Bits of Architecture

RISC-V Instruction Formats

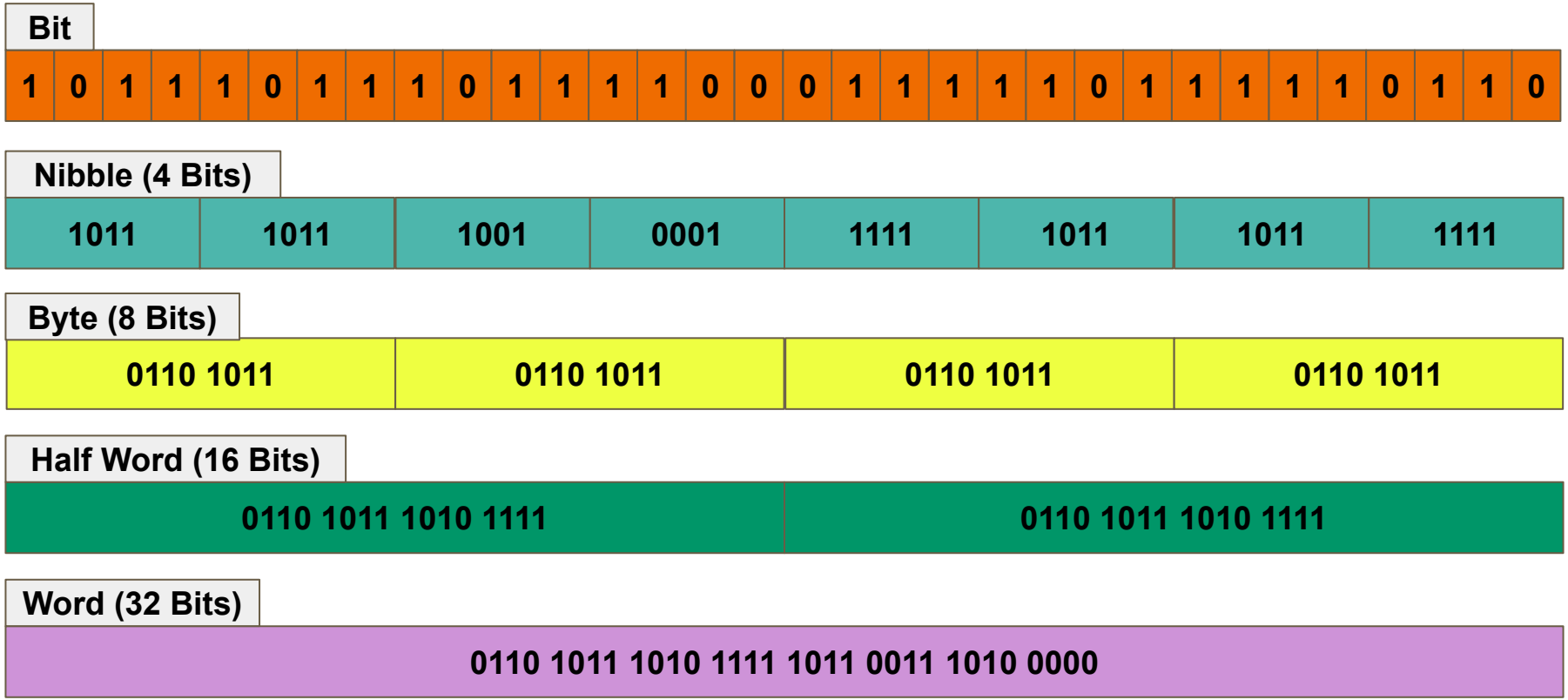
What Do Programs Looks Like?

The Stored Program Computer

- Programs are just instructions
- **Machine Code**
  - Binary representation of our instructions
- **Instruction Format**
  - The fields that compose our instructions

Instruction and Memory

Instructions Operate on Memory



RISC-V Instructions

RISC-V Basics

- 32 Registers
    - Named 0-31
- 32-bit instructions

funct7	rs2	rs1	funct3	rd	opcode
7 Bits	5 Bits	5 Bits	3 Bits	5 Bits	7 Bits

RISC-V Fields

- **OpCode**
  - Operation of the instruction
- **rd**
  - Register destination
- **funct3**
  - Additional OpCode field
- **rs1**
  - First register source
- **rs2**
  - Second register source
- **funct7**
  - Additional OpCode field

funct7	rs2	rs1	funct3	rd	opcode
7 Bits	5 Bits	5 Bits	3 Bits	5 Bits	7 Bits

Instruction Formats

- Can all instructions use the same format?
  - Tough to do in a fixed length...
- Compromise
  - Fixed length
  - Multiple formats

funct7	rs2	rs1	funct3	rd	opcode
7 Bits	5 Bits	5 Bits	3 Bits	5 Bits	7 Bits

imm	rs1	funct3	rd	opcode
11 Bits	5 Bits	3 Bits	5 Bits	7 Bits

imm	rs2	rs1	funct3	imm	opcode
7 Bits	5 Bits	5 Bits	3 Bits	5 Bits	7 Bits

Instruction Formats

R-Type Instructions

- Register-Type Instructions
  - 2 register inputs, one output

funct7	rs2	rs1	funct3	rd	opcode
7 Bits	5 Bits	5 Bits	3 Bits	5 Bits	7 Bits

I-Type Instructions

- Immediate-Type Instructions
  - Instructions that use a constant operand

imm	rs1	funct3	rd	opcode
12 Bits	5 Bits	3 Bits	5 Bits	7 Bits

S-Type Instructions

- Store-Type Instructions
  - Used for store instructions

imm	rs2	rs1	funct3	imm	opcode
7 Bits	5 Bits	5 Bits	3 Bits	5 Bits	7 Bits

SB-Type Instructions

- Conditional branching instructions
  - Same breakdown as S-Type
  - Interpret the immediate value differently

imm	rs2	rs1	funct3	imm	opcode
7 Bits	5 Bits	5 Bits	3 Bits	5 Bits	7 Bits

U-Type Instructions

- Upper Immediate Instructions
  - Used of load/add upper immediate instructions

Imm	rd	opcode
20 Bits	5 Bits	7 Bits

UJ-Type Instructions

- Jump-Instructions
  - Used for jumping somewhere in program memory

Imm	rd	opcode
20 Bits	5 Bits	7 Bits