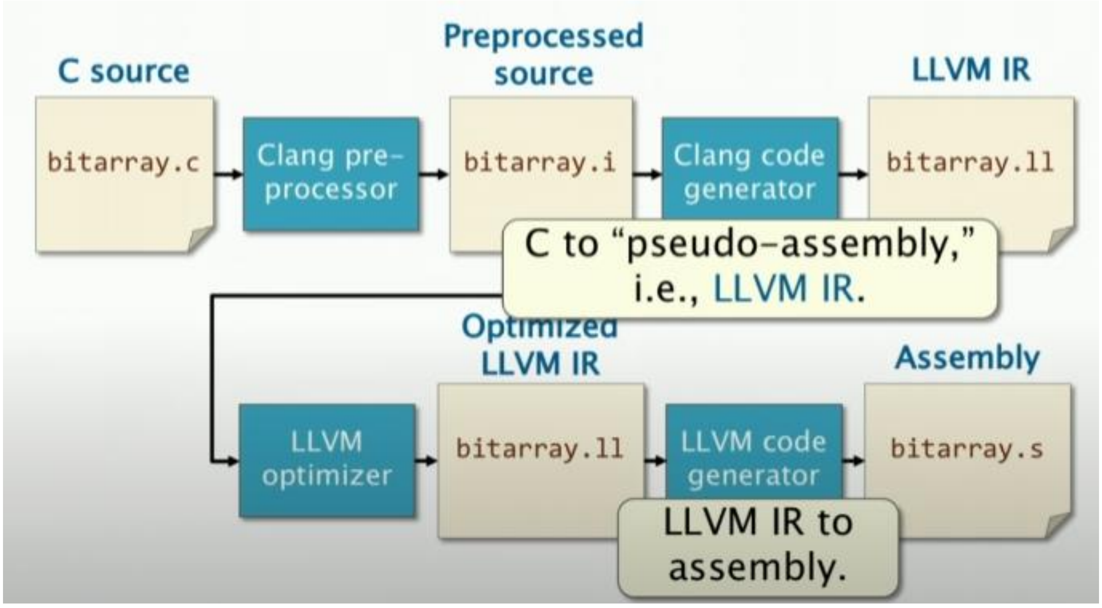
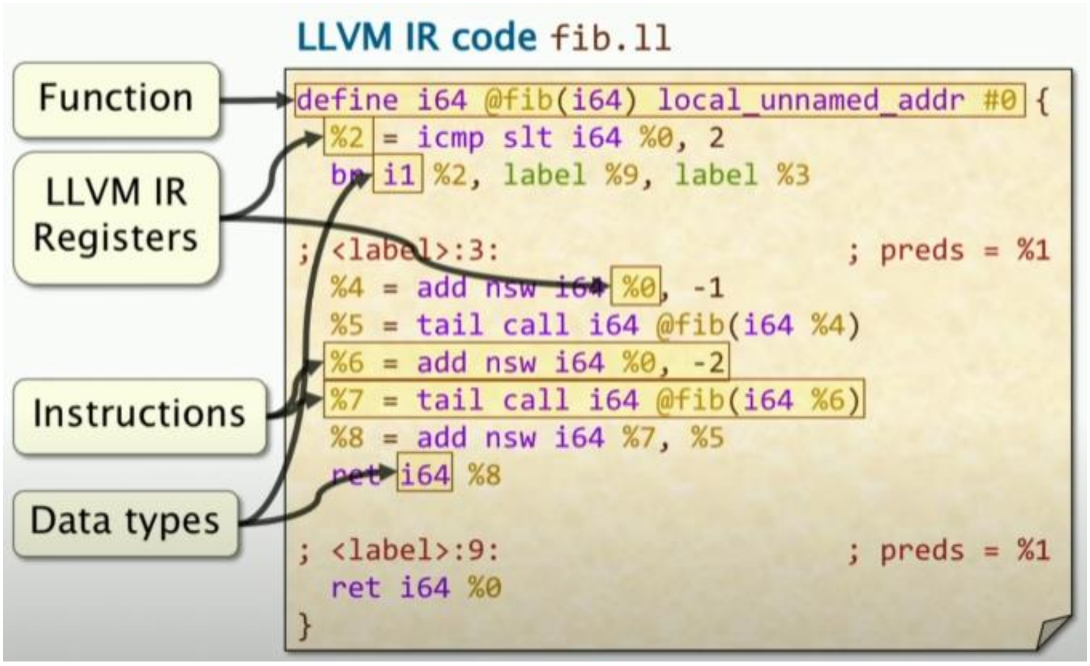
Unit 5 C to Assembly

Assembly reveals what compiler optimized and help us debug if the compiler optimization creates a bug.



The process that translate C source code to Assembly using Clang/LLVM.

An example code of LLVM IR.



LLVM IR uses a simple instruction format *<destination operand> = <opcode> <source operand>*.

The differences between LLVM IR and Assembly

1. LLVM IR has smaller instruction set
2. Infinite LLVM IR registers, similar to variables in C
3. No implicit FLAGS register or condition code
4. No explicit stack pointer or frame pointer
5. C-like type system
6. C-like functions

LLVM IR Registers

LLVM registers are like C variables which supports an infinite number of registers and register names are local to each LLVM IR function.

LLVM IR Instruction

Syntax for instructions that produce a value

%<name> = <opcode> <operand list>

Syntax for other instructions

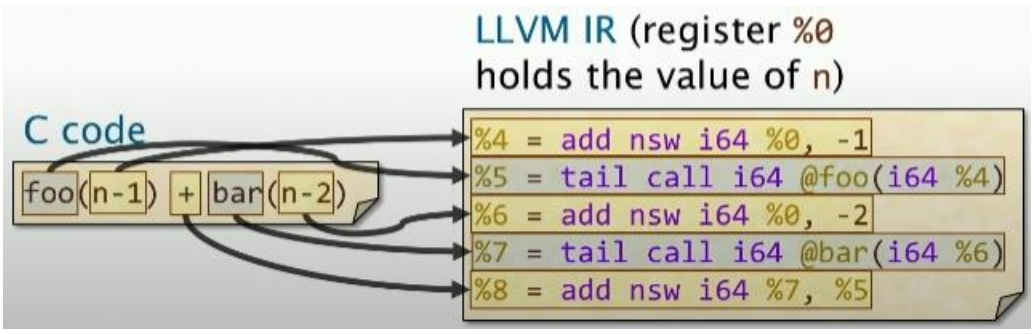
<opcode> <operand list>

Type or operation		Example(s)
Data movement	Stack allocation	alloca
	Memory read	load
	Memory write	store
	Type conversion	bitcast, ptrtoint
Arithmetic and logic	Integer arithmetic	add, sub, mul, div, shl, shr
	Floating-point arithmetic	fadd, fmul
	Binary logic	and, or, xor, not
	Boolean logic	icmp
	Address calculation	getelementptr
Control flow	Unconditional jump	br <location>
	Conditional jump	br <condition>, <true>, <false>
	Subroutines	call, ret
	Maintaining SSA form	phi

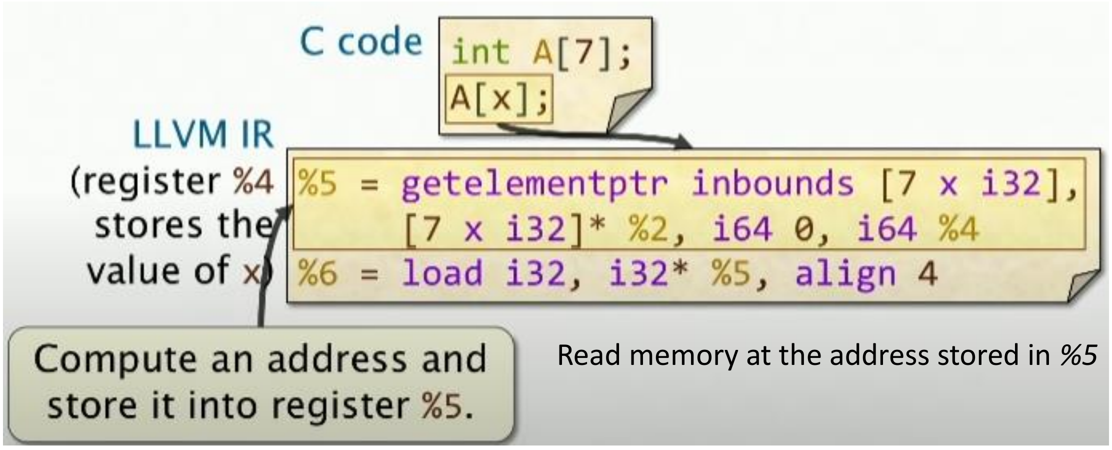
LLVM IR Data Types

- Integers: *i <number>* (Number indicate how many bits)
- Floating-points: *double, float*
- Arrays: *[<number> x <type>]*
- Structs: *{<type>, …}*
- Vectors: *<<number> x <type>>*
- Pointers: *<type>**
- Labels: *label*

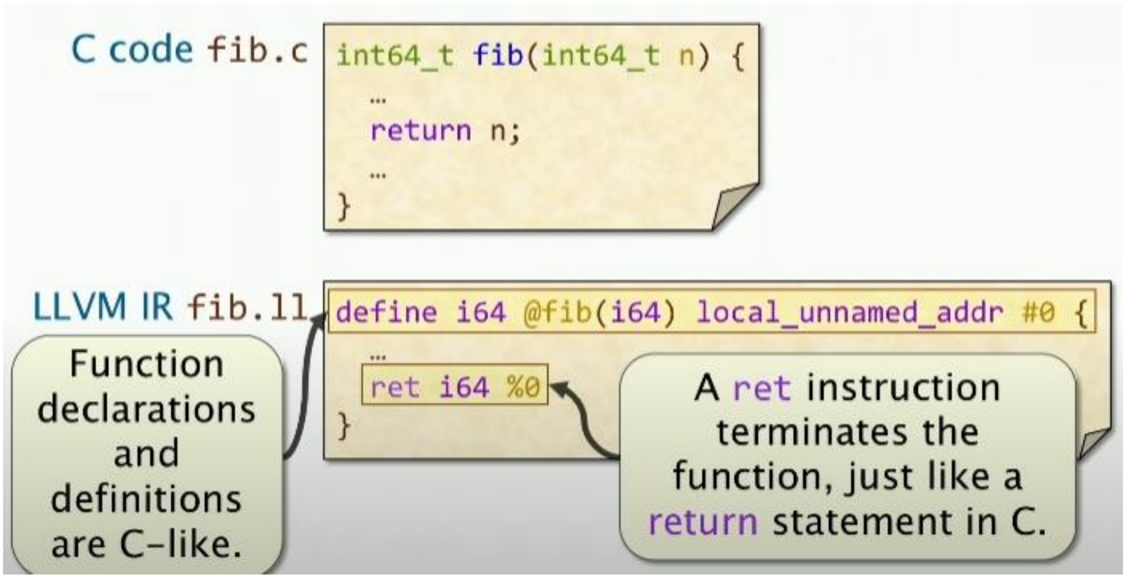
Straight Line C Code in LLVM IR



Aggregate Types



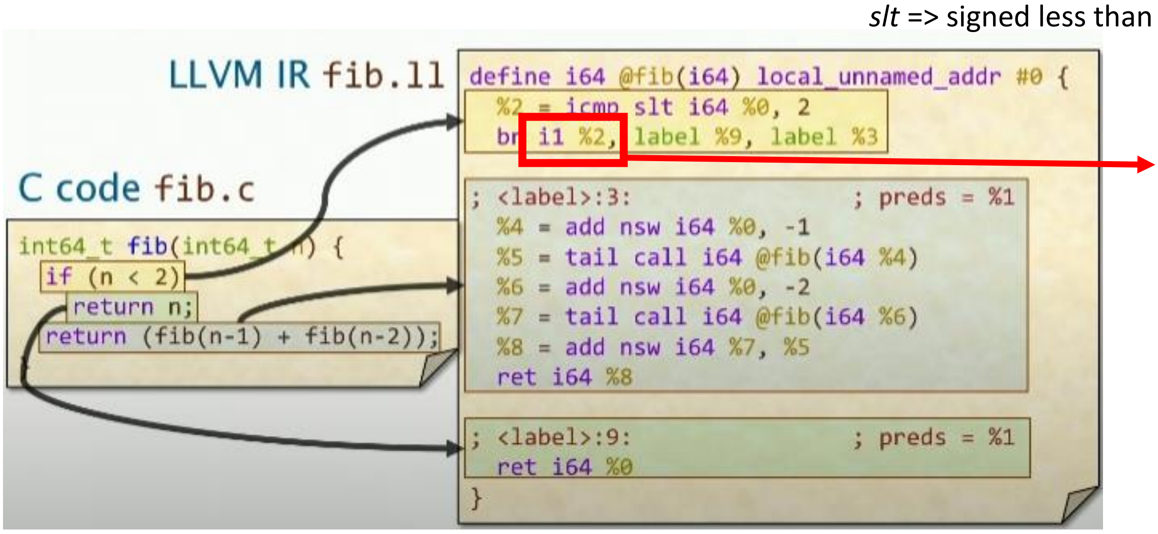
LLVM IR Functions



LLVM IR Basic Blocks and Branching

icmp => integer comparison

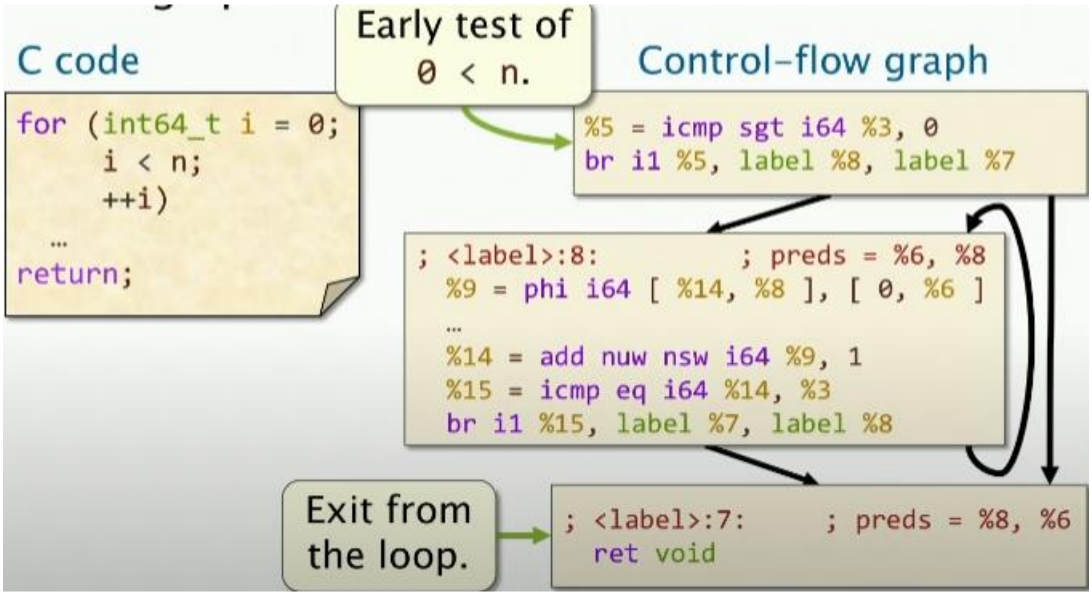
slt => signed less than



Prediction Result

Basic Blocks: Sequences of instructions where control only enters through the first and exits form the last.

LLVM IR Loops



Unit 9 What Compilers Can and Cannot do

Compiler is a software and they can have bugs.
If you know what compiler well do, you don't need to do it yourself. (Make the code clean and simple)

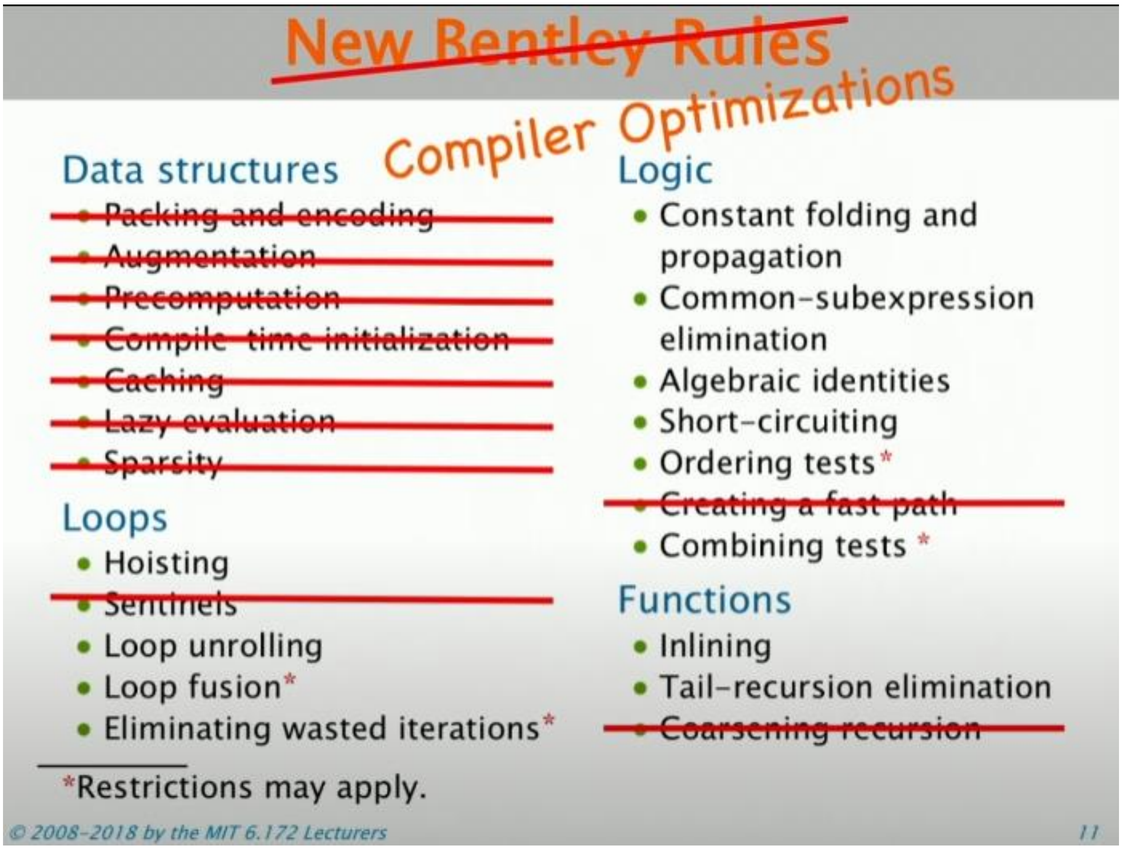
From LLVM IR to Optimized LLVM IR
Optimizing compiler performs a sequence of transformation passes on the IR code.
Each transformation pass analyzes and edits the code.
The order of the transformations is predetermined.

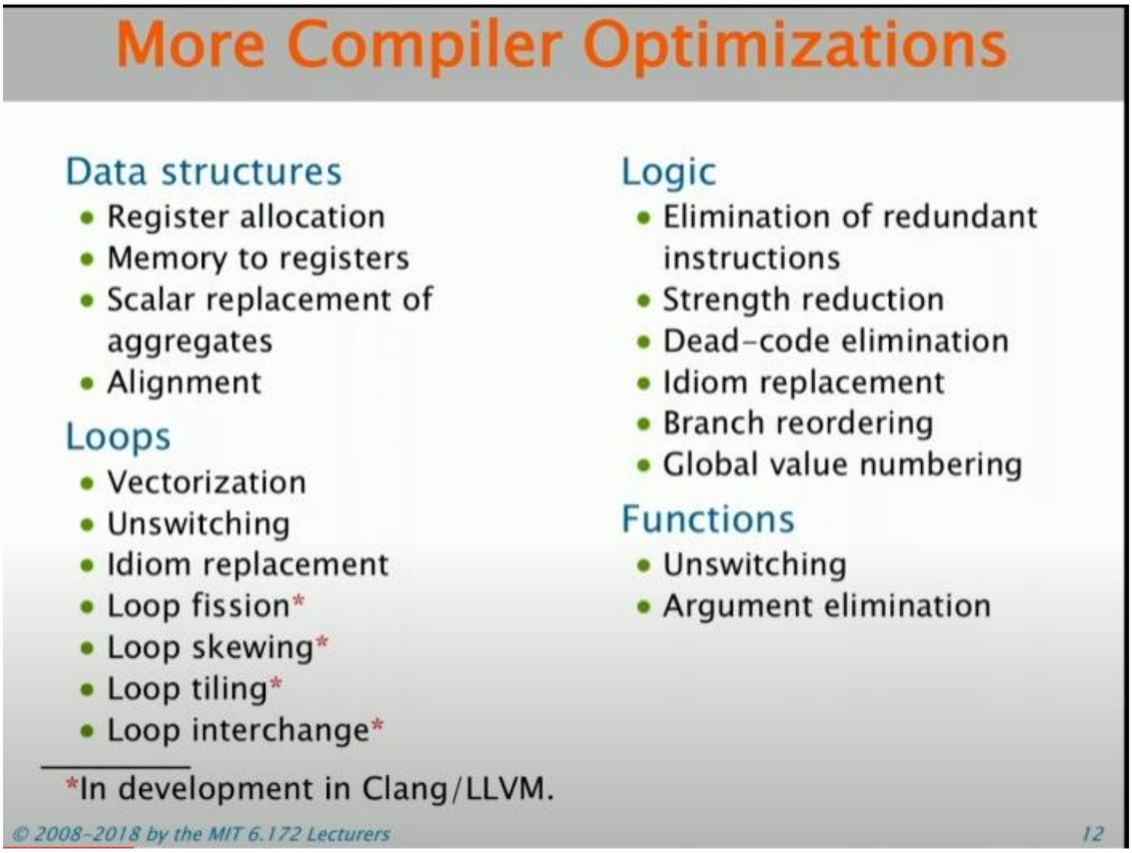
Compiler Reports
-Rpass = <string>: Produces reports of which optimizations matching *<string>* were successful.
-Rpass-missed=<string>: Produces reports of which optimizations matching *<string>* were not successful.
-Rpass-analysis=<string>: Produces reports of the analysis performed by optimizations matching *<string>*

<string> is a regular expression *".*"* for the whole report.

Compiler Optimization Compare to New Bentley Rules

Optimized compiler can perform some of the New Bentley Rules and some extra optimizations. For data structures, the compiler is good at utilize registers since accessing memory is expensive compare to registers.





Compiler Optimizations may change over time.