Midterm Review

- 1. Branch instructions
  - BHI (unsigned), BGT (signed)
    - Take a look at the preceding comparison instruction.
    - Then, you can use this instead of using complex formula in the instruction reference.
      - BRANCH IF **REGISTER** IS HIGHER/GREATHER/… THAN **OPERAND**
    - e.g. CMPA #$D0
      - Branch if 'A' is HIgher than 'operand.'
  - BMI, BVC, BNE
    - Check the result if it is Minus/signed oVerflow/Not Equal to zero
  - CMPA: A – (M)
  - TSTA: A – 0
  - V bit (signed overflow)
    - N + N → P
    - P + P → N
    - N – P → P
    - P – N → N

Midterm Review – cont'd

- 2. BRA and LBRA
  - Write a line of assembly code that begins in memory location $2450.
  - BRA <8-bit signed offset value>
  - LBRA <16-bit signed offset value>
  - When the effective (destination) address is calculated in relative addressing mode, a value that you need to add to an offset is PC.
    → We have to use PC which is the next address of the line of assembly code of (L)BRA

Midterm Review

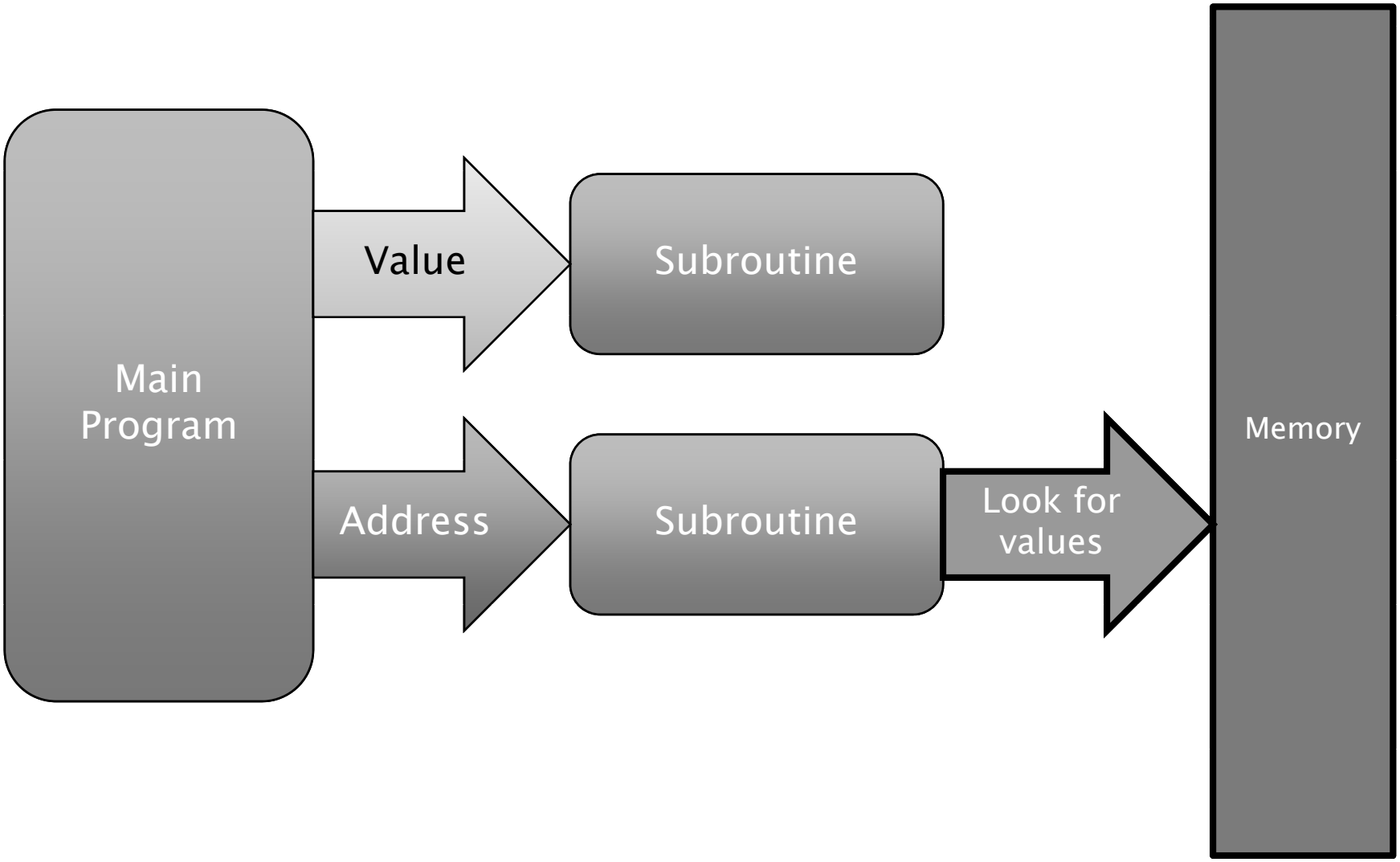
- 3. Mostly this is about calculating postbyte(s)
  - -20: You cannot use 5-bit offset. You have to use 9-bit one.

Lecture 16:
Parameter Passing

Today's Goals

- Parameter passing
- Understand how to pass parameters using the stack

Call by Value vs. Call by Reference



Passing Parameters in Registers

- Use registers to pass parameters
- The simplest type of parameter passing
- Pros vs. Cons
  - Data is immediately available to the subroutine
  - No extra preparations are needed.
  - Often fastest execution and smallest code size
  - Only a limited number of registers are available.
  - We can use ‘pass-by-reference’ to point a list of input/output values.

Example (Parameter Passing in Registers)

- Requirements
  - A subroutine that adds an array of two-byte numbers and a sample main program that calls it.
  - The array is passed by reference in X.
  - The length is passed by value in D.
  - The sum should be returned by value in D.
  - Do not worry about indicating signed or unsigned overflow.

Example (Parameter Passing in Registers)

```
          ORG      $3000
Array     dc.w     $1234,$5678,$ABCD
Length    dc.w     3

          ORG      $2000
          LDS      #$3600
          LDX      #Array   ; load X with address of list
          LDD      Length   ; Load D with actual length
          JSR      sumword
          SWI

sumword   TFR      D,Y
          LDDD     #0
          CPY      #0
Loop      BEQ      endsum
          ADDD     0,X
          INX
          INX
          DEY
          BRA      loop
endsum    RTS
```

Preserving Registers

- In the previous example, the subroutine uses Y. The value in Y is destroyed.
- If Y was in use by the main program, the main program would continue after the subroutine with an incorrect value in Y.
- To avoid this, registers used by a subroutine may be saved to the stack before a subroutine uses them.
- The saved registers are restored after the subroutine.
- We have two options
  - The caller (main program) does this.
  - The callee (subroutine) does this.

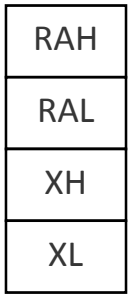
Preserving Registers

- Responsibility of the Caller:
  - The calling main program assumes all registers are destroyed by the subroutine
  - If the registers used by the subroutine are unknown (i.e. using a sub. provided by someone else), may save registers that the subroutine wouldn't affect
  - Code to save/restore registers duplicated with every subroutine call.
- Responsibility of the Callee:
  - Saves only the registers that will be used by the subroutine
  - Save/restore code only occurs once

Example – Caller Responsible

```
         ORG      $3000
Array    dc.w     $1234,$5678,$ABCD
Length   dc.w     3

         ORG      $2000
         LDS      #$3600
         LDX      #Array   ; load X with address of list
         LDD      Length   ; Load D with actual length
         PSHX
JSR      sumword
         PULX
         SWI

sumword  TFR      D,Y
         LDDD     #0
         CPY      #0
loop     BEQ      endsum
         ADDD     0,X
         INX
         INX
         DEY
         BRA      loop
endsum   RTS
```

Stack Frame



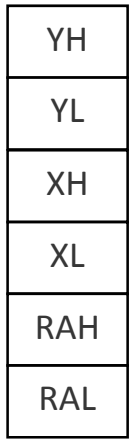
Example – Callee Responsible

```
            ORG     $3000
Array       dc.w    $1234,$5678,$ABCD
Length      dc.w    3
            ORG     $2000
            LDS     #$3600
            LDX     #Array   ; load X with address of list
            LDD     Length   ; Load D with actual length
            JSR     sumword
            SWI

sumword     PSHX
            PSHY
TFR         D,Y
            LDDD    #0
            CPY     #0
loop        BEQ     endsum
            ADDD    0,X
            INX
            INX
            DEY
            BRA     loop
endsum      PULY
            PULX

RTS
```

Why not D?

It is used to return the answer!

Stack Frame



Passing Parameters in the Stack

- Pros and Cons
  - The stack pointer is already in use for the return address
  - Indexed addressing can easily access data stored on the stack
  - The amount of data passed is not limited by the register set
  - The data passed on the stack must be removed, and this is usually the responsibility of the caller (although this can be done by the callee)
- Note:
  - If the caller will save registers on the stack, it should be done before passing parameters.
  - Why? Those parameters are supposed to be used in the subroutine.