888: LLVM

Week 1 - Introduction

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Organization

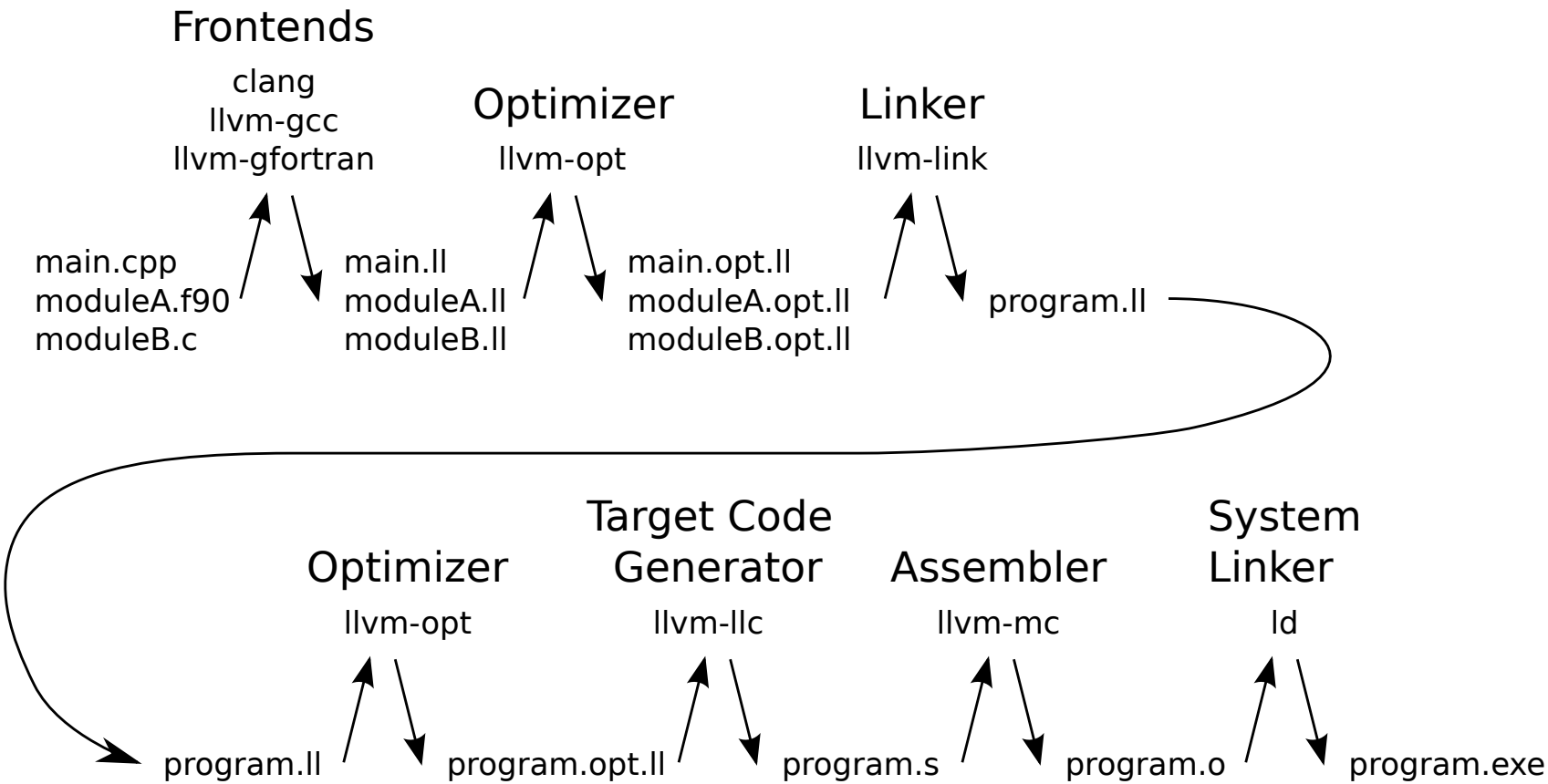
- DL 698 on Tuesdays at 2pm
- Need any help?
  - My office: Dreese 572
  - E-Mail: grosser.13@osu.edu
  - Website: `http://www.fim.uni-passau.de/~grosser`
- Weekly exercises: Given on Tuesday - Due to Sunday 6pm

What is LLVM?

- Project to build compiler infrastructure
- Subprojects
  - **LLVM - Infrastructure**
  - Clang/Dragonegg - C/C++/Objective C compiler
  - libc++ - C++ standard library
  - lldb - Debugger
- Written in C++
- OpenSource - BSD like license
- www.llvm.org

LLVM everywhere?

A static compile flow



LLVM-IR

- Base of all LLVM optimization passes
- Low level assembly like language
- Traget independent (frontends might introduce target information)
- Register machine, infinite number of named registers
- Each register is assigned exactly once (SSA)
- Load/Store Architecture
- Defined at `http://llvm.org/docs/LangRef.html`

LLVM-IR

Representations:

- In memory representation - C++ data structures
- Bitcode - Binary file (.bc)
- Human readable form - Text file (.ll)

All representation are quivalent. To translate from one to another:

```
> opt -S program.bc -o program.ll
> opt    program.ll -o program.bc
```

Creating LLVM-IR

main.c

```
int main() {
return 42;
}
```

clang -S -emit-llvm main.c -o main.ll

```
; ModuleID = 'main.ll'
target datalayout = "e-p:64:64:64-i1:8:8-i8:8:8-[...]"
target triple = "x86_64-unknown-linux-gnu"

define i32 @main() nounwind {
  %1 = alloca i32, align 4
  store i32 0, i32* %1
  ret i32 42
}
```

Compiling LLVM-IR

```
> llc main.ll -o main.s && gcc main.s -o main.exe
> ./main.exe
> echo $?
42

> lli main.ll
> echo $?
42
```

- llc - LLVM to Assembly compiler
- lli - Just in time compiler

Our first function

Create a function that calculates n^2

Our first function

Create a function that calculates n^2

```
define i32 @pow(i32 %number) {
%pow = mul i32 %number, %number
ret i32 %sqrt
}

define i32 @main() nounwind {
  %result = call i32 @pow(i32 7)
  ret i32 %result
}
```

Optimize our first function

```
> opt -O3 pow.ll -o pow.opt.ll -S
```

Optimized function

Optimize our first function

```
> opt -O3 pow.ll -o pow.opt.ll -S
```

Optimized function

```
define i32 @pow(i32 %number) nounwind readnone {
  %sqrt = mul i32 %number, %number
  ret i32 %sqrt
}

define i32 @main() nounwind readnone {
  ret i32 49
}
```

Multiple modules

```
> llvm-link module_main.ll module_pow.ll \
  -o module_combined.ll -S
```

Exercise

- Install LLVM from the source
- Git repository at: `http://llvm.org/git/llvm.git`
- Install Clang
- Git repository at: `http://llvm.org/git/clang.git`
- Take a small C project and create some