Virtual Machine and Assembler
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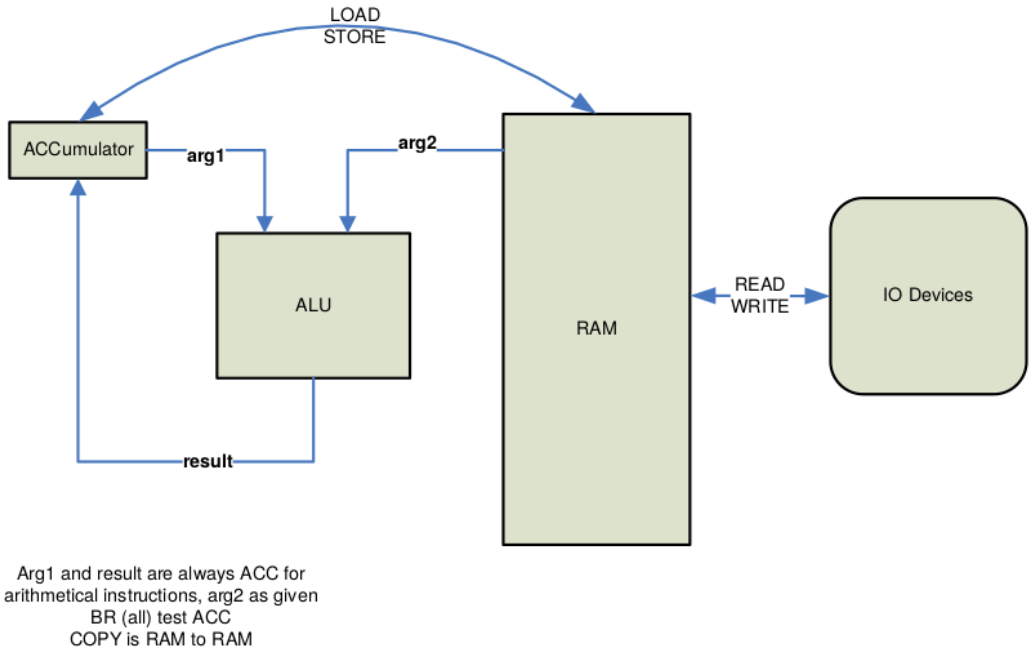
1 Simple assembler virtual machine

Assume virtual machine with the following language (assembly w/stack and accumulator).



2 Instruction Format

- Each line is independent and self-contained, and may be blank, an instruction, or a storage directive
- All delimiters are the space character
- Instructions are for an accumulator machine (left argument and result are in an implicit accumulator ACC register, except for COPY), with the following format

  XXX arguments XXX is the reserved instruction name, required, in upper case
  arguments as needed separated by spaces
  additional optional label can start any instruction (label:), just one label per line at most
  instructions (# arguments, meaning)

2.1 Instructions

- ADD (1, ACC = ACC +arg)
- BR (1, jump to arg)
- BRNEG (1, jump to arg if ACC < 0)
- BRZNEG (1, jump to arg if ACC <= 0)
- BRPOS (1, jump to arg if ACC > 0)
- BRZPOS (1, jump to arg if ACC >= 0)
- BRZERO (1, jump to arg if ACC == 0)
- COPY (2, arg1 = arg2)
- DIV (1, ACC = ACC / arg)
- MULT (1, ACC = ACC * arg)
- READ (1, arg=input integer)
- WRITE (1, put arg to output as integer)
- STOP (0, stop program)
- STORE (1, arg = ACC)
- SUB (1, ACC = ACC - arg)
- NOOP (0, nothing)
- LOAD (1, ACC=arg)

ADD, DIV, MULT, WRITE, LOAD, SUB can take either variable or immediate value
as the arg: immediate value is positive integer or negative integer

- PUSH (0, tos++)
- POP (0, tos–)
- STACKW (1,stack[tos-arg]=ACC)
- STACKR (1,ACC=stack[tos-arg])

PUSH/POP are only means to reserve/delete automatic storage.
STACKW/STACKR n - these are stack write/read instructions.
n must be a non-negative number, and the access is to nth element down from TOS, top of stack
NOTE: tos points to the topmost element on the stack

Storage directives
XXX val
XXX is a name
val is the initial value
all storage and ACC size are signed 2 bytes

Storage name and label are all names starting with latter and following with letters and digits up to eight total

2.2 Assumptions

- any proper format within line, tokens separated by BS, blank space
- all storage directives are listed following the last STOP
- all names start with letters and contain more letters or digits

3 Invocation

```
> virtMach // read from stdin

> virtMach file.asm // read from file.asm
```

4 Example ASM programs

Example:

sumOf3.asm
reads 3 arguments and returns the sum using a stack

```
 READ X
 PUSH
 LOAD X
 STACKW 0

 READ X
 PUSH
 LOAD X
 STACKW 0

 READ X
 STACKR 1
 ADD X
 STORE X
 STACKR 0
 ADD X
 STORE X
 WRITE X
 POP
 POP
 STOP
 X 0
```

Example:

sum3nostack.asm

Same as above but without a stack

```
READ X
READ Y
READ Z
LOAD X
ADD Y
ADD Z
STORE X
WRITE X
STOP
X 0
Y 0
Z 0
```

Example:

sumOfAny.asm
reads first argument and the reads as many arguments as the first argument and returns the sum

```
        READ X
        COPY Z X

LOOP1:  LOAD X
        BRZERO OUT1
        BRNEG OUT1
        READ Y
        LOAD Y
        PUSH
        STACKW 0
        LOAD X
        SUB 1
        STORE X
        BR LOOP1

OUT1:   NOOP

        LOAD 0
        STORE Y
LOOP2:  STACKR 0
        ADD Y
        STORE Y
        POP
        LOAD Z
        SUB 1
        BRZERO OUT2
        BRNEG OUT2
        STORE Z
        BR LOOP2
OUT2:   NOOP
        WRITE Y

        STOP
        X 0
        Y 0
        Z 0
```