The LLVM Assembler and Machine Code Infrastructure

Overview

Overview

- What?

Overview

- What?
- Why?

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- What?
- Why?
- How?

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- What?
- Why?
- How?
- High-Level Design Goals

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- High-Level Design Goals
- Architecture

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- Status

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- What is MC?

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  - “Machine code”

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  - Focus is working with “object files”
- Project started late 2009
  - Enabled for production in LLVM 2.8 (Oct 2010)

Why?

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- Direct object writing

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- Direct object writing
  - Simplicity, correctness, and performance
  - Single source of truth
- Advanced micro-arch optimizations
- Platform for advancing low-level tools

How?

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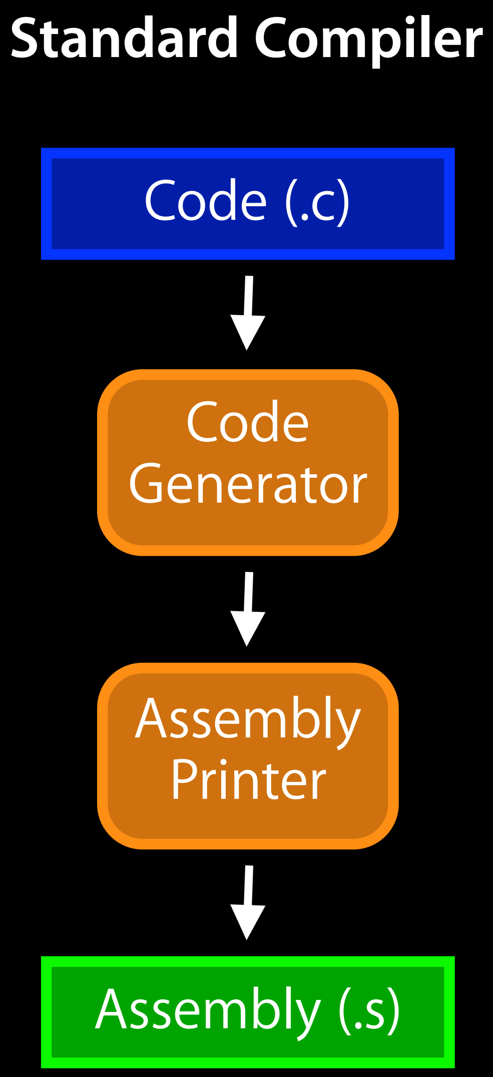
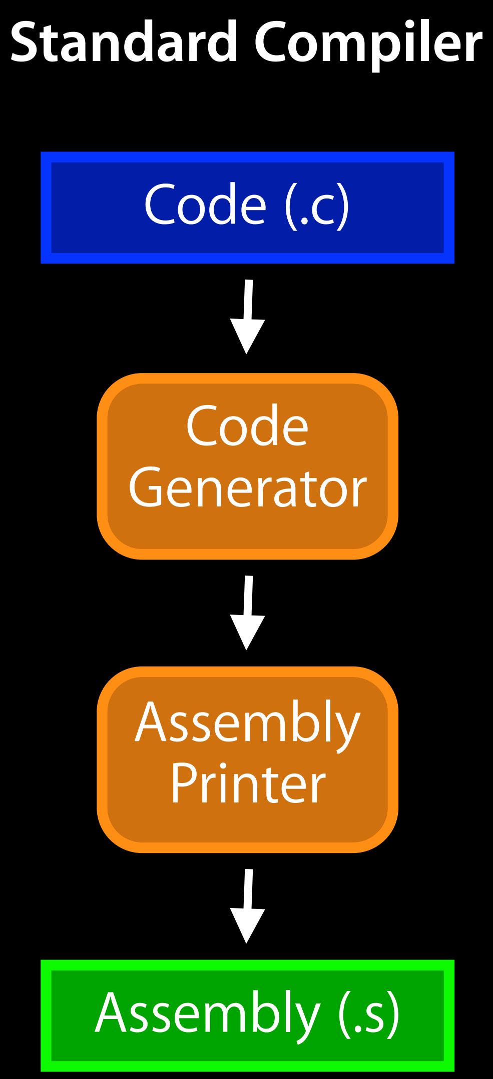


Standard Compiler
Code (.c)
Code Generator
Assembly Printer
Assembly (.s)

How?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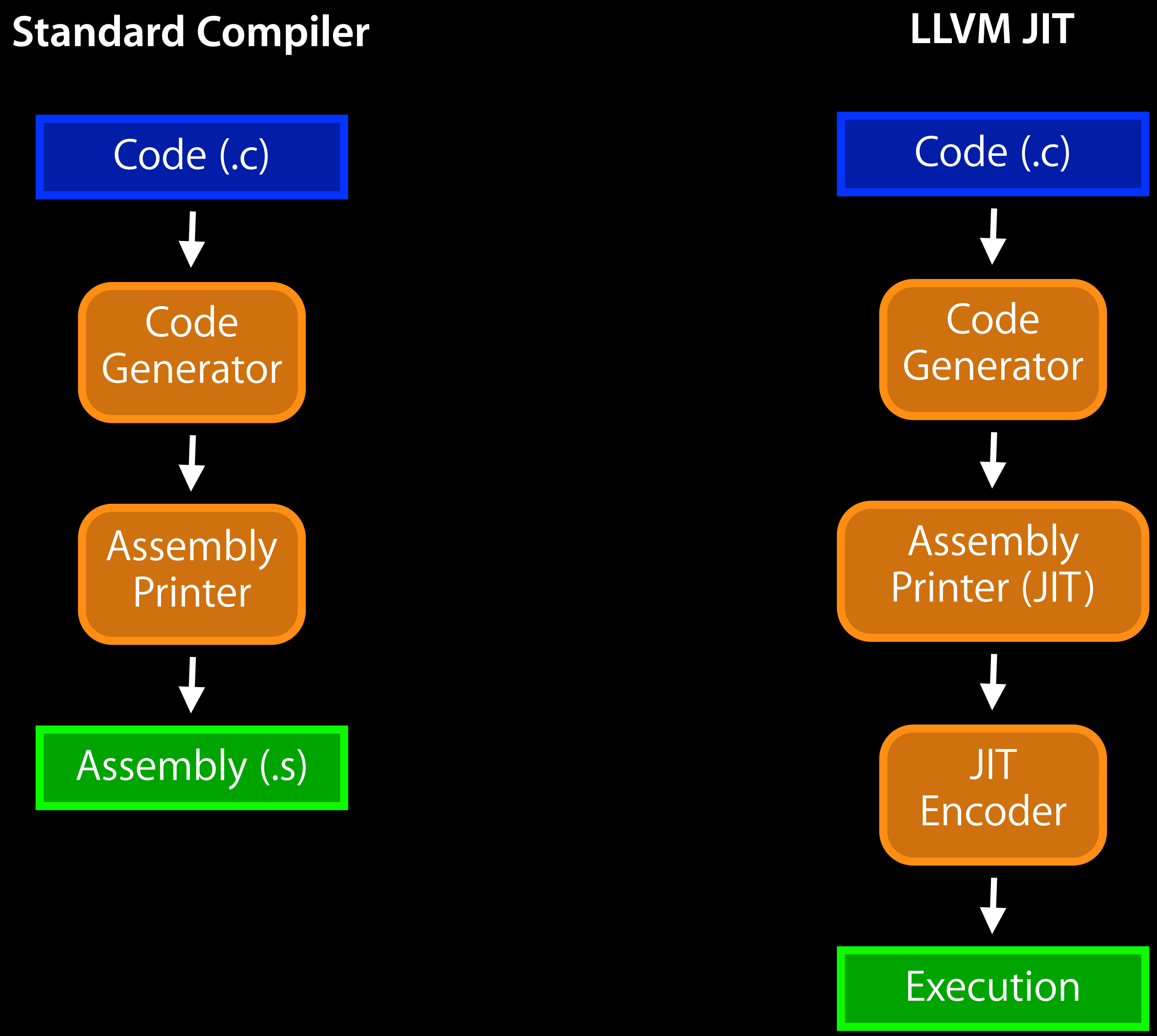

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LLVM JIT

Code (.c)

Code Generator

Assembly Printer (JIT)

JIT Encoder

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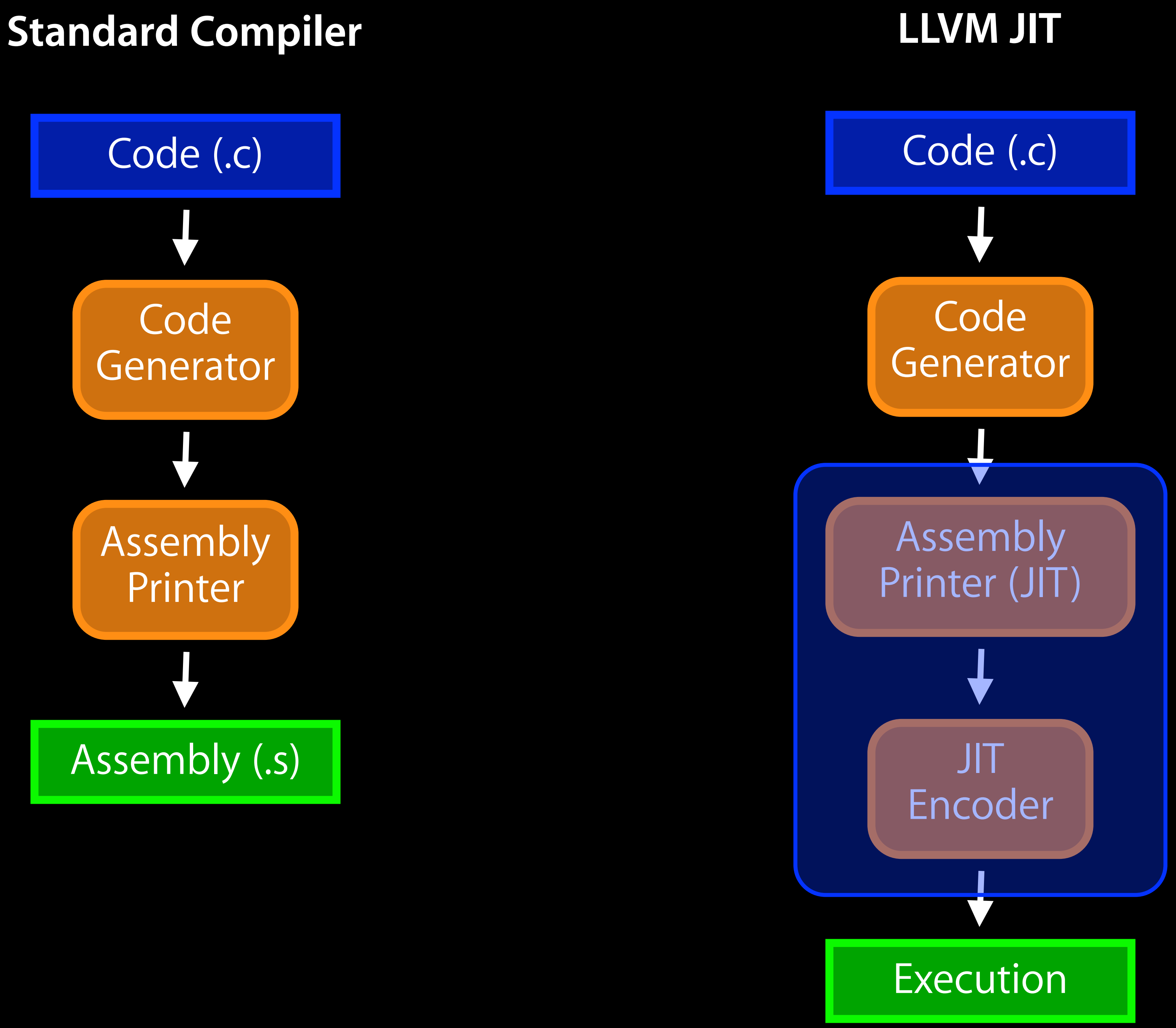

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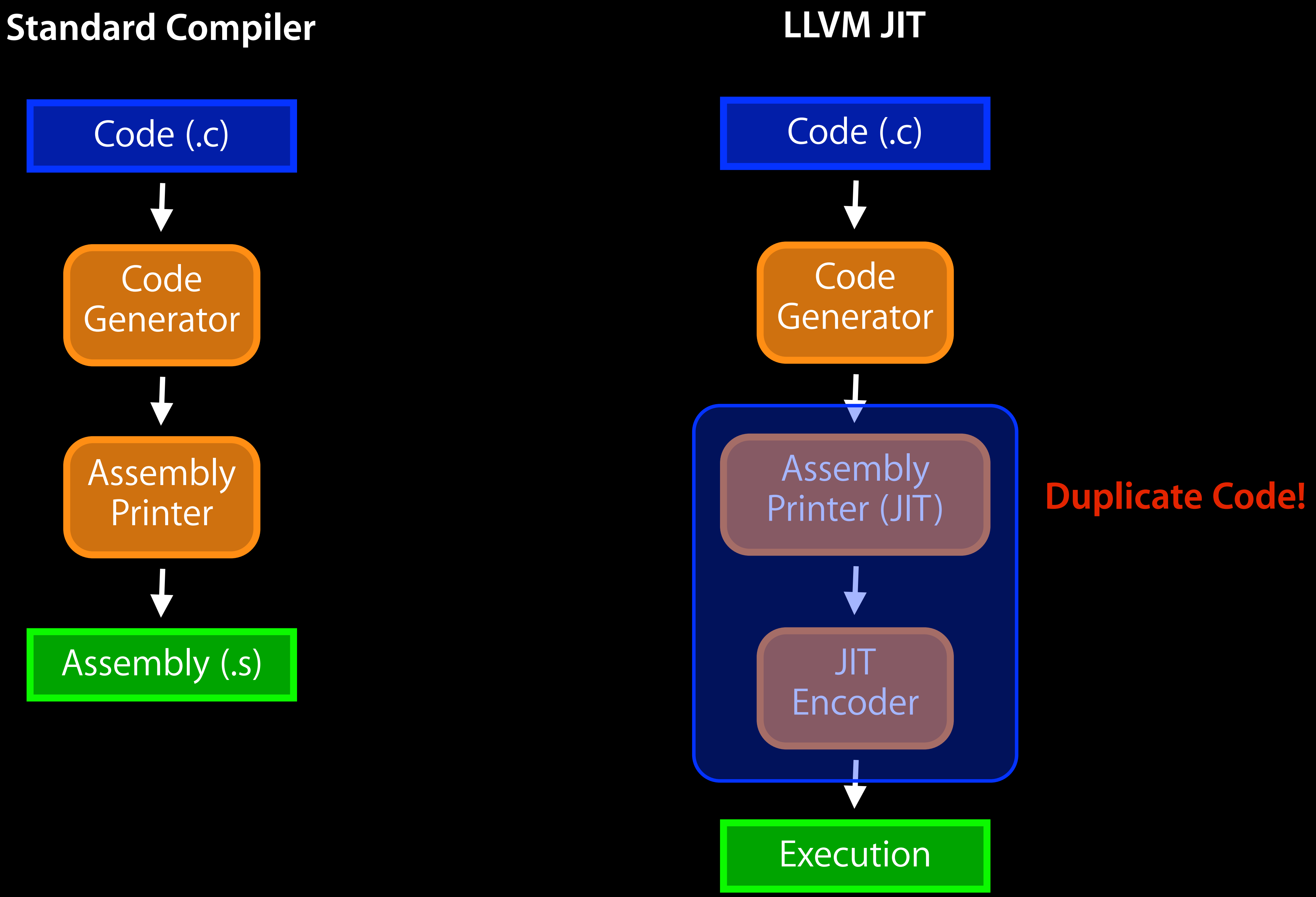
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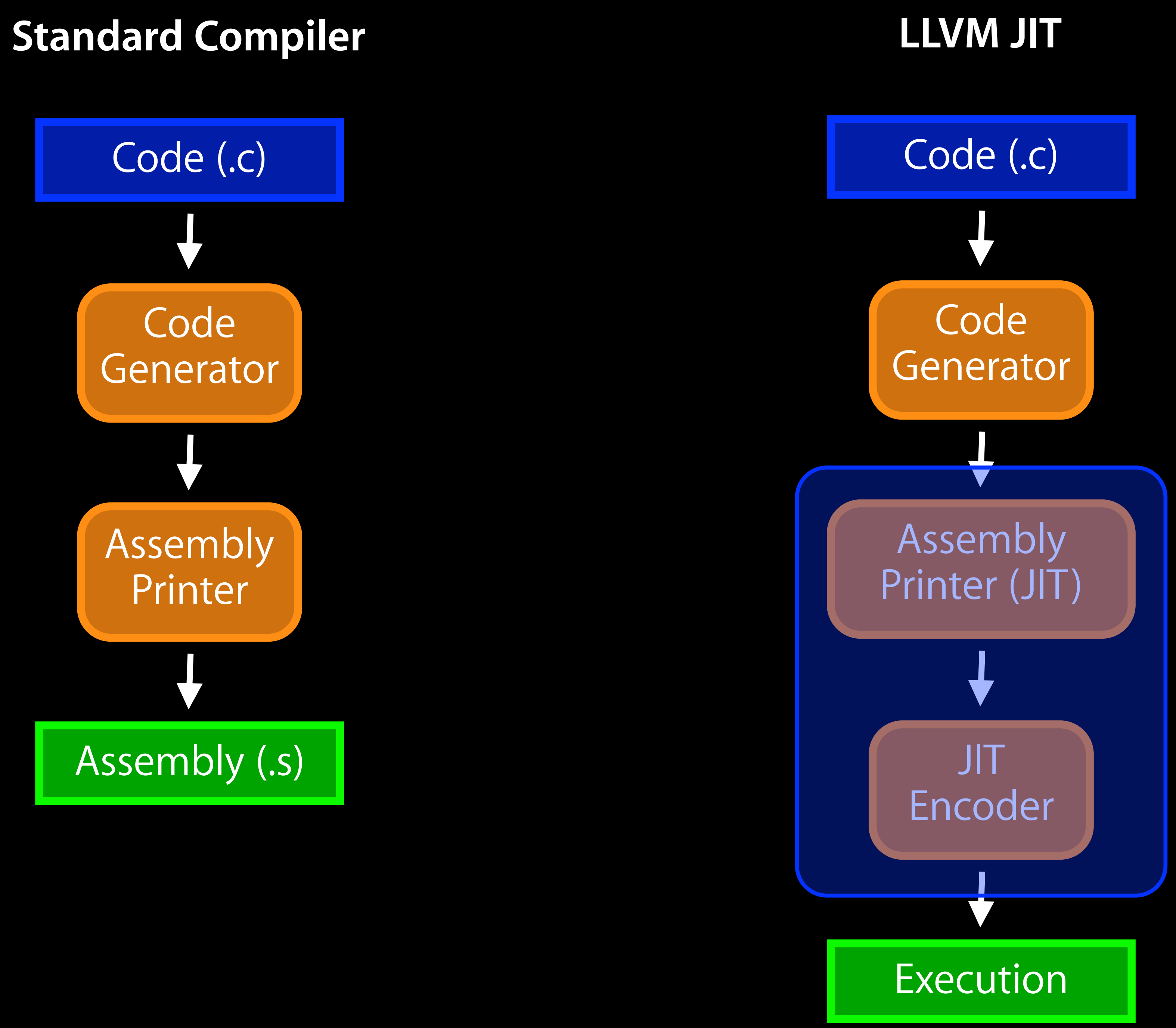

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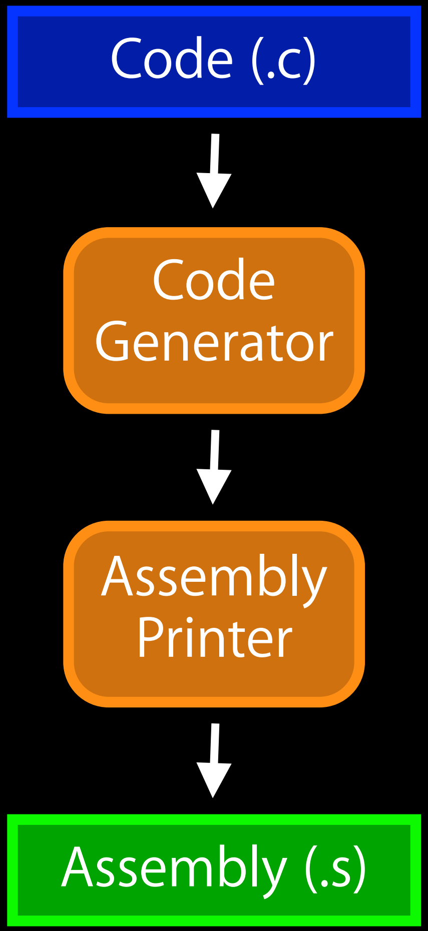
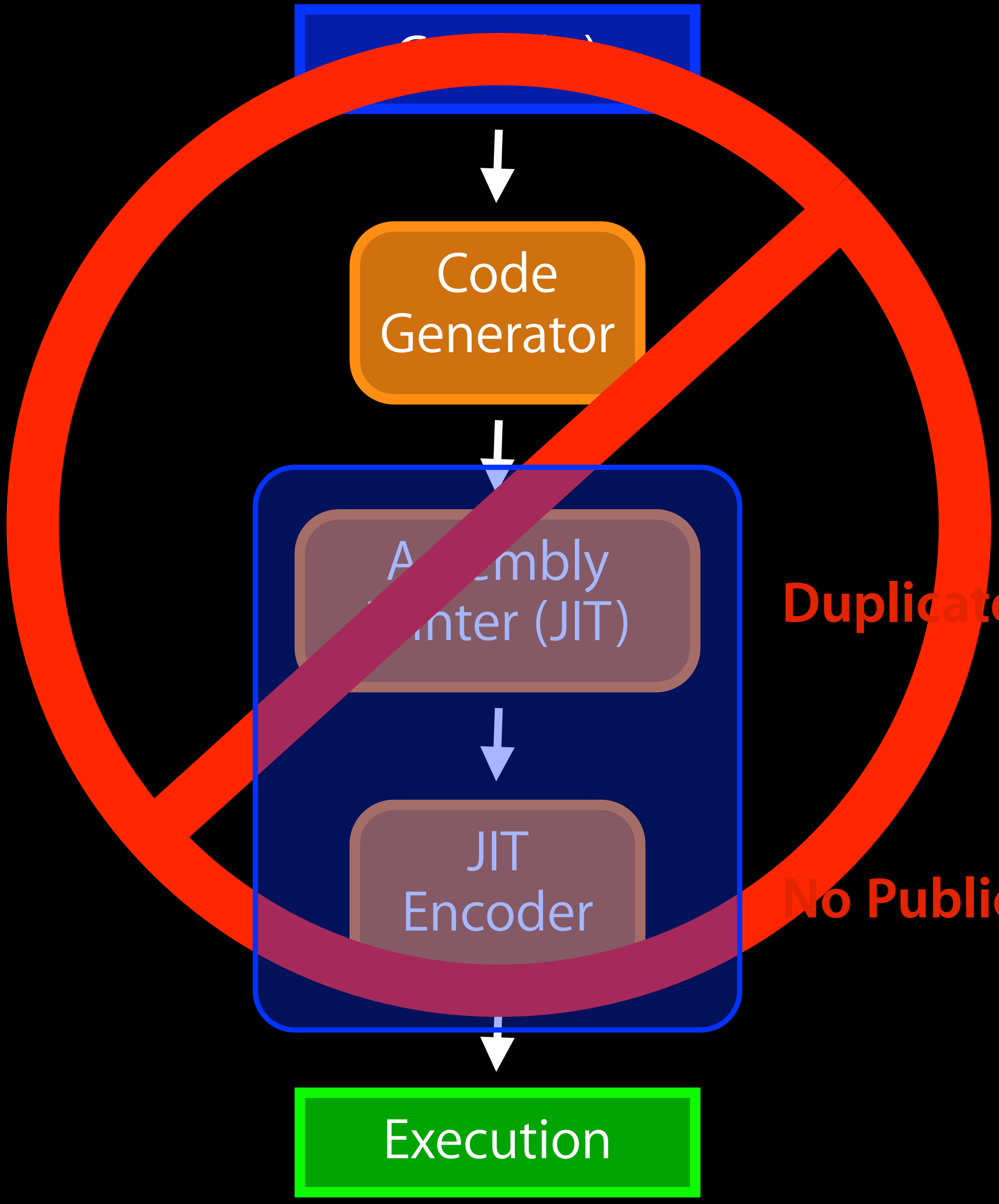
Standard Compiler



LLVM JIT



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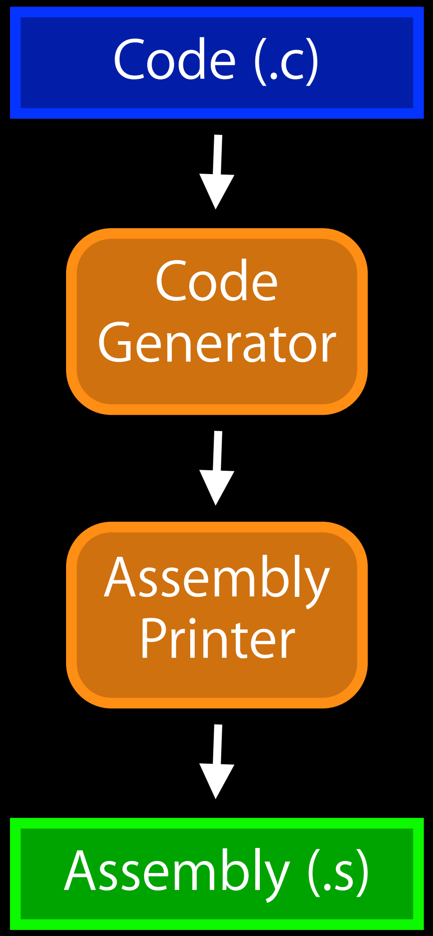
Modern Compiler



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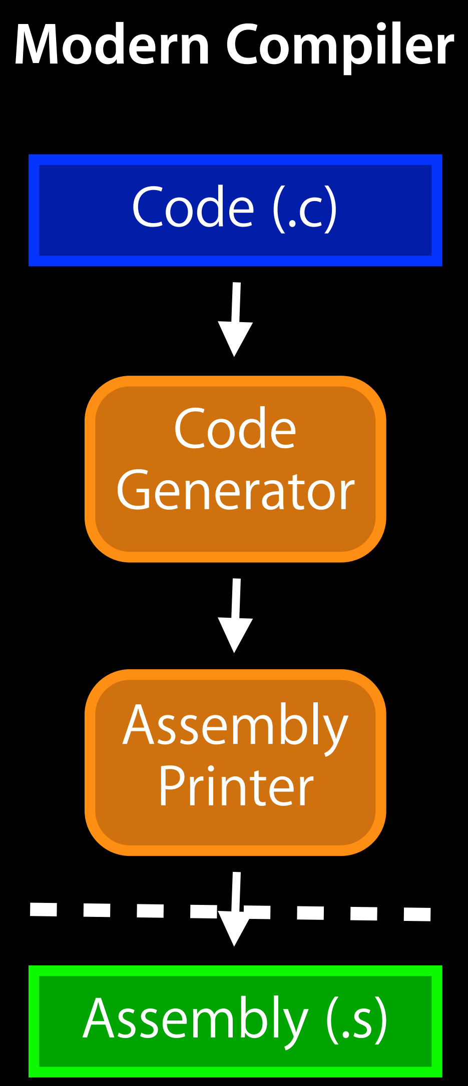
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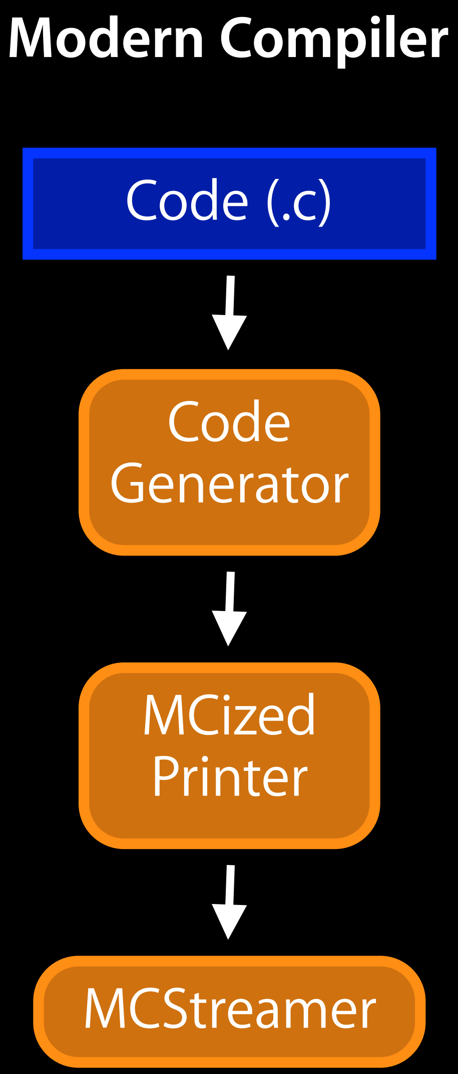
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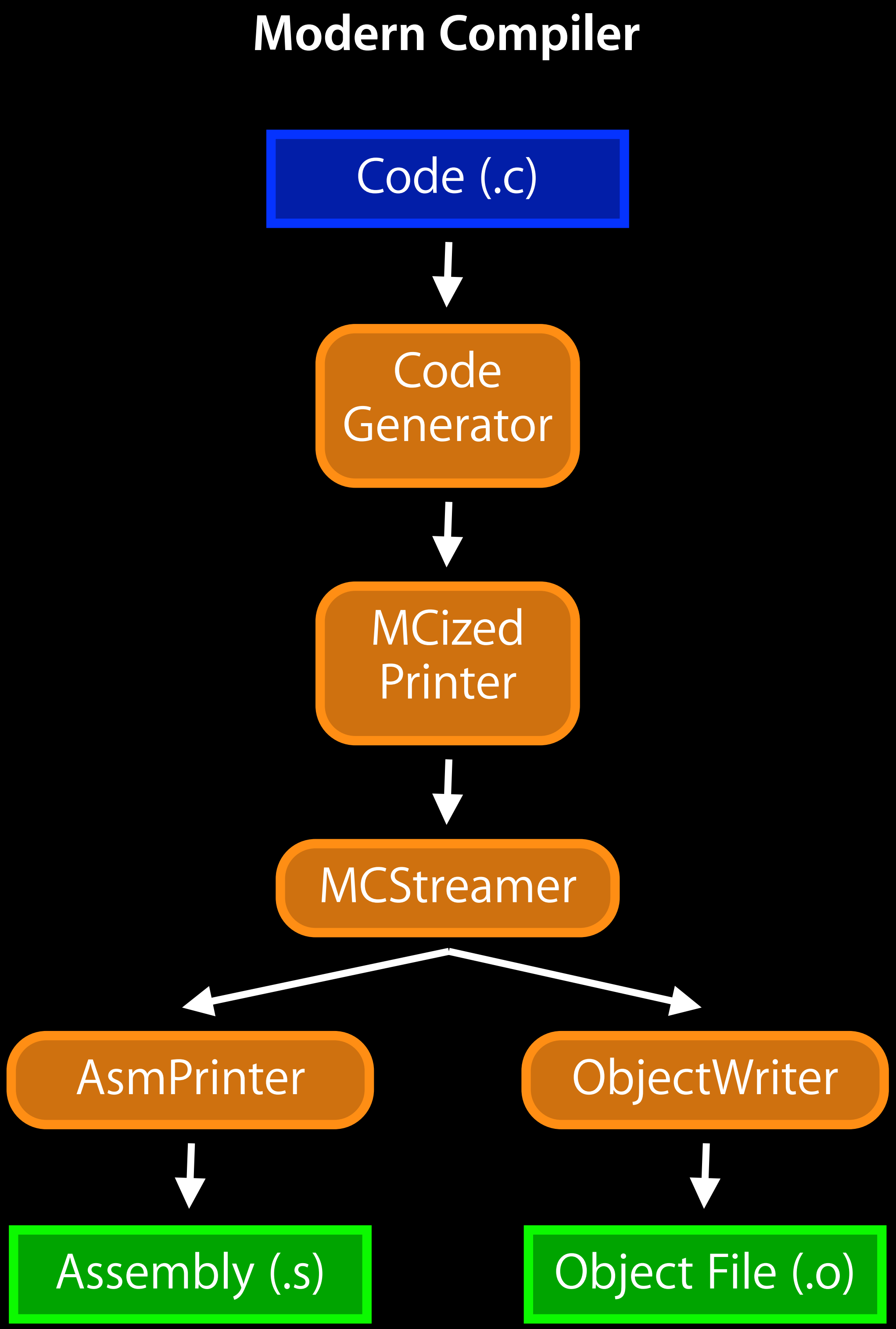
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High-Level Design Goals

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- Pluggable Targets
- Non-pluggable Object Formats

How is MC Used?

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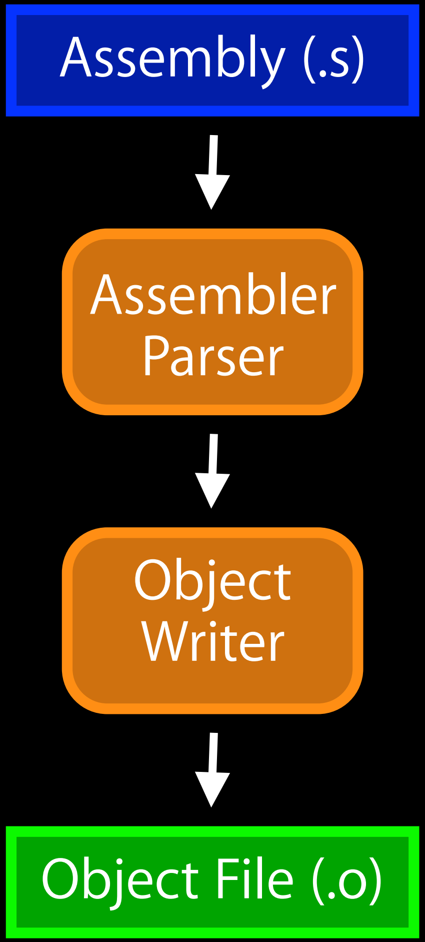

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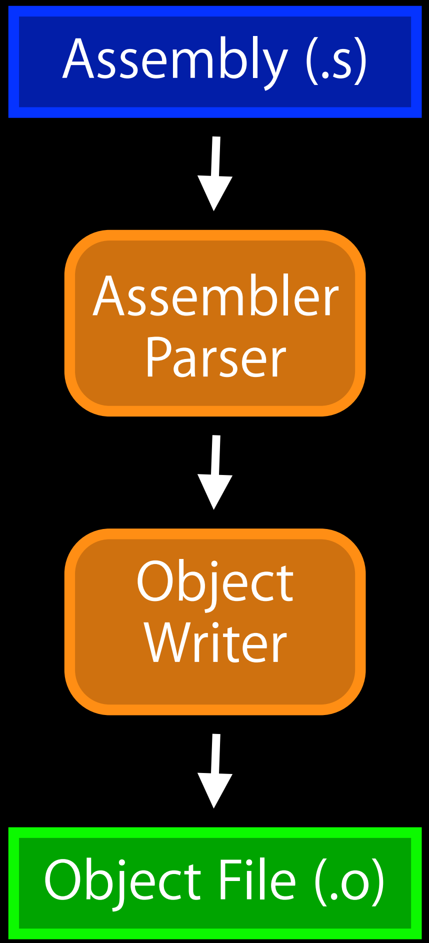

It's an Assembler!

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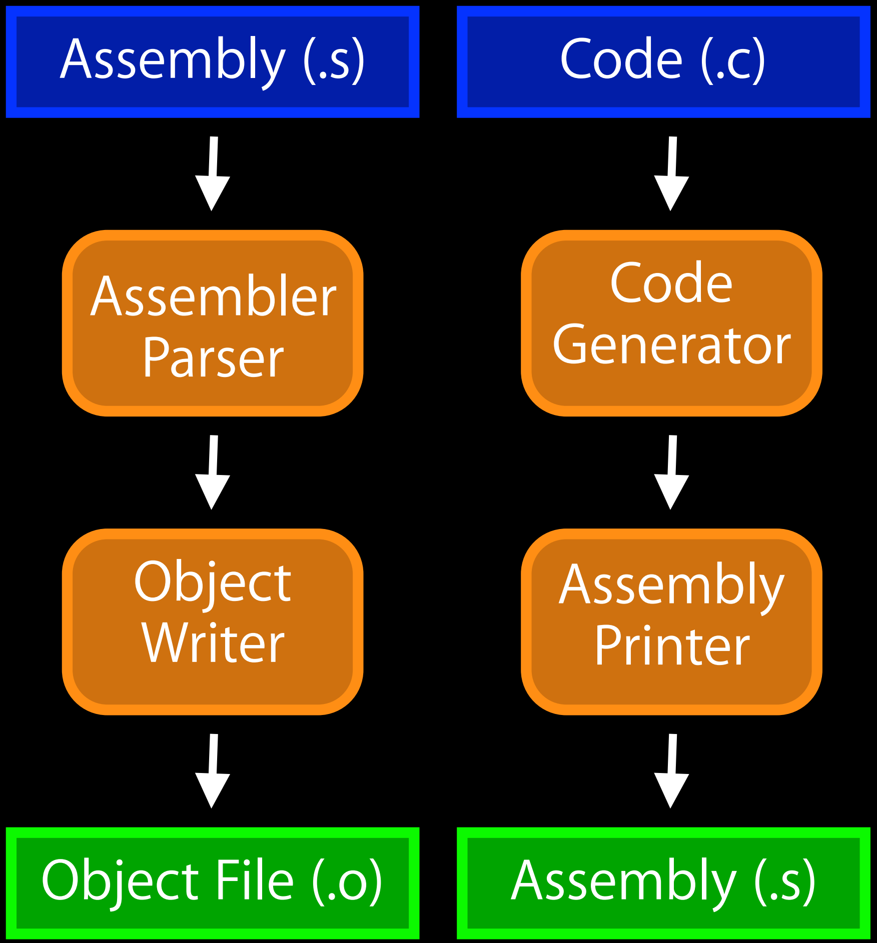

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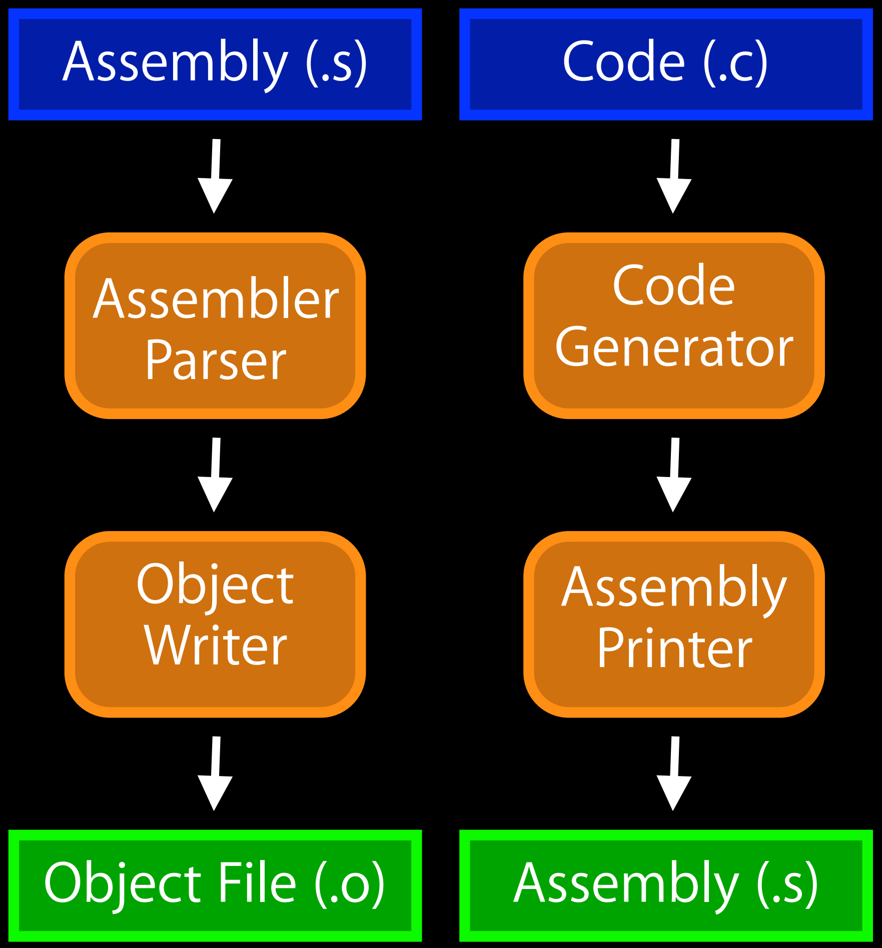

Assembly (.s)
Assembler Parser
Object Writer
Object File (.o)

Code (.c)
Code Generator
Assembly Printer
Assembly (.s)

It's an Assembler!

It's a Compiler!

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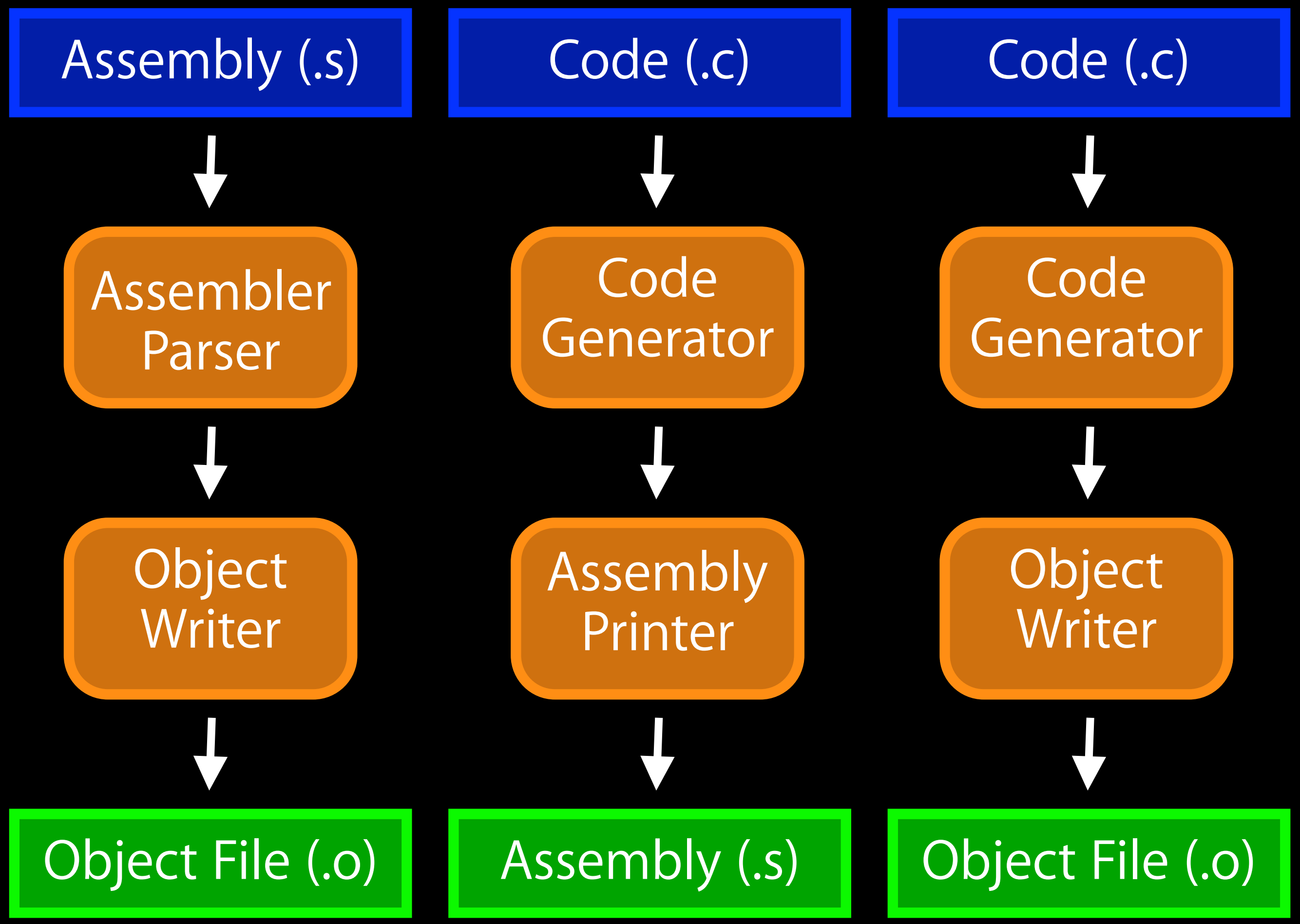

Assembly (.s) → Assembler Parser → Object Writer → Object File (.o)

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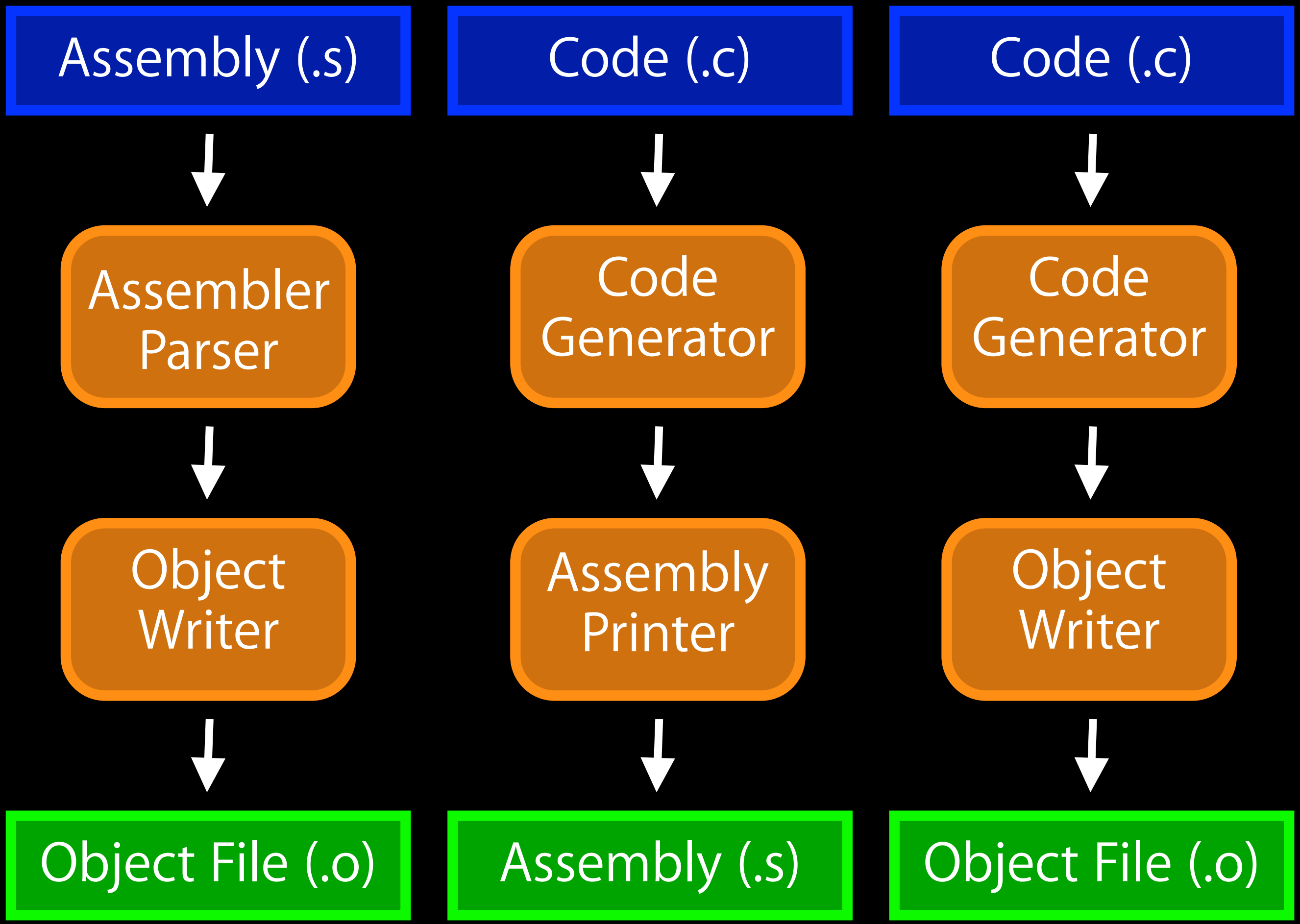

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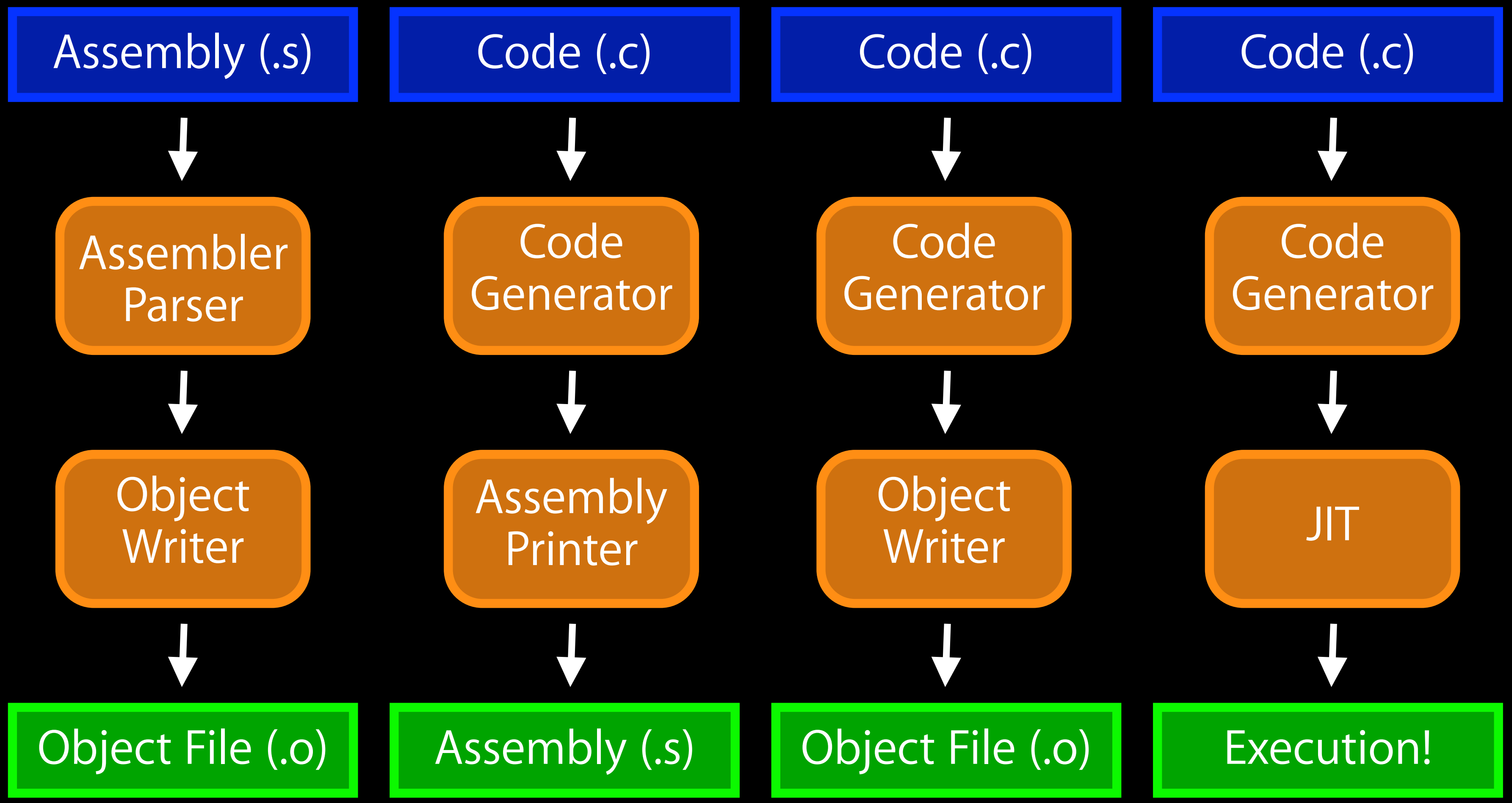

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Code (.c) → Code Generator → JIT → Execution!

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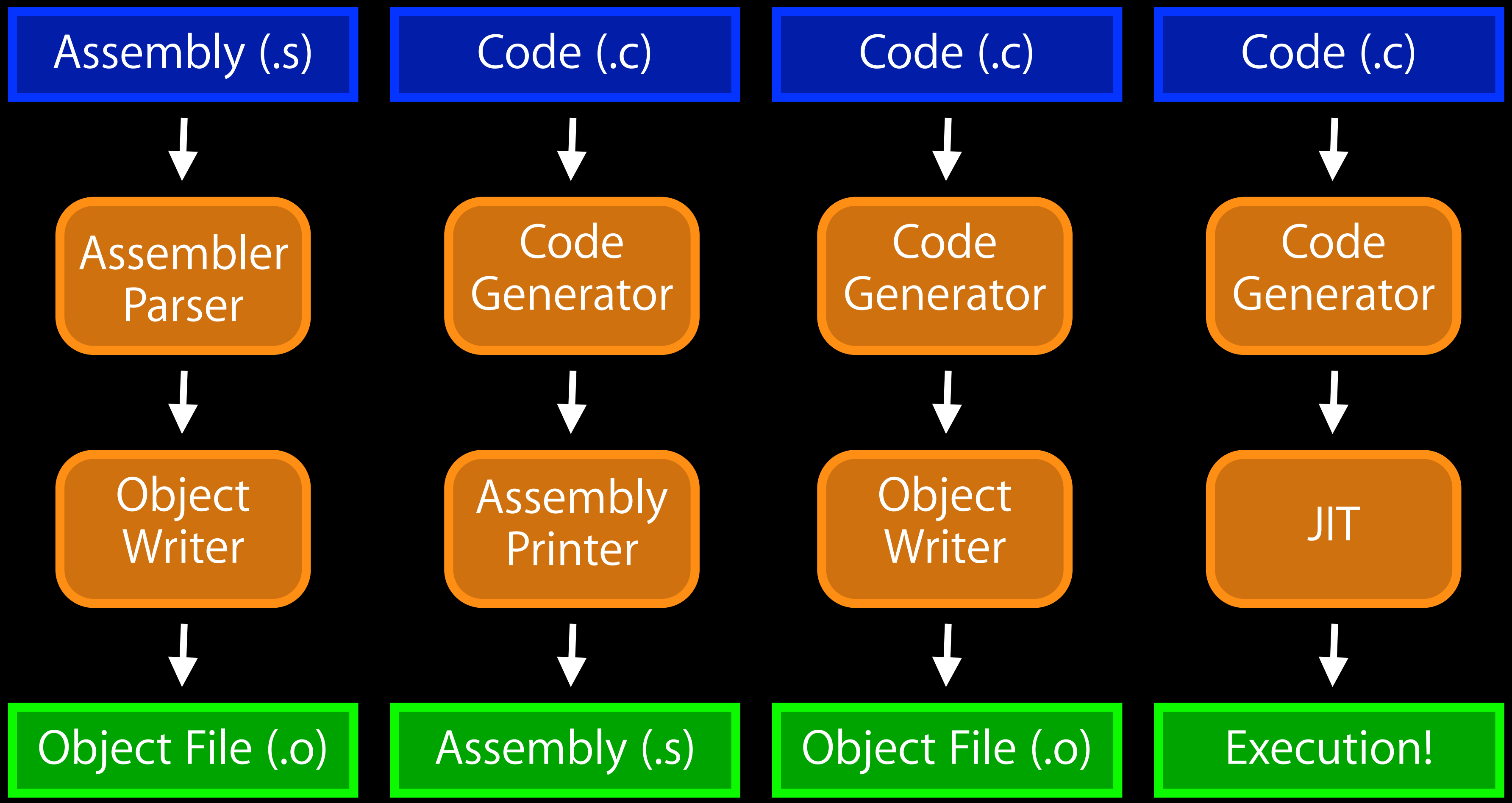

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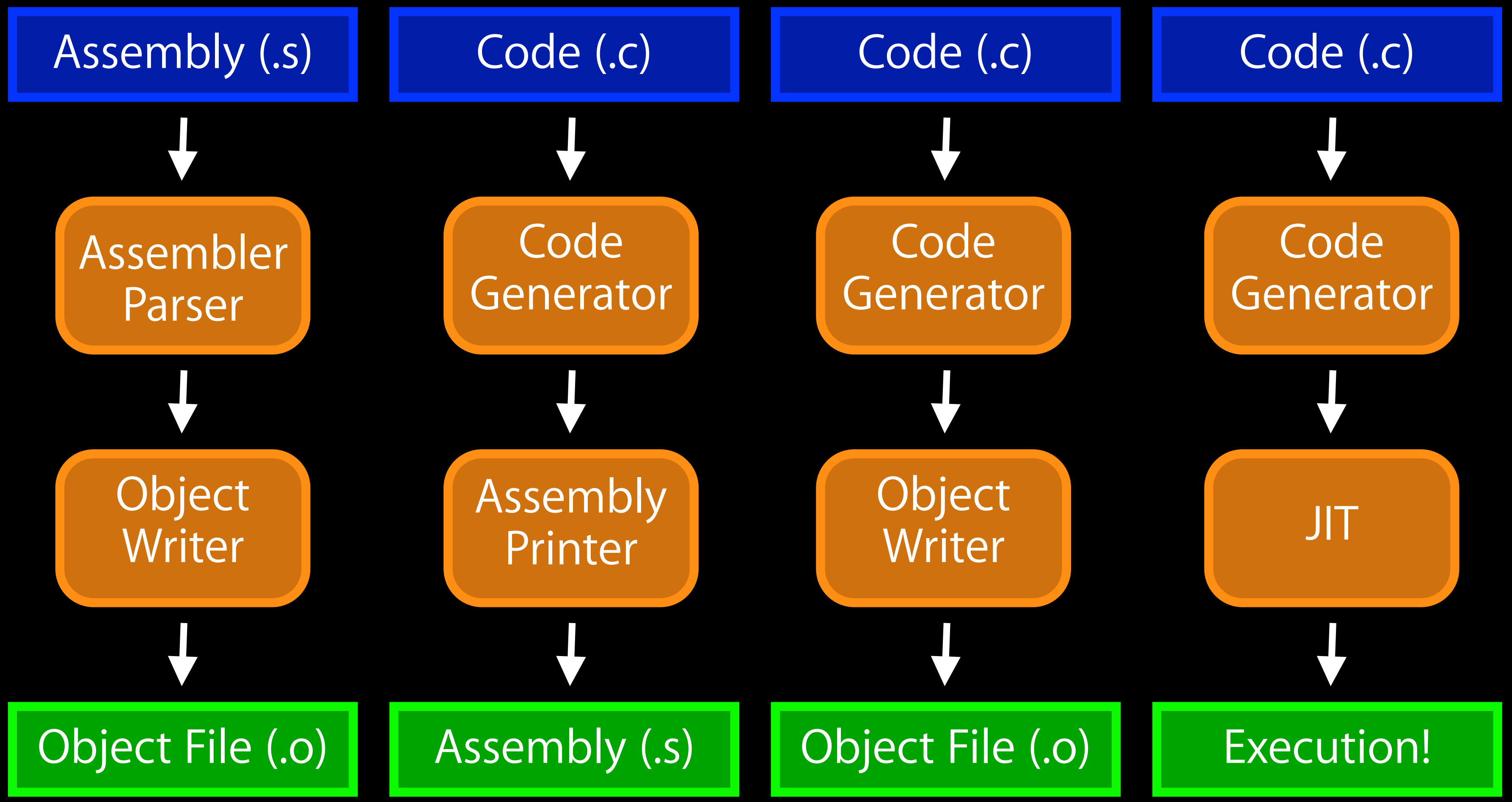

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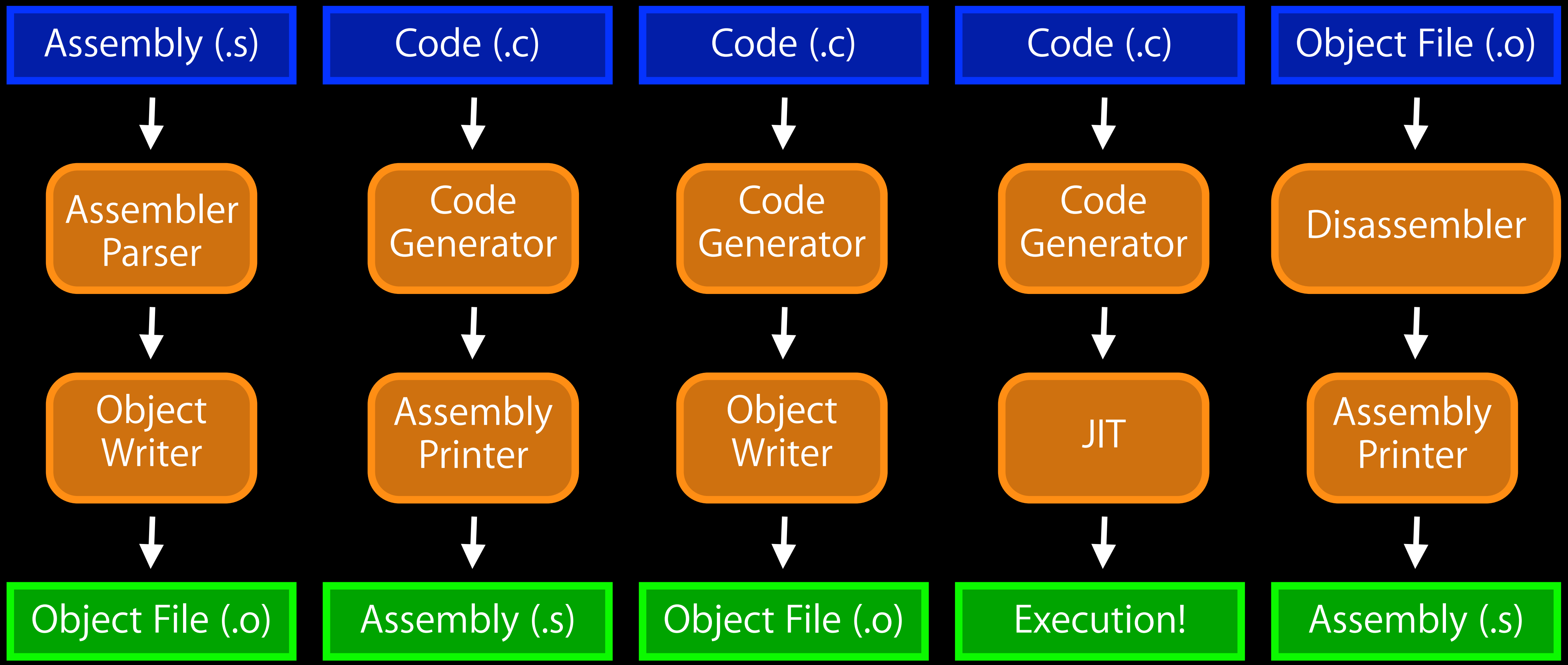

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Object File (.o) → Disassembler → Assembly Printer → Assembly (.s)

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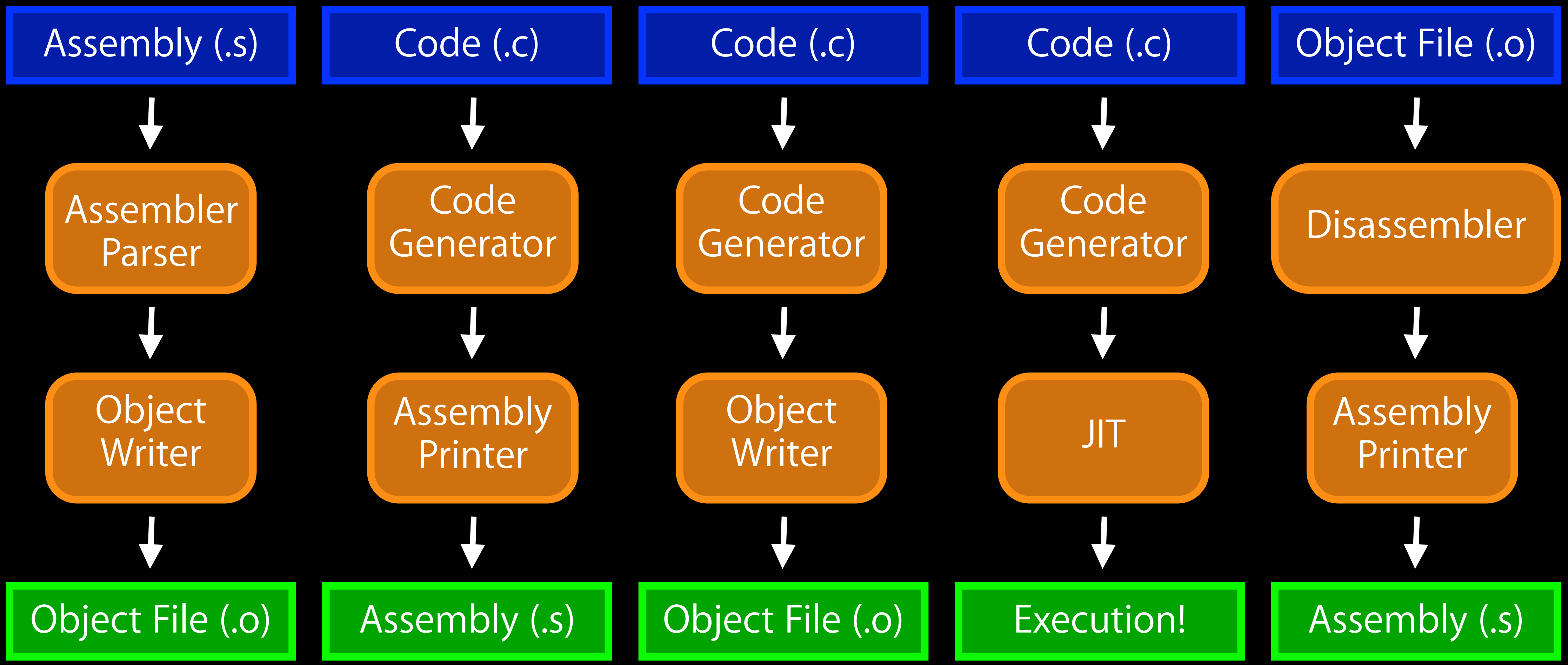

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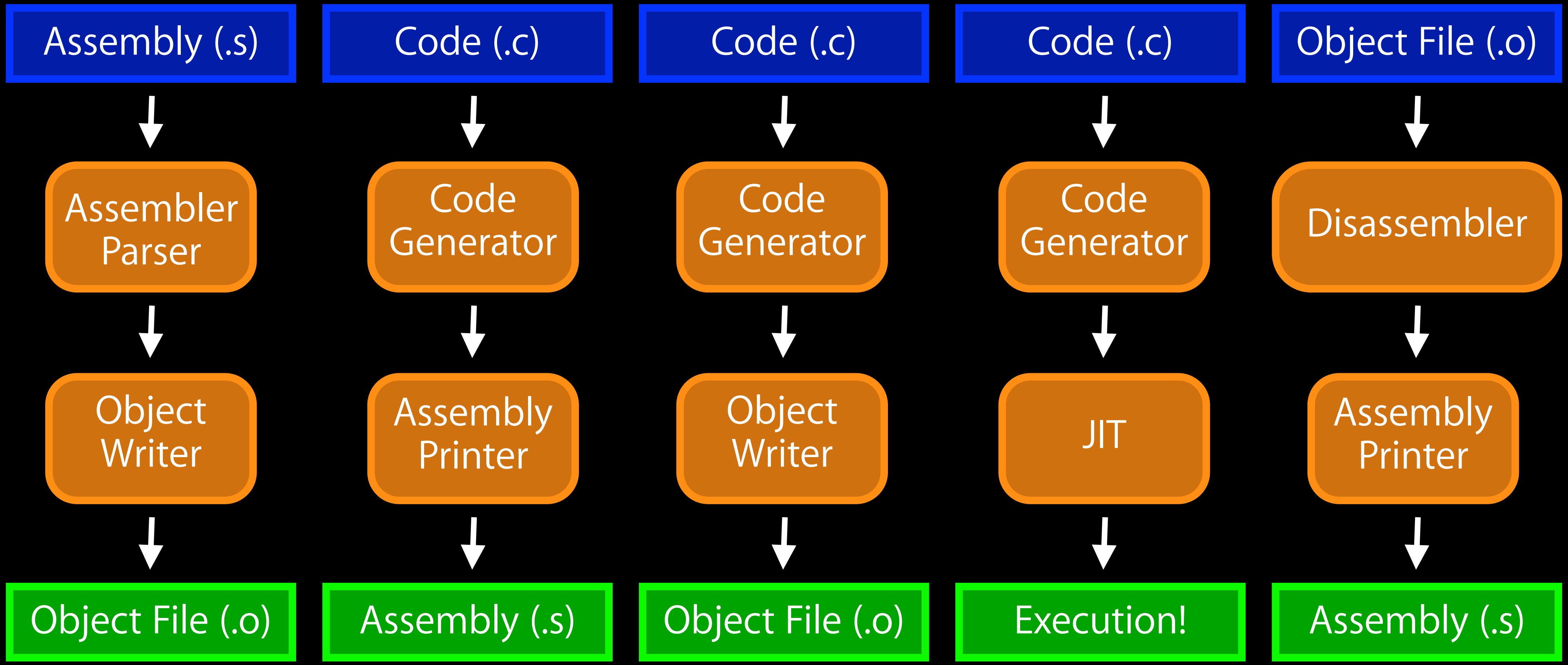

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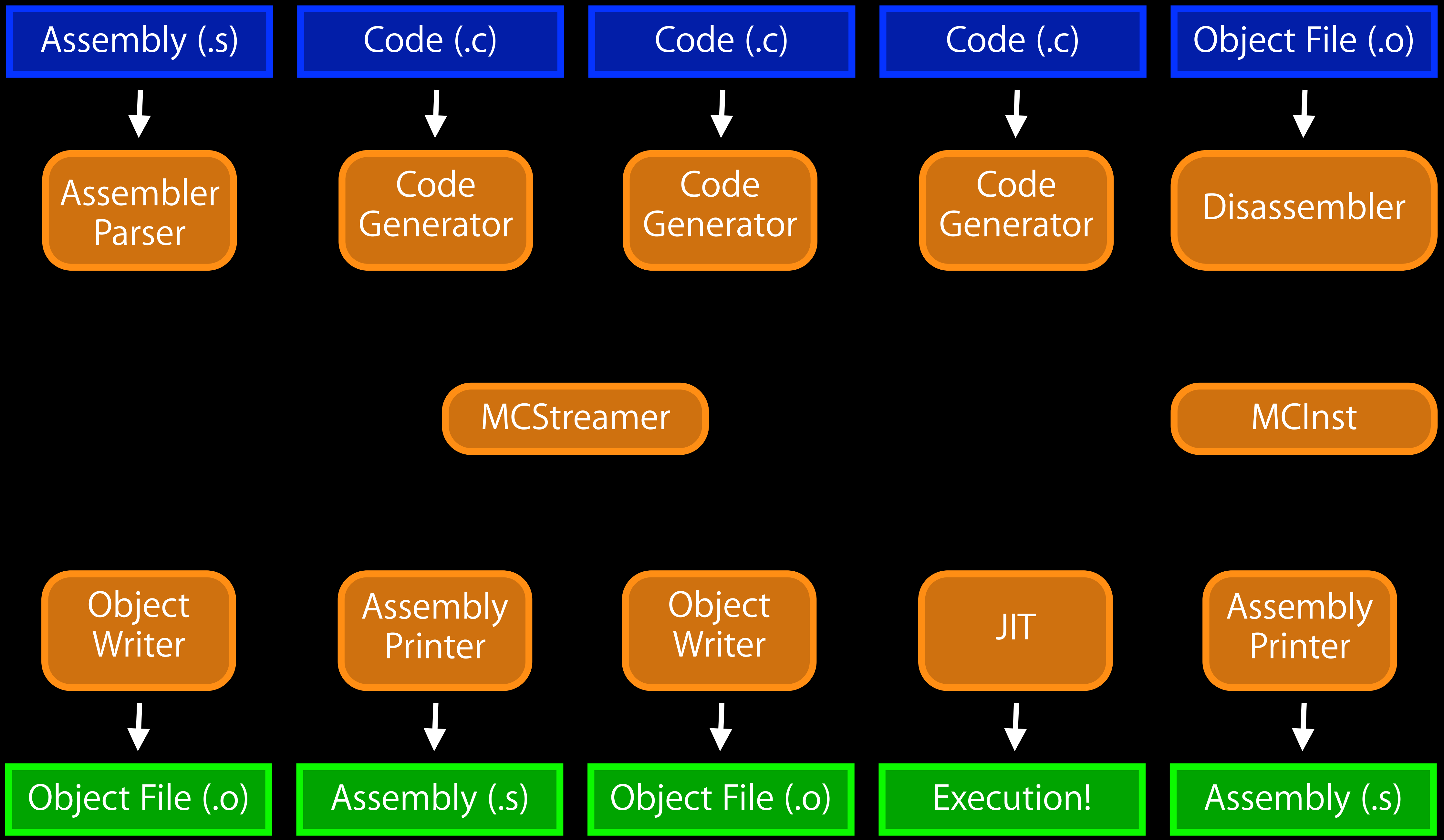

Assembly (.s)
Code (.c)
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Object File (.o)

Assembler Parser
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Disassembler

MCStreamer
MCInst

Object Writer
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Object Writer
JIT
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Object File (.o)
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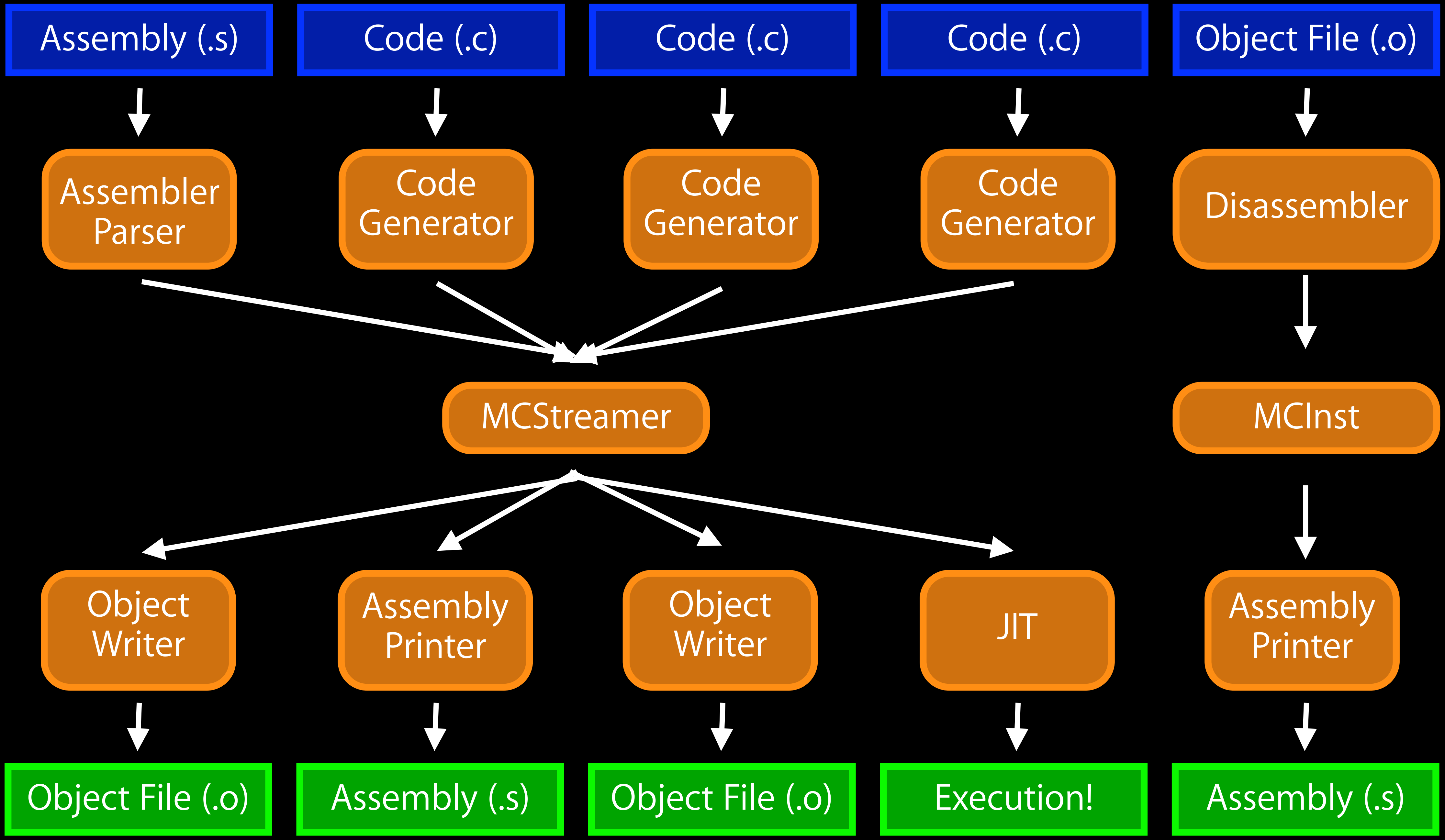

MCStreamer

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- Core MC Component

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  - Programmatic Assembler API

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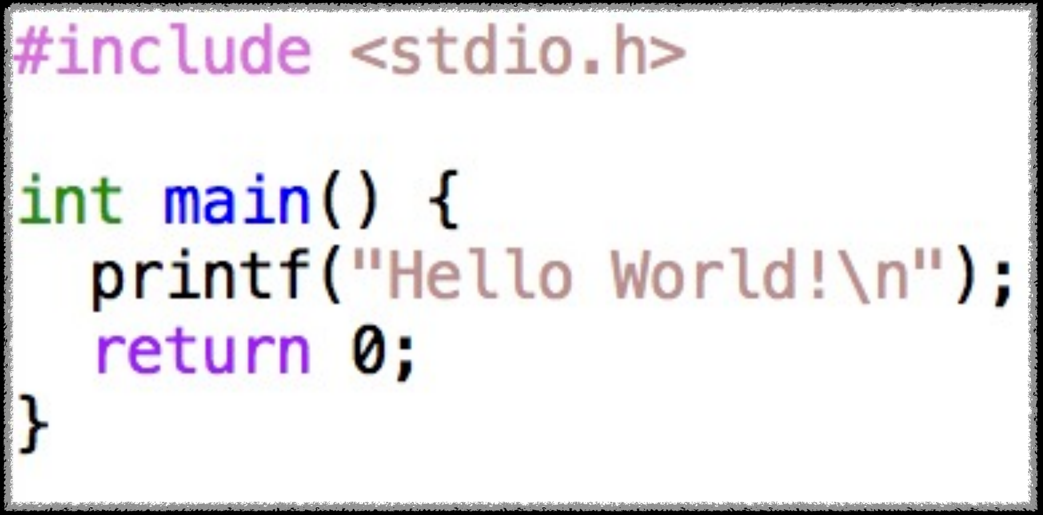
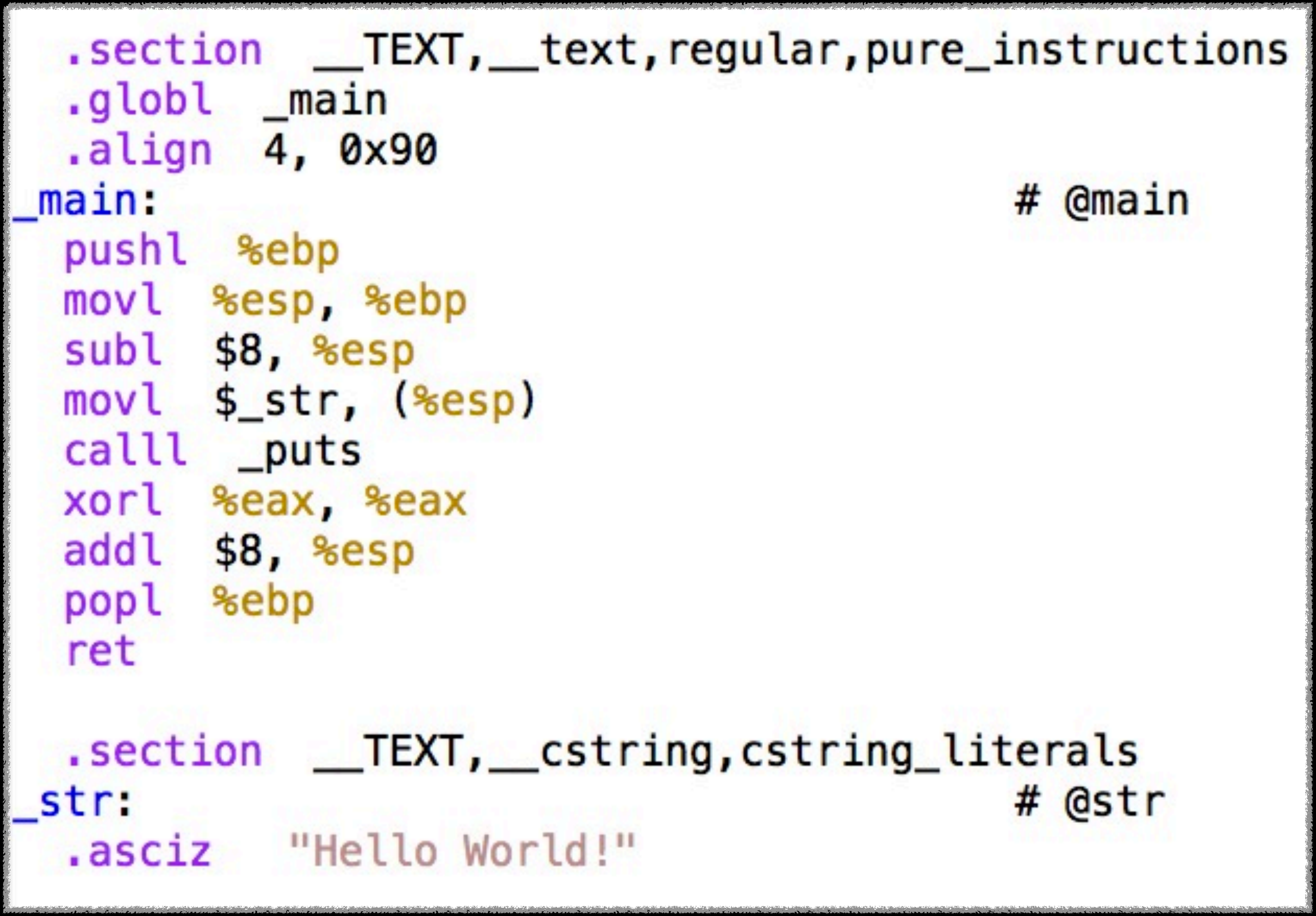


```
#include <stdio.h>

int main() {
  printf("Hello World!\n");
  return 0;
}
```

MCStreamer



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  .section  __TEXT,__text,regular,pure_instructions
  .globl  _main
  .align  4, 0x90
_main:                                            # @main
  pushl  %ebp
  movl  %esp, %ebp
  subl  $8, %esp
  movl  $_str, (%esp)
  calll  _puts
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  ret

  .section  __TEXT,__cstring,cstring_literals
_str:                                             # @str
  .asciz   "Hello World!"
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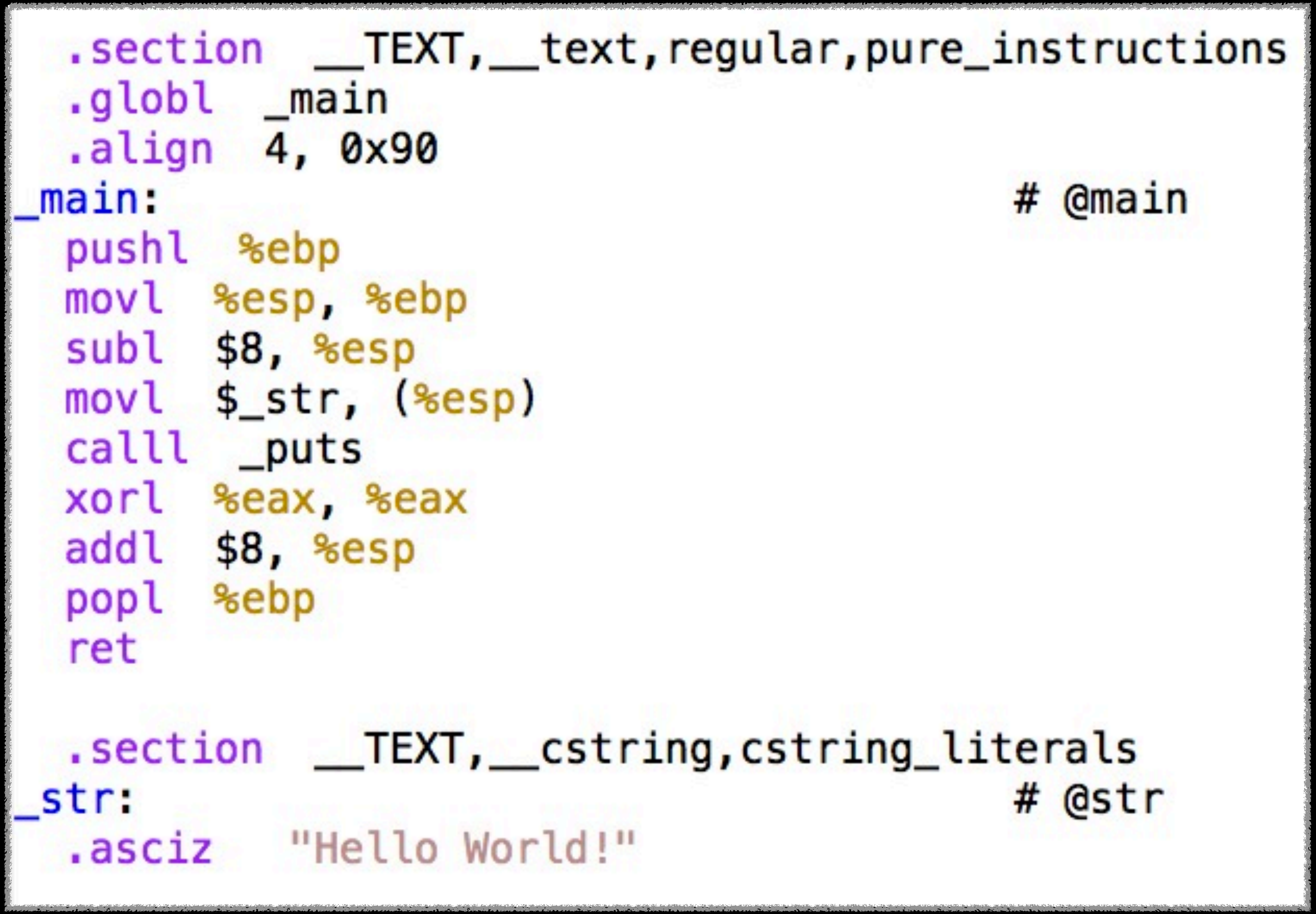

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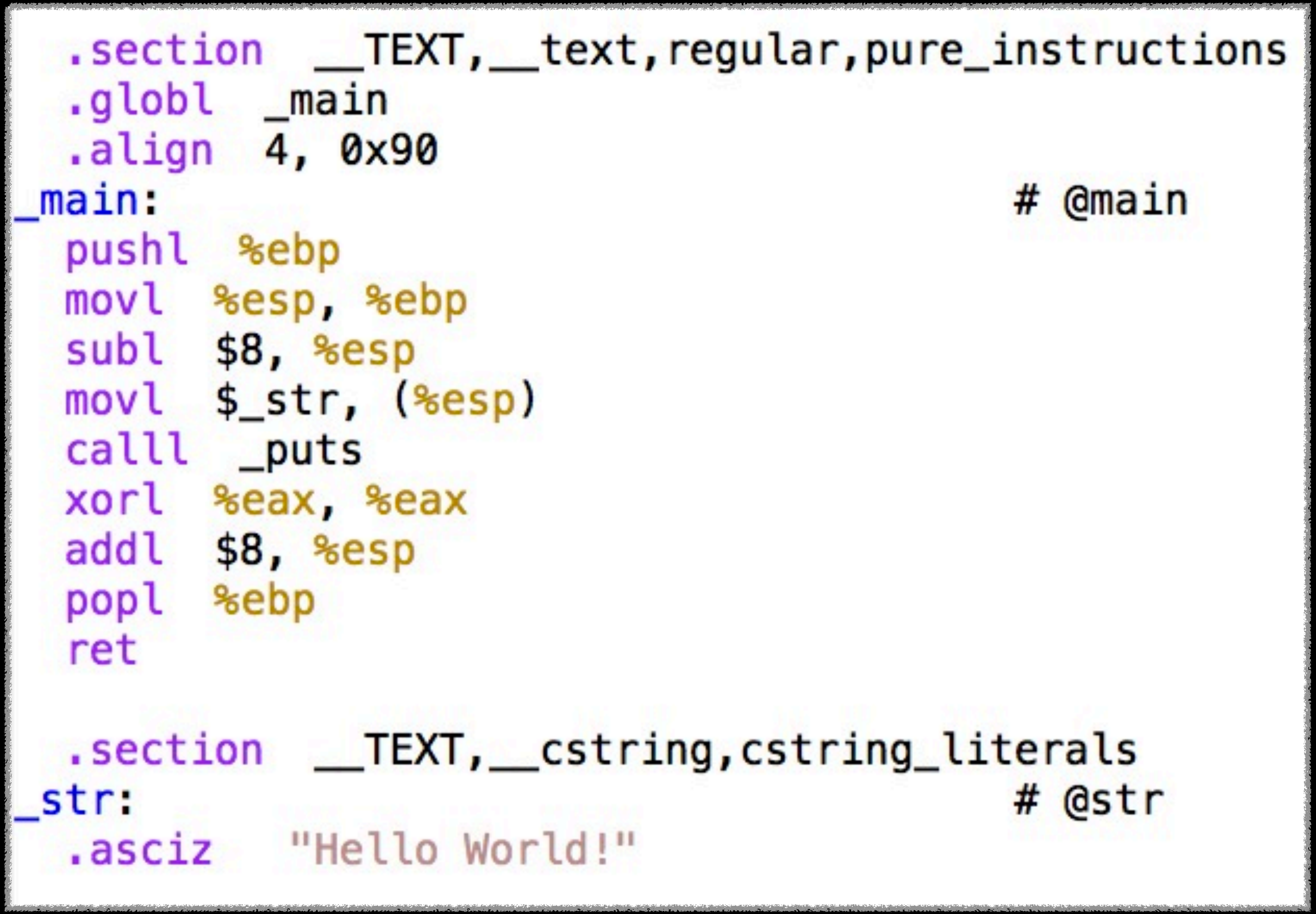

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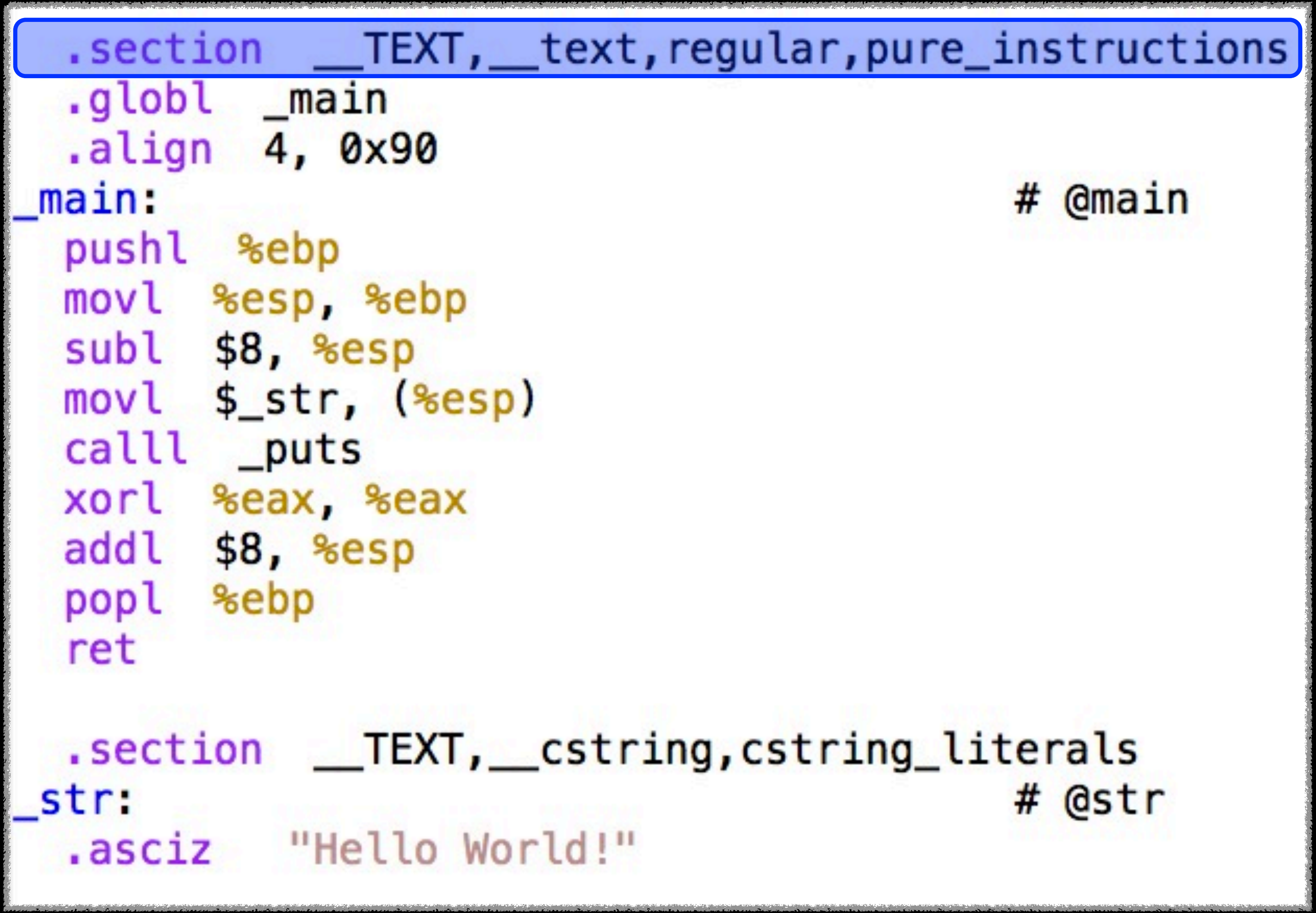

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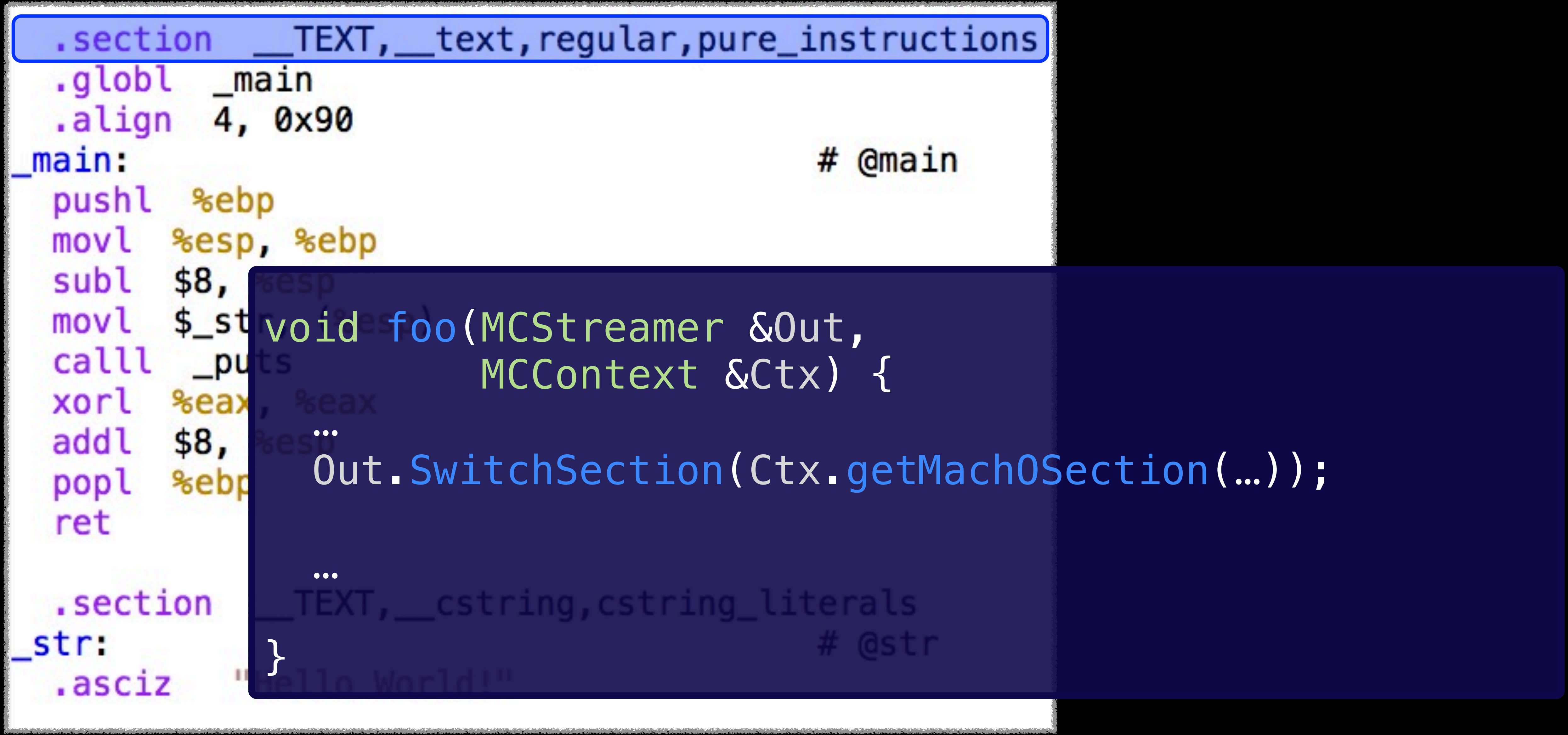

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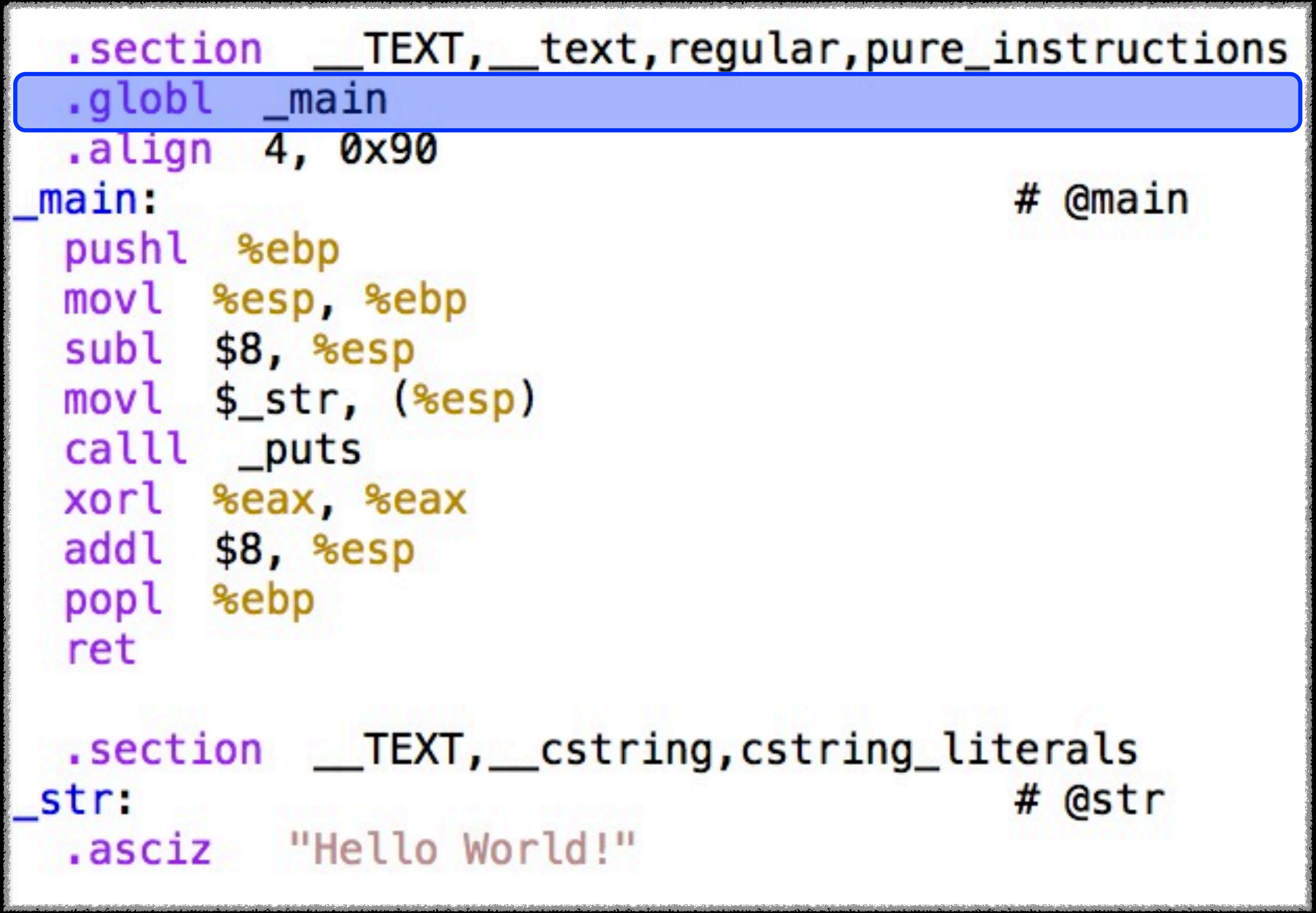
```
void foo(MCStreamer &Out,
         MCContext &Ctx) {
  …
  Out.SwitchSection(Ctx.getMachOSection(…));

  …
}
```

MCStreamer



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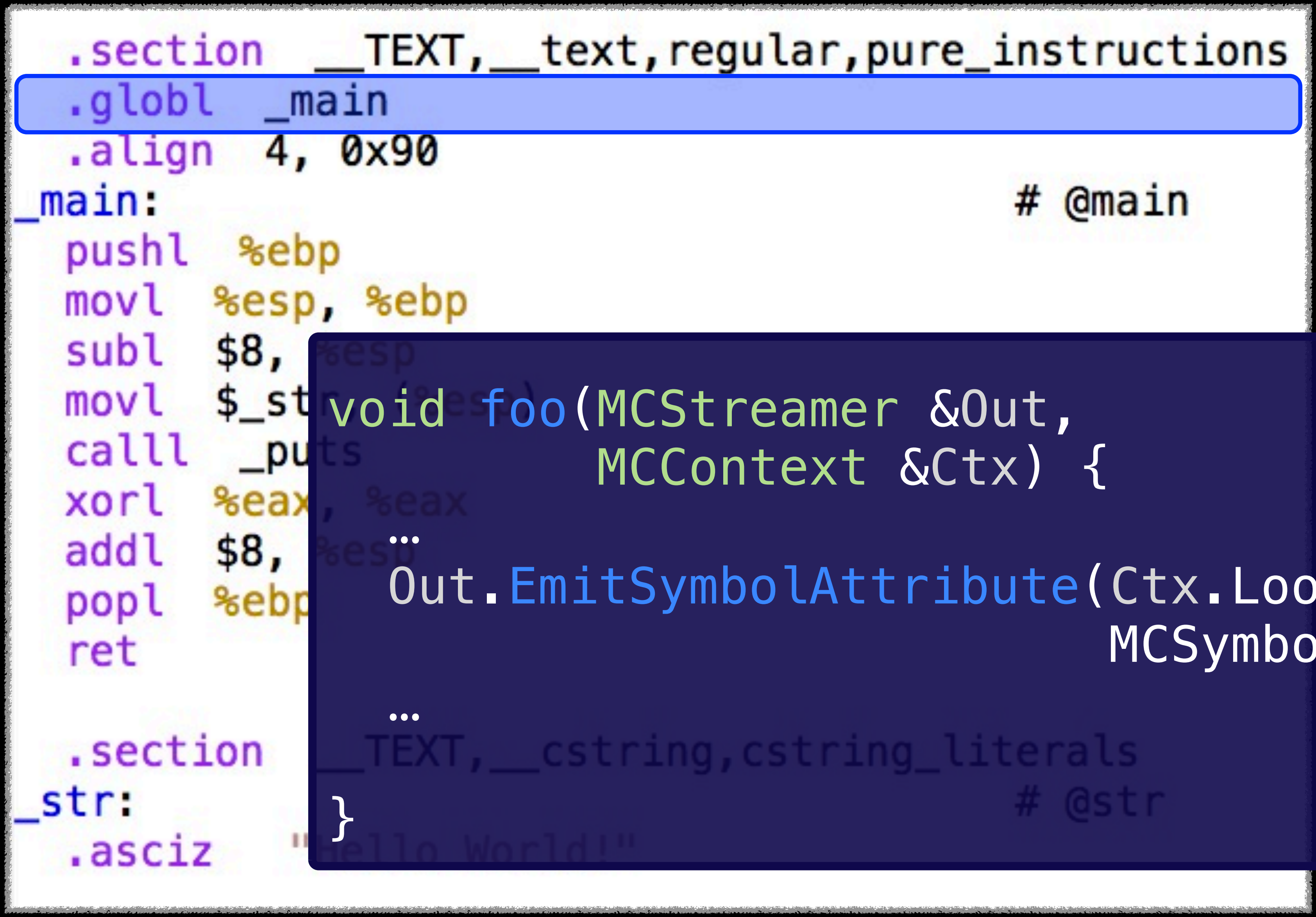

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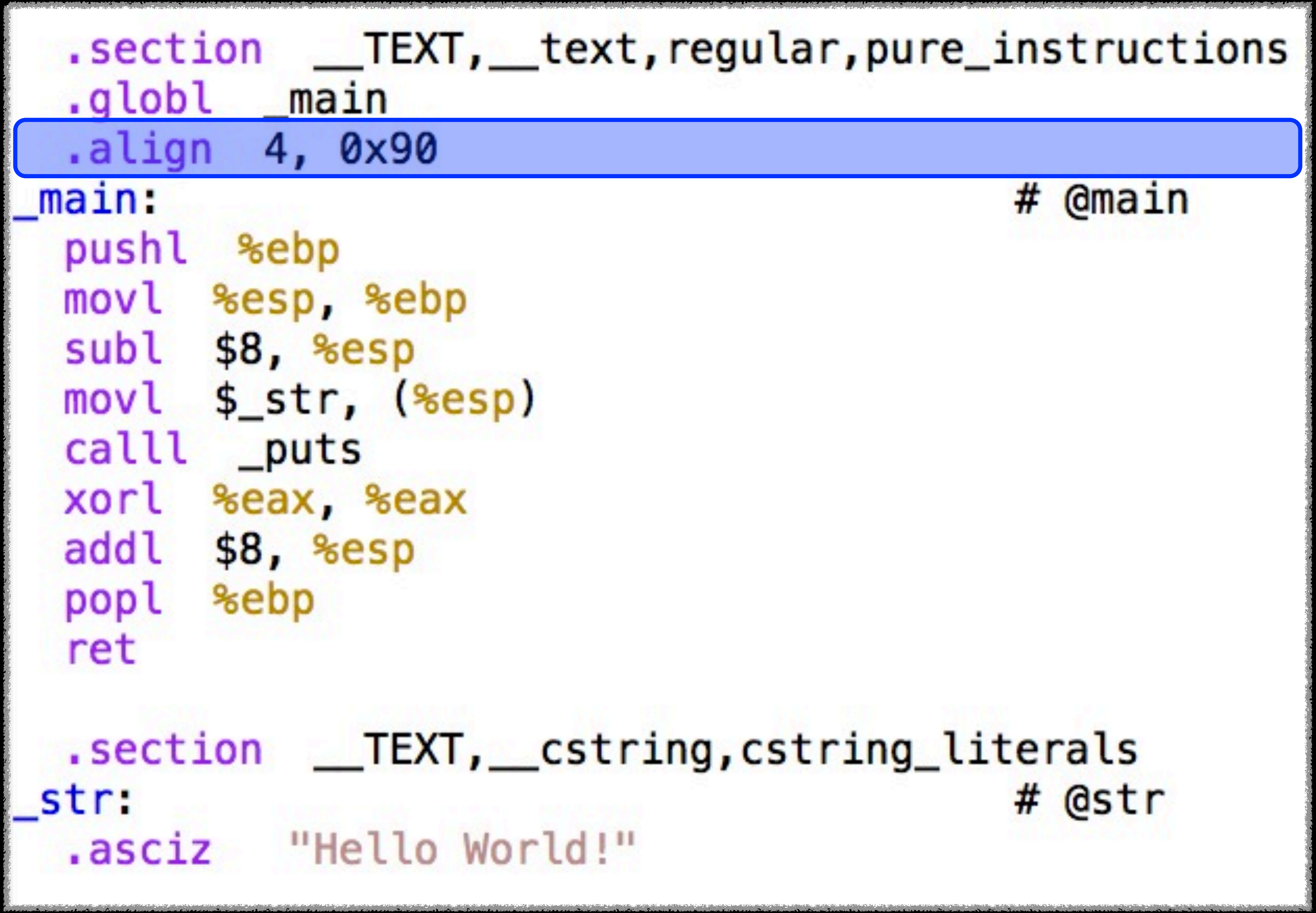
```
void foo(MCStreamer &Out,
         MCContext &Ctx) {
  …
  Out.EmitSymbolAttribute(Ctx.LookupSymbol(“_main”),
                          MCSymbolAttr::MCSA_Global);
  …
}
```

MCStreamer



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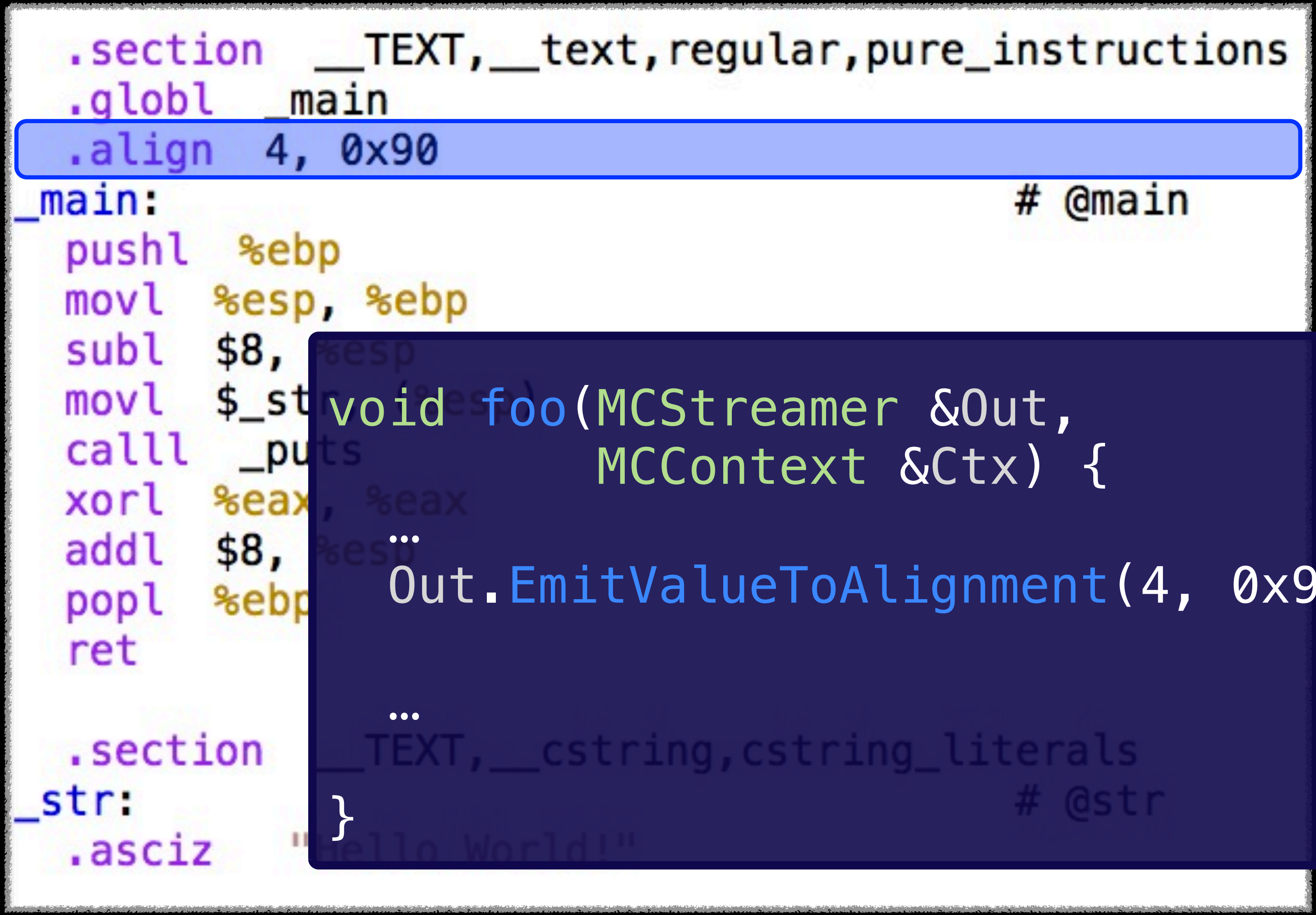

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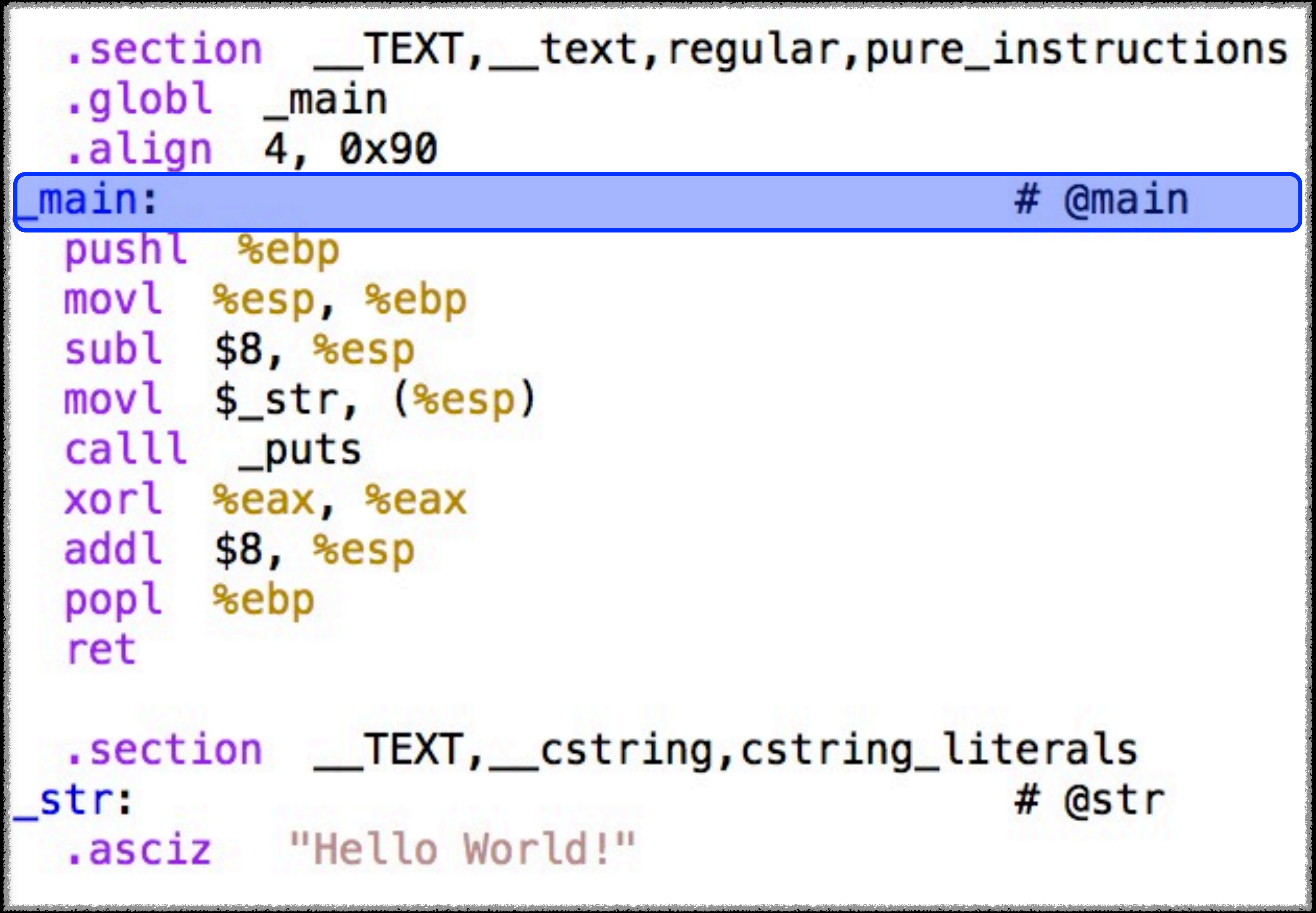
```
void foo(MCStreamer &Out,
         MCContext &Ctx) {
  …
  Out.EmitValueToAlignment(4, 0x90);

  …
}
```

MCStreamer



```
  .section  __TEXT,__text,regular,pure_instructions
  .globl  _main
  .align  4, 0x90
_main:                                      # @main
  pushl  %ebp
  movl  %esp, %ebp
  subl  $8, %esp
  movl  $_str, (%esp)
  calll  _puts
  xorl  %eax, %eax
  addl  $8, %esp
  popl  %ebp
  ret

  .section  __TEXT,__cstring,cstring_literals
_str:                                       # @str
  .asciz   "Hello World!"
```

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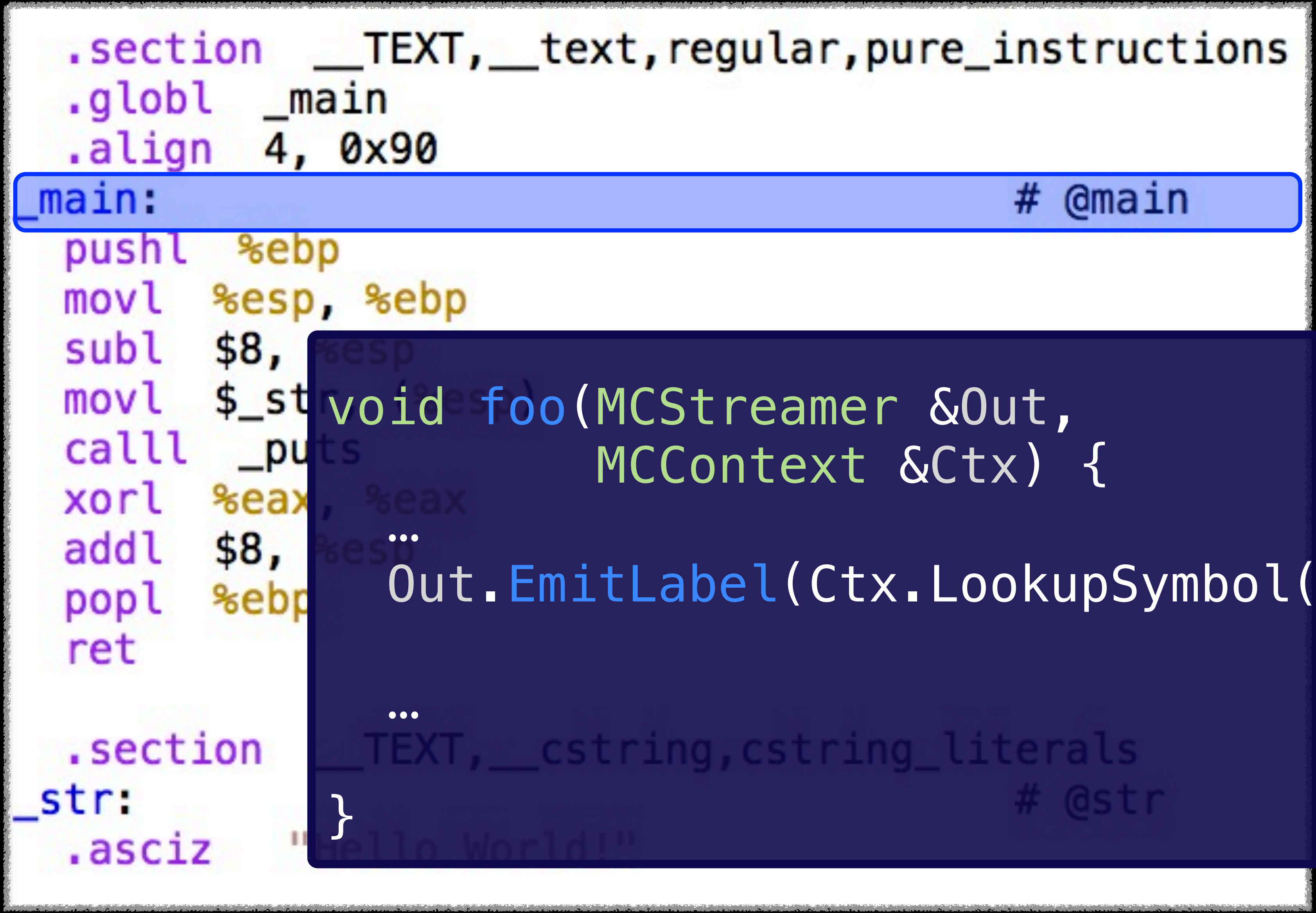

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```
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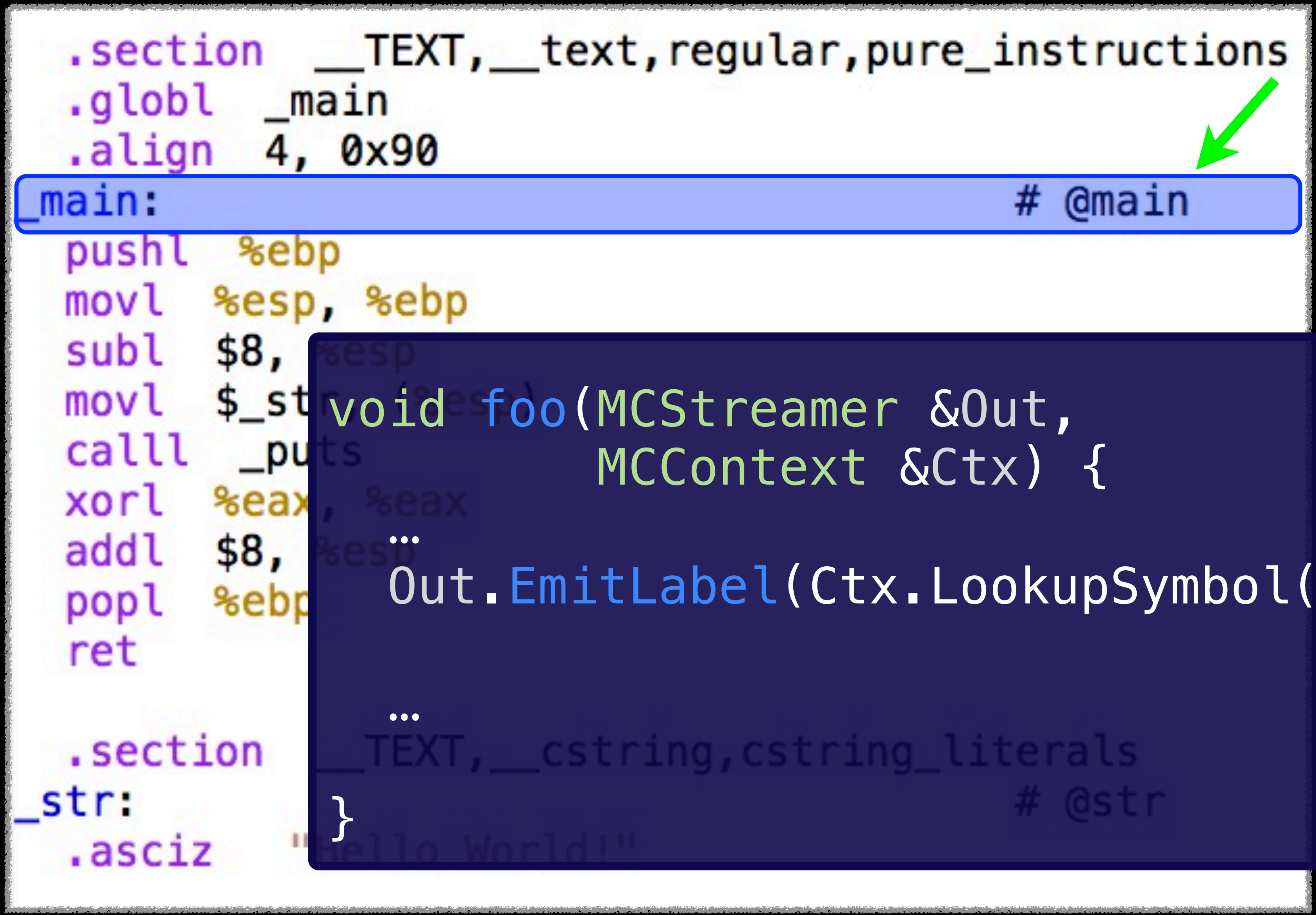
         MCContext &Ctx) {
  …
  Out.EmitLabel(Ctx.LookupSymbol(“_main”));

  …
}
```

MCStreamer



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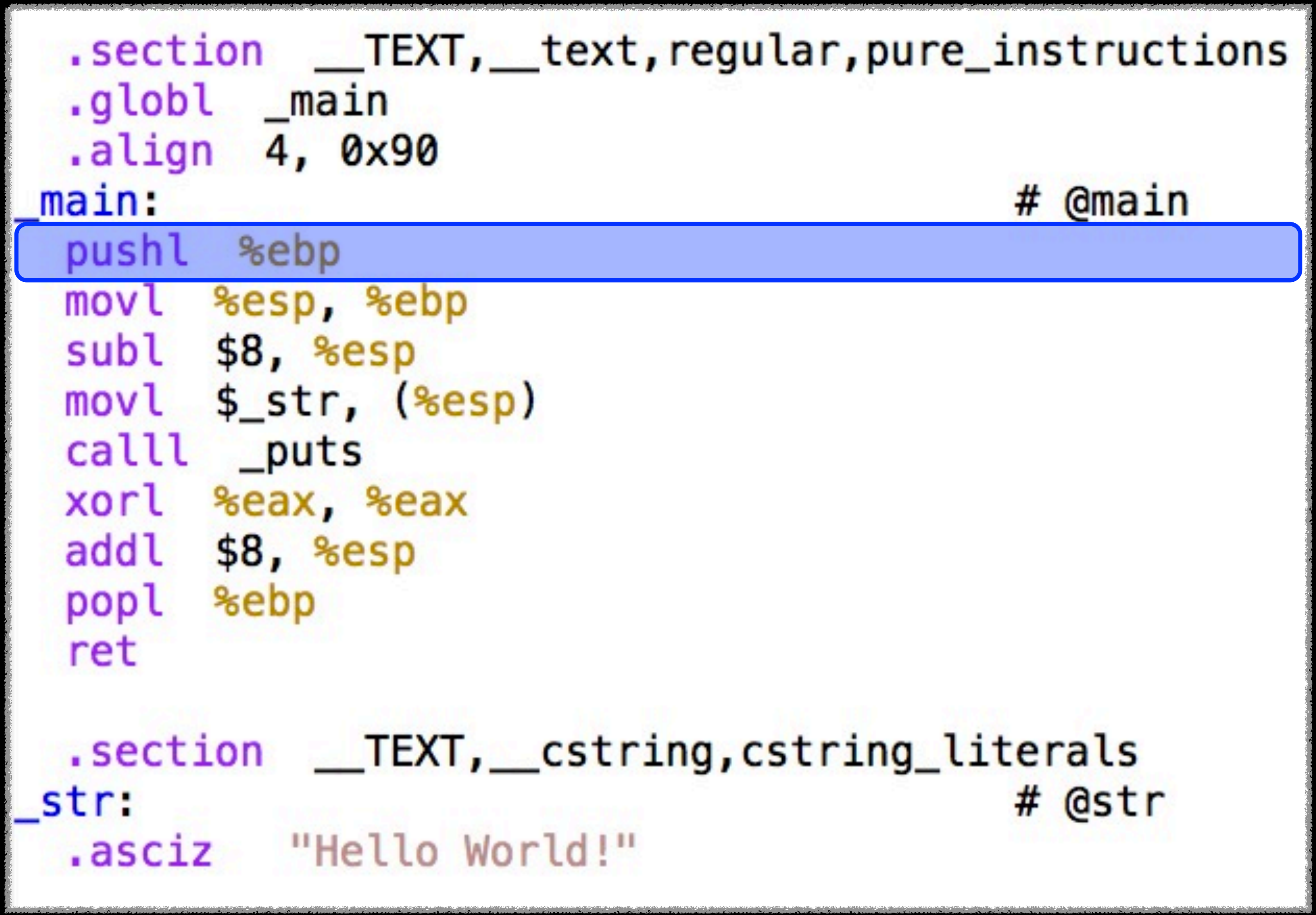
MCStreamer



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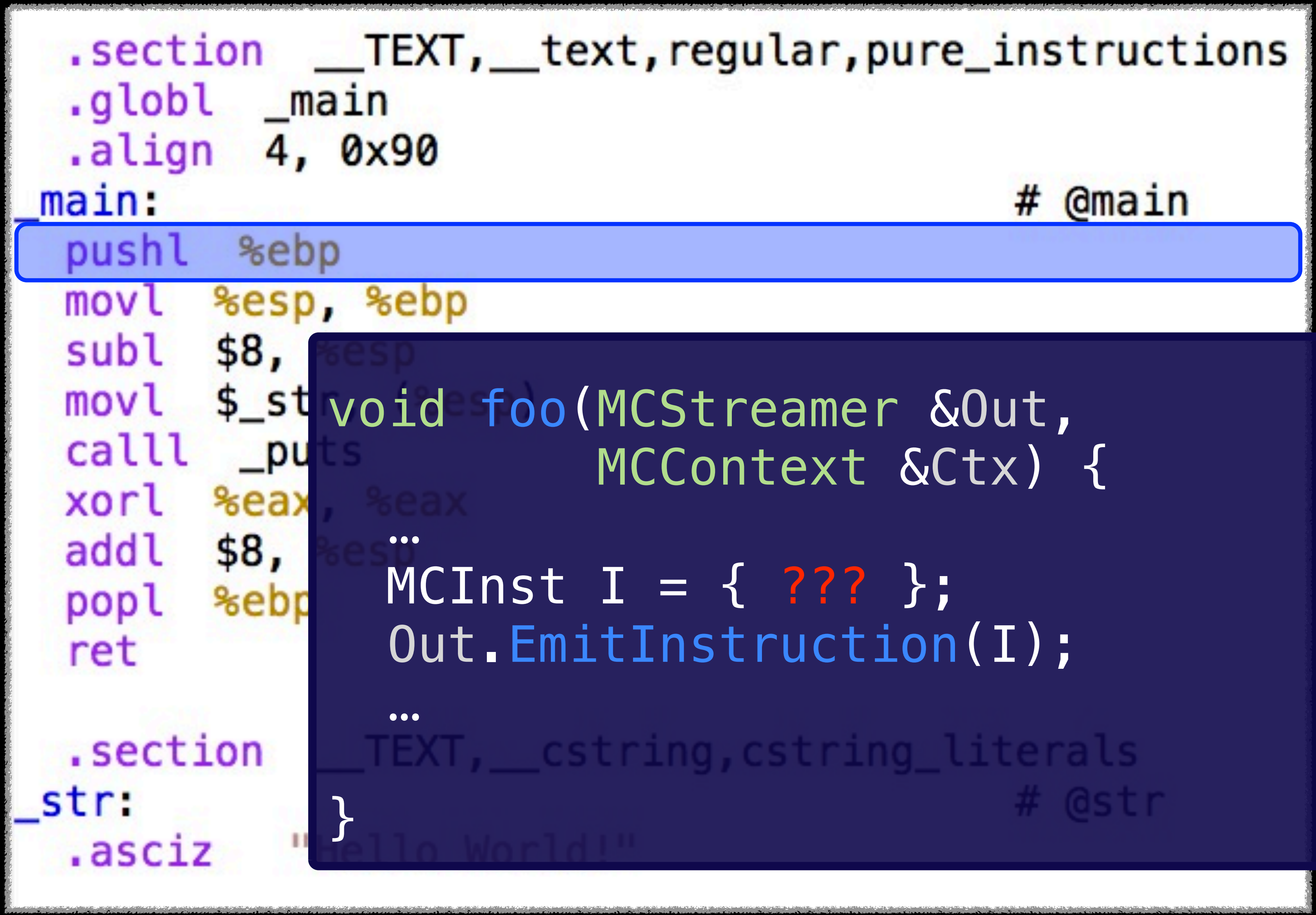

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```
void foo(MCStreamer &Out,
         MCContext &Ctx) {
  …
  MCInst I = { ??? };
  Out.EmitInstruction(I);
  …

}
```

MCInst

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   pushl %ebp              ## encoding: [0x55]
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{ X86::PUSH32r,   "pushl",  Convert__Reg1_0, { MCK_GR32 }, 0 },
{ X86::PUSH32rmr, "pushl",  Convert__Reg1_0, { MCK_GR32 }, 0 },
{ X86::PUSHCS32,  "pushl",  Convert,         { MCK_CS },
                                         Feature_In32BitMode },
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```

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Compile Wall Time (s)
4
3
2
1
0
i386.c
insn-emit.c
combine.c
insn-recog.c
🟦 System Assembler
🟩 Integrated Assembler

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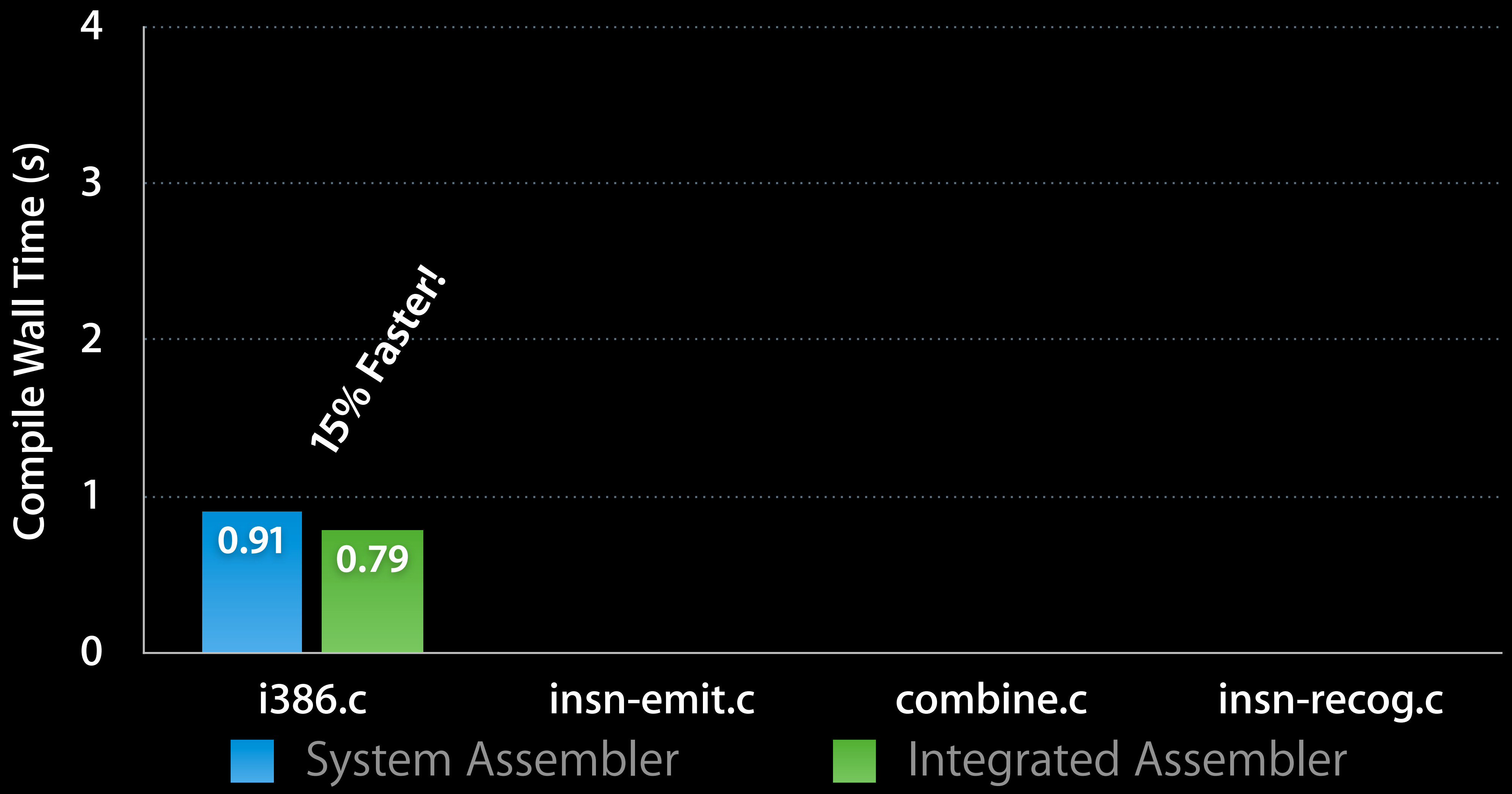

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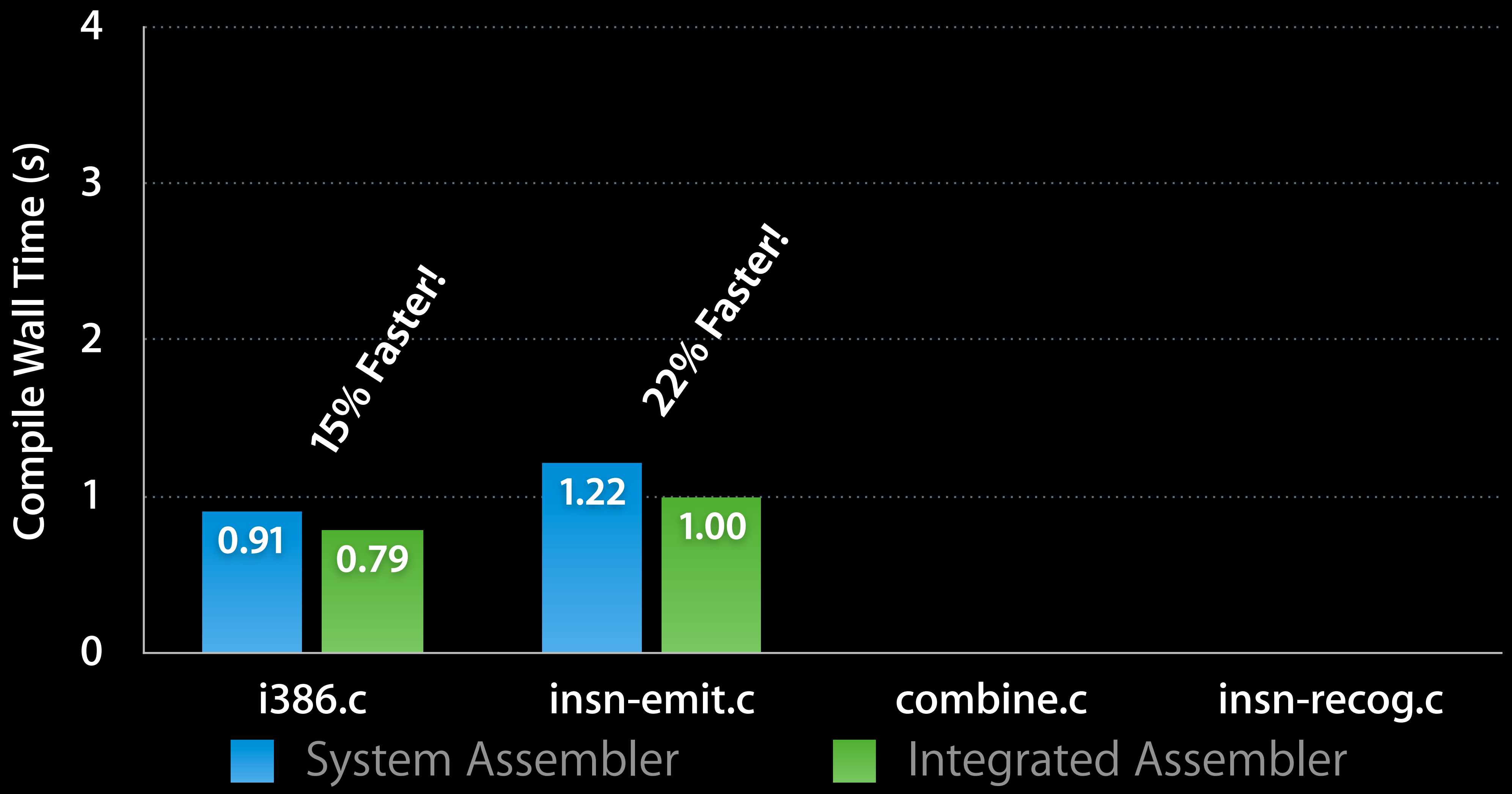

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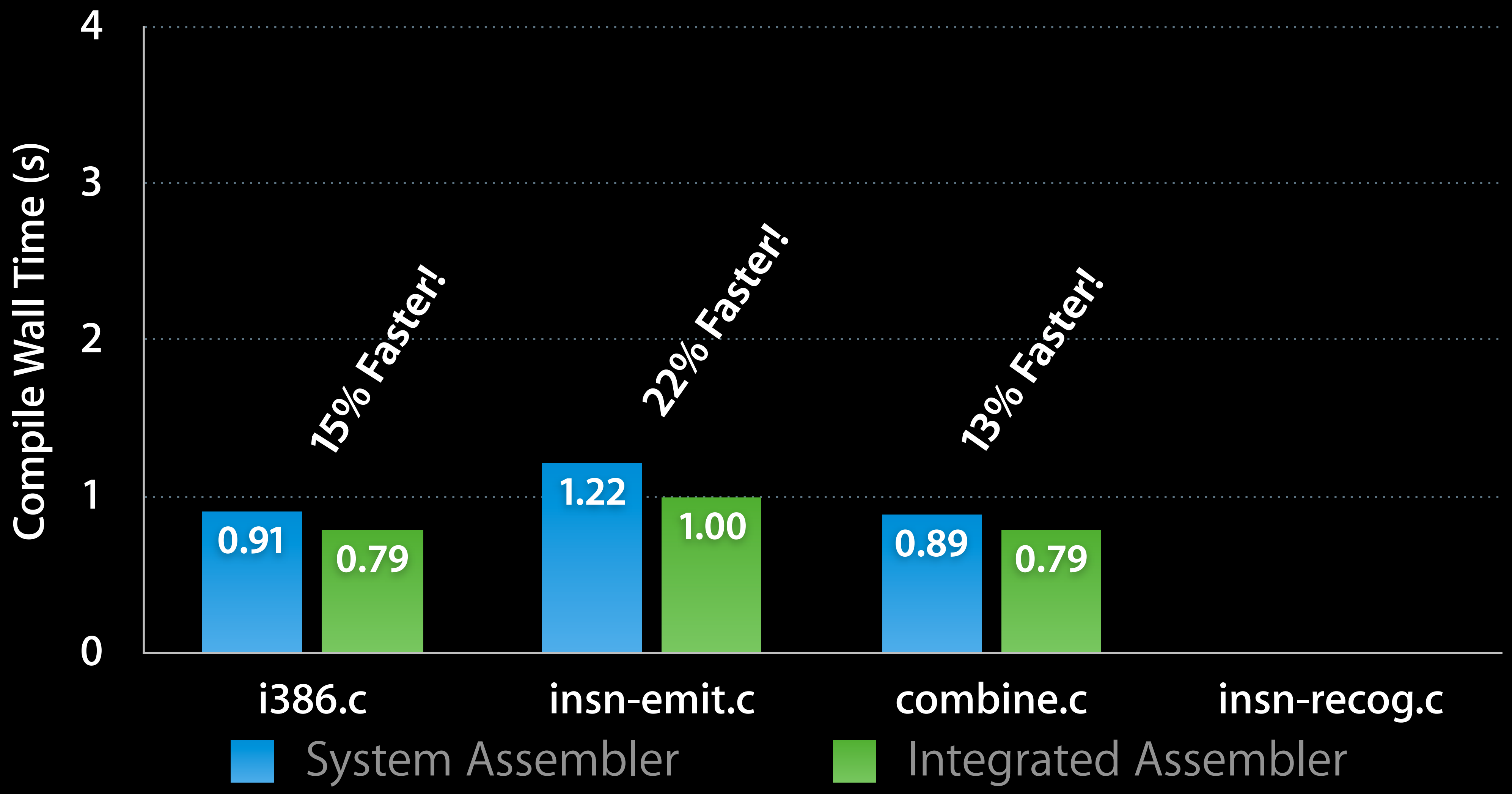

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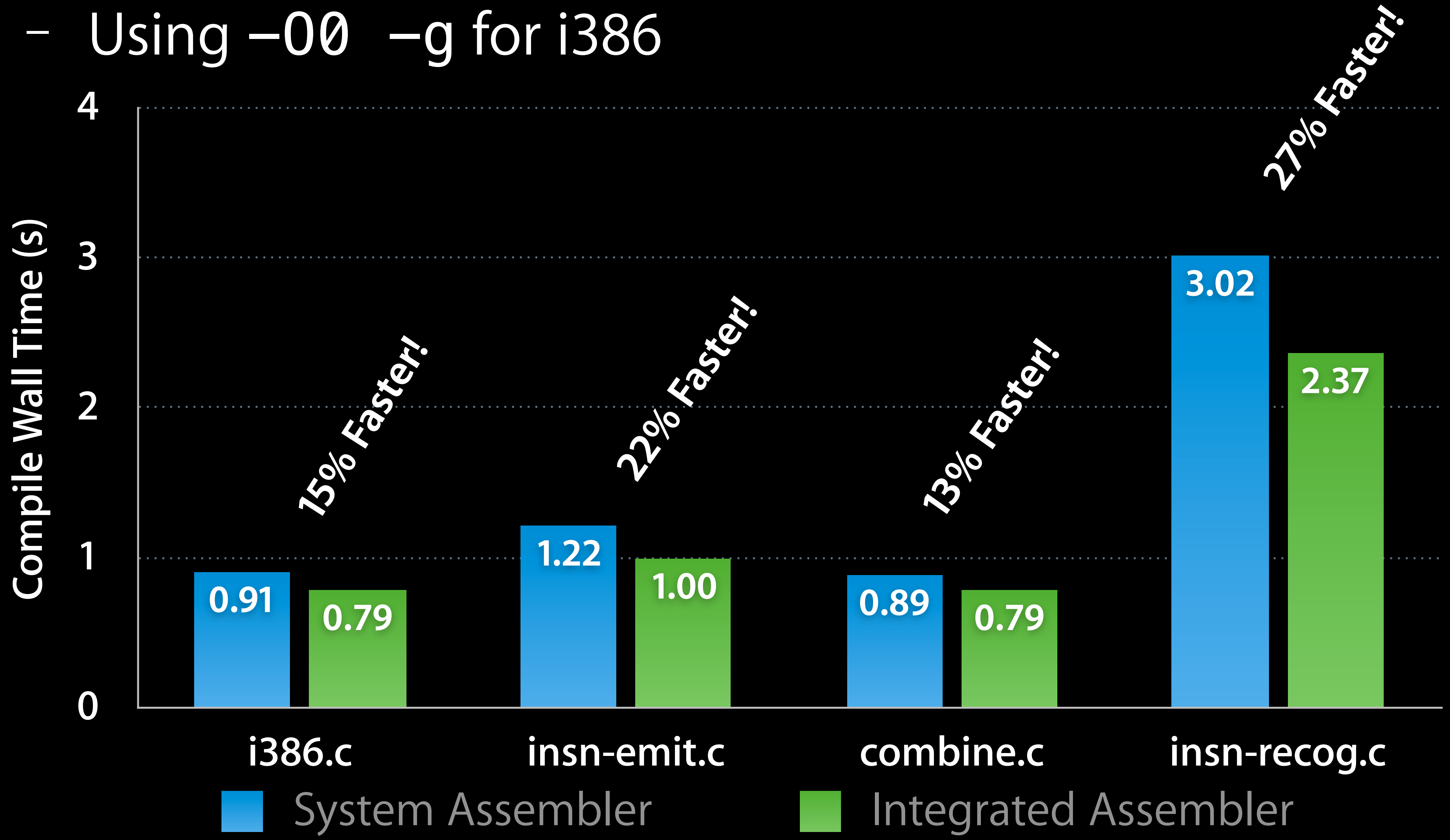

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Questions?