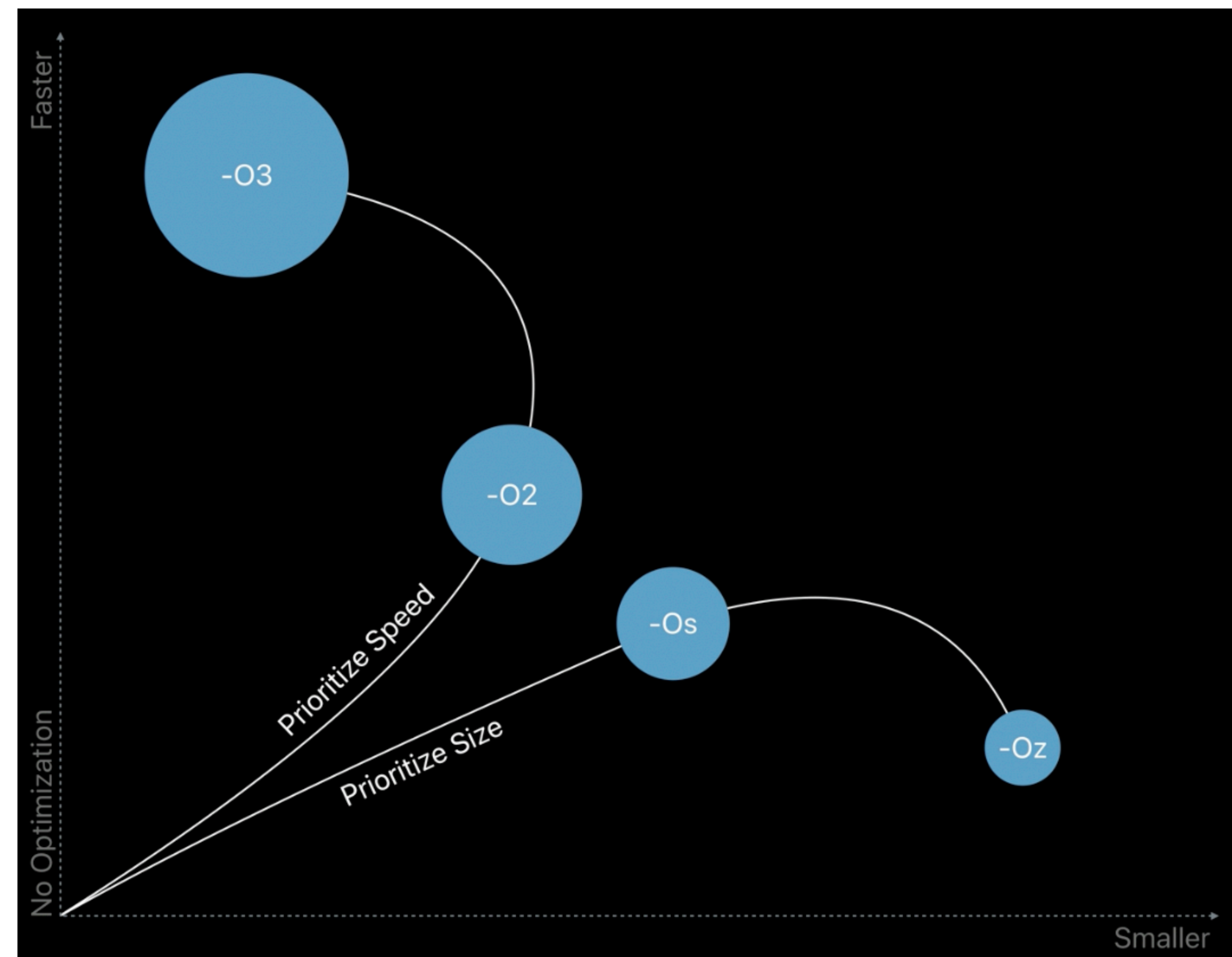
`-Oz`

Outlining:

Replacing repeated sequences of instructions with calls to equivalent functions. (smaller code => icache)

Jessica Paquette "Reducing Code Size Using Outlining"
[youtube.com/watch?v=yorld-WSOeU](https://www.youtube.com/watch?v=yorld-WSOeU)

Jessica Paquette, JF Bastien "What's New in Clang and LLVM"
developer.apple.com/videos/play/wwdc2019/409/



Swift who?

- Ahead-Of-Time (AOT) compiled, but has a large runtime library
- created to replace Objective-C on Apple's platforms (native interop with Obj-C)
- has classes and inheritance
- interfaces, generics, closures, enums with payloads
- Automatic Reference Counting (ARC)
- simple function-scoped mutable borrows (inout)
- emphasis on value semantics
- structs/primitives (“values”) are “mutable xor shared” & stored inline
- classes are mutably shared and boxed (using ARC) -> reference semantics
- collections implement value semantics by being CoW (using ARC)



Language designed for **Library Evolution**

Swift was designed to explicitly account for a **stable** ABI.

Swift espouses a *principle of least regret* for public interfaces, ensuring that the implementation details of a software module do not create a binary-compatibility contract that prevents future evolution.



Language designed for **Library Evolution**

Principles for ABI-stable library evolution:

- make all promises **explicit**
- **delineate** what can and cannot change in a stable ABI
- provide a performance model that **indirects** only when necessary
- let the authors of libraries & consumers be **in control**

Doug Gregor

*Implementing Language Support for
ABI-Stable Software Evolution in Swift and LLVM*

youtube.com/watch?v=MgPBetJWkmc

Evolving a struct

```
public struct Person {  
    public var name: String  
    public let birthDate: Date?  
    let id: Int  
}
```

```
public struct Person {  
    let id: Int  
    public let birthDate: Date?  
    public var name: String  
}
```

```
public struct Person {  
    let id: UUID  
    public var birthDate: Date?  
    public var name: String  
}
```

```
public struct Person {  
    let id: UUID  
    public var birthDate: Date?  
    public var name: String  
    public var favoriteColor: Color?  
}
```

- Person struct **changes size** when new fields are added
- **Offset** of fields changes whenever **layout** changes

Using the struct

```
import PersonLibrary
struct Classroom {
  var teacher: Person
  var students: [Person]

  func getTeacherName() -> String { teacher.name }
  var numStudents: Int { students.count }
}
```

offset

Type Layout should be as-if we had the whole program:

- *Person library* should layout the type without indirection
- Expose *metadata* with layout information:
 - size/alignment of type
 - offsets of each of the public fields

```
size_t Person_size = 32;  
size_t Person_align = 8;  
size_t Person_name_offset = 0;  
size_t Person_birthDate_offset = 8;
```

Client code (external) **indirects** through **layout metadata**

- **Access** a field:
 - read the metadata for the **field offset**
 - add that offset to the base object
 - cast the new pointer and load the field
- Store an instance on the **stack**:
 - read the metadata for instance **size**
 - emit **alloca** instruction, to setup as needed

Library code (internal) eliminates all indirection

- Access a field:
 - ~~read the metadata for the field offset~~
 - add that offset to the base object
 - cast the new pointer and load the field
- Store an instance on the **stack**:
 - ~~read the metadata for instance size~~
 - emit **alloca** instruction, to setup as needed

LLVM dynamically-sized things

- LLVM's support for **dynamically-sized** things on the **stack** has been good for Swift
- Swift makes heavy use of this for of **ABI-stable value types**:
 - you have local variable of some struct defined in an **ABI-stable library**
 - so you don't know it's size until **load time**
- Dynamic allocs can handle this nicely (with **minimal perf impact**)
- C++ desperately want all objects to have **compile-time-constant size**
- The notion of **sizeof/alignof** being **runtime values** just grates against the whole C++ model :(

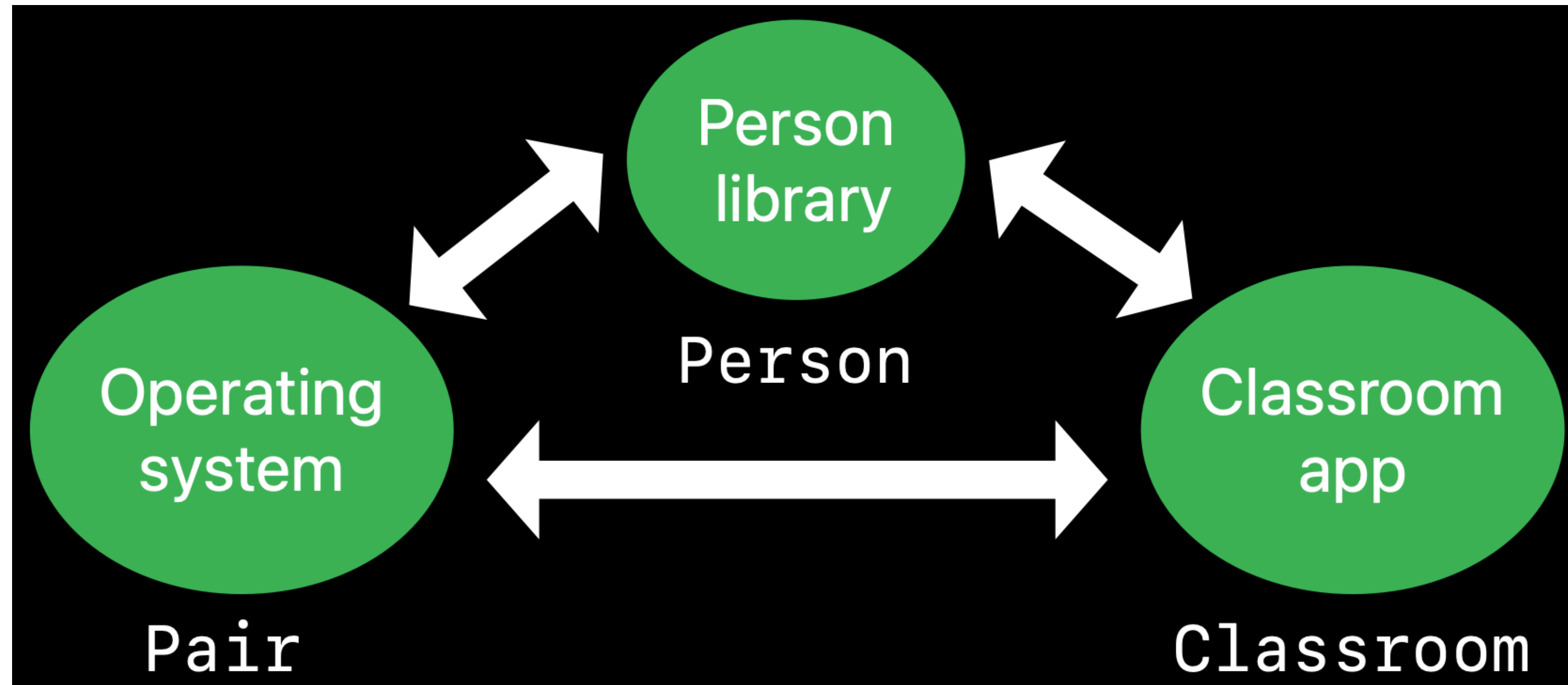
sfba.social/@dgregor79/111058162167016107

Resilience Domains

By explicitly modeling the **boundaries** between software modules that **evolve separately** vs. **together**:

- Swift is able introduce appropriate **indirections** across **separately-evolved** software modules
- while **optimizing away that indirection** within software modules that are **always compiled together**

Resilience Domains



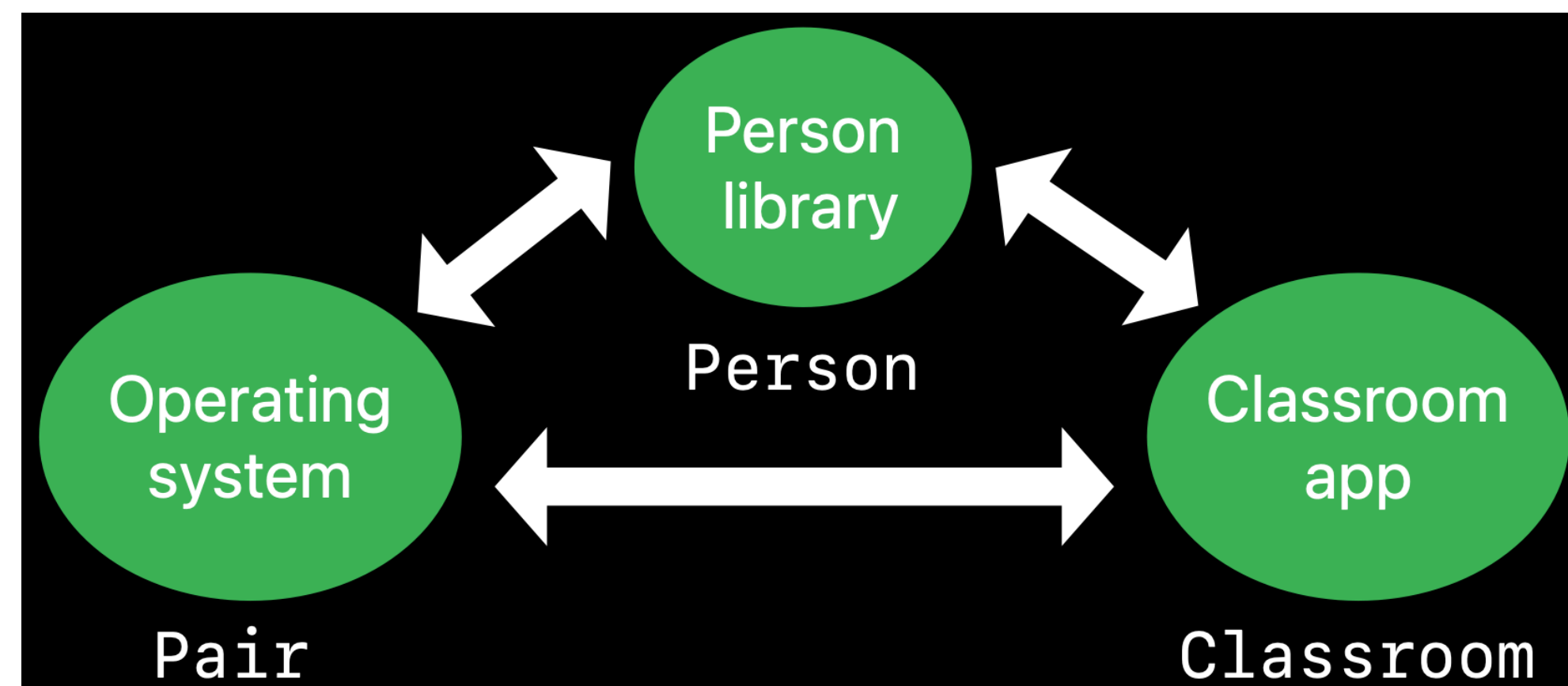
A **resilience domain** contains code that will always be **compiled together**.

A program can be composed of many different resilience domains.

Resilience domains control where the **costs** of ABI stability are paid.

Optimization and Resilience Domains

- **Across** resilience domains => maintain **stable** ABI
- **Within** a resilience domain => all implementation details are **fair game**
 - no indirections (direct access, no computed metadata)
 - no guarantees made
- Optimizations need to be aware of resilience **domain boundaries**



What if there is **only 1** resilience domain?

- There are no ABI-stable boundaries
 - all type layouts are *fixed* at **compile time**
 - stable ABI is completely irrelevant
- **You don't pay** for library evolution when you don't use it

Resilient Type Layout

By default, a type that is defined by a **dylib** has a **resilient layout**.

- **size**, **alignment**, **stride** of that type aren't **statically** known to the application
 - it must ask the **dylib** for that type's **value witness table** (at runtime!)
- **value witness table** is just the "vtable" of stuff you might want to know about any type
- this results in resilient types having to be "*boxed*" and passed around as a pointer
 - not quite... ([details](#) are interesting)
- **inside** the boundaries of the **dylib**
 - where all of its own implementation details are statically known
 - the type is handled as if it wasn't resilient (no indirections & perf costs)

Escape Hatches

Swift **ABI resilience** is the **DEFAULT** (for libraries).

You have to **Opt-Out** of Resilience, if you don't want it.

Escape Hatches

Trading future evolution for client **performance**:

- Explicit **inline** code exposed into the client
 - enables caller optimization, generic specialization
 - prevents any changes to the function's semantics

```
@inline public func swapped()  
{  
}
```

Escape Hatches

Trading future evolution for client **performance**:

- **Fixed-layout** types promise never to change layout
 - enables layout of types in client code
 - gives-up ability to add/remove/reorder fields

```
@fixedLayout
public struct Pair<First, Second>
{
}
```

Famous last words: "*This type will never need to change*"
-- author unknown 🤪

Swift Challenges

- **Large runtime** component (with compiler abilities)
 - Runtime type layout
 - Handling metadata at runtime
 - **Witness tables** & indirections
 - **Generics**<T> are particularly hard (**monomorphization**, **reabstraction**)
- Every language feature is a bit harder to design (resilient)
- Older Swift runtimes might not support new language features (OS targets)



Go in depth:

faultlore.com/blah/swift-abi/

Rust ABI Stability

Rust dev: "Can we have stable ABI?"

Rust dev: "We have stable ABI at home."

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Stable ABI at home: `#[repr(C)]`

The C ABI - Cost

Rust **FFI** itself is "zero cost" in that it has the same performance characteristics as C(++) calling C(++) code.

🐌 Where you can run into a **cost** is if you have to convert some of your internal data structures into a **C-ABI friendly representation**.

Eg.

If you use Rust strings **String/&str** but your FFI layer really wants UCS-2 strings (platform)

=> you'll pay the conversion cost in order to do the FFI itself

Status quo: `repr(C)` - fake it, till you make it 😊

- Using the C calling convention for function definitions and calls
- Using the C data layout for a type
- Definitions of C types like char, int, long, etc.
- Exporting an item under a stable linking symbol
- Limited to **C types**, mostly
- **No slices**

```
extern "C" fn  
#[repr(C)]  
std::ffi::c_*  
#[no_mangle]
```

```
u8, i64, c_int, c_char, ...  
&T, &mut T  
*const T, *mut T  
struct
```

The Future: calling convention and data layout

- Stable calling convention that supports common data types
 - `&str` `&[u8]` etc.
- Standard data layout that supports enums (with data), etc.
 - `enum` `struct`
- Stable layout guarantees of common standard library types
 - `Option` `Result` etc.

```
extern "crabi" fn  
  
#[repr(crabi)]  
  
#[repr(crabi)] in std
```

crABI

github.com/joshtripllett/rfcs/blob/text/3470-crabi.md

The Future: mechanism for exporting/importing, naming symbols and working with dynamic libraries

- Exporting items under stable linking symbols, supporting crates, modules, methods `#[export]`
- Use a crate as dynamic library, only importing the exported items `extern dyn crate`
- Cargo features for dynamically linking to Rust libraries `cargo dynamic deps`

The Future: trait objects/vtables and typeid

- A standard data layout for dynamic **trait objects** (v-tables)
 - `&dyn T` `&mut dyn T` `Box<dyn T>`
- A way of dealing with types that depend on global state (eg. **allocated objects**)
 - `Box` `Vec`
- **Stable typeid**
 - `Any` `catch_unwind`
- Access to std structures like maps through dynamic **std trait objects**
 - `&dyn HashMap` `etc.`

The Future: "*Don't stop me now!*" 🎵

- Turning parts of std into an opt-in dynamic library with a stable ABI ([std as dylib](#))
- [Tools](#) to help with detect/maintaining ABI compatibility and tools to debug ABI issues
- Store signatures, data layouts in binaries ([introspection](#))

ABI Cafe  

faultlore.com/abi-cafe/book/

Pair Your Compilers At The ABI Café:

faultlore.com/blah/abi-puns/

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Enums

Original code

```
#[non_exhaustive]
pub enum Foo {
    Variant1 { field: i64 },
    Variant2 { field: i8 },
    Variant3,
}
```

Generated code

```
pub static FOO_TY_DESC: TyDesc = TyDesc {
    size: 16,
    align: 8,
    drop: core::drop_wrapper::<Foo>,
    niche: Niche { .. },
};

pub static FOO_OFFSET_VARIANT1_FIELD: usize = 8;
pub static FOO_OFFSET_VARIANT2_FIELD: usize = 8;

pub fn get_discriminant_foo(
    val_ptr: *const u8
) -> usize;
pub fn set_discriminant_foo(
    val_ptr: *mut u8,
    discr: usize
);
```

Amanieu D'Antras

The path to a stable ABI for Rust

31:30 / 56:16



youtube.com/watch?v=MY5kYqWeV1Q

ABI: The Shiny Future

If I were to guess, I would say the  future of Rust stable ABI

- is not "One To Rule Them All" 

but

- MANY (for better or for worse...)

Rust Foundation 💰 - interop

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- [Evaluate approaches for seamless interop between C++ and Rust](#)
 - Tyler Mandry is the point-of-contact for project goal
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Rust Foundation joined INCITS in order to participate in the [C++ ISO standards process](#)

[Jon Bauman](#) attended the February [WG 21](#) meeting in Austria, where he tried to outline some the Rust/C++ interop strategy, as seen from the Rust side

Active Effort

Short term:

- Contribute engineering time to some of the key interop crates
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Meeting:

- (Feb 26) We held our first lang-team design meeting on the topic
- Notes: [Enabling seamless interop](#) 

Join the conversation

rust-lang.zulipchat.com

Anyone who is interested in the topic, please join the Rust Project **Zulip** server and start engaging on the **#t-lang/interop** channel

You'll probably also find some familiar C++ names there, too 😊

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- meet.jit.si/ferris-rules

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📖 Niko's recent (March 18) post on interop, from his "Rust in 2025" series:

smallcultfollowing.com/babysteps/blog/2025/03/18/lang-interop-extensibility

Open Discussion

What does **interop** mean for you?

What are the **interop** requirements of your project?
(constraints, limitations, priorities, goals)



Duck-Tape Chronicles

Rust/C++ Interop

Episode 1 – The ABI Menace

Episode 2 – Attack of the Codegen

SOON

 @ciura_victor

 @ciura_victor@hachyderm.io

 @ciuravictor.bsky.social

Victor Ciura

~~Principal Engineer~~

Rambling Idiot

Rust Tooling @ Microsoft