ECE 3120
Computer Systems
Arithmetic Programming

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Today:

- Algorithms & Flowchart examples
- Write programs to do arithmetic
  - Multiprecision Addition
  - Multiprecision Subtraction

Software Development Process

- **Problem definition**: Identify what should be done.
- **Develop the algorithm**. Algorithm is the overall plan for solving the problem at hand.
- An algorithm is often expressed in the following format:

  Step 1

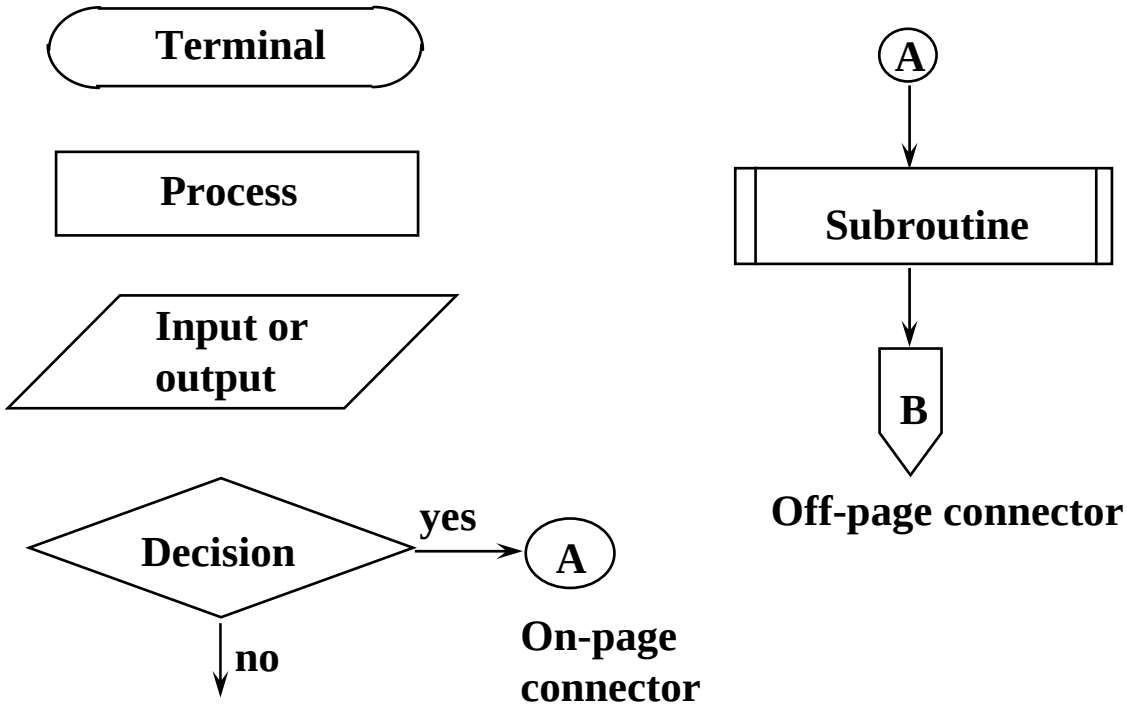
  …

  Step 2

  …

- Another way to express overall plan is to use **flowchart**.
- **Programming.** Convert the algorithm or flowchart into **programs**.
- **Program Testing**
- **Program maintenance**

Symbols of Flowchart



Programs to do simple arithmetic

Example 2.3' Write a program to add the values of memory locations at $2000, $2001, and $2002, and save the result at $2100.

Solution:

Step 1

$A \Leftarrow m[\$2000]$

Step 2

$A \Leftarrow A + m[\$2001]$

Step 3

$A \Leftarrow A + m[\$2002]$

Step 4

$\$2100 \Leftarrow A$

Example 2.4’

Write a program to subtract the contents of the memory location at $2000 from the sum of the memory locations at $2001and $2002, and store the difference at $2005.

Solution:

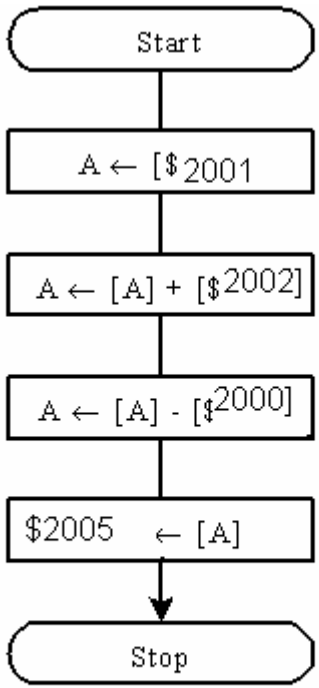


Figure 2.2 Logic flow of program 2.4

Example 2.6 Write a program to add two 16-bit numbers that are stored at $2000-$2001 and $2002-$2003 and store the sum at $2010-$2011.

Solution:

Step 1

D ⇐ m[$2000]:m[$2001]

Step 2

D ⇐ D + m[$2002]:m[$2003]

Step 3

m[$2010]:m[$2011] ⇐ D

Multiprecision arithmetic

•Arithmetic performed in a 16-bit microprocessor on numbers larger than 16 bits.

•Makes use of the carry flag (C flag) of the condition code register (CCR).

The Carry/borrow Flag

- Bit 0 of the CCR register
- Set to 1 when the addition operation produces a carry 1
- Set to 1 when the subtraction operation produces a borrow 1
- Enables the user to implement multi-precision arithmetic

Example : To add $8675 & $ 9978

Instructions:-

```
Ldd   #$8645
Addd #$9978
```

HCS12 execution of these instructions

```
    $ 8 6 4 5
+   $ 9 9 7 8
-------------
$ 1 1 F B D  ---->  Sum
  |
  v
Carry
```

Example Write down the sequence to add two 4-byte numbers $1A598183 and $76548290 and store the result in $1000~$1003.

- Multiprecision addition is performed one byte at a time

```
    1   1   1
  $1A598183
+ $76548290
  $90AE0413
```

Step 1: Add the least significant 16 bits

```
ldd     #$8183
addd    #$8290
```

Result generates a carry and therefore sets the carry flag to 1

Store contents of D in $1002~$1003

Step 2: The carry from the lower bytes must be added to the second MSB

```
ldda    #$59
adca    #$54        → $59+$54+carry → result in A
```

Store contents of A in $1001

Step 3: Add the MSBs by using the add with carry

```
ldda    #$1A
adca    #$76  → $1A +$ 76 +carry → result in A
```

Store contents of A in $1000

Next…

- Multiprecision Subtraction Example
- BCD Addition