MAC architecture

$B = b\_in$

$X = at\_a$

A = a_in

X

+

P

rst

$C = at\_c$

Y = at_b

	b_{22}	
	b_{21}	b_{12}
b_{20}	b_{11}	$b_{02}(b3)$
b_{10}	$b_{01}(b2)$	
b_{00}		
$(b1)$		

a_{02} a_{01} a_{00} $\overline{(a_1)}$

a_{12} a_{11} a_{10}

a_{22} a_{21} a_{20}

MAC $\xrightarrow{a_{12}}$ 2 $\xrightarrow{a_{23}}$ 3 $\rightarrow$

$\downarrow b_{14}$ $\downarrow b_{25}$ $\downarrow b_{36}$

4 $\xrightarrow{a_{45}}$ 5 $\xrightarrow{a_{56}}$ 6 $\rightarrow$

$\downarrow b_{47}$ $\downarrow b_{58}$ $\downarrow b_{69}$
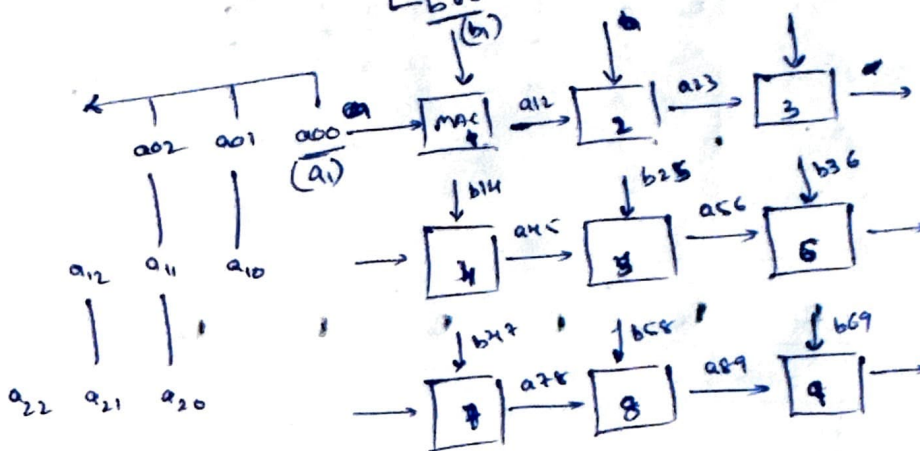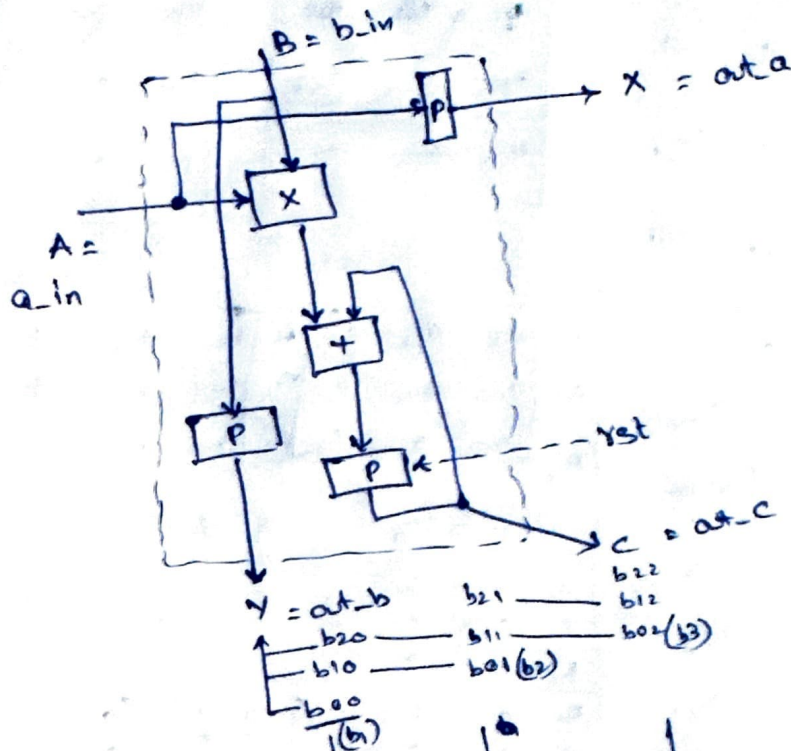
7 $\xrightarrow{a_{78}}$ 8 $\xrightarrow{a_{89}}$ 9 $\rightarrow$

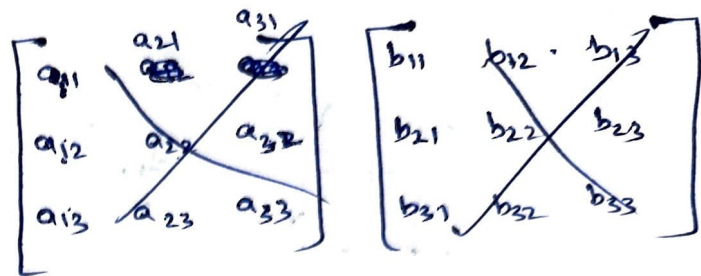① for $c_1 = a_1 + b_1 \Rightarrow c_1 +$

② $c_2 = 0$ $\Rightarrow a_{12} + b_1 \Rightarrow$

③ $c_3 = 0$

④ $c_4 = 0$

⑤ $c_5 = 0$

⑥ $c_6 = 0$

⑦ $c_7 = 0$

⑧ $c_8 = 0$

⑨ $c_9 = 0$

The top portion shows a systolic array diagram with inputs A_1, A_2, A_3 feeding rows a_{13}, a_{12}, a_{11}; a_{23}, a_{22}, a_{21}; a_{33}, a_{32}, a_{31} into processing elements $P_1, P_2, P_3, P_4, P_5, P_6, P_7, P_8, P_9$, with B_1, B_2, B_3 feeding columns b_{31}, b_{32}, b_{33}; b_{21}, b_{22}, b_{23}; b_{11}, b_{12}, b_{13}.

$$\begin{bmatrix} a_{11} & a_{21} & a_{31} \\ a_{12} & a_{22} & a_{32} \\ a_{13} & a_{23} & a_{33} \end{bmatrix} \qquad \begin{bmatrix} b_{11} & b_{12} & b_{13} \\ b_{21} & b_{22} & b_{23} \\ b_{31} & b_{32} & b_{33} \end{bmatrix}$$

$P_1 = a_{11}b_{11} + a_{12}b_{21} + a_{13}b_{31}$

$P_2 = a_{11}b_{12} + a_{12}b_{22} + a_{13}b_{32}$

$P_3 = a_{11}b_{13} + a_{12}b_{23} + a_{13}b_{33}$

$P_4 = a_{21}b_{11} + a_{22}b_{21} + a_{23}b_{31}$

$P_5 = a_{21}b_{12} + a_{22}b_{22} + a_{23}b_{32}$

$P_6 = a_{21}b_{13} + a_{22}b_{23} + a_{23}b_{33}$

$P_7 = a_{31}b_{11} + a_{32}b_{21} + a_{33}b_{31}$

$P_8 = a_{31}b_{12} + a_{32}b_{22} + a_{33}b_{32}$

$P_9 = a_{31}b_{13} + a_{32}b_{23} + a_{33}b_{33}$

$$\begin{array}{c} A_1 \\ A_2 \\ A_3 \end{array} \begin{bmatrix} a_{11} & a_{12} & a_{13} \\ a_{21} & a_{22} & a_{23} \\ a_{31} & a_{32} & a_{33} \end{bmatrix} \begin{array}{c} B_1 \\ B_2 \\ B_3 \end{array} \begin{bmatrix} b_{11} & b_{12} & b_{13} \\ b_{21} & b_{22} & b_{23} \\ b_{31} & b_{32} & b_{33} \end{bmatrix}$$

	1	2	3
A_1	1	4	7
A_2	2	5	8
A_3	3	6	9

	9	6	3
B_1	9	6	7
B_2	6	5	4
B_3	3	2	1

$$\begin{pmatrix} 1 & 4 & 7 \\ 2 & 5 & 8 \\ 3 & 6 & 9 \end{pmatrix} \begin{pmatrix} 9 & 6 & 3 \\ 8 & 5 & 2 \\ 7 & 4 & 1 \end{pmatrix}$$

clk	P_1	P_2	P_3	P_4	P_5	P_6	P_7	P_8	P_9
0	—	—	—	—	—	—	—	—	—
1	$a_{11}b_{11}$	—	—	—	—	—	—	—	—
2	$a_{12}b_{21}$	$b_{12}a_{11}$	—	$a_{21}b_{11}$	—	—	—	—	—
3	$a_{13}b_{31}$	$a_{12}b_{22}$	$a_{11}b_{13}$	$a_{22}b_{21}$	$a_{21}b_{12}$	—	$a_{31}b_{11}$	—	—
4	—	$a_{13}b_{32}$	$a_{12}b_{23}$	$a_{23}b_{31}$	$a_{22}b_{22}$	$a_{21}b_{13}$	$a_{32}b_{21}$	$a_{31}b_{12}$	—
5	—	—	$a_{13}b_{33}$	—	$a_{23}b_{32}$	$a_{22}b_{23}$	$a_{33}b_{31}$	$a_{32}b_{22}$	$a_{31}b_{13}$
6	—	—	—	—	—	$a_{23}b_{33}$	—	$a_{33}b_{32}$	$a_{32}b_{23}$
7	—	—	—	—	—	—	—	—	$a_{33}b_{33}$
8	—	—	—	—	—	—	—	—	—

$$\begin{pmatrix} 1 & 4 & 7 \\ 2 & 5 & 8 \\ 3 & 6 & 9 \end{pmatrix} \begin{pmatrix} 9 & 6 & 3 \\ 8 & 5 & 2 \\ 7 & 4 & 1 \end{pmatrix}$$

9 + 32 + 49	6 + 20 + 28	3 + 8 + 7
18 + 40 + 56	12 + 25 + 32	6 + 10 + 8
27 + 48 + 63	18 + 30 + 36	9 + 12 + 9

90

$$= \begin{bmatrix} 90 & 54 & 18 \\ 114 & 69 & 24 \\ 138 & 84 & 30 \end{bmatrix}$$