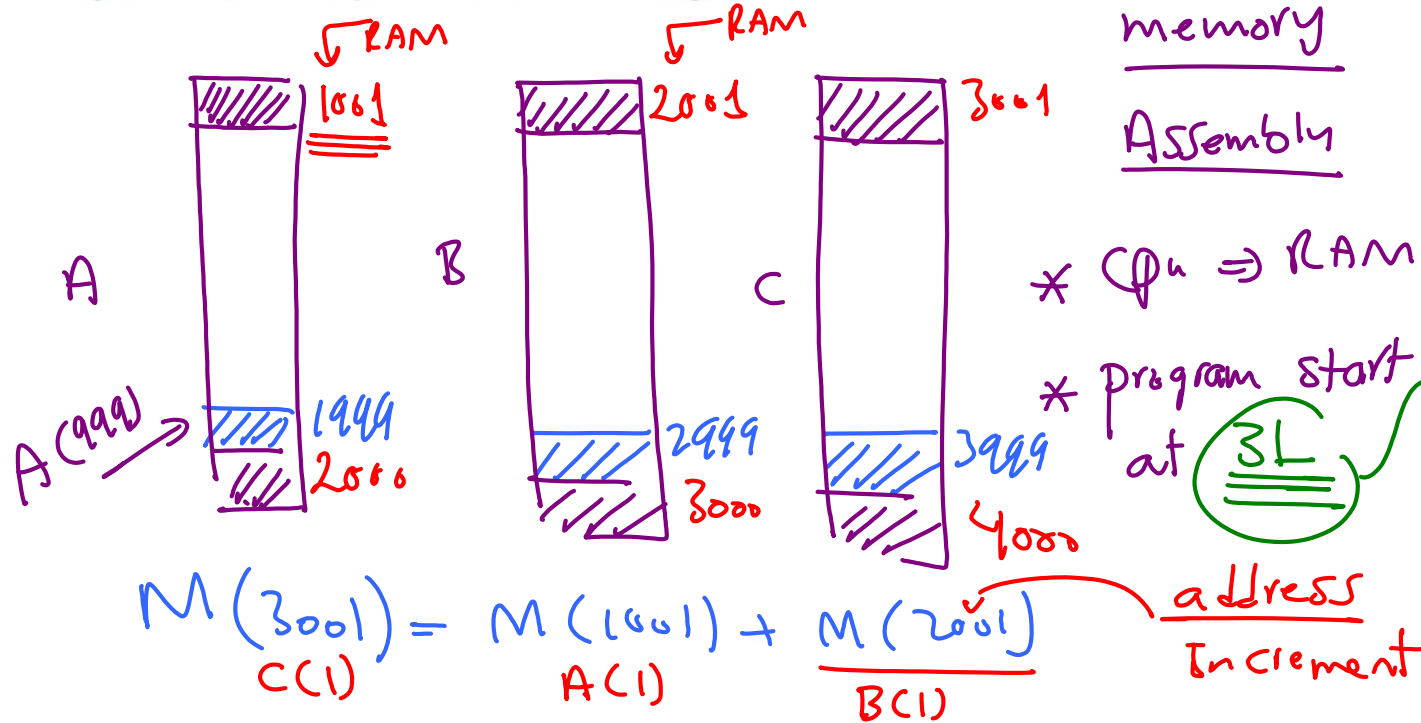
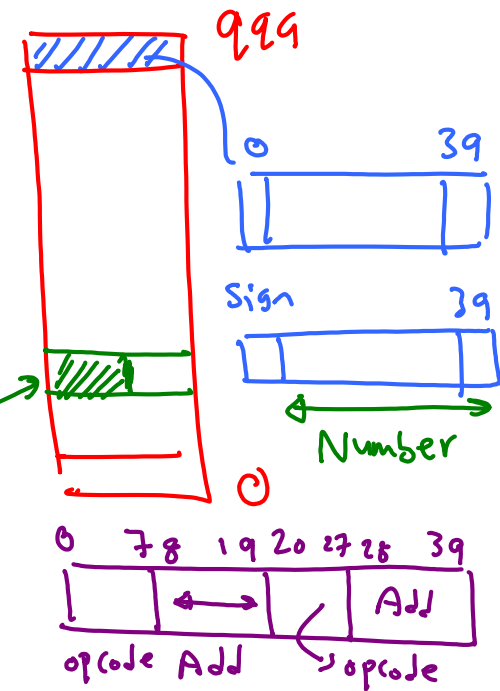


- 2.1. Let $\mathbf{A} = A(1), A(2), \dots, A(1000)$ and $\mathbf{B} = B(1), B(2), \dots, B(1000)$ be two vectors (one-dimensional arrays) comprising 1000 numbers each that are to be added to form an array $\mathbf{C}$ such that $C(I) = A(I) + B(I)$ for $I = 1, 2, \dots, 1000$. Using the IAS instruction set, write a program for this problem. Ignore the fact that the IAS was designed to have only 1000 words of storage.



IAS

Von Neumann



$N = 999$
decrement
 $\boxed{-1}$

$\Rightarrow \underline{\underline{1000}}$

program
start $\boxed{3L}$

(1) $\boxed{\text{load } M(x)}$

$\swarrow$ 1001

$\boxed{AC} \leftarrow \frac{M(1001)}{A(1)}$

(2) $\text{ADD } m(x)$

$AC \leftarrow \underline{AC} + M(2001)$
 $AC \leftarrow A(1) + B(1)$

(3) STOR

$\swarrow$ 3001
 $m(x)$
 $\downarrow$
 $C(1)$

Location	Instruction	Comments
0	999 ⁹⁹⁸	Constant (count N)
1	<u>1</u>	Constant
2	1000	Constant
3L	LOAD <u>M(2000)</u>	Transfer A(I) to AC
3R	ADD M(3000)	Compute A(I) + B(I)
4L	STOR M(4000)	Transfer sum to C(I)
4R	LOAD <u>M(0)</u>	Load count N
5L	SUB <u>M(1)</u>	Decrement N by 1
5R	JUMP+ M(6, 20:39)	Test N and branch to 6R if nonnegative
6L	JUMP M(6, 0:19)	Halt <i>Stop</i>
6R	STOR M(0)	Update N
7L	ADD M(1)	Increment AC by 1
7R	ADD M(2)	
8L	STOR M(3, <u>8:19</u>)	Modify address in 3L
8R	ADD M(2)	
9L	STOR M(3, <u>28:39</u>)	Modify address in 3R
9R	ADD M(2)	
10L	STOR M(4, 8:19)	Modify address in 4L
10R	JUMP M(3, 0:19)	Branch to 3L

$N = 999$

$C(1000)$

$A(1000)$

$B(1000)$

$AC = M(2000)$

$AC = M(2000) + M(3000)$

$M(4000)$

$AC = 999$

$AC = 998$

$\Rightarrow$ Non negative

$AC \leftarrow 998 + 1$

$AC = 999$

$AC = 999 + 1000$

$AC = 1999$

$AC = 2999$

Location	Instruction	Comments
0	999	Constant (count N)
1	1	Constant
2	1000	Constant
3L	LOAD M(2000)	Transfer A(I) to AC
3R	ADD M(3000)	Compute A(I) + B(I)
4L	STOR M(4000)	Transfer sum to C(I)
4R	LOAD M(0)	Load count N
5L	SUB M(1)	Decrement N by 1
5R	JUMP+ M(6, 20:39)	Test N and branch to 6R if nonnegative
6L	JUMP M(6, 0:19)	Halt
6R	STOR M(0)	Update N
7L	ADD M(1)	Increment AC by 1
7R	ADD M(2)	
8L	STOR M(3, 8:19)	Modify address in 3L
8R	ADD M(2)	
9L	STOR M(3, 28:39)	Modify address in 3R
9R	ADD M(2)	
10L	STOR M(4, 8:19)	Modify address in 4L
10R	JUMP M(3, 0:19)	Branch to 3L

AC = 2999

AC = 3999

- 2.10.** A benchmark program is run on a 40 MHz processor. The executed program consists of 100,000 instruction executions, with the following instruction mix and clock cycle count:

Instruction Type	Instruction Count	Cycles per Instruction
Integer arithmetic	45000	1
Data transfer	32000	2
Floating point	15000	2
Control transfer	8000	2

Determine the effective CPI, MIPS rate, and execution time for this program.