C++ now

2025

Zngur

Simplified Rust/C++ Integration

David Sankel

Zngur

Simplified Rust/C++ Integration

David Sankel | Principal Scientist
Software Technology Lab

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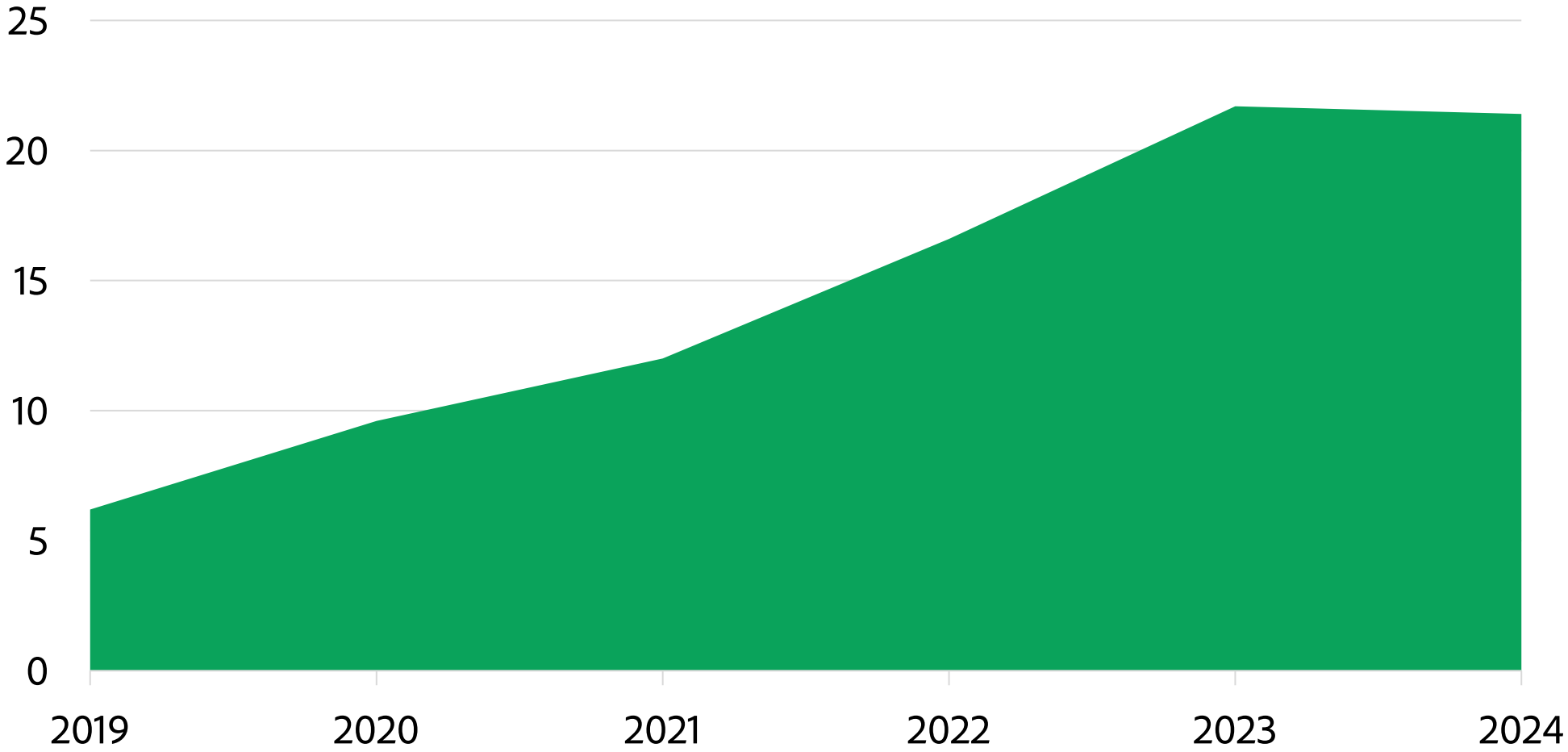
Why is Rust/C++ interop interesting?

On balance, Rust is a better tech for most applications

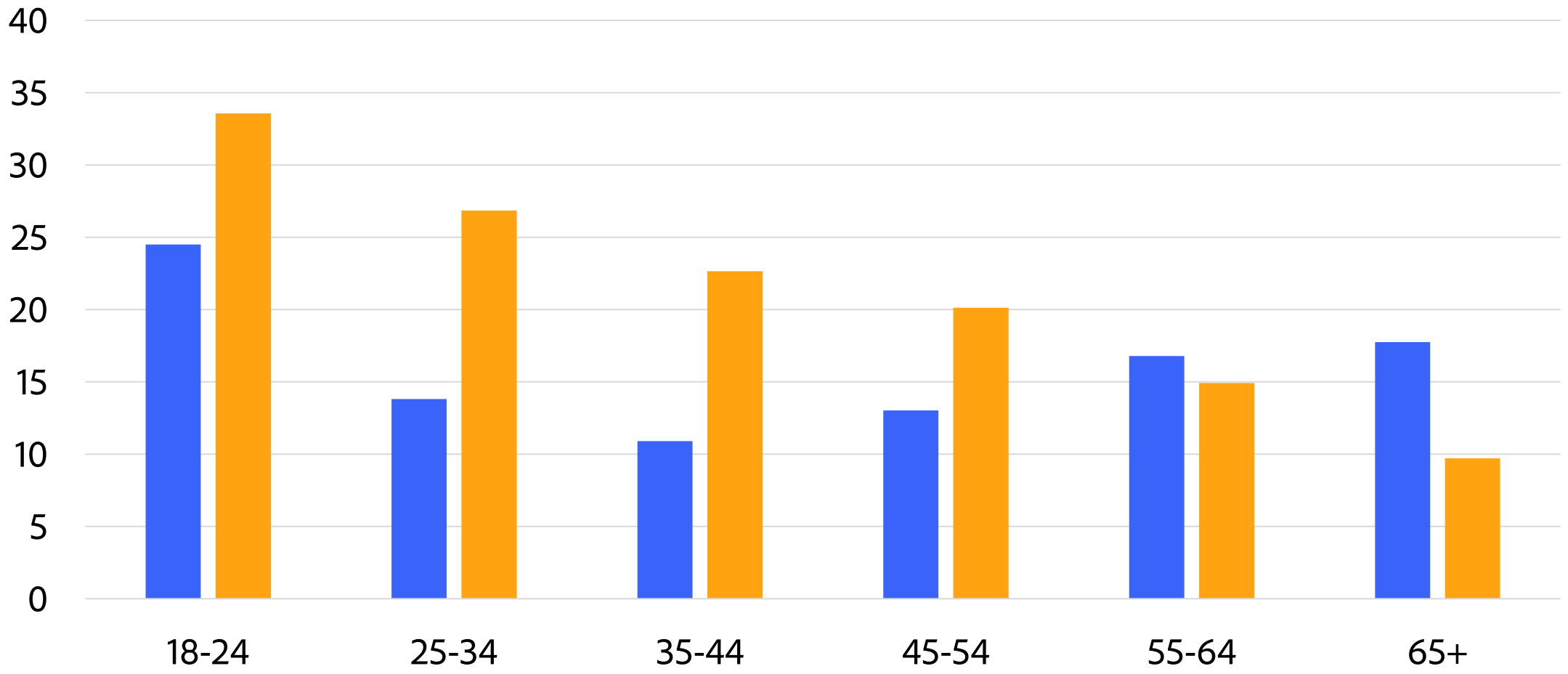
- Powerful language mechanisms
  - enums (language variants)
  - pattern matching
  - traits (~checked concepts)
- Excellent procedural-macro driven libraries
- Engineering features (documentation, side-by-side tests, etc.)
- Excellent tooling
- Ergonomics

Trends in programming languages are clear

Percentage of C++ developers also using Rust



Age vs. Percentage of Developers Wanting to use C++ vs. Rust



Evolving expectations for software safety

- Ensuring customer security against malicious exploitation is paramount.
- Adoption of memory-safe languages has the potential to reduce vulnerabilities by ~70% for new code
- Memory safety legislation is on the horizon

C++ and memory safety

- Great improvements coming…
  - Hardened standard library
  - Profiles will do something, maybe, someday to help mitigate risk
- However…
  - “Safe C++” is not moving forward
  - Safety theater abounds
  - There’s little hope

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Great! Go use Rust and leave us alone.

But all that C++ code out there!

- There's a lot
  - Photoshop alone has >30 million lines of C++
  - Brian Cantwell Smith estimated 100 billion lines of C++ in 1997
  - Sage McEnry estimated 2.8 trillion lines of all code in 2020
- That's more than the number of stars in the Milky Way

We're using that code, and we're not going to rewrite most of it.

Rust/C++ interop

What do we want in Rust/C++ interop?

- Principled design
- Good ergonomics on both sides
- Automate as much as we can
- Complete
- Practical

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Limitations of current solutions

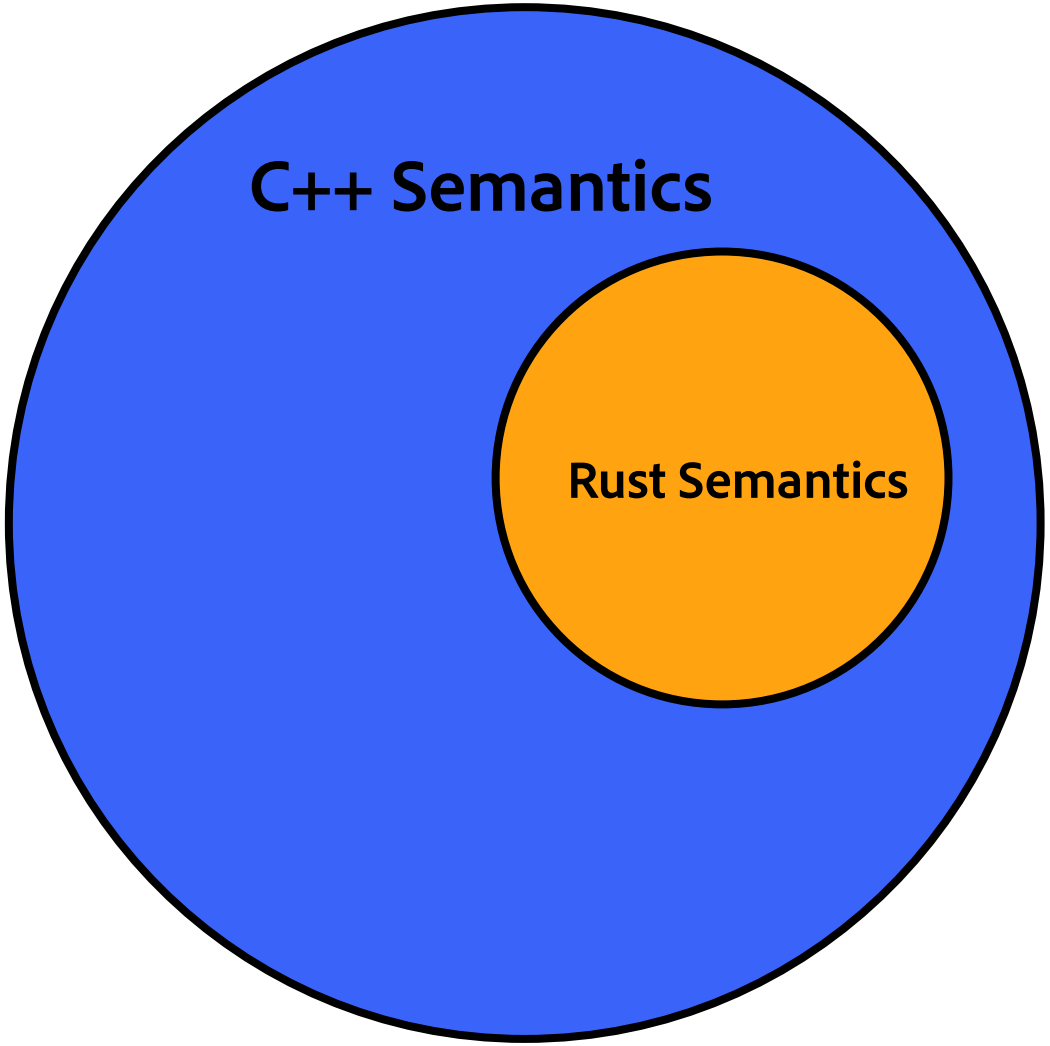
- capigen—write C APIs in Rust and generate headers
  - Requires C++ scaffolding to make decent C++ interfaces
  - Lots of complicated, unsafe code on the Rust side
  - Dealing with callbacks, allocators, etc. is painful
- cxx—write bridge code in Rust and make smart C++/Rust translations
  - "intentionally restrictive and opinionated"
  - Lacks core functionality, like function pointers
- autocxx—automate most bridging code
  - Performance (UniquePtr everywhere) and ergonomics (Pin everywhere) issues

Zngur

- /zængɑr/
- Created by Hamidreza Kalbasi
- https://github.com/HKalbasi/zngur

"[T]ries to expose arbitrary Rust types, methods and functions, while preserving its semantics and ergonomics as much as possible. Using Zngur, you can use arbitrary Rust crates in your C++ code as easily as using it in normal Rust code, and you can write idiomatic Rusty APIs for your C++ library inside C++."

Zngur's driving principle: Rust is a subset of C++ Semantics



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Example | Result errors

Rust

```
enum Result<T, E> {
  Ok(T),
  Err(E),
}
```

≈

C++

```
template<typename T>
struct Ok{ T t; };

template<typename E>
struct Err{ E e; };

template<typename T, typename E>
using Result = std::variant<Ok<T>, Err<E>>;
```

Example | exceptions

Rust

No equivalent

C++

```
throw std::runtime_error("Some error");
```

Example | memcopy relocation

Rust

```
let mut x = SomeType::new();
mem::replace(
    &mut x,
    SomeType::new());
```

C++

```
// C++23: SomeType must be “trivially copyable”
// C++26: SomeType must be “trivially relocatable”

auto x = SomeType();
alignas(SomeType) char buffer[sizeof(SomeType)];
SomeType* x_new = new (buffer) SomeType();
std::memcpy(&x, x_new, sizeof(SomeType));
```

Example | memcopy relocation

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```

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Example | General moves

C++

```
class SomeType {
  public:
    SomeType(SomeType&&);
    SomeType& operator=(SomeType&&);
  private:
    std::array<int, 64> buffer;
    int * selection; // points to buffer element
};
```

Rust

No equivalent

Example | General moves

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Moves in Rust

- Moves in Rust, unlike C++, are always memcpy
- Rust uses moves in assignment, passing arguments by value, and returning values from functions
  - Note that actual moves may be optimized out

Important consequence: C++ objects cannot be put on a Rust stack!

Example | law of exclusivity

C++

```
void f(int& x, int& y);

int main() {
  int i = 3;
  f(i, i);
}
```

Rust

```
fn f(x: &mut i32, y: &mut i32) { /*... */ }

fn main() {
    let mut a = 3;
    f(&mut a, &mut a); // error: law of exclusivity
}
```

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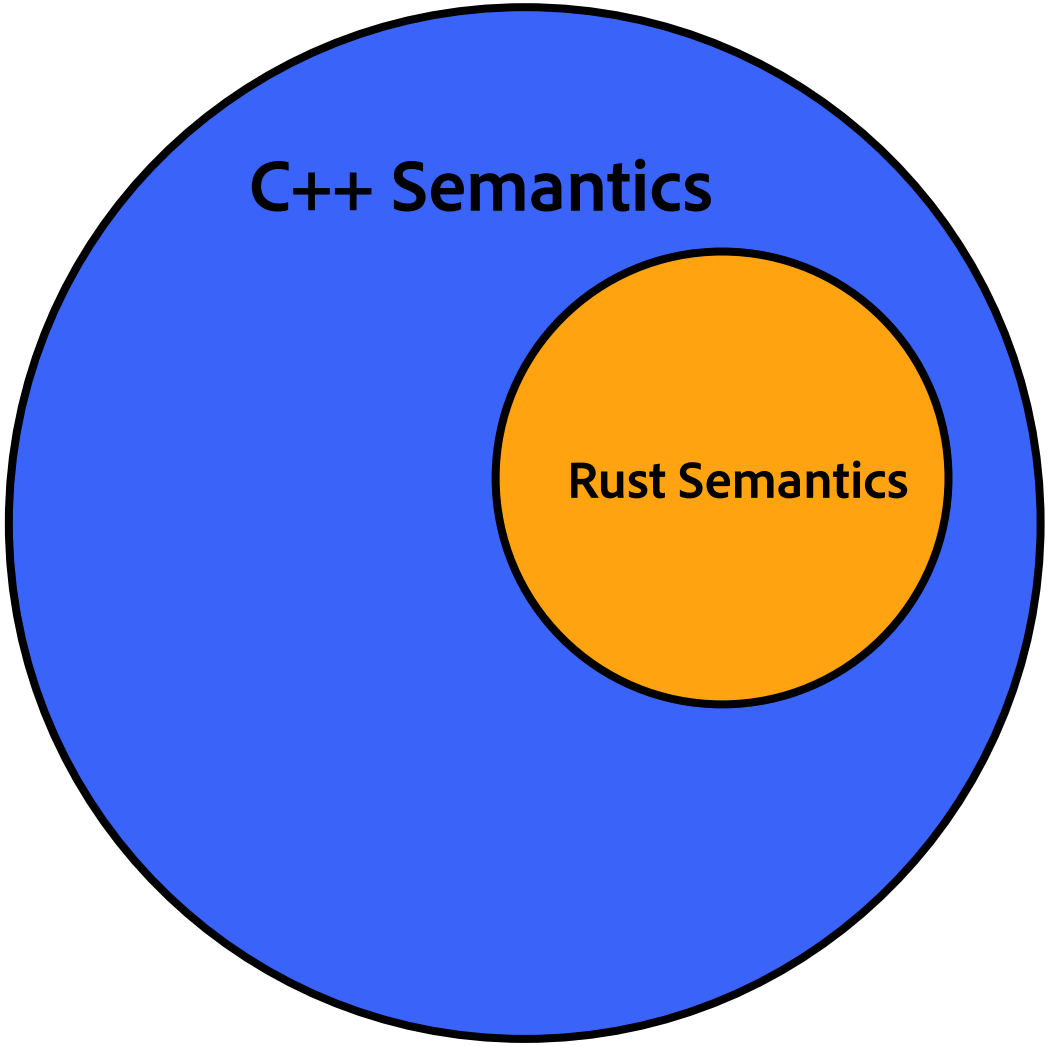
Zngur's driving principle: Rust is a subset of C++ Semantics



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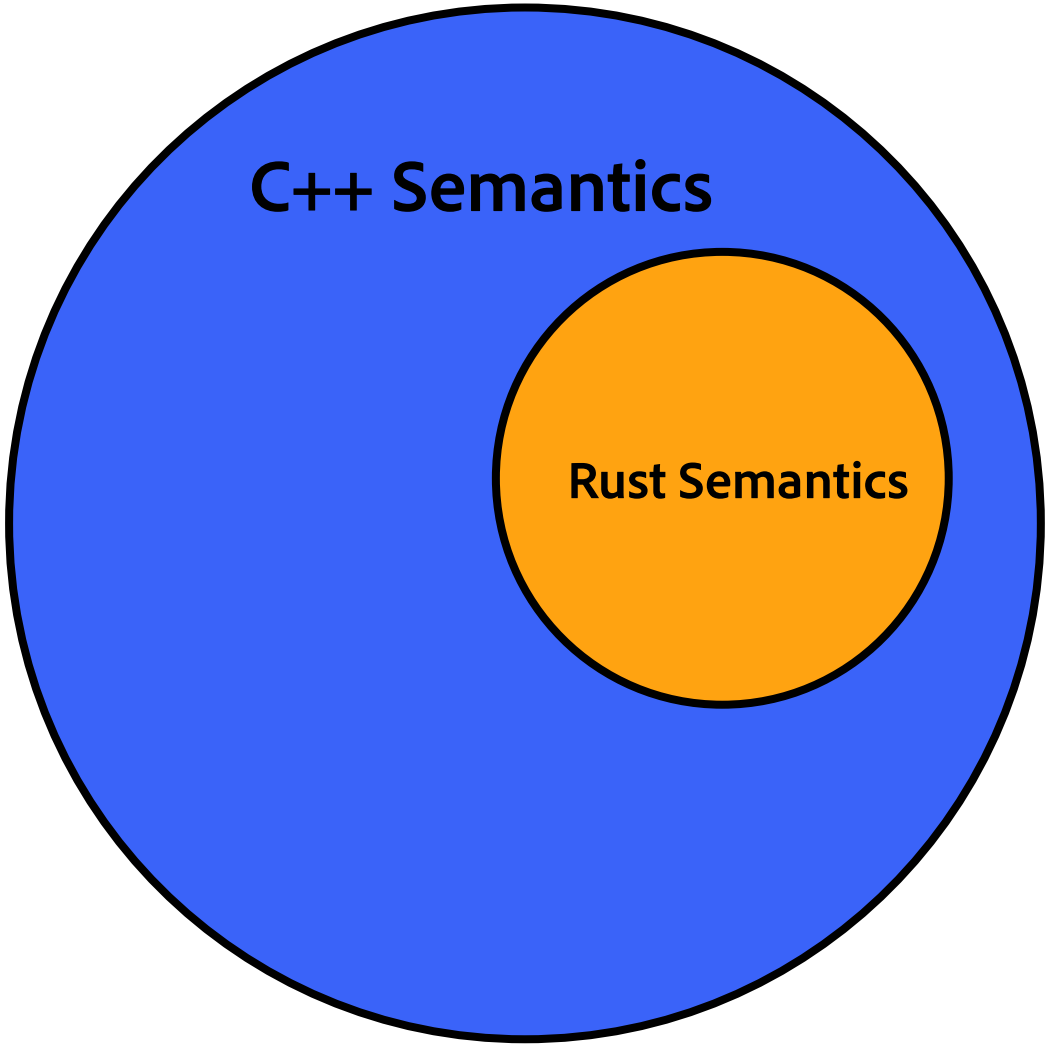


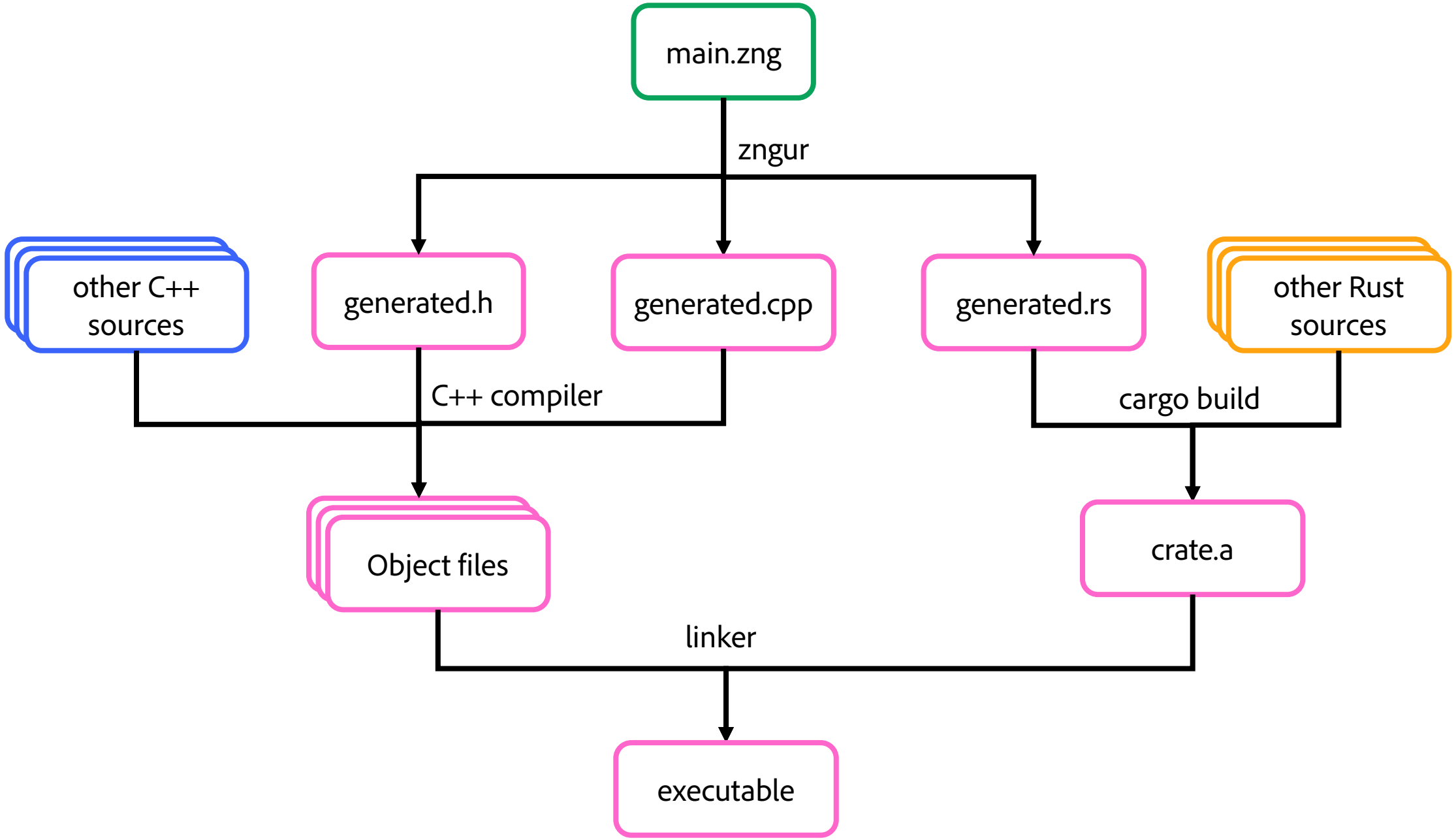
Observations

- Rust is less expressive than C++
- Rust's complexity lies in how its semantic subset is drawn

Implications

- Using Rust code from C++ should be easy
- Using C++ from Rust will be more challenging

Zngur architecture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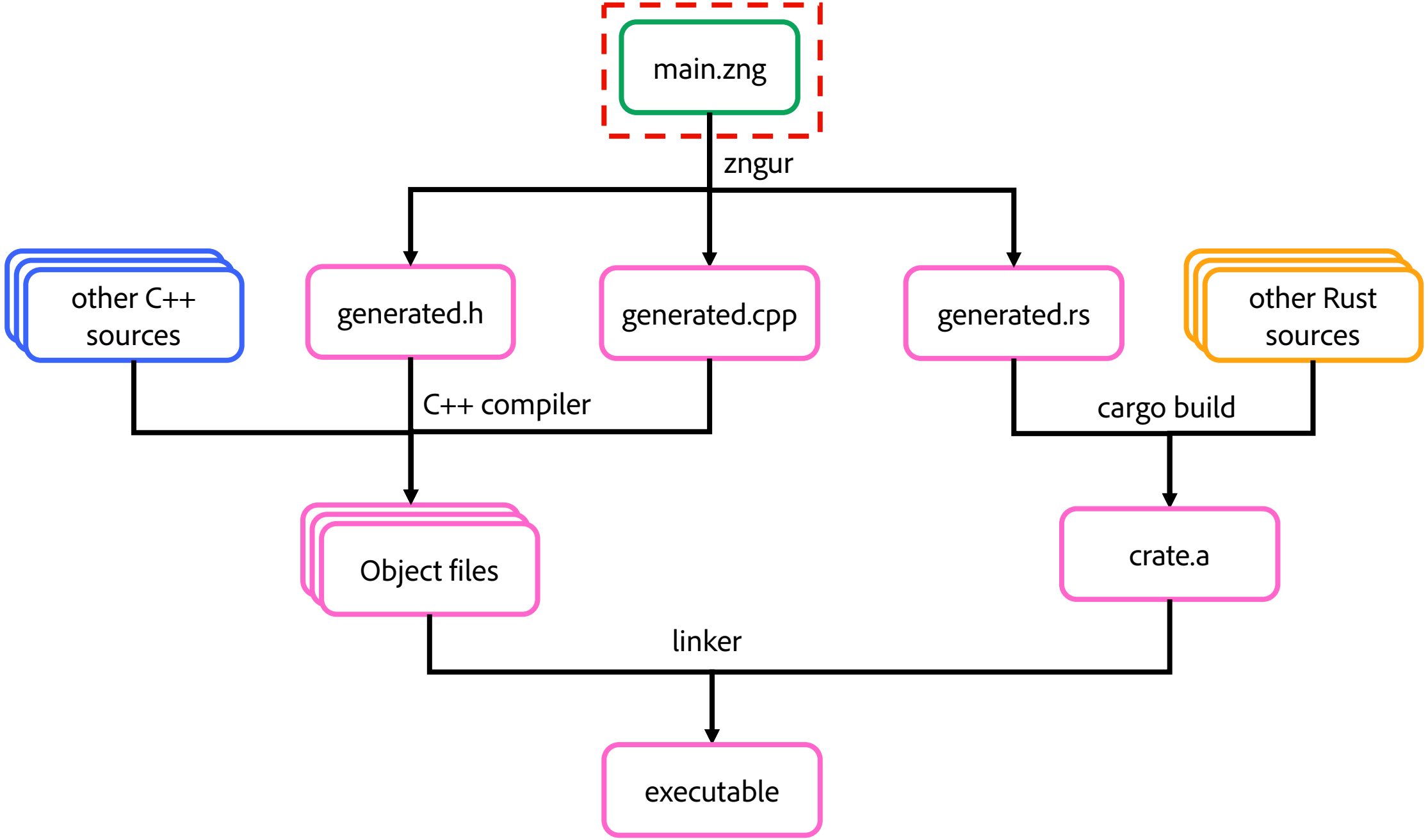
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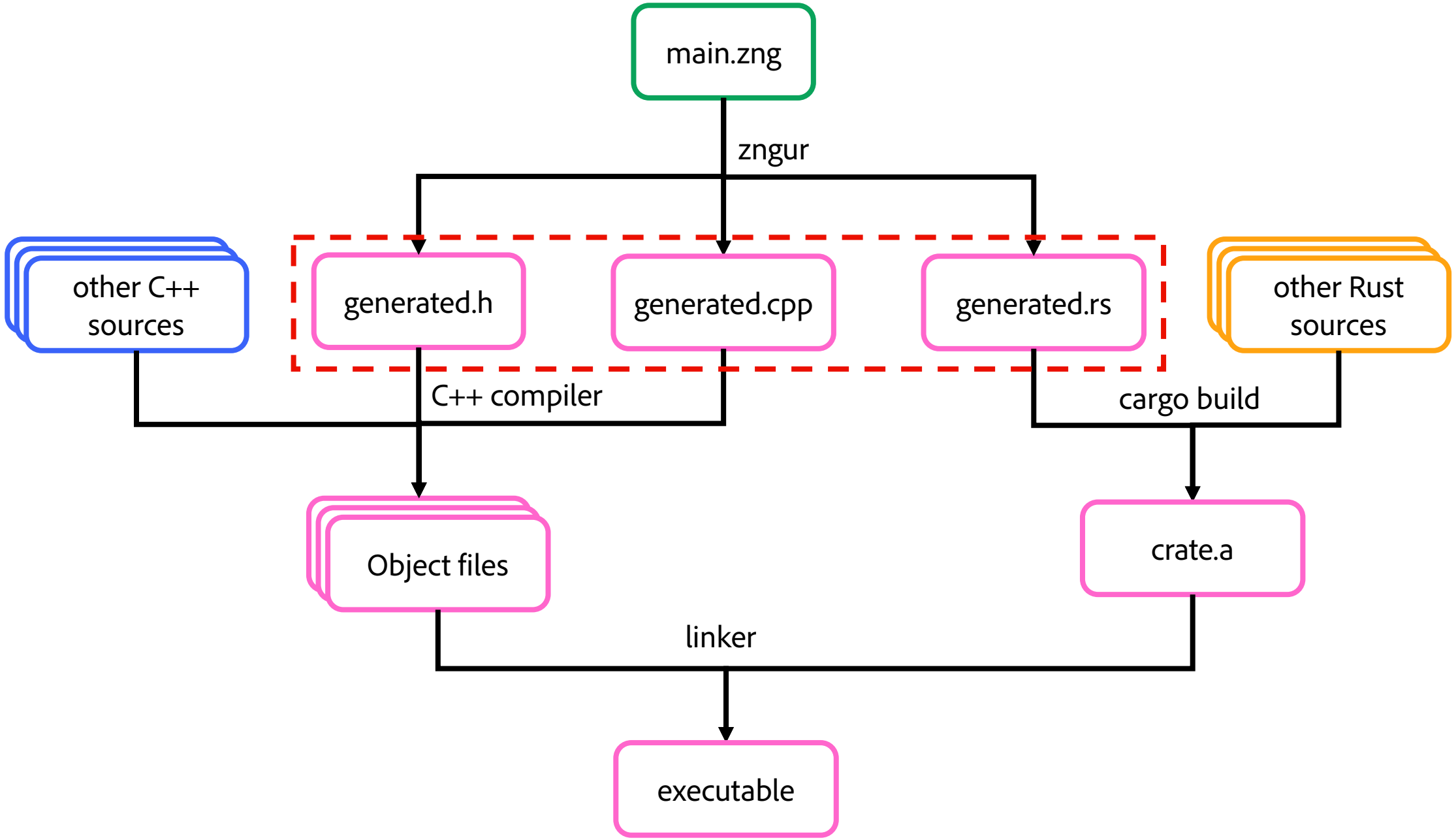
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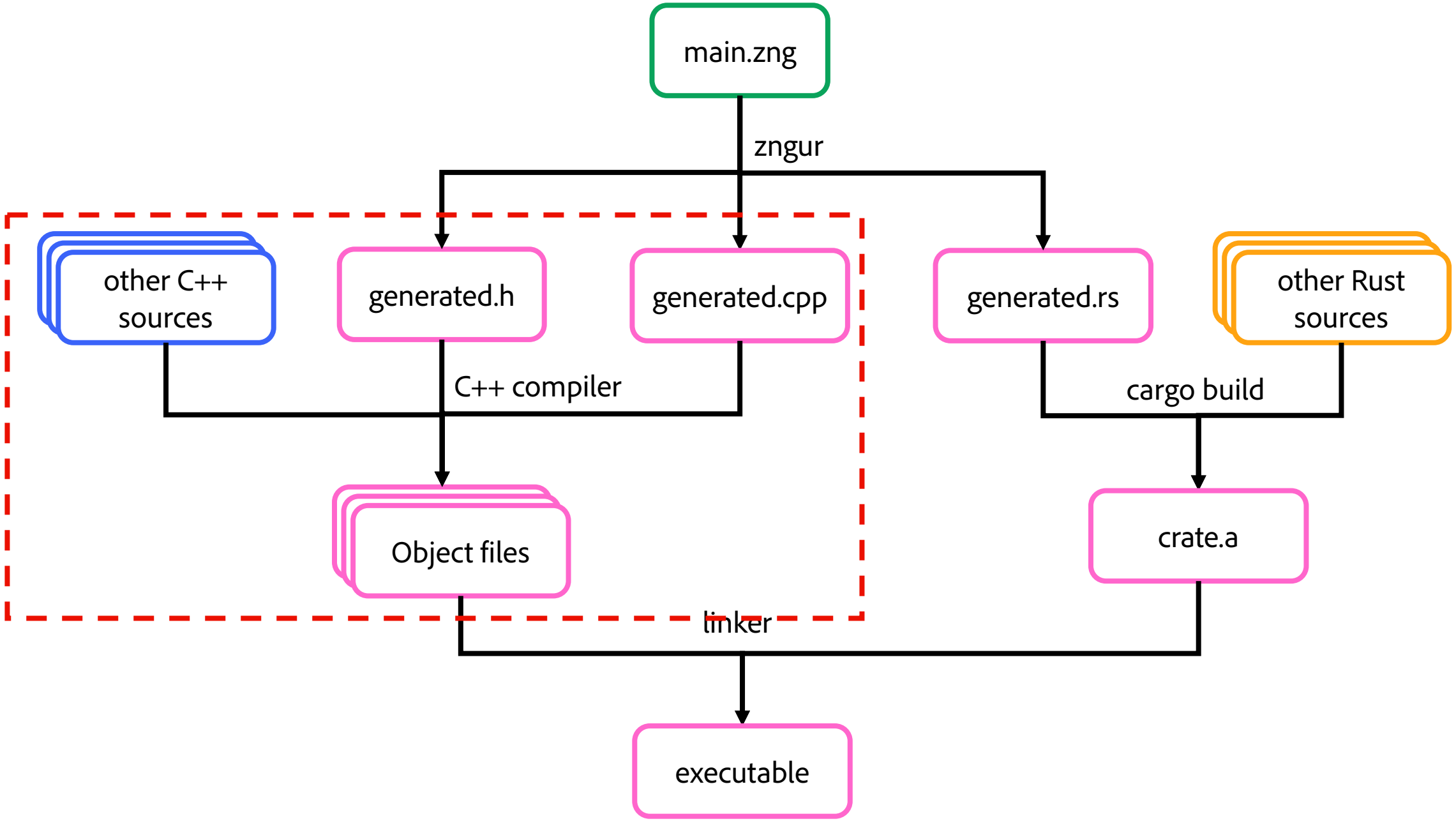
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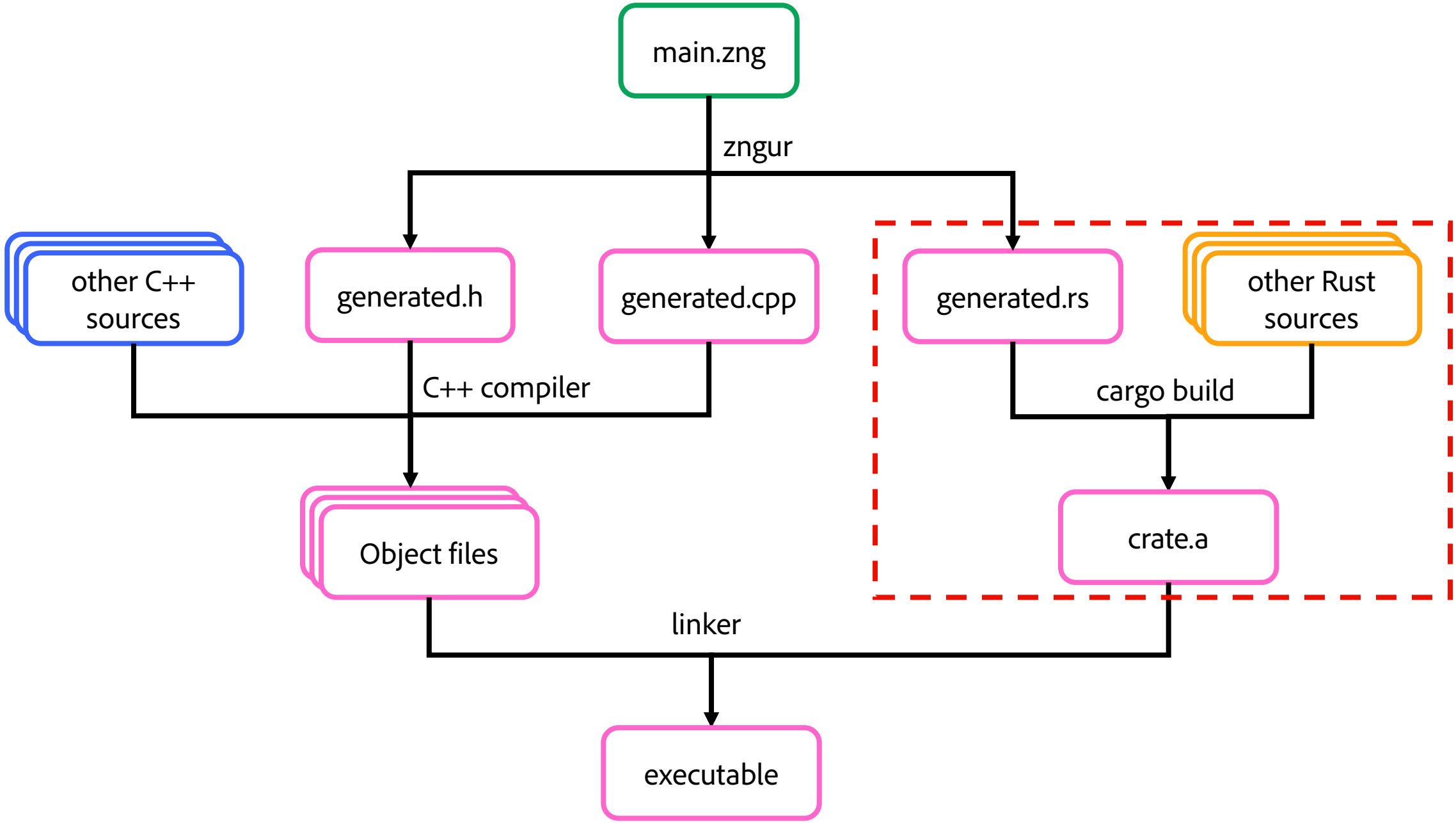
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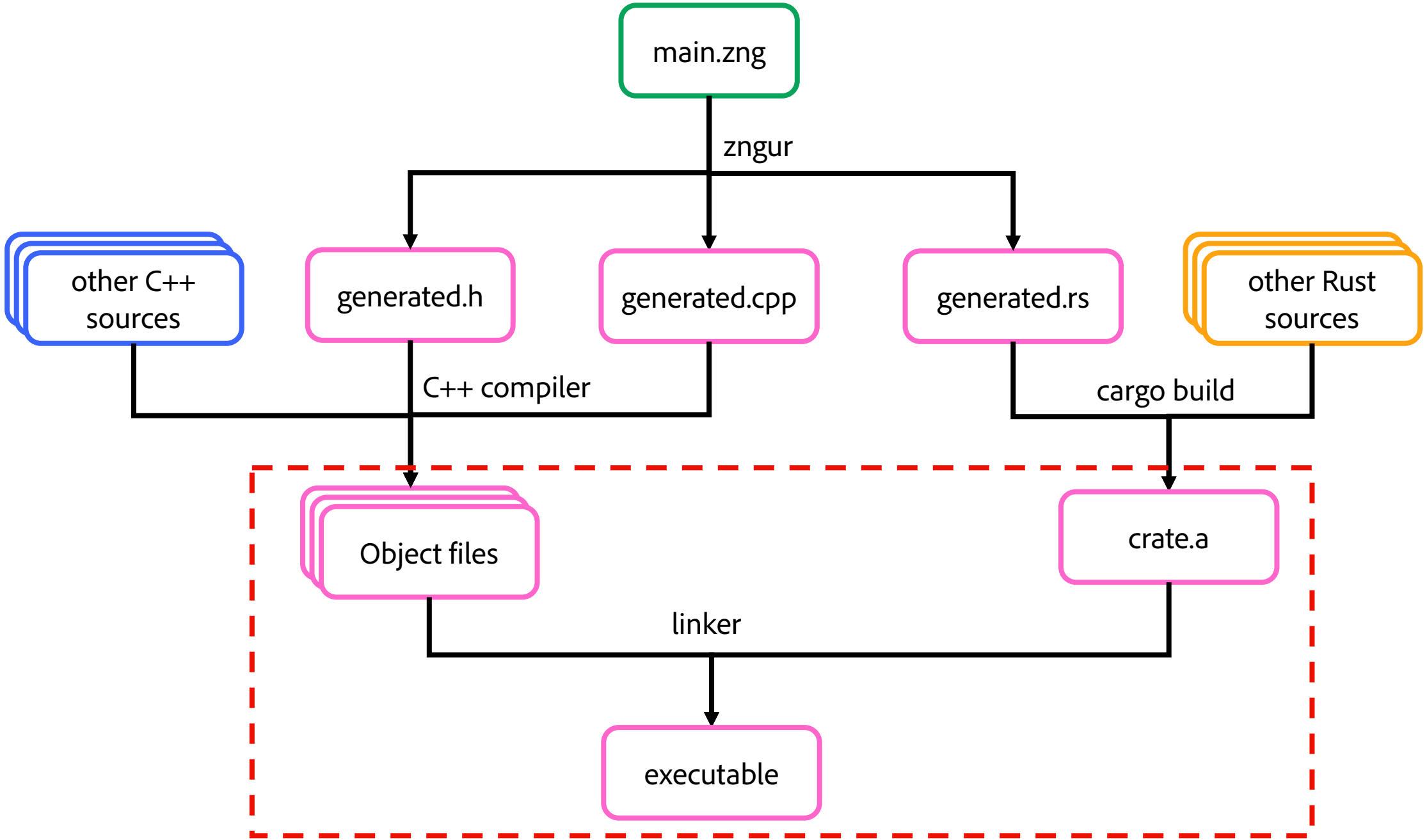
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main.zng

main.zng

- Defines the interface boundary between C++ and Rust
- Self-contained
- Rust-like syntax
- Generatable

```
type str {
    wellknown_traits(?Sized);

    fn as_ptr(&self) -> *const u8;
    fn len(&self) -> usize;
    fn to_string(&self) -> ::std::string::String;
}

extern "C++" {
    impl crate::Inventory {
        fn new_empty(u32) -> crate::Inventory;
        fn add_banana(&mut self, u32);
        fn add_item(&mut self, crate::Item);
    }
}
```

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Rust → C++

Rust → C++

```
// lib.rs
#[derive(Clone)]
pub struct Person {
    name: String,
    age: u32,
}

impl Person {
    pub fn new(name: String, age: u32) -> Self {
        Self { name, age }
    }
    pub fn name(&self) -> &str {
        &self.name
    }
    pub fn age(&self) -> u32 {
        self.age
    }
}
```

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        self.age
    }
}
```

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Rust → C++

```rust
// lib.rs
#[derive(Clone)]
pub struct Person {
    name: String,
    age: u32,
}

impl Person {
    pub fn new(name: String, age: u32) -> Self {
        Self { name, age }
    }
    pub fn name(&self) -> &str {
        &self.name
    }
    pub fn age(&self) -> u32 {
        self.age
    }
}
```

```
// main.zng
type crate::Person {
    #layout(size = 32, align = 8);

    fn new(::std::string::String, u32) -> crate::Person;
    fn name(&self) -> &str;
    fn age(&self) -> u32;

    // Clone methods
    fn clone(&self) -> crate::Person;
}
```

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Rust → C++ | initialization

```
// main.zng
type crate::Person {
   #layout(size = 32, align = 8);

   fn new(::std::string::String, u32) -> crate::Person;
   fn name(&self) -> &str;
   fn age(&self) -> u32;

   // Clone methods
   fn clone(&self) -> crate::Person;
}
```

```
// generated.h
namespace rust::crate {
class Person {
  public:
    //...
    // Creates an uninitialized `Person` object
    Person();
    //...
};
}
```

- Rust objects may be created uninitialized
- User code is responsible for initialization prior to use.
- Failure to initialize results in a segmentation fault (defined behavior).

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Rust → C++ | copy/clone

```
// main.zng
type crate::Person {
    #layout(size = 32, align = 8);

    fn new(::std::string::String, u32) -> crate::Person;
    fn name(&self) -> &str;
    fn age(&self) -> u32;

    // Clone methods
    fn clone(&self) -> crate::Person;
}
```

```
// generated.h
namespace rust::crate {
class Person {
  public:
    //...
    // Implicit copy operations disabled
    Person(const Person& other) = delete;
    Person& operator=(const Person& other) = delete;
    //...
    Person clone() const;
    //...
};
}
```

Copying objects (cloning in Rust) is explicit unless the type supports bitwise-copying. This carries over to the C++ interface.

Rust → C++ | methods

```
// main.zng
type crate::Person {
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    fn new(::std::string::String, u32) -> crate::Person;
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    // Clone methods
    fn clone(&self) -> crate::Person;
}
```

```
// generated.h
namespace rust::crate {
class Person {
  public:
    //...
    ::rust::Ref<::rust::Str> name() const;
    ::uint32_t age() const;
    // ...
};
}
```

Methods work as you might expect

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Rust references and C++ references

```
::rust::Ref<::rust::Str> name() const;
```

- Rust references are different from C++ references
  - Rust's mutable references (&mut) are exclusive. C++'s non-const references are not exclusive.
  - Rust's shared references (&) imply value stability. C++'s const references do not.
  - Rust references may be "fat" (e.g. encode additional information). C++'s references are always "thin".
- To account for differences, Zngur provides Ref and RefMut templates
  - Specializations are generated for every interface-layer type
  - Specializations include the pointer and (for dynamically-sized types) additional metadata
  - Specializations include appropriate member functions for the pointed-to objects

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Working with Rust references in C++

```
using namespace rust;
using namespace rust::crate::Person;

int main() {
    Person p = Person::new_( /*...*/ );
    {
        Ref<Person> pRef(p);
        std::cout << pRef.age() << std::endl;
    }
    {
        RefMut<Person> pRef(p);
        std::cout << pRef.age() << std::endl;
    }
}
```

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The C++ code must uphold that p is not modified while pRef exists

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Methods can be called on Ref objects directly.

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    Person p = Person::new_( /*...*/ );
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    }
    {
        RefMut<Person> pRef(p);
        std::cout << pRef.age() << std::endl;
    }
}
```

The C++ code must uphold:

a) *There is at most one RefMut referencing p at any given time.*

b) *p may only be modified through pRef.*

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Rust → C++ | additional function syntax

```
// main.zng
type crate::Person {
    #layout(size = 32, align = 8);

    fn new(::std::string::String, u32) -> crate::Person;
    fn name(&self) -> &str;
    fn age(&self) -> u32;

    // Clone methods
    fn clone(&self) -> crate::Person;
}
```

```
// generated.h
namespace rust::crate {
class Person {
  public:
    //...
    static ::rust::Ref<::rust::Str> name(
        ::rust::Ref< ::rust::crate::Person >);

    static ::uint32_t age(
        ::rust::Ref< ::rust::crate::Person >);
    // ...
};
}
```

Methods are provided as static functions as well for Rust syntax consistency

Adobe

Rust → C++ | layout

```
// main.zng
type crate::Person {
    #layout(size = 32, align = 8);

    fn new(::std::string::String, u32) -> crate::Person;
    fn name(&self) -> &str;
    fn age(&self) -> u32;

    // Clone methods
    fn clone(&self) -> crate::Person;
}
```

- The layout directive declares the size and alignment of the Rust type
- Required for placing Rust objects on the C++ stack
- When incorrect, *generated.rs* will not compile.
- Hovering over a type will give you this information in a Rust IDE.

C++ → Rust

C++ → Rust is more complex

- Requires adapter code for most things
- C++'s object model generally isn't directly representable in Rust

Adobe

Expose a C++ function to Rust

```
// main.zng

type crate::Person {
    //...
}

extern "C++" {
    fn older(&crate::Person) -> crate::Person;
}
```

Adobe

Expose a C++ function to Rust

```
// main.zng

type crate::Person {
    //...
}

extern "C++" {
    fn older(&crate::Person) -> crate::Person;
}
```

Adobe

Expose a C++ function to Rust

```
// main.zng

type crate::Person {
    //...
}

extern "C++" {
    fn older(&crate::Person) -> crate::Person;
}
```

```
// generated.h

namespace rust::exported_functions {
    ::rust::crate::Person older(
        ::rust::Ref< ::rust::crate::Person >);
}
```

```
// impl.cpp
using namespace rust::crate;
using namespace rust;

Person rust::exported_functions::older(Ref<Person> p) {
  return Person::new_(p.name().to_string(),
                      p.age()+5);
}
```

Adobe

Expose a C++ function to Rust

```
// main.zng

type crate::Person {
    //...
}

extern "C++" {
    fn older(&crate::Person) -> crate::Person;
}
```

```
// generated.h

namespace rust::exported_functions {
    ::rust::crate::Person older(
        ::rust::Ref< ::rust::crate::Person >);
}
```

```
// impl.cpp
using namespace rust::crate;
using namespace rust;

Person rust::exported_functions::older(Ref<Person> p) {
  return Person::new_(p.name().to_string(),
                      p.age()+5);
}
```

Adobe

Expose a C++ object to Rust

C++

```
struct People {
  std::vector<rust::crate::Person> data;
};

// ...
 ::People people;
people.data.push_back( Person::new_(
    Str::from_char_star("Beyoncé").to_string(),
    43));
people.data.push_back( Person::new_(
    Str::from_char_star("Jay-Z").to_string(),
    55));
print_people(people);
```

Adobe

Expose a C++ object to Rust

C++

```
struct People {
  std::vector<rust::crate::Person> data;
};
```

```
// ...
 ::People people;
people.data.push_back( Person::new_(
    Str::from_char_star("Beyoncé").to_string(),
    43));
people.data.push_back( Person::new_(
    Str::from_char_star("Jay-Z").to_string(),
    55));
print_people(people);
```

Expose a C++ object to Rust

C++

```
struct People {
  std::vector<rust::crate::Person> data;
};

// ...
 ::People people;
people.data.push_back( Person::new_(
    Str::from_char_star("Beyoncé").to_string(),
    43));
people.data.push_back( Person::new_(
    Str::from_char_star("Jay-Z").to_string(),
    55));
print_people(people);
```

Adobe

Expose a C++ object to Rust

C++

```
struct People {
  std::vector<rust::crate::Person> data;
};

// ...
 ::People people;
people.data.push_back( Person::new_(
    Str::from_char_star("Beyoncé").to_string(),
    43));
people.data.push_back( Person::new_(
    Str::from_char_star("Jay-Z").to_string(),
    55));
print_people(people);
```

Rust

```
pub fn print_people(p: &People) {
    println!("{} people:", p.len());
    for i in 0..p.len() {
        println!("- {}", p.index(i).name())
    }
}
```

Zngur

```
mod crate {
    fn print_people(&People);
}
```

Adobe

Expose a C++ object to Rust

C++

```
struct People {
  std::vector<rust::crate::Person> data;
};

::size_t Impl<rust::crate::People>::len(
        Ref<rust::crate::People> p) {
  return p.cpp().data.size();
}

Ref<Person> Impl<rust::crate::People>::index(
       Ref<rust::crate::People> p, ::size_t index) {
  if (index >= p.cpp().data.size() ) {
    abort();
  }
  return p.cpp().data[index];
}
```

Rust

```
pub struct People(
    ZngurCppOpaqueBorrowedObject);
```

Zngur

```
type crate::People {
    #cpp_ref "People";
}

extern "C++" {
    impl crate::People {
        fn len(&self) -> usize;
        fn index(&self, usize) -> &crate::Person;
    }
}
```

Adobe

Expose a C++ object to Rust

C++

```
struct People {
  std::vector<rust::crate::Person> data;
};

::size_t Impl<rust::crate::People>::len(
        Ref<rust::crate::People> p) {
  return p.cpp().data.size();
}

Ref<Person> Impl<rust::crate::People>::index(
       Ref<rust::crate::People> p, ::size_t index) {
  if (index >= p.cpp().data.size() ) {
    abort();
  }
  return p.cpp().data[index];
}
```

Rust

```
pub struct People(
    ZngurCppOpaqueBorrowedObject);
```

Zngur

```
type crate::People {
    #cpp_ref "People";
}

extern "C++" {
    impl crate::People {
        fn len(&self) -> usize;
        fn index(&self, usize) -> &crate::Person;
    }
}
```

Adobe

Expose a C++ object to Rust

C++

```
struct People {
  std::vector<rust::crate::Person> data;
};

::size_t Impl<rust::crate::People>::len(
        Ref<rust::crate::People> p) {
  return p.cpp().data.size();
}

Ref<Person> Impl<rust::crate::People>::index(
        Ref<rust::crate::People> p, ::size_t index) {
  if (index >= p.cpp().data.size() ) {
    abort();
  }
  return p.cpp().data[index];
}
```

Rust

```
pub struct People(
    ZngurCppOpaqueBorrowedObject);
```

Zngur

```
type crate::People {
    #cpp_ref "People";
}

extern "C++" {
    impl crate::People {
        fn len(&self) -> usize;
        fn index(&self, usize) -> &crate::Person;
    }
}
```

Adobe

Expose a C++ object to Rust

C++

```
struct People {
  std::vector<rust::crate::Person> data;
};

::size_t Impl<rust::crate::People>::len(
        Ref<rust::crate::People> p) {
  return p.cpp().data.size();
}

Ref<Person> Impl<rust::crate::People>::index(
       Ref<rust::crate::People> p, ::size_t index) {
 if (index >= p.cpp().data.size() ) {
   abort();
 }
 return p.cpp().data[index];
}
```

Rust

```
pub struct People(
    ZngurCppOpaqueBorrowedObject);
```

Zngur

```
type crate::People {
    #cpp_ref "People";
}

extern "C++" {
    impl crate::People {
        fn len(&self) -> usize;
        fn index(&self, usize) -> &crate::Person;
    }
}
```

Adobe

#cpp_ref

- Exposes *references* to C++ objects in Rust
- Cannot be used to obtain a value
- Efficient

Rust

```
pub struct People(
    ZngurCppOpaqueBorrowedObject);
```

Zngur

```
type crate::People {
    #cpp_ref "People";
}

extern "C++" {
    impl crate::People {
        fn len(&self) -> usize;
        fn index(&self, usize) -> &crate::Person;
    }
}
```

Adobe

#cpp_value

C++

```
rust::crate::People rust::Impl<rust::crate::People>::new_() {
  return rust::crate::People(
    rust::ZngurCppOpaqueOwnedObject::build<::People>());
}
```

Rust

```
pub struct People(
    ZngurCppOpaqueOwnedObject);
```

Zngur

```
type crate::People {
    #cpp_ref "People";
    #layout(size = 16, align = 8);
    #cpp_value "0" "::People";
    constructor(ZngurCppOpaqueOwnedObject);
}
extern "C++" {
    impl crate::People {
        fn new() -> crate::People;
        //...
    }
```

Adobe

#cpp_value

C++

```
rust::crate::People rust::Impl<rust::crate::People>::new_() {
  return rust::crate::People(
    rust::ZngurCppOpaqueOwnedObject::build<::People>());
}
```

Rust

```
pub struct People(
    ZngurCppOpaqueOwnedObject);
```

Zngur

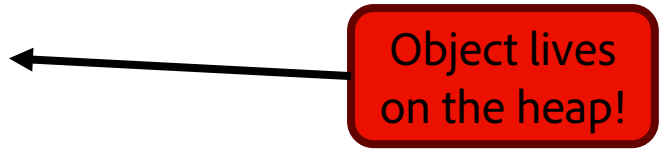
```
type crate::People {
    #cpp_ref "People";
    #layout(size = 16, align = 8);
    #cpp_value "0" "::People";
    constructor(ZngurCppOpaqueOwnedObject);
}
extern "C++" {
    impl crate::People {
        fn new() -> crate::People;
        //...
    }
```

Adobe

#cpp_value | use from Rust

Rust

```
fn test() {
    let p = People::new();
    println!("{}", p.len());
}
```

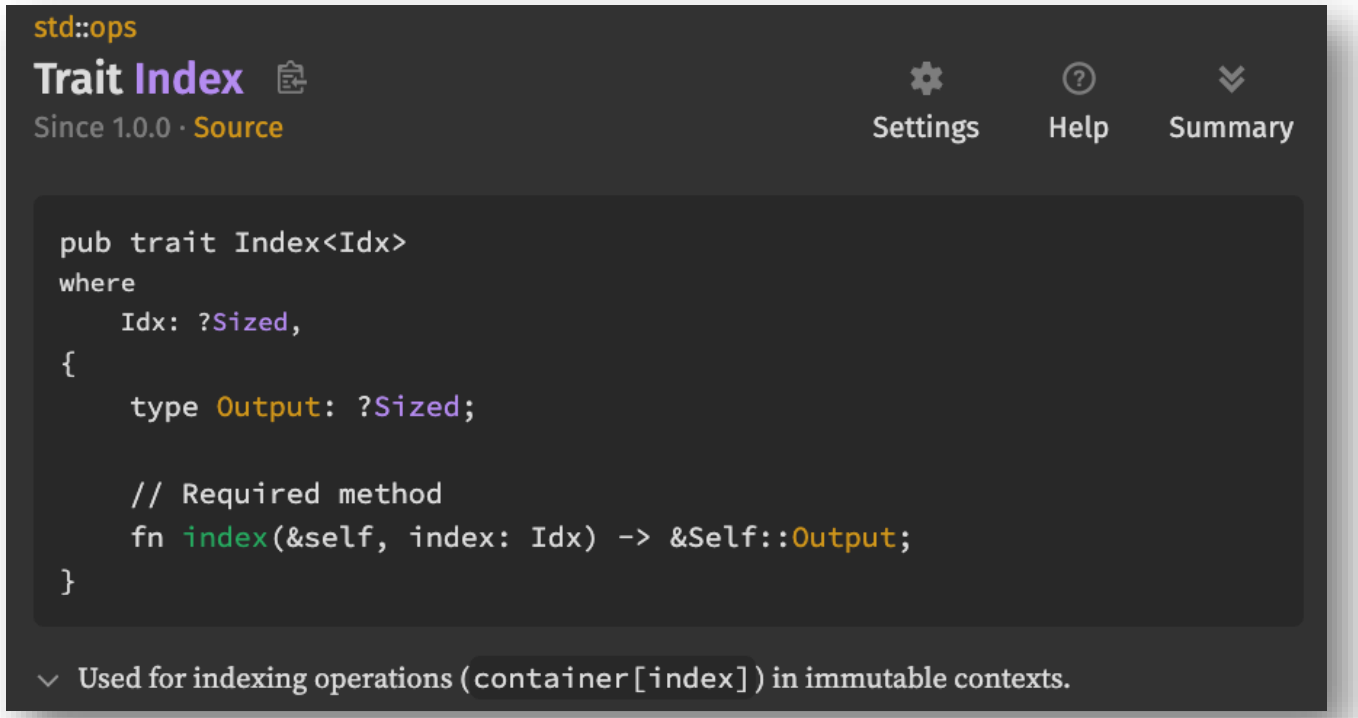


Traits

Zngur

```
extern "C++" {
    impl crate::People {
        //...
        fn index(&self, usize) -> &crate::Person;
        //....
    }
}
```

Traits



Zngur

```
extern "C++" {
   impl crate::People {
      //...
      fn index(&self, usize) -> &crate::Person;
      //....
   }
    impl ::std::ops::Index<
            usize,
            Output=crate::Person>
            for crate::People {
      fn index(&self, usize) -> &crate::Person;
   }
}
```

Traits

~~Ref<Person> Impl<rust::crate::People>::index(~~
~~Ref<rust::crate::People> p, ::size_t index) {~~

```
Ref<Person> Impl<rust::crate::People,
      rust::std::ops::Index<::size_t,
                            rust::crate::Person>>
   ::index(Ref<rust::crate::People> p,
           ::size_t index) {
  if (index >= p.cpp().data.size() ) {
    abort();
  }
  return p.cpp().data[index];
}
```

Zngur

```
extern "C++" {
   impl ::std::ops::Index<
            usize,
            Output=crate::Person>
            for crate::People {
      fn index(&self, usize) -> &crate::Person;
   }
}
```

Traits

```
pub fn print_people(p: &People) {
    println!("{} people:", p.len());
    for i in 0..p.len() {
        println!("- {}", p.index(i).name())
        println!("- {}", p[i].name())
    }
}
```

Zngur

```
extern "C++" {
    impl ::std::ops::Index<
            usize,
            Output=crate::Person>
            for crate::People {
        fn index(&self, usize) -> &crate::Person;
    }
}
```

Adobe

Dynamic traits

- Rust provides a mechanism that allows for dynamic dispatch of trait methods at runtime - dyn.
- Zngur allows C++ types to implement dynamic traits using abstract base classes (e.g. dyn)

```cpp
template <typename T>
class VectorIterator : public rust::std::iter::Iterator<T> {
  std::vector<T> vec;
  size_t pos;

public:
  VectorIterator(std::vector<T> &&v) : vec(v), pos(0) {}
  ~VectorIterator() {
    std::cout << "vector iterator has been destructed" << std::endl;
  }

  Option<T> next() override {
    if (pos >= vec.size()) {
      return Option<T>::None();
    }
    T value = vec[pos++];
    // You can construct Rust enum with fields in C++
    return Option<T>::Some(value);
  }
};
```

PNG parsing from C++

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TOTAL CVE Records: 276577

NOTICE: Transition to the all-new CVE website at WWW.CVE.ORG and CVE Record Format JSON are underway.

NOTICE: Support for the legacy CVE download formats ended on June 30, 2024.
New CVE List download format is available now on CVE.ORG.

HOME > CVE > SEARCH RESULTS

Search Results

There are **75** CVE Records that match your search.

Name	Description
CVE-2021-4214	A heap overflow flaw was found in libpngs' pngimage.c program. This flaw allows an attacker with local network access to pass a specially crafted PNG file to the pngimage utility, causing an application to crash, leading to a denial of service.
CVE-2019-9423	In opencv calls that use libpng, there is a possible out of bounds write due to a missing bounds check. This could lead to local escalation of privilege with no additional execution privileges required. User interaction is not required for exploitation. Product: AndroidVersions: Android-10Android ID: A-110986616
CVE-2019-7317	png_image_free in png.c in libpng 1.6.x before 1.6.37 has a use-after-free because png_image_free_function is called under png_safe_execute.
CVE-2019-6129	** DISPUTED ** png_create_info_struct in png.c in libpng 1.6.36 has a memory leak, as demonstrated by pngcp. NOTE: a third party has stated "I don't think it is libpng's job to free this buffer."
CVE-2019-3572	An issue was discovered in libming 0.4.8. There is a heap-based buffer over-read in the function writePNG in the file util/dbl2png.c of the dbl2png command-line program. Because this is associated with an erroneous call to png_write_row in libpng, an out-of-bounds write might occur for some memory layouts.
CVE-2019-14373	An issue was discovered in image_save_png in image/image-png.cpp in Free Lossless Image Format (FLIF) 0.3. Attackers can trigger a heap-based buffer over-read in libpng via a crafted flif file.
CVE-2018-14876	An issue was discovered in image_save_png in image/image-png.cpp in Free Lossless Image Format (FLIF) 0.3. Attackers can trigger a longjmp that leads to an uninitialized stack frame after a libpng error concerning the IHDR image width.
CVE-2018-14550	An issue has been found in third-party PNM decoding associated with libpng 1.6.35. It is a stack-based buffer overflow in the function get_token in pnm2png.c in pnm2png.

PNG Decoder/Encoder

Rust CI passing | docs passing | crates.io v0.18.0-rc | license MIT OR Apache-2.0

Robust and performant PNG decoder/encoder in pure Rust. Also supports APNG.

No `unsafe` code, battle-tested, and fuzzed on OSS-fuzz.

Performance

Performance is typically on par with or better than libpng.

Includes a fast encoding mode powered by fdeflate that is dramatically faster than the fastest mode of libpng while *simultaneously* providing better compression ratio.

On nightly Rust compiler you can slightly speed up decoding of some images by enabling the `unstable` feature of this crate.

Adobe

Safe PNG parsing from C++

```
#include <iostream>
#include <generated.h>

int main() {
  auto path = rust::Str::from_char_star("test.png");

  auto decoder = rust::png::Decoder<rust::std::fs::File>
        ::new_(rust::std::fs::File::open(path).unwrap());

  auto header_info = decoder.read_header_info()
                                    .unwrap();
  std::cout << "Width=" << header_info.width() << '\n';
            "\nHeight=" << header_info.height() << '\n';
}
```

Safe PNG parsing from C++

```
#include <iostream>
#include <generated.h>

int main() {
 auto path = rust::Str::from_char_star("test.png");

  auto decoder = rust::png::Decoder<rust::std::fs::File>
        ::new_(rust::std::fs::File::open(path).unwrap());

  auto header_info = decoder.read_header_info()
                                    .unwrap();
  std::cout << "Width=" << header_info.width() << '\n';
             "\nHeight=" << header_info.height() << '\n';
}
```

Adobe

Safe PNG parsing from C++

```
#include <iostream>
#include <generated.h>

int main() {
  auto path = rust::Str::from_char_star("test.png");

  auto decoder = rust::png::Decoder<rust::std::fs::File>
        ::new_(rust::std::fs::File::open(path).unwrap());

  auto header_info = decoder.read_header_info()
                                    .unwrap();
  std::cout << "Width=" << header_info.width() << '\n';
               "\nHeight=" << header_info.height() << '\n';
}
```

Using the decoder

```rust
use std::fs::File;
// The decoder is a build for reader and can be used to set various decoding options
// via `Transformations`. The default output transformation is `Transformations::IDENTITY`.
let decoder = png::Decoder::new(File::open("tests/pngsuite/basi0g01.png").unwrap());
let mut reader = decoder.read_info().unwrap();
// Allocate the output buffer.
let mut buf = vec![0; reader.output_buffer_size()];
// Read the next frame. An APNG might contain multiple frames.
let info = reader.next_frame(&mut buf).unwrap();
// Grab the bytes of the image.
let bytes = &buf[..info.buffer_size()];
// Inspect more details of the last read frame.
let in_animation = reader.info().frame_control.is_some();
```

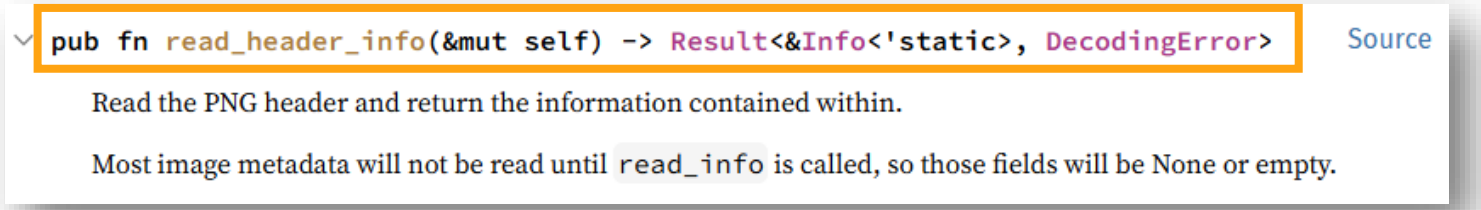
Safe PNG parsing from C++

```
#include <iostream>
#include <generated.h>

int main() {
  auto path = rust::Str::from_char_star("test.png");

  auto decoder = rust::png::Decoder<rust::std::fs::File>
        ::new_(rust::std::fs::File::open(path).unwrap());

  auto header_info = decoder.read_header_info()
                            .unwrap();
  std::cout << "Width=" << header_info.width() << '\n';
            "\nHeight=" << header_info.height() << '\n';
}
```



Safe PNG parsing from C++

```
#include <iostream>
#include <generated.h>

int main() {
  auto path = rust::Str::from_char_star("test.png");

  auto decoder = rust::png::Decoder<rust::std::fs::File>
        ::new_(rust::std::fs::File::open(path).unwrap());

  auto header_info = decoder.read_header_info()
                                    .unwrap();
  std::cout << "Width=" << header_info.width() << '\n';
               "\nHeight=" << header_info.height() << '\n';
}
```

Safe PNG parsing from C++

```
#include <iostream>
#include <generated.h>

int main() {
  auto path = rust::Str::from_char_star("test.png");

  auto decoder = rust::png::Decoder<rust::std::fs::File>
        ::new_(rust::std::fs::File::open(path).unwrap());

  auto header_info = decoder.read_header_info()
                                  .unwrap();
  std::cout << "Width=" << header_info.width() << '\n';
               "\nHeight=" << header_info.height() << '\n';
}
```

```
include!("generated.rs");

trait PngInfoExt {
    fn width(&self) -> u32;
    fn height(&self) -> u32;
}

impl<'a> PngInfoExt for png::Info<'a> {
    fn width(&self) -> u32 {
        self.width
    }
    fn height(&self) -> u32 {
        self.height
    }
}
```

Safe PNG parsing from C++

```
#include <iostream>
#include <generated.h>

int main() {
  auto path = rust::Str::from_char_star("test.png");

  auto decoder = rust::png::Decoder<rust::std::fs::File>
        ::new_(rust::std::fs::File::open(path).unwrap());

  auto header_info = decoder.read_header_info()
                                    .unwrap();
  std::cout << "Width=" << header_info.width() << '\n';
               "\nHeight=" << header_info.height() << '\n';
}
```

```
include!("generated.rs");

trait PngInfoExt {
    fn width(&self) -> u32;
    fn height(&self) -> u32;
}

impl<'a> PngInfoExt for png::Info<'a> {
    fn width(&self) -> u32 {
        self.width
    }
    fn height(&self) -> u32 {
        self.height
    }
}
```

Adobe

Safe PNG parsing from C++

```
#include <iostream>
#include <generated.h>

int main() {
  auto path = rust::Str::from_char_star("test.png");

  auto decoder = rust::png::Decoder<rust::std::fs::File>
        ::new_(rust::std::fs::File::open(path).unwrap());

  auto header_info = decoder.read_header_info()
                                    .unwrap();
  std::cout << "Width=" << header_info.width() << '\n';
             "\nHeight=" << header_info.height() << '\n';
}
```

```
// main.zng
type str {
    wellknown_traits(?Sized);
}

type std::fs::File {
    #layout(size = 8, align = 8);
    fn open(&str) -> std::io::Result<std::fs::File>;
}

type std::io::Result<std::fs::File> {
    #layout(size = 16, align = 8);
    fn unwrap(self) -> std::fs::File;
}

type png::Decoder<std::fs::File> {
```

Adobe

Safe PNG parsing from C++

```
#include <iostream>
#include <generated.h>

int main() {
  auto path = rust::Str::from_char_star("test.png");

  auto decoder = rust::png::Decoder<rust::std::fs::File>
        ::new_(rust::std::fs::File::open(path).unwrap());

  auto header_info = decoder.read_header_info()
                                    .unwrap();
  std::cout << "Width=" << header_info.width() << '\n';
               "\nHeight=" << header_info.height() << '\n';
}
```

```
// main.zng
type str {
    wellknown_traits(?Sized);
}

type std::fs::File {
    #layout(size = 8, align = 8);
    fn open(&str) -> std::io::Result<std::fs::File>;
}

type std::io::Result<std::fs::File> {
    #layout(size = 16, align = 8);
    fn unwrap(self) -> std::fs::File;
}

type png::Decoder<std::fs::File> {
```

Safe PNG parsing from C++

```
#include <iostream>
#include <generated.h>

int main() {
  auto path = rust::Str::from_char_star("test.png");

  auto decoder = rust::png::Decoder<rust::std::fs::File>
        ::new_(rust::std::fs::File::open(path).unwrap());

  auto header_info = decoder.read_header_info()
                                    .unwrap();
  std::cout << "Width=" << header_info.width() << '\n';
               "\nHeight=" << header_info.height() << '\n';
}
```

```
}

type std::fs::File {
    #layout(size = 8, align = 8);
    fn open(&str) -> std::io::Result<std::fs::File>;
}

type std::io::Result<std::fs::File> {
    #layout(size = 16, align = 8);
    fn unwrap(self) -> std::fs::File;
}

type png::Decoder<std::fs::File> {
    #layout(size = 656, align = 8);
    fn new(std::fs::File) -> png::Decoder<std::fs::File>;
    fn read_header_info(&mut self) ->
        core::result::Result<&png::Info, png::DecodingError>;
}

type core::result::Result<&png::Info,
png::DecodingError> {
```

Adobe

Safe PNG parsing from C++

```
#include <iostream>
#include <generated.h>

int main() {
  auto path = rust::Str::from_char_star("test.png");

  auto decoder = rust::png::Decoder<rust::std::fs::File>
        ::new_(rust::std::fs::File::open(path).unwrap());

  auto header_info = decoder.read_header_info()
                                    .unwrap();
  std::cout << "Width=" << header_info.width() << '\n';
               "\nHeight=" << header_info.height() << '\n';
}
```

```
type std::io::Result<std::fs::File> {
    #layout(size = 16, align = 8);
    fn unwrap(self) -> std::fs::File;
}

type png::Decoder<std::fs::File> {
    #layout(size = 656, align = 8);
    fn new(std::fs::File) -> png::Decoder<std::fs::File>;
    fn read_header_info(&mut self) ->
        core::result::Result<&png::Info, png::DecodingError>;
}

type core::result::Result<&png::Info,
png::DecodingError> {
    #layout(size = 32, align = 8);
    fn unwrap(self) -> &png::Info;
}

type png::Info {
    #layout(size = 432, align = 8);
```

Adobe

Safe PNG parsing from C++

```
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int main() {
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    #layout(size = 656, align = 8);
    fn new(std::fs::File) -> png::Decoder<std::fs::File>;
    fn read_header_info(&mut self) ->
        core::result::Result<&png::Info, png::DecodingError>;
}

type core::result::Result<&png::Info,
png::DecodingError> {
    #layout(size = 32, align = 8);
    fn unwrap(self) -> &png::Info;
}

type png::Info {
    #layout(size = 432, align = 8);
```

Adobe

Safe PNG parsing from C++

```
#include <iostream>
#include <generated.h>

int main() {
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        ::new_(rust::std::fs::File::open(path).unwrap());

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    fn new(std::fs::File) -> png::Decoder<std::fs::File>;
    fn read_header_info(&mut self) ->
        core::result::Result<&png::Info, png::DecodingError>;
}

type core::result::Result<&png::Info,
png::DecodingError> {
    #layout(size = 32, align = 8);
    fn unwrap(self) -> &png::Info;
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Adobe

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```
type png::Decoder<std::fs::File> {
    #layout(size = 656, align = 8);
    fn new(std::fs::File) -> png::Decoder<std::fs::File>;
    fn read_header_info(&mut self) ->
        core::result::Result<&png::Info, png::DecodingError>;
}

type core::result::Result<&png::Info,
png::DecodingError> {
    #layout(size = 32, align = 8);
    fn unwrap(self) -> &png::Info;
}

type png::Info {
    #layout(size = 432, align = 8);
    fn width(&self) -> u32;
    fn height(&self) -> u32;
}
```

build.bat

```
zngur generate main.zng
cargo build
clang++ -I. main.cpp target/debug/png_example.lib -lws2_32 -luserenv -lntdll
```

PNG example retrospective

- Safe PNG parsing in C++ took about an hour
- Adding a Rust dependency *was easier than adding a C++ dependency*
- Happy with how the C++ code looks
- Integration into a build system (e.g. CMake) would take more time, but no major obstacles anticipated

Summing it up…

- Many good reasons to adopt Rust
  - Features
  - Demographic shift
  - Safety improvements
- Zngur makes for a great C++/Rust interop experience
  - Strong semantics subset model
  - Ergonomic on both sides
- Door is now open for using Rust libraries in C++

C++ @ Adobe!


Adobe