Resource Constraints

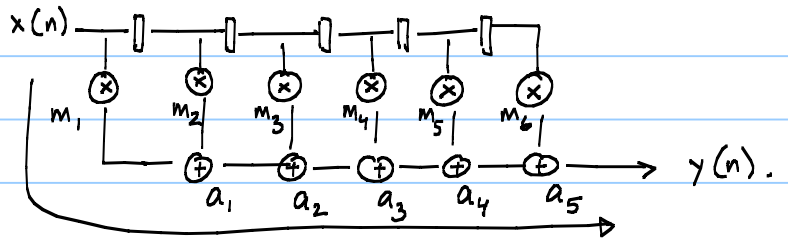
Note Title 2/25/2010

References

- VLSI Digital Signal Processing
  - K. K. Parhi, Wiley 1999
- Synthesis & Optimization of Digital Circuits
  - G. de Micheli, TMH, 1993.

6 - tap FIR filter.

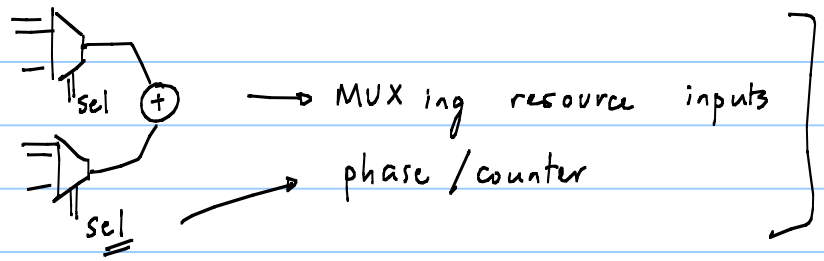
Coefficients : $h_0 .. h_5$



Assume : mult, add each take 1 cycle

Critical path : $m_1 - a_1 - a_2 - a_3 - a_4 - a_5$ = 6 cycles

Cycle #	Ops.	Resources
1:	m_1 m_2 m_3 m_4 m_5 m_6	6 M
2:	a_1	1 A
3:	a_2	1 A
4:	a_3	1 A
5:	a_4	1 A
6:	a_5	1 A



Resource utilization: What % of time is resource used.

eg. 1A: 6 clock cycles ⇒ max 6 additions

Here we do 5 ⇒ Utilization = 5/6 = 83%

Multipliers: 6 M, 6 cycles ⇒ 36 mults.

Utilization = 6/36 = 16.67 %

m_1, m_2 must be in cycle 1, else a_1 cannot be in 2.

But other mults can move to later cycles.

1:	m_1 m_2	2M
2:	a_1 m_3 m_4	2M, 1A
3:	a_2 m_5 m_6	2M, 1A
4:	a_3	1A
5:	a_4	1A
6:	a_5	1A

Overall: # mults = max over all cycles # mults in that cycle.

= 2M

adds = 1A

Utilization: Add: 5/6. = 83.33%

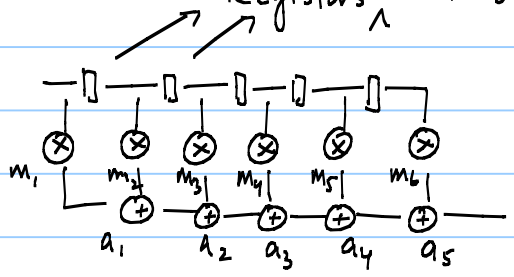
Mult: 6/12 = 50% (prev. 16.67%).

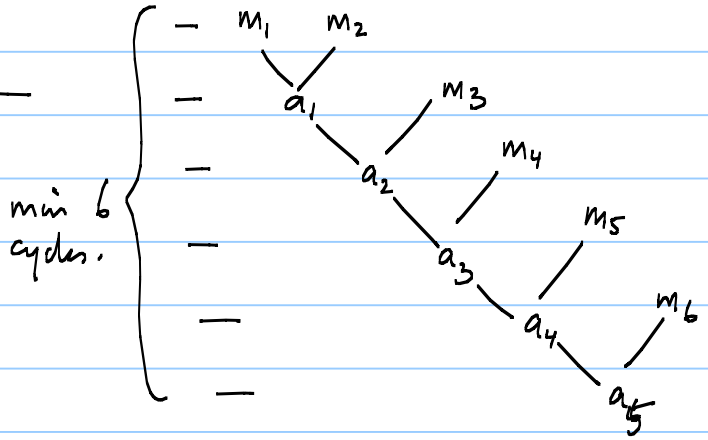
Tighter resource constraint: 1M, 1A.

1:	m_1				
2:	m_2		Util:	Mult:	$6/7 \simeq 84\%$
3:	a_1	m_3		Add:	$5/7 = 73\%$
4:	a_2	m_4			
5:	a_3	m_5			
6:	a_4	m_6			
7:	a_5				

(Delays)

Registers can be removed while understanding dependencies



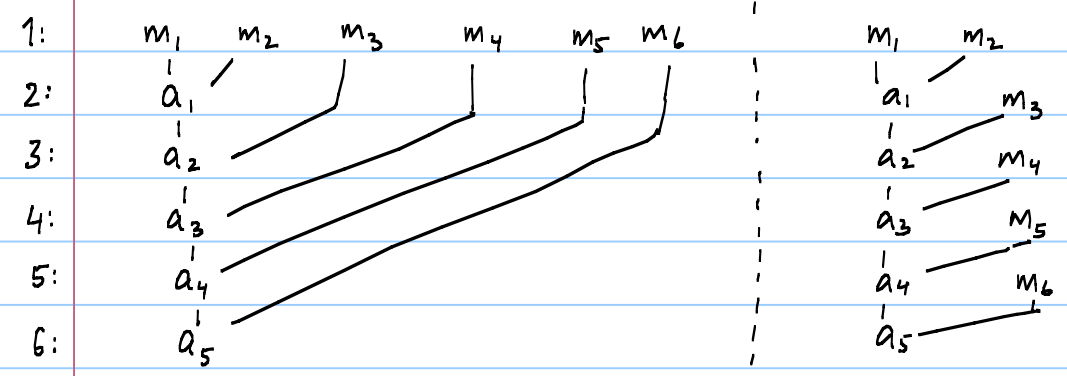


As Soon As Possible schedule

ASAP

As Late As Possible

ALAP



Mobility : ALAP time − ASAP time for each function

eg. Mobility $(m_1) = 1 - 1 = 0$

$(m_3) = 2 - 1 = 1$

$(m_6) = 5 - 1 = 4$

Time bound (theoretical) = $\frac{\text{Total \# of ops of a type}}{\text{\# resources of that type.}}$

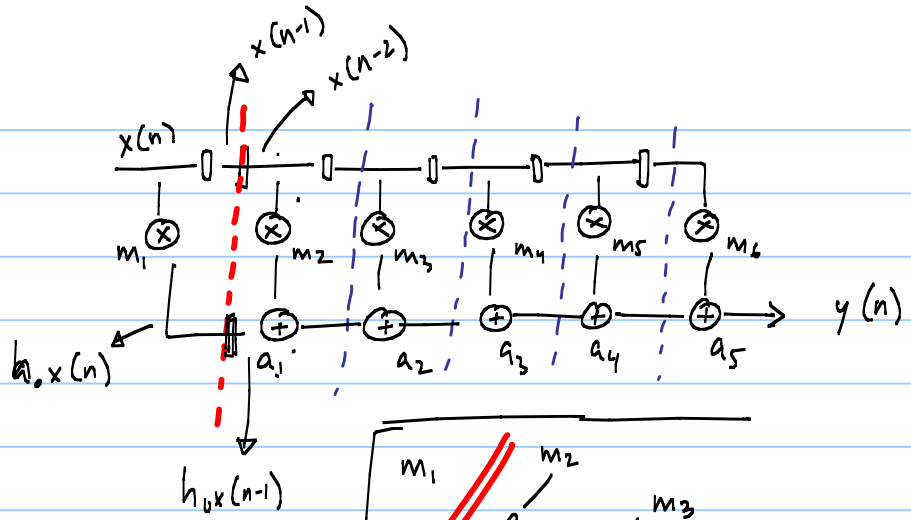
System bound = max over all types of resources

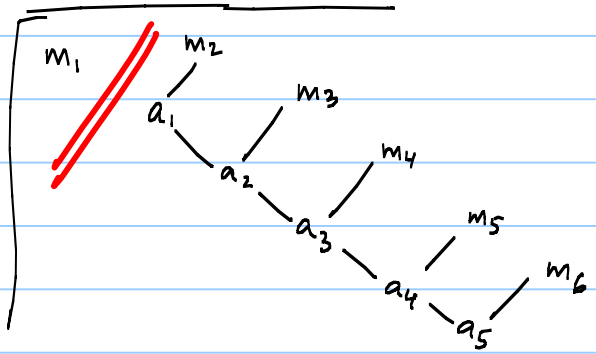
eg: 6 Mults 2 M ⇒ min 3 time units.

1 M ⇒ min 6 time units.

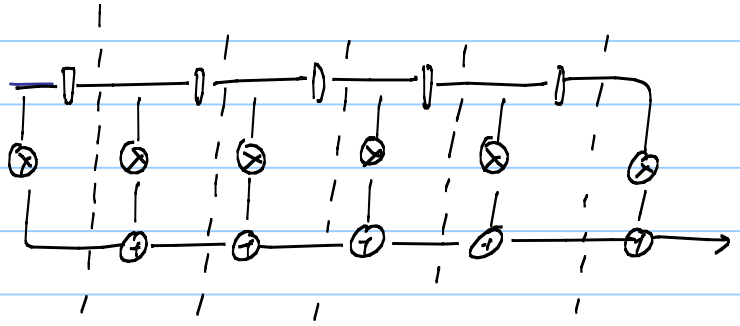
Addition 1 A ⇒ min 5 time units

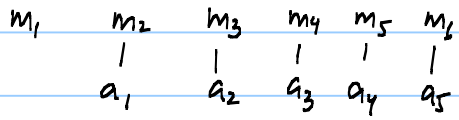
If resource constraint = (1M, 1A) ⇒ max (6, 5) = 6 time units





1:	m_2		Iteration/ Sample
2:	a_1	m_3	
3:	a_2	m_4	
4:	a_3	m_5	
5:	a_4	m_6	
6:	a_5	m_1	

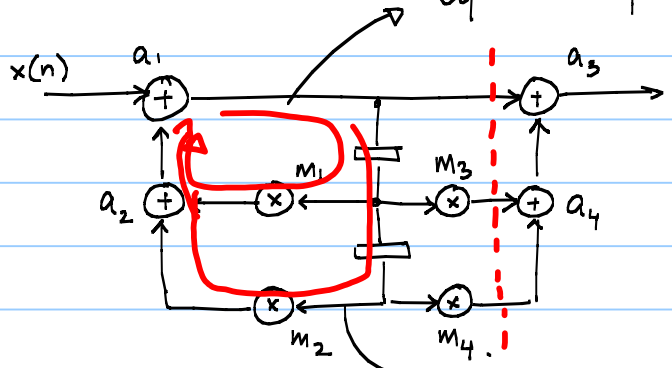




If 6 M, 5 A $\Rightarrow$ all mults in cycle 1, all adds in 2.

<u>2 cycles</u> sufficient

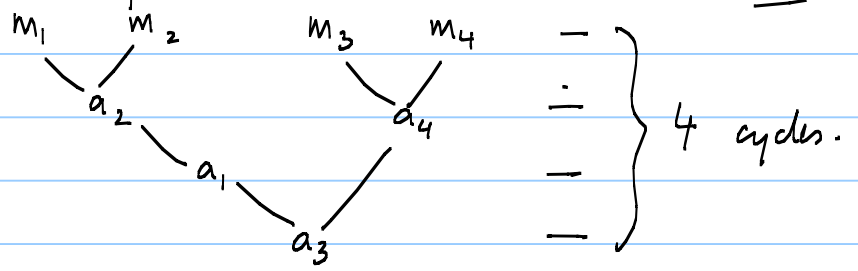
Cycle: Loop bound $\frac{T_m + 2T_a}{1} = 3$

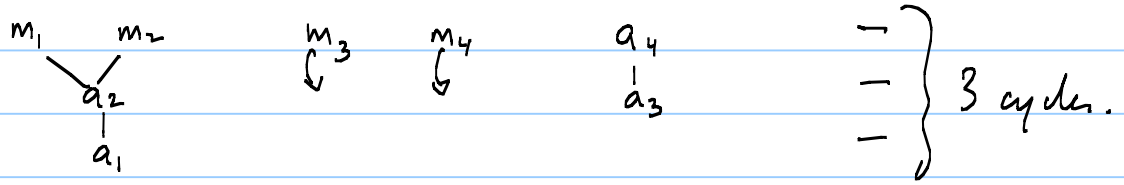


(m_2) (a_1, a_2)

Loop bound: $\frac{T_m + 2T_a}{2} = 1.5$

Iteration period bound = $\max(3, 1.5) = 3$.

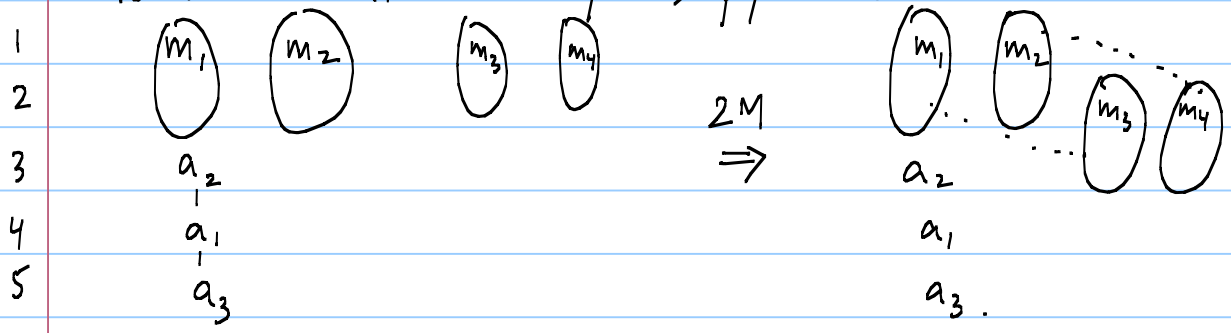


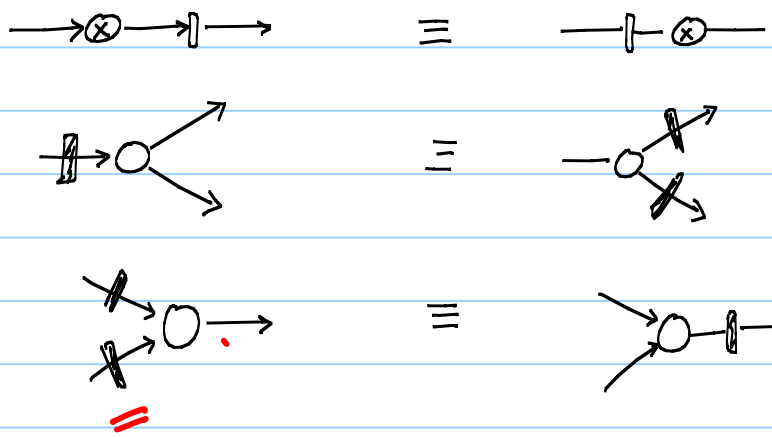


2 mults
2 adders

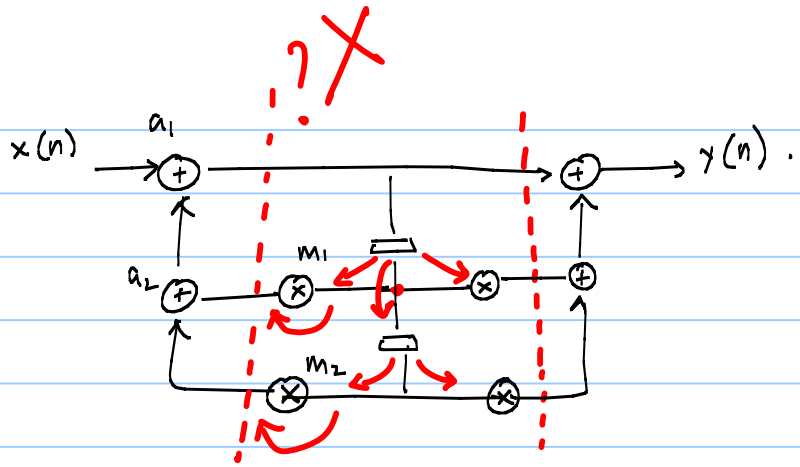
1: m_1 m_2 a_4
2: m_3 m_4 a_2 a_3
3: a_1

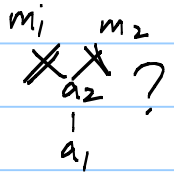
Assume mult = 2 cycles, pipelined.

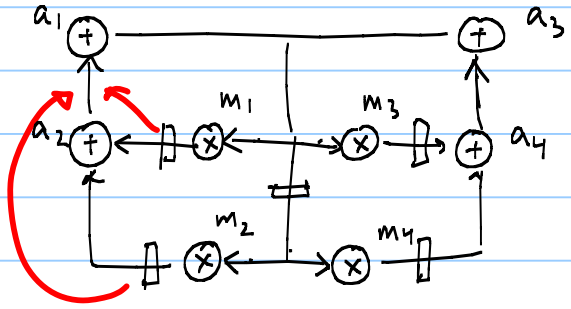


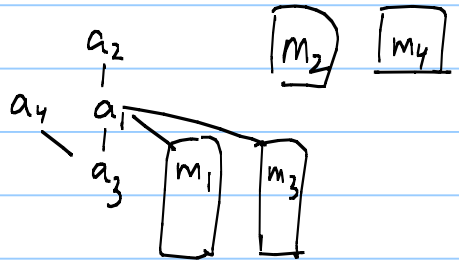


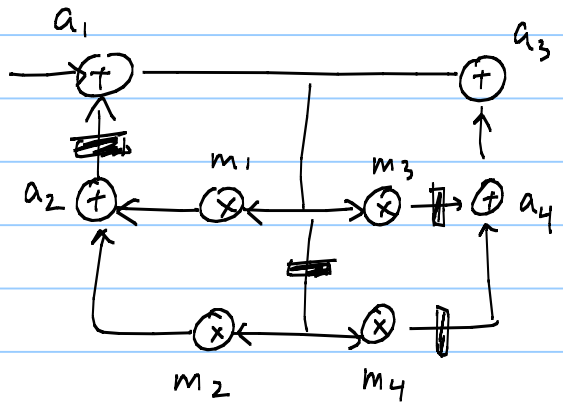
Retiming - extension of pipelining

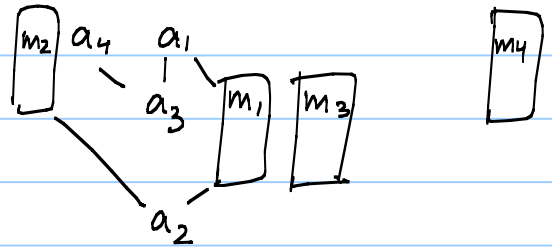

x(n)
a1
y(n).
m1
a2
m2


m1
m2
a2
a1
?


a1
a3
m1
m3
a2
a4
m2
m4


a2
m2
m4
a4
a1
a3
m1
m3


a1
a3
a2
m1
m3
a4
m2
m4


m2
a4
a1
a3
m1
m3
m4
a2