Sequence 4.6 – IRBuilder

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Creating an IR of the program

How to build an IR representation of our program ?

- Instead of writing IR directly, we call a programmatic API, the *IR Builder*
    - Faster: IR is directly built in memory
    - Robust: The API enforces many legality rules of the IR
    - Cleaner: The IR Builder offers high-level abstractions for building the IR

Principles of Design

- An IR Builder keeps track of an *insert point*. New instructions are added after the insert point which is then automatically moved forward.
- High level builders for complex patterns such as:
  - Calling multi-parameters functions
  - Accessing the field of a structure
  - Creating conditional branches

Context and Function

- A Builder operates in a given *Context*
  - The *Context* captures the global data of a compilation unit
  - Whenever the builder creates a new global variable, global type, or function declaration, it is added to the *Context*
- A Builder inserts instructions in a given *BasicBlock*
  - A *BasicBlock* operates within a *Context* and belongs to a *Function*

Inserting new instructions

How to translate (10+5)*2 in IR ?

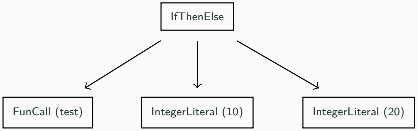
```
llvm:IRBuilder Builder(Context);
llvm::BasicBlock *const body =
    llvm::BasicBlock::Create(Context, "body", current_function);

Builder.SetInsertPoint(body);

llvm::Value * a =
    Builder.CreateAdd(Builder.getInt32(10), Builder.getInt32(5));
llvm::value * b =
    Builder.CreateMul(a, Builder.getInt32(2));
```

How to translate Tiger AST to LLVM IR

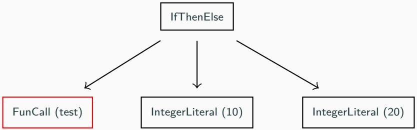
```
if test() then 10 else 20
```



Translate with a visitor that returns LLVM values !

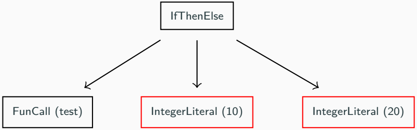
FunCall

```
// Simplified ! (no static link + no arguments)
llvm::Value *IRGenerator::visit(const FunCall &call) {
  const FunDecl &decl = call.get_decl().get();
  llvm::Function *callee =
    Module->getFunction(decl.get_external_name().get());
  return Builder.CreateCall(callee, {}, "call");
}
```

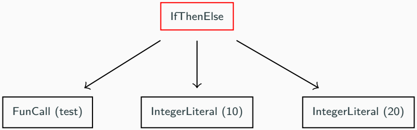


IntegerLiteral

```
llvm::Value *IRGenerator::visit(const IntegerLiteral &literal) {
  return Builder.getInt32(literal.value);
}
```



IfThenElse



IfThenElse is more complex: diverging control requires multiple basic blocks. To simplify, in the following we assume that the if always returns a value.

IfThenElse: Prolog

```
llvm::Value *IRGenerator::visit(const IfThenElse &ite) {

  // We create an allocation in the function entry block
  // to store the if result (see lecture 4.4)
  llvm::Value *const result =
    alloca_in_entry(llvm_type(ite.get_type()), "if_result");

  // We create three empty basic blocks
  llvm::BasicBlock *const then_block =
      llvm::BasicBlock::Create(Context, "if_then", current_function);
  llvm::BasicBlock *const else_block =
      llvm::BasicBlock::Create(Context, "if_else", current_function);
  llvm::BasicBlock *const end_block =
      llvm::BasicBlock::Create(Context, "if_end", current_function);
```

IfThenElse: Condition

We branch depending on the condition,

```
Builder.CreateCondBr(
    Builder.CreateIsNotNull(ite.get_condition().accept(*this)),
    then_block,
    else_block);
```

`ite.get_condition().accept(*this)` returns the result LLVM Value of the FunCall `test()` translation.

IfThenElse: Then and Else bodies

```
Builder.SetInsertPoint(then_block);
llvm::Value *const then_result =
  ite.get_then_part().accept(*this);
Builder.CreateStore(then_result, result);
Builder.CreateBr(end_block);

Builder.SetInsertPoint(else_block);
llvm::Value *const else_result =
  ite.get_else_part().accept(*this);
Builder.CreateStore(else_result, result);
Builder.CreateBr(end_block);
```

IfThenElse: Epilog

```
llvm::Value *const result =
  alloca_in_entry(llvm_type(ite.get_type()), "if_result");
...

Builder.SetInsertPoint(end_block);
return Builder.CreateLoad(result);
```