Lecture - 07

Stack Control

- A ***stack*** is a sequence of storage locations that are accessible from only one end referred to as the ***top of the stack.***

- Two operations: ***Push*** and ***Pop***.

- Push or pop changes the position of the stack top by an amount that depends on the length of the operand pushed or popped.

- A stack is controlled by an address register called the ***stack pointer SP.*** It contains the address of the new stack top.

Stack Control in Motorola 680X0

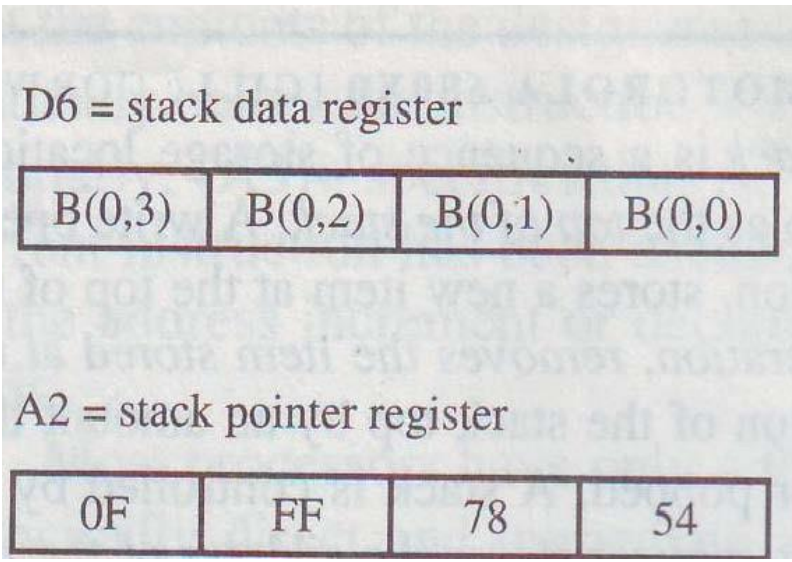
- Motorola 680X0 has no explicit hardware for stack support. But its various addressing modes make it easy to treat any contiguous region of its external memory M as a stack.

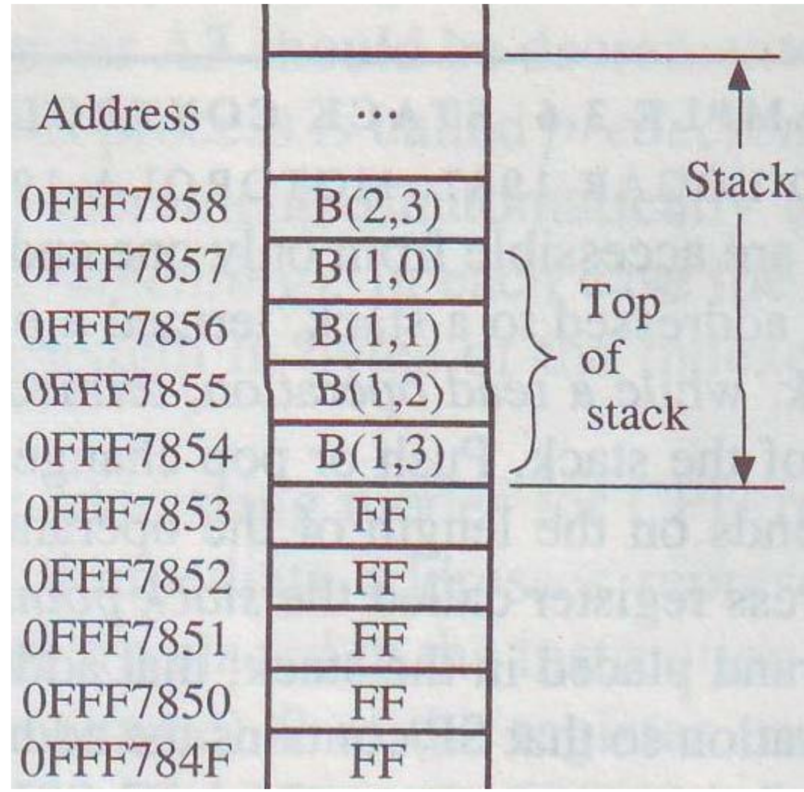
- Suppose the address register A2 of the 680X0 is designated as stack pointer and the stack grows toward the low addresses of M.

- To push the content of D6 (data register) into the stack requires a single instruction MOVE.L D6, -(A2) which is equivalent to A2:=A2-4 and M(A2):=D6.

- The pop instruction is MOVE.L (A2)+, D6 which is equivalent to D6:=M(A2) and A2:=A2+4

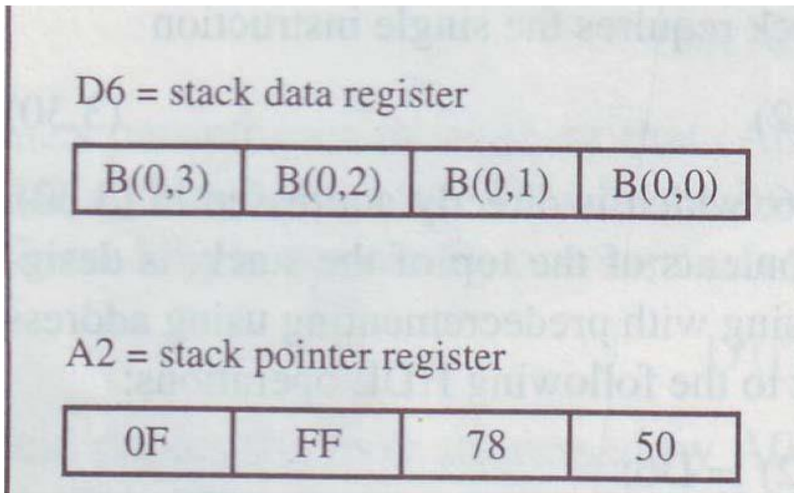
Stack Control in Motorola 680X0

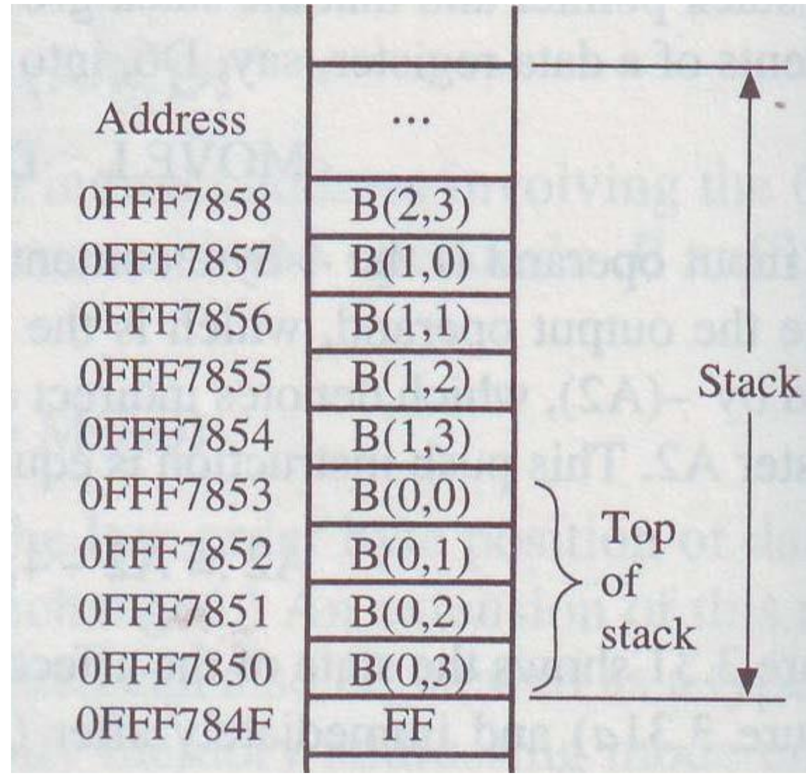




Prior the execution of MOVE.L D6, -(A2)

Stack Control in Motorola 680X0





After the execution of MOVE.L D6, -(A2)

Number of Addresses

- **Three-address instruction:**
  ADD Z, X, Y
  Z:= X+Y.

- **Two-address instruction:**
  ADD X, Y
  X:= X+Y.

- **One-address instruction:**
  ADD X
  AC:=AC+X.

Number of Addresses

Implement X:=A×B+C×C, where A, B, C and X are stored in the memory.

Instruction	Comment
LOAD A	AC:=A
MULTIPY B	AC:= AC * B
STORE T	M(T):= AC
LOAD C	AC:= C
MULTIPLY C	AC:=AC * C
ADD T	AC:= AC + T
STORE X	M(X) : = AC

One address machine

Instruction	Comment
MOVE T, A	T:=A
MULTIPLY T, B	T:= T * B
MOVE X, C	X:=C
MULTIPLY X, C	X:= X * C
ADD X, T	X:=X+T

Two address machine

Instruction	Comment
MULTIPLY T, A, B	T:= A * B
MULTIPLY X, C, C	X:= C * C
ADD X, X, T	X:= X + T

Three address machine

Accumulator Architectures

- **Instruction set:**

  add A, sub A, mult A, div A, . . .

  load A, store A

- **Example: A*B - (A+B*C)**

  load B

  mul C

  add A

  store D

  load A

  mul B

  sub D

B	B*C	A+B*C	A+B*C	A	A*B	A*B-(A+B*C)

Accumulator Architecture : Pros and Cons

- **Pros**
  - Very low hardware requirements
  - Easy to design and understand

- **Cons**
  - Accumulator becomes the bottleneck
  - Little ability for parallelism or pipelining
  - High memory traffic

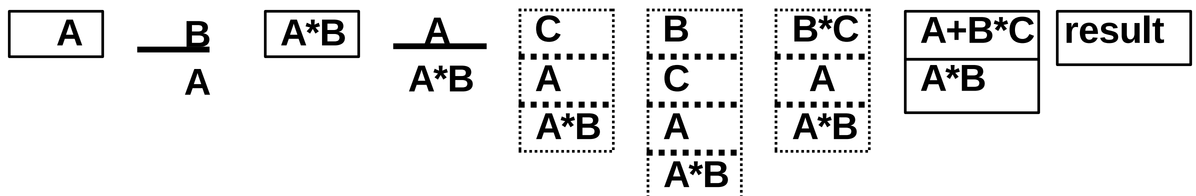
Zero Address Machine (Stack Based Architecture)

- Addresses are eliminated by storing operands in a push-down stack.
- All the operands are required to be in the top locations in the stack.
- Stack pointer automatically keeps track of the stack top.
- Push and pop operations are needed to transfer data to and from the stack.
- For example, X+Y is invoked by ADD that causes the top two operands, which should be X and Y, to be removed from the stack and added. The resulting sum X+Y is then placed at the top of the stack.

Stack Architectures

Example: A*B - (A+C*B)

push A
push B
mul
push A
push C
push B
mul
add
sub



Stack Architecture: Pros and Cons

- **Pros**
  - implicit operand addressing. Maintained by top of the stack.
  - Low hardware requirements.

- **Cons**
  - Stack becomes the bottleneck.
  - Little ability for parallelism or pipelining.
  - Data is not always at the top of stack when need, so additional instructions like POP and SWAP are needed.

The Requirements for Instruction Set

- It should be **complete**. We should be able to construct a machine language program to evaluate any function that is computable using a reasonable amount of memory space.

- It should be **efficient**. The frequently required functions can be performed rapidly using relatively few instructions.

- It should be **regular**. The instruction set should contain expected opcodes and addressing modes.

- The instruction should be **compatible** with those of existing machine.

Classification of Instruction

- **Data transfer instructions** – Copy information. Example: ***load, store, move*** instruction.
- **Arithmetic instructions** – Perform operations on numerical data. Example: ***add, sub, mul*****, div** etc.
- **Logical instructions** - Boolean and non-numerical operations. Example: **AND, NOT** etc.
- **Program control instructions** – It change the sequence in which program are executed. Example: Branch instruction.
- **Input-Output (IO) instructions** – It cause information to be transferred to or from external IO devices. Example: PRINT LINE.