CS 3725 Mar. 8/12

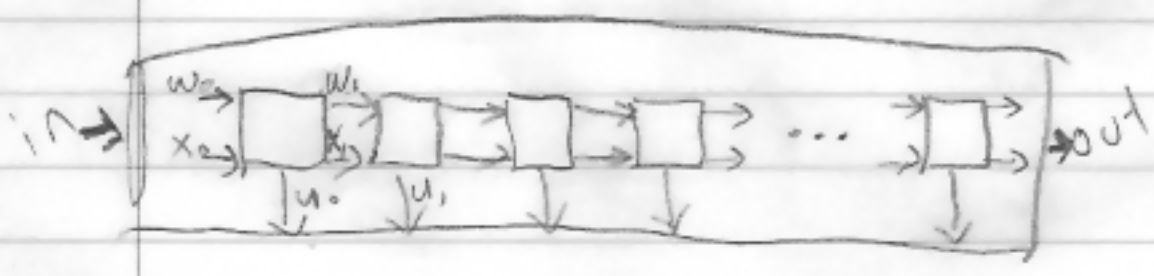
Systolic Machine

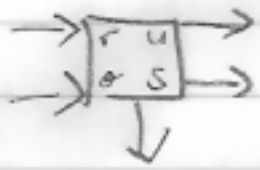
Example Linear Systolic Machine
Calculates point-wise sum of products

ie. $W = W_3, W_2, W_1, W_0$
$X = X_3, X_2, X_1, X_0$

We want to calculate
W_0X_0
$W_0X_0 + W_1X_1$
$W_0X_0 + W_1X_1 + W_2X_2$

In general, $\sum_{i=0}^{k} W_iX_i$, for k.



Where a module 

Defn of a Module

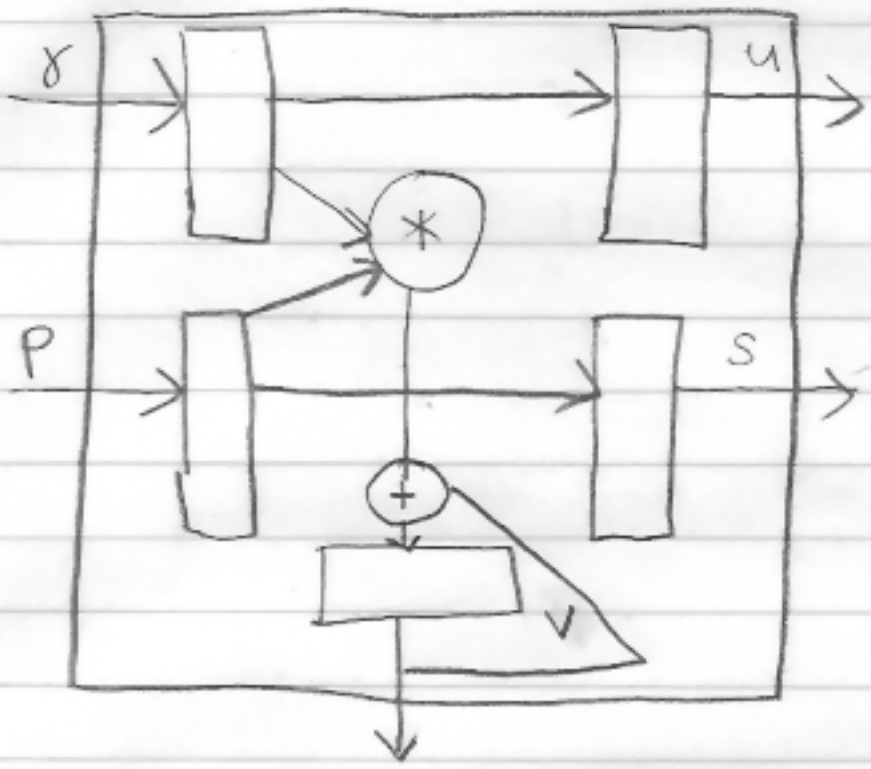
$u(t+1) = r(t)$ } "flow through"
$s(t+1) = p(t)$ }
$\Theta(t+1) = u(t) + r(t) * p(t)$

Difference between Systolic Array and Data Pipeline,

① In Data Pipeline the stages are different. But in systolic array, all the "stages" (modules) are same.

② In Data Pipelining, stages do not have memory but systolic array modules have internal memory.

Circuit Design of a Module

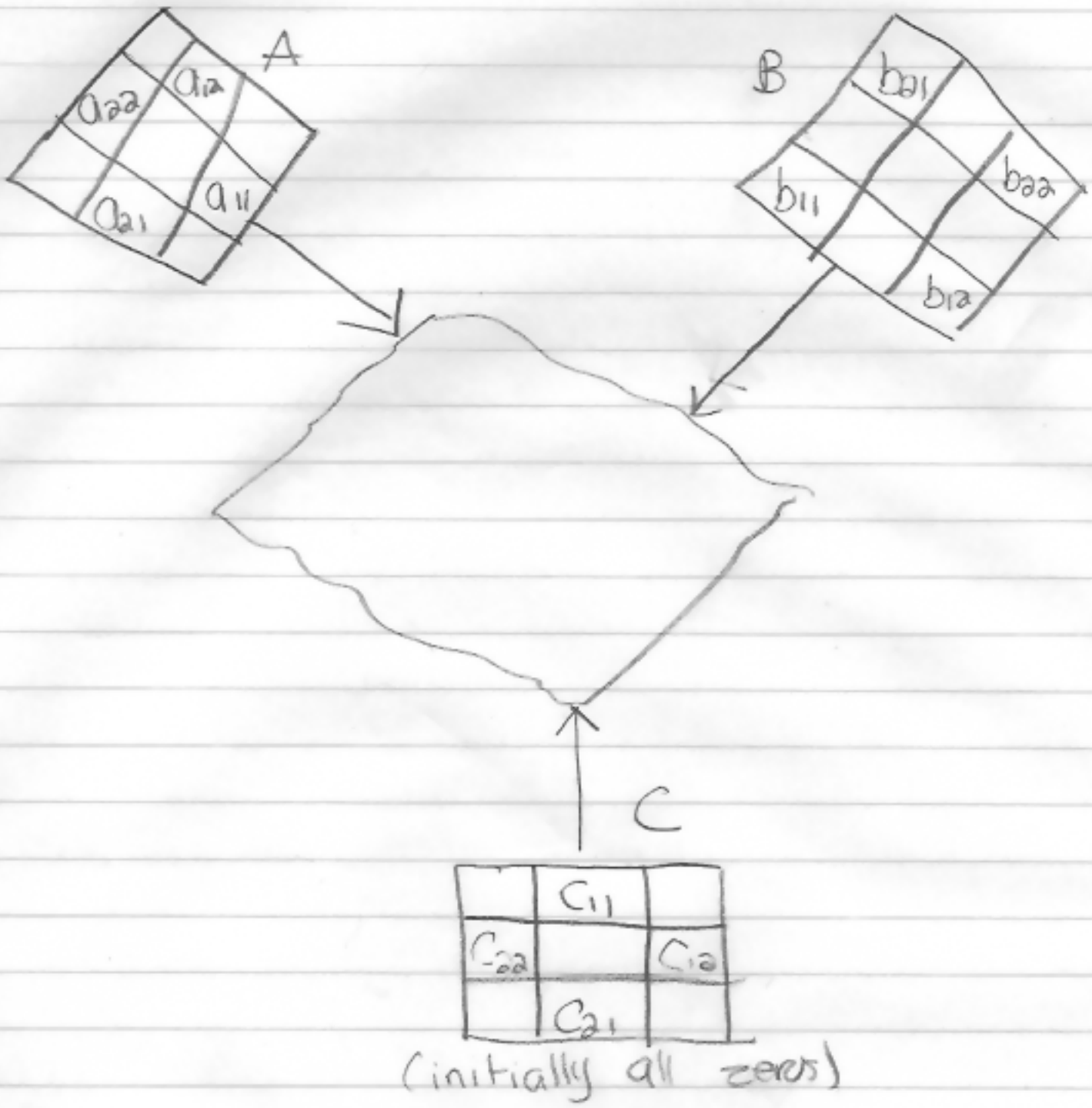


Matrix Multiplication

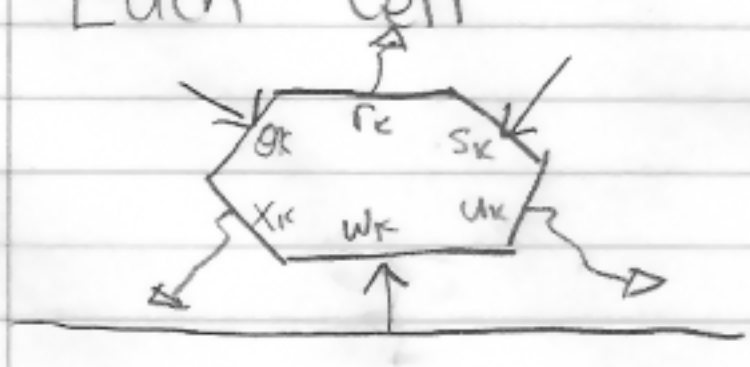
Let $A = \begin{bmatrix} a_{11} & a_{12} \\ a_{21} & a_{22} \end{bmatrix}$ $B = \begin{bmatrix} b_{11} & b_{12} \\ b_{21} & b_{22} \end{bmatrix}$

Obtain $C = A * B = \begin{bmatrix} C_{11} & C_{12} \\ C_{21} & C_{22} \end{bmatrix}$

Where
$C_{11} = a_{11}b_{11} + a_{12}b_{21}$
$C_{21} = a_{21}b_{11} + a_{22}b_{21}$
$C_{12} = a_{11}b_{12} + a_{12}b_{22}$
$C_{22} = a_{21}b_{12} + a_{22}b_{22}$



Each Cell



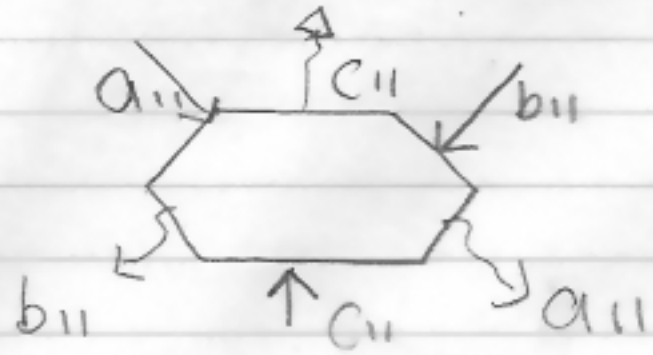
$x_k = s_{K-1}$ } flow through
$v_K = y_{K-1}$

$r_K = w_{K-1} + y_{K-1} * s_{K-1}$

Example 2

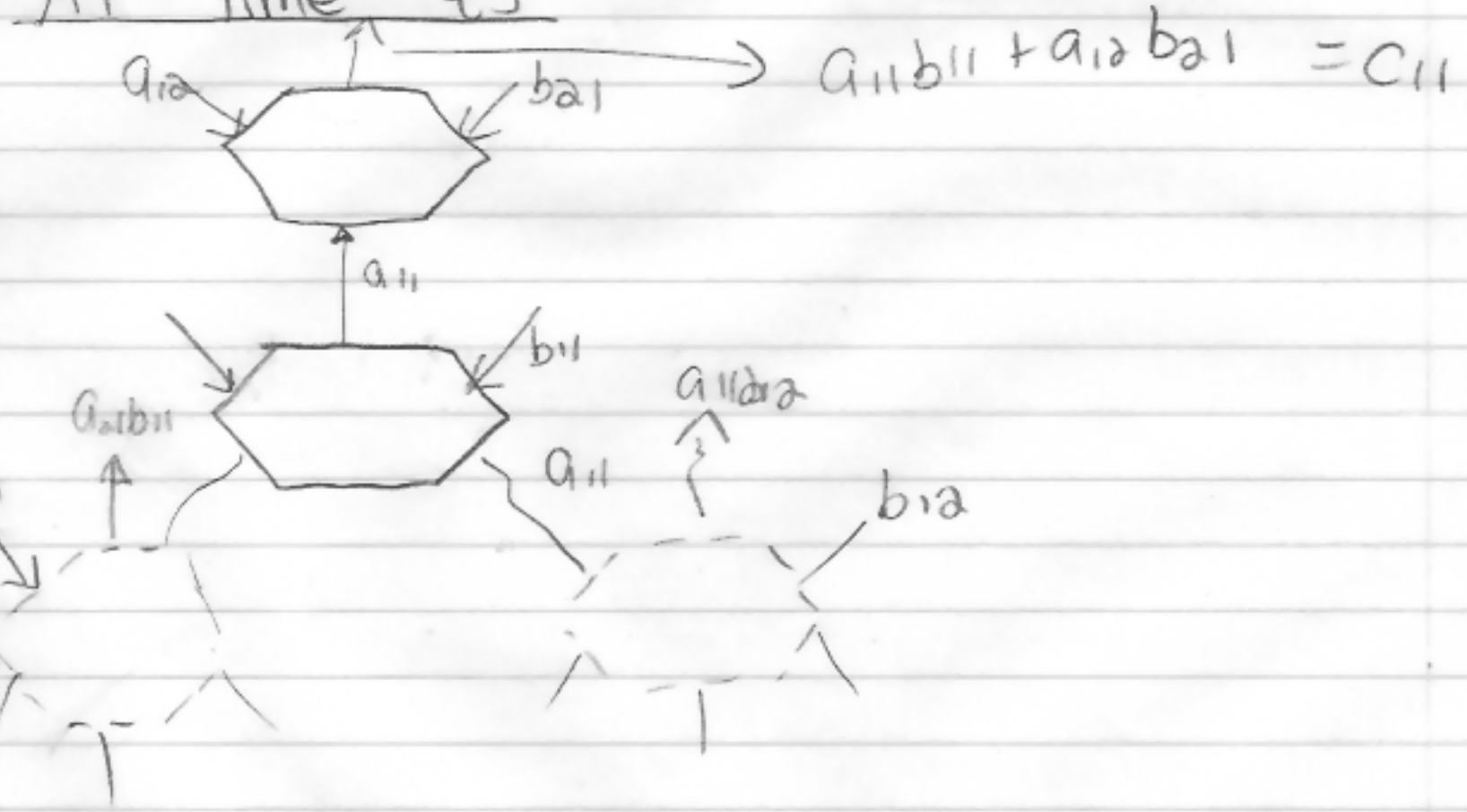
Note that $w_k = y_{k-1}$

At Time t2



$$c_{11} = \hat{c}_{11} + a_{11} b_{11}$$

At time t3



$$a_{11}b_{11} + a_{12}b_{21} = c_{11}$$