

# The Cost of Zero Cost

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Introduction

Trough the  
stages

Other  
examples

Project Euler  
Problem 1  
bitfield

Questions

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# 1 Introduction

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## 3 Other examples

# What?

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- analyze code generated by the compiler
- at different stages
- start at macro expansion
- go down towards assembly

# Why (not)? / Disclaimer

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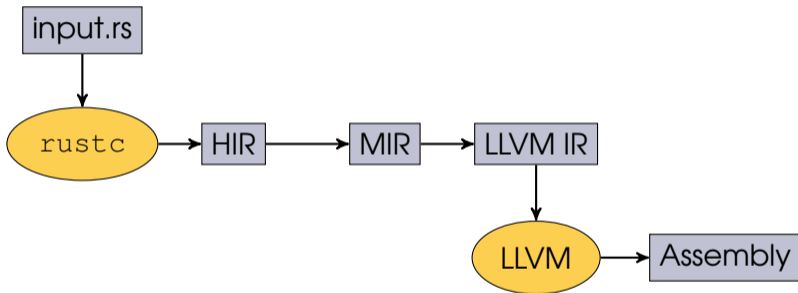
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Questions

- curiosity
- understand details of an algorithm (complexity)
- find bottlenecks and hurdles to proper optimization
  - after benchmarking
  - after optimizing the algorithmic complexity

# Compilation flow



- various intermediate representation
- have a textual representation, but are really data structures

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# Running example

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```
1  #[inline(never)]
2  fn puts(i: i32) {
3      println!("{}", i);
4  }
5
6  fn main() {
7      for i in 0..255 {
8          puts(i);
9      }
10 }
```



# Macro expansion

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## ■ nightly only

```
$ rustc --pretty expanded -Z unstable-options <input.rs>
```

```
$ cargo rustc -- --pretty expanded -Z unstable-options
```

# Macro expansion (abridged result)

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```
7  #[inline(never)]
8  fn puts(i: i32) {
9      {
10         ::std::io::_print(::std::fmt::Arguments::new_v1(
11             &["", "\n"], &match (&i,) {
12                 (arg0,) => [
13                     ::std::fmt::ArgumentV1::new(
14                         arg0,
15                         ::std::fmt::Display::fmt
16                             )
17                 ],
18             }
19         ));
20     };
21 }
22 fn main() { for i in 0..255 { puts(i); } }
```

- **H**igh-level **I**ntermediate **R**epresentation

- roughly an abstract syntax tree

- constructs are expanded and desugared

```
$ rustc +nightly -Z unpretty=hir <input.rs>
```

```
$ cargo +nightly rustc -- -Z unpretty=hir
```

```
$ cargo inspect (https://github.com/mre/cargo-inspect/)
```

- **M**id-level **I**ntermediate **R**epresentation
- simple core language
- has some constructs the surface language doesn't (e. g. `goto`)
- structured in basic blocks

```
$ rustc +nightly -Z unpretty=mir <input.rs>
```

```
$ cargo +nightly rustc -- -Z unpretty=mir
```

```
$ cargo inspect --unpretty mir
```

# LLVM IR

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- **LLVM Intermediate Representation**
- infinite register machine
- SSA-like representation (only one static definition per register)
- memory is accessed through pointers held in registers
- Language Reference: <https://llvm.org/docs/LangRef.html>

```
$ rustc --emit llvm-ir <input.rs>
```

```
$ cargo rustc -- --emit llvm-ir
```

# Assembly

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- opcodes as interpreted by the CPU
  - usually `<opcode> <op1>, <op2>`
  - limited number of registers
- ```
$ rustc --emit asm <input.rs>
```
- ```
$ cargo rustc -- --emit asm
```

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# Project Euler Problem 1

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Questions

```
1 fn main() {  
2     let x: u32 = (0u32..=1000)  
3         .filter(|x| x % 3 == 0 || x % 5 == 0)  
4         .sum();  
5     println!("{}", x);  
6 }
```



# bitfield

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```
1 use bitfield::bitfield;
2 bitfield! {
3     struct DataInterface(u8);
4     impl Debug;
5     pub sds, set_sds: 6, 5;
6     pub tdm, set_tdm: 4, 3;
7     pub dif, set_dif: 2, 0;
8 }
9 fn main() {
10     let mut di = DataInterface(0);
11     di.set_tdm(2);
12     di.set_sds(1);
13     di.set_dif(4);
14
15     send_spi(di.0);
16 }
```

Thank you for your attention.  
Any questions?



<https://babelmonkeys.de/~florob/talks/RC-2019-02-06-zero-cost.pdf>