Implementing Optimization

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SWPP Practice Session

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Optimization

- Rewriting the code so that it does the same job faster
- In LLVM: use optimization pass
- Optimization pass may do one of the following:
  - Refactor the code into simpler form
  - Rewrite simplified code to make them run faster

Example – Constant Folding

- Reduce simple constant arithmetic into a single constant
- Code and examples are at class repository!

```
define i32 @constant_fold() {
  %a = add i32 1, 2
  %b = sub i32 %a, 1
  ret i32 %b
}
```

```
define i32 @constant_fold() {
  ret i32 2
}
```

Example – Use to Undef

- Replace values used in undef_zone to undef
- Code and examples are at class repository!

```
define i32 @f(i1 %cond, i32 %arg) {
  %inst = add i32 1, 1
  br i1 %cond, label %undef_zone, label %normal_zone
undef_zone:
  %x1 = add i32 %arg, 0 ; %x1 = add i32 undef, 0
  ret i32 %inst         ; ret i32 undef
normal_zone:
  %x2 = add i32 %arg, 0
  ret i32 %inst
}
```

Example – Instruction Matching

- Matches values yielded from certain instruction sequence
- Code and examples are at class repository!

Testing the Optimization

- How do we know if our optimization works as intended?
- Testing is an easier and most widely used method
- LLVM offers FileCheck for IR-based testing

FileCheck

- Syntactic check (regex match)
- Write regexes to match against as comments in IR

```
define i32 @constant_fold() {
; CHECK-LABEL: @constant_fold(
; CHECK-NEXT:    ret i32 2
  %a = add i32 1, 2
  %b = sub i32 %a, 1
  ret i32 %b
}
```

```
define i32 @f(i32 %x, i32 %y) {
; CHECK-LABEL: @f(
; CHECK-NEXT: [[Z:%.*]] = add i32 %x, %y
; CHECK-NEXT: ret i32 [[Z]]
  %z = add i32 %x, %y
  %z2 = add i32 %z, 0
  ret i32 %z2
}
```

FileCheck Test Directives

- Test directives: Instruct how to match output texts
  - `CHECK` : Simply check for existence of match
  - `CHECK-NEXT` : Check that the very next line matches the pattern
  - `CHECK-NOT` : Check that such pattern does not exist
  - `CHECK-LABEL` : Only match the code inside the specified block
- Check the official documentation page for more details

How to Use FileCheck

- `~/<llvm>/bin/opt -passes="my-opt" src.ll -S -o tgt.ll`
- `~/<llvm>/bin/FileCheck src.ll < tgt.ll`

Verifying the Optimization

- Optimization is a behavioral refinement
- Does our optimization actually ‘refines’?
  - Reasoning about the refinement is difficult
  - ⋯ Which makes verifying the optimization hard as well
- Solution: let program to do the reasoning for us!

Alive2

- Automatically checks refinement between pair of IRs
- Take a look at `install-alive2.sh` to install Alive2
- `/<alive2-build-dir>/alive-tv src.ll tgt.ll`
- Or use the interactive webpage

- We may require you to use Alive2 in the project!