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1.

a)

	Processor 1	Processor 2	Processor 3	
1	R_A			→ cold miss
2		R_B		→ cold miss
3			R_C	→ cold miss
4	W_A			
5			R_C	→ false sharing miss
6		R_A		→ true sharing miss
7	W_B			
8			R_A	→ true sharing miss
9			R_B	→ hit

Time step 1, 2, 3 ⇒ first access to the block

Time step 4 : p1 S $\xrightarrow{W_A}$ M ; p2 = I ; p3 = I

Time step 5 ⇒ miss but C did not be changed

p1 = S, p2 = I p3 = I $\xrightarrow{R_C}$ S,

Time step 6 ⇒ miss but be changed by P1

p1 = S ; p2 = S ; p3 = S

Time step 7 ⇒ p1 = S $\xrightarrow{W_B}$ M ; p2 = I ; p3 = I

Time step 8 ⇒ miss and change by P1

p1 = S p2 = I p3 = I $\xrightarrow{R_A}$ S

b)

False sharing miss will not send the processor new data to cache. Therefore, it can be ignored

c)

	Processor 1	Processor 2	Processor 3
1	R_A		
2		R_B	
3			R_C
4	W_A		
5			R_C
6		R_A	
7	W_B		
8			R_A
9			R_B

$70 \times 3 + 10 + 70 + 70 + 10 + 70 + 0 = 440$

- 70×3: Read from memory
- 10: BusUpgr
- 70: Read-exclusive by cache
- 70: Read-exclusive by next level
- 10: BusUpgr
- 70: Read-exclusive by next level
- 0: read hit

$$\frac{440 - 70}{440} \times 100\% = 84\%$$

2.

a) home node = requesting node; memory = clean

Cycle = 50 + 1 = 51 cycle

Traffic: N/A

b) home node = requesting node; memory = dirty

Cycle = 50 + 20 + 50 + 100 + 50 + 1 = 271 cycle

Traffic: 6 + 6 + 32 = 44 byte

c) home node ≠ requestion node; memory = clean

Cycle = 20 + 50 + 100 + 50 + 1 = 221 cycle

Traffic = 6 + 6 + 32 = 44 byte

d) home node ≠ requestion node; memory = dirty

home node = remote node

Cycle = 20 + 50 + 100 + 50 + 1 = 221 cycle

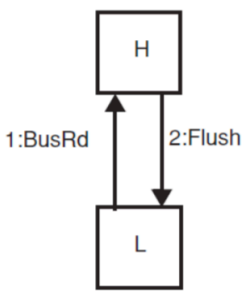
Traffic = 6 + 6 + 32 = 44 byte.

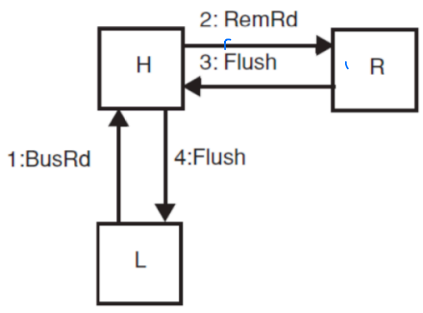
e) home node ≠ requesting node; memory = dirty

remote node ≠ home node

Cycle = 20 + 50 + 20 + 50 + 100 + 50 + 100 + 50 + 1 = 441

Traffic = 6 + 6 + 6 + 32 + 6 + 32 = 88





3.

P1	P2	P3
A=1	R1=A	R2=B
	B=1	R3=A

there has 8 conditions total.

if do ↓

P1 A=1

P2 R1=A=1

P3 R2=B=1 R3=A=1

In the conclusion, R3 is not be 0. Therefore, 1,1,0 will not be sequentially consistent.

4.

a)

$n=1$ $(K-1)\times 2$

$n=2$ $(K-1)\times 2\times 2\times K$

$n=3$ $(K-1)\times 2\times 3\times K^2$

$\Downarrow$

$2\times n\times K^{n-1}(K-1)$

b)

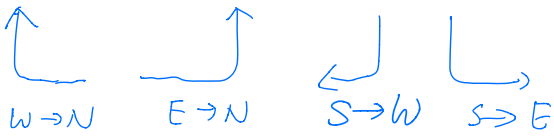
bandwith $= K^{n-1}$ uni-directional $= 2K^{n-1}$

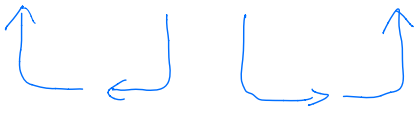
c)

max channel load $= \frac{K^{n-1}}{2}$

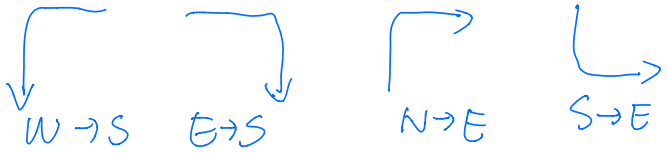
5.

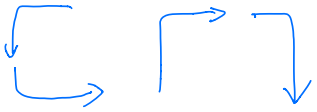
a) it is connected but not dead-lock





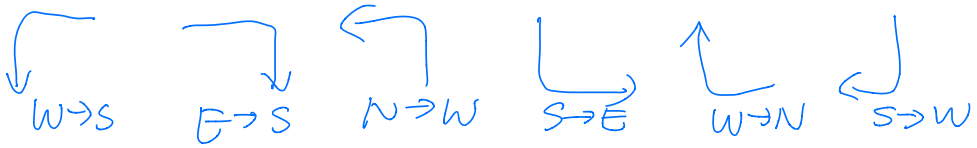
b)

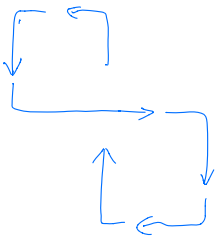




it is not connected and not dead-lock

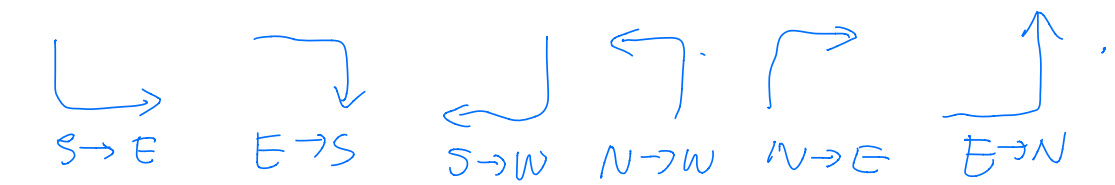
c)

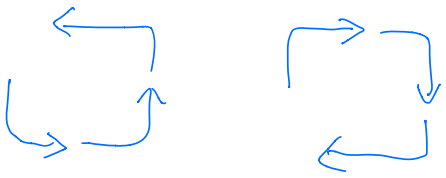




it's not connected and dead-lock

d)





it's connected and not dead-lock