

FFI in Rust

Lessons from OpenSSL

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Basics

What is FFI?

“A foreign function interface (FFI) is a mechanism by which a program written in one programming language can call routines or make use of services written in another.”

Why FFI?

Lots of code has been written in languages that aren't Rust!

- ▶ Use Rust to accelerate portions of programs written in higher level languages. (jni, neon, ruru)
- ▶ Expose a C interface for your Rust library. (regex)
- ▶ Interact with libraries exposing C APIs. (openssl, curl, rusqlite)

Example

```
struct foo {  
    long a;  
    char *b;  
};  
int fizzbuzz(const struct foo *f);
```

```
#[repr(C)]  
struct foo {  
    a: c_long,  
    b: *mut c_char,  
}  
extern {  
    fn fizzbuzz(f: *const foo) -> c_int;  
}
```

openssl-sys

-sys?

A '-sys' crate provides a direct transcription of a C API into Rust - think of them as Rust's version of header files.

Also responsible for linking to the C library.

Bindgen

Bindgen uses libclang to parse C headers and produce Rust definitions from them.

```
$ bindgen fizzbuzz.h
/* automatically generated by rust-bindgen */

#![allow(dead_code,
          non_camel_case_types,
          non_upper_case_globals,
          non_snake_case)]
#[repr(C)]
#[derive(Copy, Clone)]
#[derive(Debug)]
pub struct foo {
    pub a: ::std::os::raw::c_long,
    ...
}
```

Caveats

While Bindgen is fantastic to quickly get Rust bindings for a header, it has some drawbacks:

- ▶ libclang is a fairly heavyweight dependency.
- ▶ It can be a bit verbose, particularly when system headers are included.
- ▶ It produces definitions valid in the environment it's run.

rust-openssl does not use bindgen for its bindings.

The Manual Approach

You will get things wrong if you try to do it by hand.

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```
extern {  
    pub fn SSL_CTX_use_certificate_file(  
        ctx: *mut SSL_CTX,  
        cert_file: *const c_char,  
        file_type: c_int)  
        -> c_int;  
  
    pub fn SSL_CTX_use_certificate_chain_file(  
        ctx: *mut SSL_CTX,  
        cert_chain_file: *const c_char,  
        file_type: c_int) // OOPS  
        -> c_int;  
}
```

ctest

The 'ctest' crate will check that your bindings correctly correspond to the C definitions.

```
error: incompatible pointer types returning 'int  
      (SSL_CTX *, const char *)' (aka 'int (struct  
      ssl_ctx_st *, const char *)') from a function  
      with result type 'int (*)(SSL_CTX *, const  
      char *, int)' (aka 'int (*)(struct ssl_ctx_st *,  
      const char *, int)')  
      [-Werror,-Wincompatible-pointer-types]
```

```
return SSL_CTX_use_certificate_chain_file;  
      ~~~~~
```

Version/Feature Detection

OpenSSL releases are not binary compatible, but 1.0.1, 1.0.2, and 1.1.0 are all supported by rust-openssl. Features have been added and removed; structs have been made opaque.

OpenSSL's feature set can be customized at compile time. Constants, functions, and even struct fields are removed!

```
struct ssl_ctx_st {  
    // ...  
    int references;  
    // ...  
# ifndef OPENSSL_NO_TLSEXT  
    unsigned alpn_client_proto_list_len;  
    // ...  
# endif  
    // ...  
};
```

Version/Feature Detection

The `opensslv.h` header contains `#defines` for the version and all compile time feature flags. Parse it in a build script and turn those into Rust `cfgs`!

```
#[repr(C)]
pub struct SSL_CTX {
    // ...
    pub references: c_int,
    // ...
    #[cfg(all(not(sslconf = "OPENSSL_NO_TLSEXT"),
              ssl102))]
    alpn_client_proto_list_len: c_uint,
    // ...
}
```

openssl

Ownership

Figuring it Out

Ownership semantics are as important to C libraries as they are in Rust, but handled implicitly.

If you're lucky, your library defines ownership conventions:

- ▶ OpenSSL - get1/get0, set1/set0, add1/add0
- ▶ Core Foundation - The Create Rule

Figuring it Out

These are probably not enough.

The majority of OpenSSL's APIs do not use the get1/get0 convention!

Some functions are special snowflakes - `X509_STORE_add_cert` takes ownership of its argument even when an error is encountered.

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The Source is the Only Source of Truth.

Translating

openssl takes a dual-type approach - think Path/PathBuf:

```
pub struct X509Ref(UnsafeCell<()>);

pub struct X509(*mut ffi::X509);

impl Drop for X509 { /* ... */ }

impl Deref for X509 {
    type Target = X509Ref;
    // ...
}

impl DerefMut for X509 { /* ... */ }
```

Fun With Pointers

```
impl X509Ref {
    pub unsafe fn from_ptr<'a>(ptr: *mut ffi::X509)
                                -> &'a X509Ref {
        &*(ptr as *mut _)
    }

    pub fn as_ptr(&self) -> *mut ffi::X509 {
        self as *const _ as *mut _
    }
}

impl Deref for X509 {
    fn deref(&self) -> &X509Ref {
        unsafe { X509Ref::from_ptr(self.0) }
    }
}
```

Enums

Rust enums are not like C enums!

Callbacks

Never forget about panics! Unwinding through non-Rust is undefined behavior.

Version/Feature Detection

Recall:

- ▶ Three versions of OpenSSL supported. Each adds and removes functionality.
- ▶ Features can be disabled at OpenSSL build time.

Approach:

- ▶ Cargo features for each OpenSSL version. Each enables functionality exposed in that version *when linking against it*. Crates can ask openssl-sys which version has been detected in a build script.
- ▶ Features that are disabled by OpenSSL build flags are simply removed when those flags are set.

Stay True to the Library

... But Not Always

OpenSSL's default TLS configuration is a **nightmare**.

On the client side, certificate validation is disabled entirely by default (!!). Even if you turn that on, hostname validation is either not supported at all or must be enabled and configured separately.

On the server side, ephemeral key exchange is disabled by default. The steps to enable ECDHE are different in *each* of the OpenSSL versions we support!

On both sides, SSLv2 and SSLv3 will be enabled by default (maybe), and the default cipher suite list is larger than recommended.

... But Not Always

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If you are using an `SslContext` directly, you are probably doing it wrong.

Clients - `SslConnector` provides a configuration modeled after Python 3.6's.

Servers - `SslAcceptor` provides configurations modeled after the modern and intermediate profiles of Mozilla's Server Side TLS recommendations.

Wrapup

Questions?