Άσκηση 1

Ορίζουμε αρχικά ως:

- MR_{Li}: miss rate (%)
- hit_{Li}: cycles needed to resolve a hit (cycles)
- MP_{Li}: miss penalty time (cycles)
- $AMAT_{Li}$: average memory access time (cycles)

Επομένως, σύμφωνα με την εκφώνηση:

- MR_{L1} = 100% - 97.5% = 2.5% = 0.025
- hit_{L1} = 1 cycle
- MP_{L1} = 90 cycles
- MR_{L2} = 100% - 88% = 12% = 0.12
- hit_{L2} = ???
- MP_{L2} = MP_{L1} = 90 cycles

Άρα για την 1η περίπτωση:

$$AMAT_{L1} = 1 \cdot hit_{L1} + MR_{L1} \cdot MP_{L1} = 1 \cdot 1 + 0.025 \cdot 90 = 3.25 \, cycles$$

Ενώ, στην 2η περίπτωση θα ισχύει:

$$AMAT_{L1+L2} = 1 \cdot hit_{L1} + MR_{L1} \cdot (hit_{L2} + MR_{L2} \cdot MP_{L2}) = 1 \cdot 1 + 0.025 \cdot (hit_{L2} + 0.12 \cdot 90) =$$
$$= 1 + 0.025 \cdot (hit_{L2} + 10.8)$$

Θέλουμε:

$$\frac{AMAT_{L1}}{AMAT_{L1+L2}} \geq 2.4 \;\rightarrow\; \frac{3.25}{1 + 0.025 \cdot (hit_{L2} + 10.8)} \geq 2.4 \;\rightarrow \ldots \rightarrow\; hit_{L2} \leq 3.3\bar{6} \, cycles$$

Δοκιμάζοντας τις τιμές 3 και 4, προκύπτει πως:

$$hit_{L2} = 3: \frac{AMAT_{L1}}{AMAT_{L1+L2}} = \frac{3.25}{1.345} = 9.42 \geq 2.4, \alpha\pi o\delta\varepsilon\kappa\tau\acute{\eta}$$

$$hit_{L2} = 4: \frac{AMAT_{L1}}{AMAT_{L1+L2}} = \frac{3.25}{1.37} = 2.37 \leq 2.4, \mu\eta \,\alpha\pi o\delta\varepsilon\kappa\tau\acute{\eta}$$

Άρα **$hit_{L2}^{(max)}$ = 3.**

Άσκηση 2

- *Ερώτημα (α)*

Η **cache έχει** 256/32/2 = **4 sets**, ενώ **κάθε block χωρά** 32/8 = **4 στοιχεία** ενός πίνακα. Επομένως, στην ανάλυση μας, θα έχουμε έναν πίνακα 4x2, όπου κάθε κελί θα χωρά 4 στοιχεία ενός πίνακα και μάλιστα με την παρακάτω διάταξη. Θα τονίζουμε με **bold** το block που δείχνει η LRU.

i=0, j=0: *m m m h*

B[0][0]: compulsory miss:

i = 0,2,4	j = 0-3	B[0][0-3]	-
	j = 4-7		
i = 1,3,5	j = 0-3		
	j = 4-7		

A[0][0]: compulsory miss:

i = 0,2,4	j = 0-3	**B[0][0-3]**	A[0][0-3]
	j = 4-7		
i = 1,3,5	j = 0-3		
	j = 4-7		

C[0]: compulsory miss:

i = 0,2,4	j = 0-3	C[0-3]	**A[0][0-3]**
	j = 4-7		
i = 1,3,5	j = 0-3		
	j = 4-7		

A[0][0]: hit:

i = 0,2,4	j = 0-3	**C[0-3]**	A[0][0-3]
	j = 4-7		
i = 1,3,5	j = 0-3		
	j = 4-7		

i=0, j=2: *m h m h*

B[0][2]: conflict miss:

i = 0,2,4	j = 0-3	B[0][0-3]	**A[0][0-3]**
	j = 4-7		
i = 1,3,5	j = 0-3		
	j = 4-7		

A[0][2]: hit:

i = 0,2,4	j = 0-3	**B[0][0-3]**	A[0][0-3]
	j = 4-7		
i = 1,3,5	j = 0-3		
	j = 4-7		

C[2]: conflict miss:

i = 0,2,4	j = 0-3	C[0-3]	**A[0][0-3]**
	j = 4-7		
i = 1,3,5	j = 0-3		
	j = 4-7		

A[0][2]: hit:

i = 0,2,4	j = 0-3	**C[0-3]**	A[0][0-3]
	j = 4-7		
i = 1,3,5	j = 0-3		
	j = 4-7		

i=0, j=4: *m m m h*

B[0][4]: compulsory miss:

i = 0,2,4	j = 0-3	**C[0-3]**	A[0][0-3]
	j = 4-7	B[0][4-7]	-
i = 1,3,5	j = 0-3		
	j = 4-7		

A[0][4]: compulsory miss:

i = 0,2,4	j = 0-3	**C[0-3]**	A[0][0-3]
	j = 4-7	**B[0][4-7]**	A[0][4-7]
i = 1,3,5	j = 0-3		
	j = 4-7		

C[4]: compulsory miss:

i = 0,2,4	j = 0-3	**C[0-3]**	A[0][0-3]
	j = 4-7	C[4-7]	**A[0][4-7]**
i = 1,3,5	j = 0-3		
	j = 4-7		

A[0][4]: hit:

i = 0,2,4	j = 0-3	**C[0-3]**	A[0][0-3]
	j = 4-7	**C[4-7]**	A[0][4-7]
i = 1,3,5	j = 0-3		
	j = 4-7		

i=0, j=6: *m h m h*

B[0][6]: conflict miss:

i = 0,2,4	j = 0-3	**C[0-3]**	A[0][0-3]
	j = 4-7	B[0][4-7]	**A[0][4-7]**
i = 1,3,5	j = 0-3		
	j = 4-7		

A[0][6]: hit:

i = 0,2,4	j = 0-3	**C[0-3]**	A[0][0-3]
	j = 4-7	**B[0][4-7]**	A[0][4-7]
i = 1,3,5	j = 0-3		
	j = 4-7		

C[6]: conflict miss:

i = 0,2,4	j = 0-3	**C[0-3]**	A[0][0-3]
	j = 4-7	C[4-7]	**A[0][4-7]**
i = 1,3,5	j = 0-3		
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A[0][6]: hit:

i = 0,2,4	j = 0-3	**C[0-3]**	A[0][0-3]
	j = 4-7	**C[4-7]**	A[0][4-7]
i = 1,3,5	j = 0-3		
	j = 4-7		

Άρα για i=0 έχουμε **6 hits** (και 10 misses).

i=1, j=0: m m h h

B[1][0]: compulsory miss:

i = 0,2,4	j = 0-3	**C[0-3]**	A[0][0-3]
	j = 4-7	**C[4-7]**	A[0][4-7]
i = 1,3,5	j = 0-3	B[1][0-3]	-
	j = 4-7		

A[1][0]: compulsory miss:

i = 0,2,4	j = 0-3	**C[0-3]**	A[0][0-3]
	j = 4-7	**C[4-7]**	A[0][4-7]
i = 1,3,5	j = 0-3	**B[1][0-3]**	A[1][0-3]
	j = 4-7		

C[0]: hit:

i = 0,2,4	j = 0-3	C[0-3]	**A[0][0-3]**
	j = 4-7	**C[4-7]**	A[0][4-7]
i = 1,3,5	j = 0-3	**B[1][0-3]**	A[1][0-3]
	j = 4-7		

A[1][0]: hit:

i = 0,2,4	j = 0-3	C[0-3]	**A[0][0-3]**
	j = 4-7	**C[4-7]**	A[0][4-7]
i = 1,3,5	j = 0-3	**B[1][0-3]**	A[1][0-3]
	j = 4-7		

i=1, j=2: h h h h

B[1][2]: hit:

i = 0,2,4	j = 0-3	C[0-3]	**A[0][0-3]**
	j = 4-7	**C[4-7]**	A[0][4-7]
i = 1,3,5	j = 0-3	B[1][0-3]	**A[1][0-3]**
	j = 4-7		

A[1][2]: hit:

i = 0,2,4	j = 0-3	C[0-3]	**A[0][0-3]**
	j = 4-7	**C[4-7]**	A[0][4-7]
i = 1,3,5	j = 0-3	**B[1][0-3]**	A[1][0-3]
	j = 4-7		

C[2]: hit:

i = 0,2,4	j = 0-3	C[0-3]	**A[0][0-3]**
	j = 4-7	**C[4-7]**	A[0][4-7]
i = 1,3,5	j = 0-3	**B[1][0-3]**	A[1][0-3]
	j = 4-7		

A[1][2]: hit:

i = 0,2,4	j = 0-3	C[0-3]	**A[0][0-3]**
	j = 4-7	**C[4-7]**	A[0][4-7]
i = 1,3,5	j = 0-3	**B[1][0-3]**	A[1][0-3]
	j = 4-7		

i=1, j=4: m m h h

B[1][4]: compulsory miss:

i = 0,2,4	j = 0-3	C[0-3]	**A[0][0-3]**
	j = 4-7	**C[4-7]**	A[0][4-7]
i = 1,3,5	j = 0-3	**B[1][0-3]**	A[1][0-3]
	j = 4-7	B[1][4-7]	-

A[1][4]: compulsory miss:

i = 0,2,4	j = 0-3	C[0-3]	**A[0][0-3]**
	j = 4-7	**C[4-7]**	A[0][4-7]
i = 1,3,5	j = 0-3	**B[1][0-3]**	A[1][0-3]
	j = 4-7	**B[1][4-7]**	A[1][4-7]

C[4]: hit:

i = 0,2,4	j = 0-3	C[0-3]	**A[0][0-3]**
	j = 4-7	C[4-7]	**A[0][4-7]**
i = 1,3,5	j = 0-3	**B[1][0-3]**	A[1][0-3]
	j = 4-7	**B[1][4-7]**	A[1][4-7]

A[1][4]: hit:

i = 0,2,4	j = 0-3	C[0-3]	**A[0][0-3]**
	j = 4-7	C[4-7]	**A[0][4-7]**
i = 1,3,5	j = 0-3	**B[1][0-3]**	A[1][0-3]
	j = 4-7	**B[1][4-7]**	A[1][4-7]

i=1, j=6: h h h h

B[1][6]: hit:

i = 0,2,4	j = 0-3	C[0-3]	**A[0][0-3]**
	j = 4-7	C[4-7]	**A[0][4-7]**
i = 1,3,5	j = 0-3	**B[1][0-3]**	A[1][0-3]
	j = 4-7	B[1][4-7]	**A[1][4-7]**

A[1][6]: hit:

i = 0,2,4	j = 0-3	C[0-3]	**A[0][0-3]**
	j = 4-7	C[4-7]	**A[0][4-7]**
i = 1,3,5	j = 0-3	**B[1][0-3]**	A[1][0-3]
	j = 4-7	**B[1][4-7]**	A[1][4-7]

C[6]: hit:

i = 0,2,4	j = 0-3	C[0-3]	**A[0][0-3]**
	j = 4-7	C[4-7]	**A[0][4-7]**
i = 1,3,5	j = 0-3	**B[1][0-3]**	A[1][0-3]
	j = 4-7	**B[1][4-7]**	A[1][4-7]

A[1][6]: hit:

i = 0,2,4	j = 0-3	C[0-3]	**A[0][0-3]**
	j = 4-7	C[4-7]	**A[0][4-7]**
i = 1,3,5	j = 0-3	**B[1][0-3]**	A[1][0-3]
	j = 4-7	**B[1][4-7]**	A[1][4-7]

Άρα για i=1 έχουμε **12 hits** (και 4 misses).

i=2, j=0: *m m m h*

B[2][0]: compulsory miss:

i = 0,2,4	j = 0-3	**C[0-3]**	B[2][0-3]
	j = 4-7	C[4-7]	**A[0][4-7]**
i = 1,3,5	j = 0-3	**B[1][0-3]**	A[1][0-3]
	j = 4-7	**B[1][4-7]**	A[1][4-7]

A[2][0]: compulsory miss:

i = 0,2,4	j = 0-3	A[2][0-3]	**B[2][0-3]**
	j = 4-7	C[4-7]	**A[0][4-7]**
i = 1,3,5	j = 0-3	**B[1][0-3]**	A[1][0-3]
	j = 4-7	**B[1][4-7]**	A[1][4-7]

C[0]: conflict miss:

i = 0,2,4	j = 0-3	**A[2][0-3]**	C[0-3]
	j = 4-7	C[4-7]	**A[0][4-7]**
i = 1,3,5	j = 0-3	**B[1][0-3]**	A[1][0-3]
	j = 4-7	**B[1][4-7]**	A[1][4-7]

A[2][0]: hit:

i = 0,2,4	j = 0-3	A[2][0-3]	**C[0-3]**
	j = 4-7	C[4-7]	**A[0][4-7]**
i = 1,3,5	j = 0-3	**B[1][0-3]**	A[1][0-3]
	j = 4-7	**B[1][4-7]**	A[1][4-7]

i=2, j=4: *m m m h*

B[2][4]: compulsory miss:

i = 0,2,4	j = 0-3	A[2][0-3]	**C[0-3]**
	j = 4-7	**C[4-7]**	B[2][4-7]
i = 1,3,5	j = 0-3	**B[1][0-3]**	A[1][0-3]
	j = 4-7	**B[1][4-7]**	A[1][4-7]

A[2][4]: compulsory miss:

i = 0,2,4	j = 0-3	A[2][0-3]	**C[0-3]**
	j = 4-7	A[2][4-7]	**B[2][4-7]**
i = 1,3,5	j = 0-3	**B[1][0-3]**	A[1][0-3]
	j = 4-7	**B[1][4-7]**	A[1][4-7]

C[4]: conflict miss:

i = 0,2,4	j = 0-3	A[2][0-3]	**C[0-3]**
	j = 4-7	**A[2][4-7]**	C[4-7]
i = 1,3,5	j = 0-3	**B[1][0-3]**	A[1][0-3]
	j = 4-7	**B[1][4-7]**	A[1][4-7]

A[2][4]: hit:

i = 0,2,4	j = 0-3	A[2][0-3]	**C[0-3]**
	j = 4-7	A[2][4-7]	**C[4-7]**
i = 1,3,5	j = 0-3	**B[1][0-3]**	A[1][0-3]
	j = 4-7	**B[1][4-7]**	A[1][4-7]

i=2, j=2: *m h m h*

B[2][2]: conflict miss:

i = 0,2,4	j = 0-3	**A[2][0-3]**	B[2][0-3]
	j = 4-7	C[4-7]	**A[0][4-7]**
i = 1,3,5	j = 0-3	**B[1][0-3]**	A[1][0-3]
	j = 4-7	**B[1][4-7]**	A[1][4-7]

A[2][2]: hit:

i = 0,2,4	j = 0-3	A[2][0-3]	**B[2][0-3]**
	j = 4-7	C[4-7]	**A[0][4-7]**
i = 1,3,5	j = 0-3	**B[1][0-3]**	A[1][0-3]
	j = 4-7	**B[1][4-7]**	A[1][4-7]

C[2]: conflict miss:

i = 0,2,4	j = 0-3	**A[2][0-3]**	C[0-3]
	j = 4-7	C[4-7]	**A[0][4-7]**
i = 1,3,5	j = 0-3	**B[1][0-3]**	A[1][0-3]
	j = 4-7	**B[1][4-7]**	A[1][4-7]

A[2][2]: hit:

i = 0,2,4	j = 0-3	A[2][0-3]	**C[0-3]**
	j = 4-7	C[4-7]	**A[0][4-7]**
i = 1,3,5	j = 0-3	**B[1][0-3]**	A[1][0-3]
	j = 4-7	**B[1][4-7]**	A[1][4-7]

i=2, j=6: *m h m h*

B[2][6]: conflict miss:

i = 0,2,4	j = 0-3	A[2][0-3]	**C[0-3]**
	j = 4-7	**A[2][4-7]**	B[2][4-7]
i = 1,3,5	j = 0-3	**B[1][0-3]**	A[1][0-3]
	j = 4-7	**B[1][4-7]**	A[1][4-7]

A[2][6]: hit:

i = 0,2,4	j = 0-3	A[2][0-3]	**C[0-3]**
	j = 4-7	A[2][4-7]	**B[2][4-7]**
i = 1,3,5	j = 0-3	**B[1][0-3]**	A[1][0-3]
	j = 4-7	**B[1][4-7]**	A[1][4-7]

C[6]: conflict miss:

i = 0,2,4	j = 0-3	A[2][0-3]	**C[0-3]**
	j = 4-7	**A[2][4-7]**	C[4-7]
i = 1,3,5	j = 0-3	**B[1][0-3]**	A[1][0-3]
	j = 4-7	**B[1][4-7]**	A[1][4-7]

A[2][6]: hit:

i = 0,2,4	j = 0-3	A[2][0-3]	**C[0-3]**
	j = 4-7	A[2][4-7]	**C[4-7]**
i = 1,3,5	j = 0-3	**B[1][0-3]**	A[1][0-3]
	j = 4-7	**B[1][4-7]**	A[1][4-7]

Άρα για i=2 έχουμε **6 hits** (και 10 misses).

i=3, j=0: *m m m h*

B[3][0]: compulsory miss:

i = 0,2,4	j = 0-3	A[2][0-3]	**C[0-3]**
	j = 4-7	A[2][4-7]	**C[4-7]**
i = 1,3,5	j = 0-3	B[3][0-3]	**A[1][0-3]**
	j = 4-7	**B[1][4-7]**	A[1][4-7]

A[0][0]: conflict miss:

i = 0,2,4	j = 0-3	**A[2][0-3]**	A[0][0-3]
	j = 4-7	A[2][4-7]	**C[4-7]**
i = 1,3,5	j = 0-3	B[3][0-3]	**A[1][0-3]**
	j = 4-7	**B[1][4-7]**	A[1][4-7]

C[0]: conflict miss:

i = 0,2,4	j = 0-3	C[0-3]	**A[0][0-3]**
	j = 4-7	A[2][4-7]	**C[4-7]**
i = 1,3,5	j = 0-3	B[3][0-3]	**A[1][0-3]**
	j = 4-7	**B[1][4-7]**	A[1][4-7]

A[0][0]: hit:

i = 0,2,4	j = 0-3	**C[0-3]**	A[0][0-3]
	j = 4-7	A[2][4-7]	**C[4-7]**
i = 1,3,5	j = 0-3	B[3][0-3]	**A[1][0-3]**
	j = 4-7	**B[1][4-7]**	A[1][4-7]

i=3, j=2: *h h h h*

B[3][2]: hit:

i = 0,2,4	j = 0-3	**C[0-3]**	A[0][0-3]
	j = 4-7	A[2][4-7]	**C[4-7]**
i = 1,3,5	j = 0-3	B[3][0-3]	**A[1][0-3]**
	j = 4-7	**B[1][4-7]**	A[1][4-7]

A[0][2]: hit:

i = 0,2,4	j = 0-3	**C[0-3]**	A[0][0-3]
	j = 4-7	A[2][4-7]	**C[4-7]**
i = 1,3,5	j = 0-3	B[3][0-3]	**A[1][0-3]**
	j = 4-7	**B[1][4-7]**	A[1][4-7]

C[2]: hit:

i = 0,2,4	j = 0-3	C[0-3]	**A[0][0-3]**
	j = 4-7	A[2][4-7]	**C[4-7]**
i = 1,3,5	j = 0-3	B[3][0-3]	**A[1][0-3]**
	j = 4-7	**B[1][4-7]**	A[1][4-7]

A[0][2]: hit:

i = 0,2,4	j = 0-3	**C[0-3]**	A[0][0-3]
	j = 4-7	A[2][4-7]	**C[4-7]**
i = 1,3,5	j = 0-3	B[3][0-3]	**A[1][0-3]**
	j = 4-7	**B[1][4-7]**	A[1][4-7]

i=3, j=4: *m m m h*

B[3][4]: compulsory miss:

i = 0,2,4	j = 0-3	**C[0-3]**	A[0][0-3]
	j = 4-7	A[2][4-7]	**C[4-7]**
i = 1,3,5	j = 0-3	B[3][0-3]	**A[1][0-3]**
	j = 4-7	B[3][4-7]	**A[1][4-7]**

A[0][4]: conflict miss:

i = 0,2,4	j = 0-3	**C[0-3]**	A[0][0-3]
	j = 4-7	**A[2][4-7]**	A[0][4-7]
i = 1,3,5	j = 0-3	B[3][0-3]	**A[1][0-3]**
	j = 4-7	B[3][4-7]	**A[1][4-7]**

C[4]: conflict miss:

i = 0,2,4	j = 0-3	**C[0-3]**	A[0][0-3]
	j = 4-7	**C[4-7]**	A[0][4-7]
i = 1,3,5	j = 0-3	B[3][0-3]	**A[1][0-3]**
	j = 4-7	B[3][4-7]	**A[1][4-7]**

A[0][4]: hit:

i = 0,2,4	j = 0-3	**C[0-3]**	A[0][0-3]
	j = 4-7	**C[4-7]**	A[0][4-7]
i = 1,3,5	j = 0-3	B[3][0-3]	**A[1][0-3]**
	j = 4-7	B[3][4-7]	**A[1][4-7]**

i=3, j=6: *h h h h*

B[3][6]: hit:

i = 0,2,4	j = 0-3	**C[0-3]**	A[0][0-3]
	j = 4-7	**C[4-7]**	A[0][4-7]
i = 1,3,5	j = 0-3	B[3][0-3]	**A[1][0-3]**
	j = 4-7	B[3][4-7]	**A[1][4-7]**

A[0][6]: hit:

i = 0,2,4	j = 0-3	**C[0-3]**	A[0][0-3]
	j = 4-7	**C[4-7]**	A[0][4-7]
i = 1,3,5	j = 0-3	B[3][0-3]	**A[1][0-3]**
	j = 4-7	B[3][4-7]	**A[1][4-7]**

C[6]: hit:

i = 0,2,4	j = 0-3	**C[0-3]**	A[0][0-3]
	j = 4-7	C[4-7]	**A[0][4-7]**
i = 1,3,5	j = 0-3	B[3][0-3]	**A[1][0-3]**
	j = 4-7	B[3][4-7]	**A[1][4-7]**

A[0][6]: hit:

i = 0,2,4	j = 0-3	**C[0-3]**	A[0][0-3]
	j = 4-7	**C[4-7]**	A[0][4-7]
i = 1,3,5	j = 0-3	B[3][0-3]	**A[1][0-3]**
	j = 4-7	B[3][4-7]	**A[1][4-7]**

Άρα για i=3 έχουμε **10 hits** (και 6 misses).

i=4, j=0: *m h m h*   i=4, j=2: *h h h h*

B[0][0]: conflict miss:

i = 0,2,4	j = 0-3	B[0][0-3]	**A[0][0-3]**
	j = 4-7	**C[4-7]**	A[0][4-7]
i = 1,3,5	j = 0-3	B[3][0-3]	**A[1][0-3]**
	j = 4-7	B[3][4-7]	**A[1][4-7]**

A[1][0]: hit:

i = 0,2,4	j = 0-3	B[0][0-3]	**A[0][0-3]**
	j = 4-7	**C[4-7]**	A[0][4-7]
i = 1,3,5	j = 0-3	**B[3][0-3]**	A[1][0-3]
	j = 4-7	B[3][4-7]	**A[1][4-7]**

C[0]: conflict miss:

i = 0,2,4	j = 0-3	**B[0][0-3]**	C[0-3]
	j = 4-7	**C[4-7]**	A[0][4-7]
i = 1,3,5	j = 0-3	**B[3][0-3]**	A[1][0-3]
	j = 4-7	B[3][4-7]	**A[1][4-7]**

A[1][0]: hit:

i = 0,2,4	j = 0-3	**B[0][0-3]**	C[0-3]
	j = 4-7	**C[4-7]**	A[0][4-7]
i = 1,3,5	j = 0-3	**B[3][0-3]**	A[1][0-3]
	j = 4-7	B[3][4-7]	**A[1][4-7]**

B[0][2]: hit:

i = 0,2,4	j = 0-3	B[0][0-3]	**C[0-3]**
	j = 4-7	**C[4-7]**	A[0][4-7]
i = 1,3,5	j = 0-3	**B[3][0-3]**	A[1][0-3]
	j = 4-7	B[3][4-7]	**A[1][4-7]**

A[1][2]: hit:

i = 0,2,4	j = 0-3	B[0][0-3]	**C[0-3]**
	j = 4-7	**C[4-7]**	A[0][4-7]
i = 1,3,5	j = 0-3	**B[3][0-3]**	A[1][0-3]
	j = 4-7	B[3][4-7]	**A[1][4-7]**

C[2]: hit:

i = 0,2,4	j = 0-3	**B[0][0-3]**	C[0-3]
	j = 4-7	**C[4-7]**	A[0][4-7]
i = 1,3,5	j = 0-3	**B[3][0-3]**	A[1][0-3]
	j = 4-7	B[3][4-7]	**A[1][4-7]**

A[1][2]: hit:

i = 0,2,4	j = 0-3	**B[0][0-3]**	C[0-3]
	j = 4-7	**C[4-7]**	A[0][4-7]
i = 1,3,5	j = 0-3	**B[3][0-3]**	A[1][0-3]
	j = 4-7	B[3][4-7]	**A[1][4-7]**

i=4, j=4: *m h m h*   i=4, j=6: *h h h h*

B[0][4]: conflict miss:

i = 0,2,4	j = 0-3	**B[0][0-3]**	C[0-3]
	j = 4-7	B[0][4-7]	**A[0][4-7]**
i = 1,3,5	j = 0-3	**B[3][0-3]**	A[1][0-3]
	j = 4-7	B[3][4-7]	**A[1][4-7]**

A[1][4]: hit:

i = 0,2,4	j = 0-3	**B[0][0-3]**	C[0-3]
	j = 4-7	B[0][4-7]	**A[0][4-7]**
i = 1,3,5	j = 0-3	**B[3][0-3]**	A[1][0-3]
	j = 4-7	**B[3][4-7]**	A[1][4-7]

C[4]: conflict miss:

i = 0,2,4	j = 0-3	**B[0][0-3]**	C[0-3]
	j = 4-7	**B[0][4-7]**	C[4-7]
i = 1,3,5	j = 0-3	**B[3][0-3]**	A[1][0-3]
	j = 4-7	**B[3][4-7]**	A[1][4-7]

A[1][4]: hit:

i = 0,2,4	j = 0-3	**B[0][0-3]**	C[0-3]
	j = 4-7	**B[0][4-7]**	C[4-7]
i = 1,3,5	j = 0-3	**B[3][0-3]**	A[1][0-3]
	j = 4-7	**B[3][4-7]**	A[1][4-7]

B[0][6]: hit:

i = 0,2,4	j = 0-3	**B[0][0-3]**	C[0-3]
	j = 4-7	B[0][4-7]	**C[4-7]**
i = 1,3,5	j = 0-3	**B[3][0-3]**	A[1][0-3]
	j = 4-7	**B[3][4-7]**	A[1][4-7]

A[1][6]: hit:

i = 0,2,4	j = 0-3	**B[0][0-3]**	C[0-3]
	j = 4-7	B[0][4-7]	**C[4-7]**
i = 1,3,5	j = 0-3	**B[3][0-3]**	A[1][0-3]
	j = 4-7	**B[3][4-7]**	A[1][4-7]

C[6]: hit:

i = 0,2,4	j = 0-3	**B[0][0-3]**	C[0-3]
	j = 4-7	**B[0][4-7]**	C[4-7]
i = 1,3,5	j = 0-3	**B[3][0-3]**	A[1][0-3]
	j = 4-7	**B[3][4-7]**	A[1][4-7]

A[1][6]: hit:

i = 0,2,4	j = 0-3	**B[0][0-3]**	C[0-3]
	j = 4-7	**B[0][4-7]**	C[4-7]
i = 1,3,5	j = 0-3	**B[3][0-3]**	A[1][0-3]
	j = 4-7	**B[3][4-7]**	A[1][4-7]

Άρα για i=4 έχουμε **12 hits** (και 4 misses).

i=5, j=0: *m m h h*

B[1][0]: conflict miss:

i = 0,2,4	j = 0-3	**B[0][0-3]**	C[0-3]
	j = 4-7	**B[0][4-7]**	C[4-7]
i = 1,3,5	j = 0-3	B[1][0-3]	**A[1][0-3]**
	j = 4-7	**B[3][4-7]**	A[1][4-7]

A[2][0]: conflict miss:

i = 0,2,4	j = 0-3	A[2][0-3]	**C[0-3]**
	j = 4-7	**B[0][4-7]**	C[4-7]
i = 1,3,5	j = 0-3	B[1][0-3]	**A[1][0-3]**
	j = 4-7	**B[3][4-7]**	A[1][4-7]

C[0]: hit:

i = 0,2,4	j = 0-3	**A[2][0-3]**	C[0-3]
	j = 4-7	**B[0][4-7]**	C[4-7]
i = 1,3,5	j = 0-3	B[1][0-3]	**A[1][0-3]**
	j = 4-7	**B[3][4-7]**	A[1][4-7]

A[2][0]: hit:

i = 0,2,4	j = 0-3	A[2][0-3]	**C[0-3]**
	j = 4-7	**B[0][4-7]**	C[4-7]
i = 1,3,5	j = 0-3	B[1][0-3]	**A[1][0-3]**
	j = 4-7	**B[3][4-7]**	A[1][4-7]

i=5, j=2: *h h h h*

B[1][2]: hit:

i = 0,2,4	j = 0-3	A[2][0-3]	**C[0-3]**
	j = 4-7	**B[0][4-7]**	C[4-7]
i = 1,3,5	j = 0-3	B[1][0-3]	**A[1][0-3]**
	j = 4-7	**B[3][4-7]**	A[1][4-7]

A[2][2]: hit:

i = 0,2,4	j = 0-3	A[2][0-3]	**C[0-3]**
	j = 4-7	**B[0][4-7]**	C[4-7]
i = 1,3,5	j = 0-3	B[1][0-3]	**A[1][0-3]**
	j = 4-7	**B[3][4-7]**	A[1][4-7]

C[2]: hit:

i = 0,2,4	j = 0-3	**A[2][0-3]**	C[0-3]
	j = 4-7	**B[0][4-7]**	C[4-7]
i = 1,3,5	j = 0-3	B[1][0-3]	**A[1][0-3]**
	j = 4-7	**B[3][4-7]**	A[1][4-7]

A[2][2]: hit:

i = 0,2,4	j = 0-3	A[2][0-3]	**C[0-3]**
	j = 4-7	**B[0][4-7]**	C[4-7]
i = 1,3,5	j = 0-3	B[1][0-3]	**A[1][0-3]**
	j = 4-7	**B[3][4-7]**	A[1][4-7]

i=5, j=4: *m m h h*

B[1][4]: conflict miss:

i = 0,2,4	j = 0-3	A[2][0-3]	**C[0-3]**
	j = 4-7	**B[0][4-7]**	C[4-7]
i = 1,3,5	j = 0-3	B[1][0-3]	**A[1][0-3]**
	j = 4-7	B[1][4-7]	**A[1][4-7]**

A[2][4]: conflict miss:

i = 0,2,4	j = 0-3	A[2][0-3]	**C[0-3]**
	j = 4-7	A[2][4-7]	**C[4-7]**
i = 1,3,5	j = 0-3	B[1][0-3]	**A[1][0-3]**
	j = 4-7	B[1][4-7]	**A[1][4-7]**

C[4]: hit:

i = 0,2,4	j = 0-3	A[2][0-3]	**C[0-3]**
	j = 4-7	**A[2][4-7]**	C[4-7]
i = 1,3,5	j = 0-3	B[1][0-3]	**A[1][0-3]**
	j = 4-7	B[1][4-7]	**A[1][4-7]**

A[2][4]: hit:

i = 0,2,4	j = 0-3	A[2][0-3]	**C[0-3]**
	j = 4-7	A[2][4-7]	**C[4-7]**
i = 1,3,5	j = 0-3	B[1][0-3]	**A[1][0-3]**
	j = 4-7	B[1][4-7]	**A[1][4-7]**

i=5, j=6: *h h h h*

B[1][6]: hit:

i = 0,2,4	j = 0-3	A[2][0-3]	**C[0-3]**
	j = 4-7	A[2][4-7]	**C[4-7]**
i = 1,3,5	j = 0-3	B[1][0-3]	**A[1][0-3]**
	j = 4-7	B[1][4-7]	**A[1][4-7]**

A[2][6]: hit:

i = 0,2,4	j = 0-3	A[2][0-3]	**C[0-3]**
	j = 4-7	A[2][4-7]	**C[4-7]**
i = 1,3,5	j = 0-3	B[1][0-3]	**A[1][0-3]**
	j = 4-7	B[1][4-7]	**A[1][4-7]**

C[6]: hit:

i = 0,2,4	j = 0-3	A[2][0-3]	**C[0-3]**
	j = 4-7	**A[2][4-7]**	C[4-7]
i = 1,3,5	j = 0-3	B[1][0-3]	**A[1][0-3]**
	j = 4-7	B[1][4-7]	**A[1][4-7]**

A[2][6]: hit:

i = 0,2,4	j = 0-3	A[2][0-3]	**C[0-3]**
	j = 4-7	A[2][4-7]	**C[4-7]**
i = 1,3,5	j = 0-3	B[1][0-3]	**A[1][0-3]**
	j = 4-7	B[1][4-7]	**A[1][4-7]**

Άρα για i=5 έχουμε **12 hits** (και 4 misses).

Συνολικά, λοιπόν:

i=0

B[0][0] A[0][0] C[0] A[0][0]: m m m h

B[0][2] A[0][2] C[2] A[0][2]: m h m h

B[0][4] A[0][4] C[4] A[0][4]: m m m h

B[0][6] A[0][6] C[6] A[0][6]: m h m h

i=1

B[1][0] A[1][0] C[0] A[1][0]: m m h h

B[1][2] A[1][2] C[2] A[1][2]: h h h h

B[1][4] A[1][4] C[4] A[1][4]: m m h h

B[1][6] A[1][6] C[6] A[1][6]: h h h h

i=2

B[2][0] A[2][0] C[0] A[2][0]: m m m h

B[2][2] A[2][2] C[2] A[2][2]: m h m h

B[2][4] A[2][4] C[4] A[2][4]: m m m h

B[2][6] A[2][6] C[6] A[2][6]: m h m h

i=3

B[3][0] A[0][0] C[0] A[0][0]: m m m h

B[3][2] A[0][2] C[2] A[0][2]: h h h h

B[3][4] A[0][4] C[4] A[0][4]: m m m h

B[3][6] A[0][6] C[6] A[0][6]: h h h h

i=4

B[0][0] A[1][0] C[0] A[1][0]: m h m h

B[0][2] A[1][2] C[2] A[1][2]: h h h h

B[0][4] A[1][4] C[4] A[1][4]: m h m h

B[0][6] A[1][6] C[6] A[1][6]: h h h h

i=5

B[1][0] A[2][0] C[0] A[2][0]: m m h h

B[1][2] A[2][2] C[2] A[2][2]: h h h h

B[1][4] A[2][4] C[4] A[2][4]: m m h h

B[1][6] A[2][6] C[6] A[2][6]: h h h h

Άρα συνολικά, έχουμε **58 hits**, **38 misses**.

- *Ερώτημα (β)*

Η **cache έχει** 256/32/4 = **2 sets**, ενώ **κάθε block χωρά** 32/8 = **4 στοιχεία** ενός πίνακα. Επομένως, στην ανάλυση μας, θα έχουμε έναν πίνακα 2x4, όπου κάθε κελί θα χωρά 4 στοιχεία ενός πίνακα. Θα τονίζουμε με **bold** το block που δείχνει η LRU.

i=0, j=0: *m m m h*

B[0][0]: compulsory miss:

j=0-3	B[0][0-3]			
j=4-7				

A[0][0]: compulsory miss:

j=0-3	**B[0][0-3]**	A[0][0-3]	-	
j=4-7				

C[0]: compulsory miss:

j=0-3	**B[0][0-3]**	A[0][0-3]	C[0-3]	
j=4-7				

A[0][0]: hit

j=0-3	**B[0][0-3]**	A[0][0-3]	C[0-3]	
j=4-7				

i=0, j=4: *m m m h*

B[0][4]: compulsory miss:

j=0-3	**B[0][0-3]**	A[0][0-3]	C[0-3]	
j=4-7	B[0][4-7]			

A[0][4]: compulsory miss:

j=0-3	**B[0][0-3]**	A[0][0-3]	C[0-3]	
j=4-7	**B[0][4-7]**	A[0][4-7]		

C[4]: compulsory miss:

j=0-3	**B[0][0-3]**	A[0][0-3]	C[0-3]	
j=4-7	**B[0][4-7]**	A[0][4-7]	C[4-7]	

A[0][4]: hit:

j=0-3	**B[0][0-3]**	A[0][0-3]	C[0-3]	
j=4-7	**B[0][4-7]**	A[0][4-7]	C[4-7]	

i=0, j=2: *h h h h*

B[0][2]: hit:

j=0-3	B[0][0-3]	A[0][0-3]	**C[0-3]**	
j=4-7				

A[0][2]: hit:

j=0-3	B[0][0-3]	A[0][0-3]	**C[0-3]**	
j=4-7				

C[0]: hit:

j=0-3	**B[0][0-3]**	A[0][0-3]	C[0-3]	
j=4-7				

A[0][2]: hit:

j=0-3	**B[0][0-3]**	A[0][0-3]	C[0-3]	
j=4-7				

i=0, j=6: *h h h h*

B[0][6]: hit:

j=0-3	**B[0][0-3]**	A[0][0-3]	C[0-3]	
j=4-7	B[0][4-7]	A[0][4-7]	**C[4-7]**	

A[0][6]: hit:

j=0-3	**B[0][0-3]**	A[0][0-3]	C[0-3]	
j=4-7	B[0][4-7]	A[0][4-7]	**C[4-7]**	

C[6]: hit:

j=0-3	**B[0][0-3]**	A[0][0-3]	C[0-3]	
j=4-7	**B[0][4-7]**	A[0][4-7]	C[4-7]	

A[0][6]: hit:

j=0-3	**B[0][0-3]**	A[0][0-3]	C[0-3]	
j=4-7	**B[0][4-7]**	A[0][4-7]	C[4-7]	

Άρα για i=0 έχουμε **10 hits** (και 6 misses).

i=1, j=0: *m m h h*

B[1][0]: compulsory miss:

j=0-3	**B[0][0-3]**	A[0][0-3]	C[0-3]	B[1][0-3]
j=4-7	**B[0][4-7]**	A[0][4-7]	C[4-7]	

A[1][0]: compulsory miss:

j=0-3	A[1][0-3]	A[0][0-3]	**C[0-3]**	B[1][0-3]
j=4-7	**B[0][4-7]**	A[0][4-7]	C[4-7]	

C[0]: hit:

j=0-3	A[1][0-3]	A[0][0-3]	C[0-3]	**B[1][0-3]**
j=4-7	**B[0][4-7]**	A[0][4-7]	C[4-7]	

A[1][0]: hit:

j=0-3	A[1][0-3]	A[0][0-3]	C[0-3]	**B[1][0-3]**
j=4-7	**B[0][4-7]**	A[0][4-7]	C[4-7]	

i=1, j=4: *m m h h*

B[1][4]: compulsory miss:

j=0-3	A[1][0-3]	**A[0][0-3]**	C[0-3]	B[1][0-3]
j=4-7	**B[0][4-7]**	A[0][4-7]	C[4-7]	B[1][4-7]

A[1][4]: compulsory miss:

j=0-3	A[1][0-3]	**A[0][0-3]**	C[0-3]	B[1][0-3]
j=4-7	A[1][4-7]	A[0][4-7]	**C[4-7]**	B[1][4-7]

C[4]: hit:

j=0-3	A[1][0-3]	**A[0][0-3]**	C[0-3]	B[1][0-3]
j=4-7	A[1][4-7]	A[0][4-7]	C[4-7]	**B[1][4-7]**

A[1][4]: hit:

j=0-3	A[1][0-3]	**A[0][0-3]**	C[0-3]	B[1][0-3]
j=4-7	A[1][4-7]	**A[0][4-7]**	C[4-7]	B[1][4-7]

i=1, j=2: *h h h h*

B[1][2]: hit:

j=0-3	A[1][0-3]	**A[0][0-3]**	C[0-3]	B[1][0-3]
j=4-7	**B[0][4-7]**	A[0][4-7]	C[4-7]	

A[1][2]: hit:

j=0-3	A[1][0-3]	**A[0][0-3]**	C[0-3]	B[1][0-3]
j=4-7	**B[0][4-7]**	A[0][4-7]	C[4-7]	

C[2]: hit:

j=0-3	A[1][0-3]	**A[0][0-3]**	C[0-3]	B[1][0-3]
j=4-7	**B[0][4-7]**	A[0][4-7]	C[4-7]	

A[1][2]: hit:

j=0-3	A[1][0-3]	**A[0][0-3]**	C[0-3]	B[1][0-3]
j=4-7	**B[0][4-7]**	A[0][4-7]	C[4-7]	

i=1, j=6: *h h h h*

B[1][6]: hit:

j=0-3	A[1][0-3]	**A[0][0-3]**	C[0-3]	B[1][0-3]
j=4-7	A[1][4-7]	**A[0][4-7]**	C[4-7]	B[1][4-7]

A[1][6]: hit:

j=0-3	A[1][0-3]	**A[0][0-3]**	C[0-3]	B[1][0-3]
j=4-7	A[1][4-7]	**A[0][4-7]**	C[4-7]	B[1][4-7]

C[6]: hit:

j=0-3	A[1][0-3]	**A[0][0-3]**	C[0-3]	B[1][0-3]
j=4-7	A[1][4-7]	**A[0][4-7]**	C[4-7]	B[1][4-7]

A[1][6]: hit:

j=0-3	A[1][0-3]	**A[0][0-3]**	C[0-3]	B[1][0-3]
j=4-7	A[1][4-7]	**A[0][4-7]**	C[4-7]	B[1][4-7]

Άρα για i=1 έχουμε **12 hits** (και 4 misses).

i=2, j=0: *m m h h*

B[2][0]: miss:

j=0-3	A[1][0-3]	B[2][0-3]	C[0-3]	**B[1][0-3]**
j=4-7	A[1][4-7]	**A[0][4-7]**	C[4-7]	B[1][4-7]

A[2][0]: miss:

j=0-3	A[1][0-3]	B[2][0-3]	**C[0-3]**	A[2][0-3]
j=4-7	A[1][4-7]	**A[0][4-7]**	C[4-7]	B[1][4-7]

C[0]: hit:

j=0-3	**A[1][0-3]**	B[2][0-3]	C[0-3]	A[2][0-3]
j=4-7	A[1][4-7]	**A[0][4-7]**	C[4-7]	B[1][4-7]

A[2][0]: hit:

j=0-3	**A[1][0-3]**	B[2][0-3]	C[0-3]	A[2][0-3]
j=4-7	A[1][4-7]	**A[0][4-7]**	C[4-7]	B[1][4-7]

i=2, j=4: *m m h h*

B[2][4]: miss:

j=0-3	A[1][0-3]	B[2][0-3]	C[0-3]	A[2][0-3]
j=4-7	A[1][4-7]	B[2][4-7]	C[4-7]	**B[1][4-7]**

A[2][4]: miss:

j=0-3	**A[1][0-3]**	B[2][0-3]	C[0-3]	A[2][0-3]
j=4-7	A[1][4-7]	B[2][4-7]	**C[4-7]**	A[2][4-7]

C[4]: hit:

j=0-3	A[1][0-3]	B[2][0-3]	C[0-3]	A[2][0-3]
j=4-7	**A[1][4-7]**	B[2][4-7]	C[4-7]	A[2][4-7]

A[2][4]: hit:

j=0-3	**A[1][0-3]**	B[2][0-3]	C[0-3]	A[2][0-3]
j=4-7	**A[1][4-7]**	B[2][4-7]	C[4-7]	A[2][4-7]

i=2, j=2: *h h h h*

B[2][2]: hit:

j=0-3	**A[1][0-3]**	B[2][0-3]	C[0-3]	A[2][0-3]
j=4-7	A[1][4-7]	**A[0][4-7]**	C[4-7]	B[1][4-7]

A[2][2]: hit:

j=0-3	**A[1][0-3]**	B[2][0-3]	C[0-3]	A[2][0-3]
j=4-7	A[1][4-7]	**A[0][4-7]**	C[4-7]	B[1][4-7]

C[2]: hit:

j=0-3	**A[1][0-3]**	B[2][0-3]	C[0-3]	A[2][0-3]
j=4-7	A[1][4-7]	**A[0][4-7]**	C[4-7]	B[1][4-7]

A[2][2]: hit:

j=0-3	**A[1][0-3]**	B[2][0-3]	C[0-3]	A[2][0-3]
j=4-7	A[1][4-7]	**A[0][4-7]**	C[4-7]	B[1][4-7]

i=2, j=6: *h h h h*

B[2][6]: hit:

j=0-3	**A[1][0-3]**	B[2][0-3]	C[0-3]	A[2][0-3]
j=4-7	**A[1][4-7]**	B[2][4-7]	C[4-7]	A[2][4-7]

A[2][6]: hit:

j=0-3	**A[1][0-3]**	B[2][0-3]	C[0-3]	A[2][0-3]
j=4-7	**A[1][4-7]**	B[2][4-7]	C[4-7]	A[2][4-7]

C[6]: hit:

j=0-3	**A[1][0-3]**	B[2][0-3]	C[0-3]	A[2][0-3]
j=4-7	**A[1][4-7]**	B[2][4-7]	C[4-7]	A[2][4-7]

A[2][6]: hit:

j=0-3	**A[1][0-3]**	B[2][0-3]	C[0-3]	A[2][0-3]
j=4-7	**A[1][4-7]**	B[2][4-7]	C[4-7]	A[2][4-7]

Άρα για i=2 έχουμε **12 hits** (και 4 misses).

Για τα υπόλοιπα i προκύπτει παρόμοιο μοτίβο (**12 hits** και 4 misses).

Άρα, **συνολικά** έχουμε **70 hits** και **26 misses**.

Είναι προφανές πως η **2 η περίπτωση είναι προτιμότερη**.