Instruction Set Architectures (ISA)

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ISA (Instruction Set Architecture)

- The words of computer's language are called instructions.
- Its vocabulary is called an instruction set.
- We will see the instruction set of a real computer:
  - the form written by people.
  - the form read by the computer.
- The ISA defines the interface between hardware and software.
  - Hardware consists of logic and memory.
  - Software is machine code that runs on the hardware.
- The ISA is used by compiler writers to specify what code to generate.
- The ISA is used by hardware designers to build the data and control paths.
- The ISA is their common language.

ISA (Instruction Set Architecture)

The main features of an ISA are:

- Instructions and operands
- Registers
- Memory Access
- Word size

ISA (Instruction Set Architecture)

- Typical instructions include:
  - ADD
  - SUB
  - AND
  - EOR
- The source of the values come from the instructions operands (registers).
- The storage where its operation is saved is also specified by the operands (registers).
- An operand specifies a source or destination for the instruction to operate on.

ISA (Instruction Set Architecture)

- Most ISA use a fixed size set of registers as operands.
- Common register set sizes include 8, 16 and 32.
- The number of registers is usually a power of 2.
  - index will be based on a number of bits, a power of two.
- The number of bits stored in a register, the width, is often used to describe the **word size** of the computer.
  - The common word sizes are: 8, 16, 32, and 64 bits

ISA (Instruction Set Architecture)

- Since the register set is fixed, most ISA provide instructions to read and write data to/from memory.
- The methods of accessing memory is one of the main features of an ISA.
- Some ISA only allow one memory access per instruction, while other more complex ISA allow multiple accesses.
- ISA can also provide operations using memory location, not only registers.
    - In this course: save a register to the memory and load data from the memory to a register.

ISA Examples

- ARM
  - The ARM ISA include several version, some with 32 bit words and some with 64 bit words.
  - The most common ISA in cell phone is ARM.
- x86
  - The x86 ISA is manufactured by Intel and AMD. It was originally created by Intel.
  - Its version include 16, 32, and 64 bit word sizes. x86 ISA mostly occur in Desktop PC and servers.
- MIPS
  - MIPs originally used in high end workstations.
  - Computers with this architecture are found in embedded systems.
- RISC-V
  - RISC-V is new open source architecture.
  - It has 32, 64, and 128 word size versions.

ISA Examples

- Some historic ISAs from the 1960s, 1970s, and 1980s are PDP-11/8, VAX, IBM System/360
- Micro-controllers (Arduino) use 8-bit ISAs, some architectures are AVR, 8051, 6800

ARMv4

- This course studies the ARMv4 Instruction Set Architecture
- Its main features are:
  - All instructions use a 32-bit encoding
  - Most instructions can be conditionally skipped
  - Memory is accessed with load/store instructions
    - Only one memory access per instruction

ARMv4

- 16 Registers
  - R0 - arguments, return values, temporary
  - R1-R3 - arguments, temporaries
  - R4-R11 - callee saved
  - R12 - temporary
  - R13 (SP) - Stack Pointer
  - R14 (LR) - Link Register
  - R15 (PC) - Program Counter
- Memory is byte addressable, 8/16/32 bits can also be accessed at a time
- CPSR (Current Program Status Register) provides a N, Z, C, and V status bits.

ARMv4

Some online references for programming the ARM ISA are:

- Davespace
- thinkgeek.com
- www.coranac.com
- azeria-labs.com

Questions?