CS61C — Precheck: CALL, Boolean Algebra

Spring 2025 — Discussion 7

## 1 Discussion Pre-Check

1.1 The compiler may output pseudoinstructions.

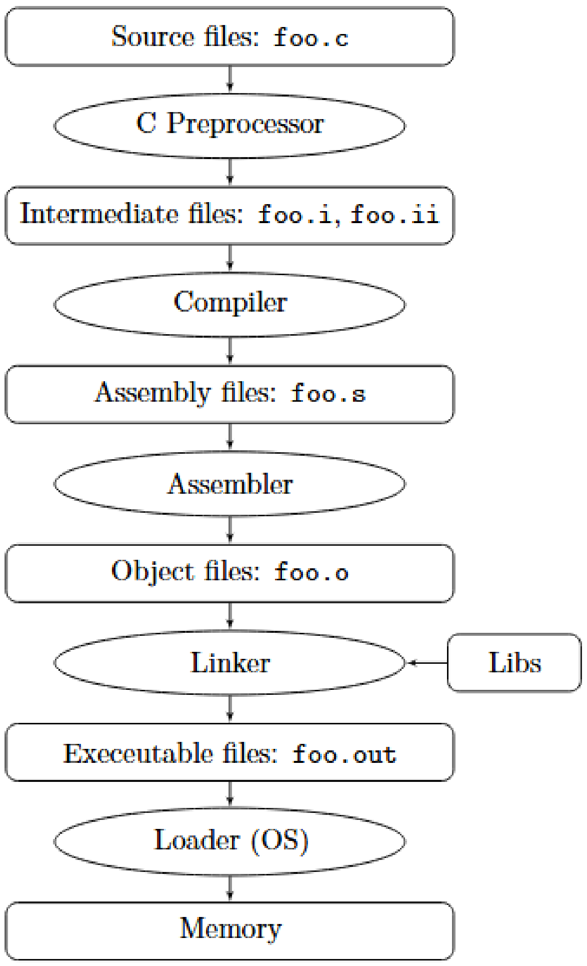
1.2 The main job of the assembler is to perform optimizations on the assembly code.

1.3 The object files produced by the assembler are only moved, not edited, by the linker.

1.4 The destination of all jump instructions is completely determined after linking.

## 2 CALL

The following is a diagram of the CALL stack detailing how C programs are built and executed by machines:



To translate a C program to an executable:

1. (C Preprocessor): translates all defined macros before passing to the compiler.
2. **Compiler**: Translates high-level language code (e.g. `foo.c`) to assembly
   - **Output**: Assembly language code (RISC-V) which may contain pseudoinstructions!
3. **Assembler**: Replaces pseudoinstructions and creates an *object file* with machine language, symbol table, relocation table, and debugging information.
   - **Output**: Object file (`foo.o`)
4. **Linker**: Combines multiple object files / libraries to create an executable.
   - **Output**: Executable machine code (e.g. `foo.out`).
5. **Loader**: Creates the environment to run machine code and begins execution.

2.1 How many passes through the code does the Assembler have to make? Why?

$\boxed{2.2}$ Which step in CALL resolves relative addressing? Absolute addressing?

$\boxed{2.3}$ Describe the six main parts of the object files outputted by the Assembler (Header, Text, Data, Relocation Table, Symbol Table, Debugging Information).

## 3 Boolean Logic

In digital electronics, it is often important to get certain outputs based on your inputs, as laid out by a truth table. Truth tables map directly to Boolean expressions, and Boolean expressions map directly to logic gates. However, in order to minimize the number of logic gates needed to implement a circuit, it is often useful to simplify long Boolean expressions.

We can simplify expressions using the nine key laws of Boolean algebra:

| Name | AND Form | OR form |
|---|---|---|
| Commutative | $x \cdot y = y \cdot x$ | $x + y = y + x$ |
| Associative | $(xy)z = x(yz)$ | $(x + y) + z = x + (y + z)$ |
| Identity | $x \cdot 1 = x$ | $x + 0 = x$ |
| Null | $x \cdot 0 = 0$ | $x + 1 = 1$ |
| Absorption | $x \cdot (x + y) = x$ | $x + x \cdot y = x$ |
| Distributive | $(x + y) \cdot (x + z) = x + yz$ | $x \cdot (y + z) = xy + xz$ |
| Idempotent | $x \cdot x = x$ | $x + x = x$ |
| Inverse | $x \cdot \overline{x} = 0$ | $x + \overline{x} = 1$ |
| De Morgan's | $\overline{x \cdot y} = \overline{x} + \overline{y}$ | $\overline{x + y} = \overline{x} \cdot \overline{y}$ |

Additionally, we have many boolean functions which take boolean signals (0 or 1) as input and output a boolean result (0 or 1). When designing digital systems, boolean functions are represented as **logic gates**.

3.1 Label each of the following logic gates with their respective boolean function, and draw a truth table representing their outputs: