More about the new loop

Exercise:

- Write an assembly program for the extended count that adds the numbers 7, 6, 5, 4, 3, and put the result in RA after the loop terminates. Then, translate the assembly program to machine instructions.

- We can initialize the RA = 7 and RB = 0. In each iteration, add RA to RB, and store the result in RB. The loop is terminated when RA is 3. Since the conditional branching can branch only if the ALU result is 0, so, in each iteration, we can decrement RA by 3. If the result is 0, then break out of the loop; Otherwise, add 2 to the result, which will make RA decrement by 1 each time.

- If using pseudocode, we can have something like

```plaintext
0  RA <= 7
1  RB <= 0
2  while (RA >= 3) {
3      RB <= RA + RB
4      RA <= RA - 1 
5  }
6  RA <= RB
```
• If using mnemonics to translate the above pseudocode into assembly program, we can have

0       LOAD RA 7 # RA <= 7
1       LOAD RB 0 # RB <= 0
2       ADD RA RB RB # RB <= RA + RB
3       ADD RA 1101 RA # RA = RA - 3
4       BRZ 7 # if RA = 3, end the loop
5       ADD RA 0010 RA # RA = RA + 2, if RA != 3, decrement RA by 1
6       BRA 2 # back to the start of the loop for the next iteration
7       LOAD RA RB # RA <= RB

• We then can translate the above assembly program to machine instructions, which will be the program stored in Program Memory.

#    J1  J0  S1  S0  C1  C0  O0  D3  D2  D1  D0
0    0   0   0   1   0   1   0   0   1   1   1
1    0   0   0   1   0   1   1   0   0   0   0 (way2:S1S0=10, D3~D0=dddd)
2    0   0   0   0   0   0   1   d   d   d   d
3    0   0   0   1   0   0   0   1   1   0   1
4    1   0   d   d   d   d   d   0   1   1   1
5    0   0   0   1   0   0   0   0   0   1   0
6    1   1   d   d   d   d   d   0   0   1   0
7    0   0   0   0   0   1   0   d   d   d   d

The IAS Computer

What is the IAS computer?
- We’ve talked about the programmable circuits. Let’s take a look at the first electronic computer that could store programs in memory.
- This first electronic computer is called IAS computer, as it’s the first electronic computer built at the Institute for Advanced Study (ISA) in Princeton.
- IAS computer is also called Von Neumann machine, as the paper describing its design was edited by John Von Neumann.
- IAS computer is the father of all modern computers, and its primary over concept was storing the program in memory.
- Here is the structure of the IAS computer.
- It contains
  - A main memory, which stores both data and instructions
  - An ALU capable of operating on binary data (CA: central arithmetical)
  - A control unit, which interprets the instructions in the memory and causes them to be executed (CC: central control)
  - I/O equipment operated by the control unit
- IAS computer contains 4096 \(2^{12}\) memory locations. The memory locations are called, words.
- Each word is 40-bit long, and could hold one piece of data or two instructions. (binary format)
  - Each number is represented by a sign bit and a 39-bit value.
  - Each instruction consisting of an 8-bit operation code (opcode) specifying the operation to be performed and a 12-bit address designating one of the words in memory (numbered from 0 to 4095)
Data Path

- Let’s look into the CA and CC and see how different parts are connected.
- In addition to PC and IR, a few more registers are used. Although they have different names, they are used to store various information.

• **AC (accumulator)** and **MQ (multiplier quotient)**: hold temporarily operands and results of ALU operations.

• **MBR (memory buffer register)**: contains a word to be stored in memory or sent to the I/O unit, or is used to receive a word from memory or from the I/O unit.

• **IBR (instruction buffer register)**: hold temporarily the right-hand instruction from a word in memory.

• **MAR (memory address register)**: specifies the address in memory of the word to be written from or read into the MBR.