

Preparation for Midterm

Iakovos Mavroidis

Problem:

Find average stall cycles per branch for a BTB. Make the following assumptions :

- Prediction accuracy of BTB = 90%
- Buffer Hit rate = 80%
- Taken branches = 50%

Instruction in buffer	Prediction	Actual branch	Penalty cycles
yes	taken	taken	0
yes	taken	not taken	2
no		taken	2
no		not taken	0

Problem:

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no		taken	2
no		not taken	0

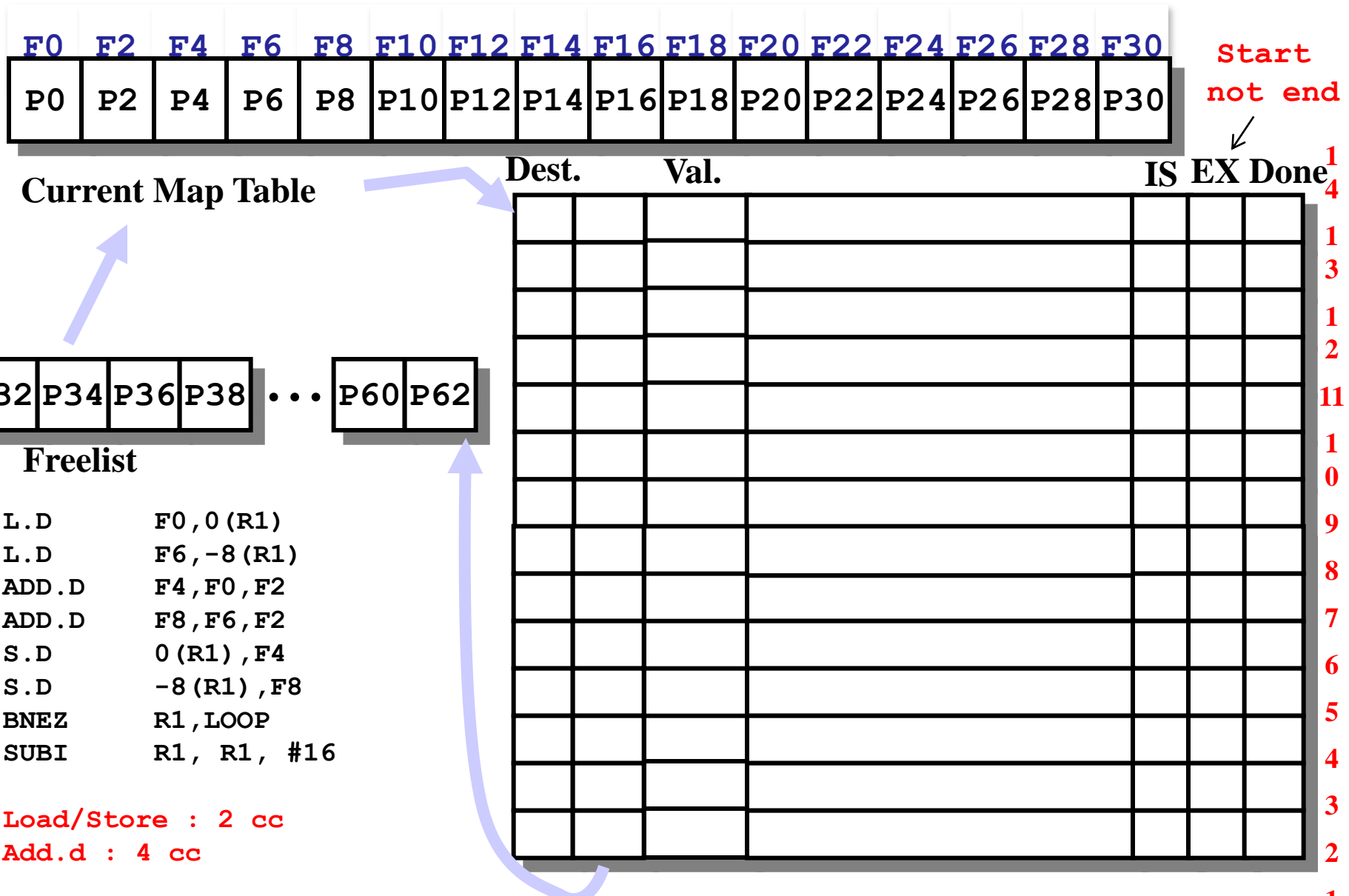
Solution:

Probability (branch in buffer, but actually not taken) = Percent buffer hit rate \times Percent incorrect predictions = $80\% \times 10\% = \mathbf{0.08}$

Probability (branch not in buffer, but actually taken) = Percent buffer miss rate \times Percent taken branches = $20\% \times 50\% = \mathbf{0.10}$

Branch penalty = $(0.08 + 0.10) \times 2 = \mathbf{0.36}$

2-way Superscalar with explicit RR and Branch Prediction



2-way Superscalar with explicit RR and Branch Prediction (cycle 1)

F0	F2	F4	F6	F8	F10	F12	F14	F16	F18	F20	F22	F24	F26	F28	F30
P32	P2	P4	P6	P8	P10	P12	P14	P16	P18	P20	P22	P24	P26	P28	P30

Current Map Table

Dest. Val. IS EX Done

							1
							4
							1
							3
							1
							2
							11
							1
							0
							9
							8
							7
							6
							5
							4
							3
F0	P0		L.D	P32, 0 (R1)		1	2

P34	P36	P38	P40	...	P60	P62
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Freelist

```
L.D    F0, 0 (R1)
L.D    F6, -8 (R1)
ADD.D  F4, F0, F2
ADD.D  F8, F6, F2
S.D    0 (R1), F4
S.D    -8 (R1), F8
BNEZ   R1, LOOP
SUBI   R1, R1, #16
```

Load/Store : 2 cc

Add.d : 4 cc

2-way Superscalar with explicit RR and Branch Prediction (cycle 2)

F0	F2	F4	F6	F8	F10	F12	F14	F16	F18	F20	F22	F24	F26	F28	F30
P32	P2	P36	P34	P8	P10	P12	P14	P16	P18	P20	P22	P24	P26	P28	P30

Current Map Table

Dest. Val. IS EX Done

Dest.	Val.	IS	EX	Done						
					1					
					4					
					1					
					3					
					1					
					2					
					11					
					1					
					0					
					9					
					8					
					7					
					6					
					5					
F4	P4		ADD.D	P36, P32, P2	2					4
F6	P6		L.D	P34, -8 (R1)	2					3
F0	P0		L.D	P32, 0 (R1)	1	2				2

1
4
1
3
1
2
11
1
0
9
8
7
6
5
4
3
2
1

P38	P40	P42	P44	...	P60	P62
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Freelist

```

L.D      F0, 0 (R1)
L.D      F6, -8 (R1)
ADD.D    F4, F0, F2
ADD.D    F8, F6, F2
S.D      0 (R1), F4
S.D      -8 (R1), F8
BNEZ     R1, LOOP
SUBI     R1, R1, #16
    
```

Load/Store : 2 cc

Add.d : 4 cc

2-way Superscalar with explicit RR and Branch Prediction (cycle 3)

F0	F2	F4	F6	F8	F10	F12	F14	F16	F18	F20	F22	F24	F26	F28	F30
P32	P2	P36	P34	P38	P10	P12	P14	P16	P18	P20	P22	P24	P26	P28	P30

Current Map Table

Dest.		Val.	IS	EX	Done	
						4
						1
						3
						1
						2
						11
						1
						0
						9
						8
						7
-	-		S.D	0 (R1) , P36	3	6
F8	P8		ADD.D	P38 , P34 , P2	3	5
F4	P4		ADD.D	P36 , P32 , P2	2	4
F6	P6		L.D	P34 , -8 (R1)	2	3
F0	P0		L.D	P32 , 0 (R1)	1	2
						1

1
4
1
3
1
2
11
1
0
9
8
7
6
5
4
3
2
1



Freelist

```

L.D      F0,0 (R1)
L.D      F6,-8 (R1)
ADD.D    F4,F0,F2
ADD.D    F8,F6,F2
S.D      0 (R1),F4
S.D      -8 (R1),F8
BNEZ     R1,LOOP
SUBI     R1,R1,#16
  
```

Load/Store : 2 cc
Add.d : 4 cc

2-way Superscalar with explicit RR and Branch Prediction (cycle 4)

F0	F2	F4	F6	F8	F10	F12	F14	F16	F18	F20	F22	F24	F26	F28	F30
P32	P2	P36	P34	P38	P10	P12	P14	P16	P18	P20	P22	P24	P26	P28	P30

Current Map Table

	Dest.	Val.	IS	EX	Done	
						1
						4
						1
						3
						1
						2
						11
						1
						0
						9
						8
-	-	S.D -8 (R1) , P38	4			7
-	-	S.D 0 (R1) , P36	3			6
F8	P8	ADD.D P38 , P34 , P2	3			5
F4	P4	ADD.D P36 , P32 , P2	2	4		4
F6	P6	L.D P34 , -8 (R1)	2	4		3
F0	P0	M[R1] L.D P32 , 0 (R1)	1	2	4	2
						1

P40	P42	P44	P46	...	P60	P62
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Freelist

```
L.D      F0,0 (R1)
L.D      F6,-8 (R1)
ADD.D    F4,F0,F2
ADD.D    F8,F6,F2
S.D      0(R1),F4
S.D      -8(R1),F8
BNEZ    R1,LOOP
SUBI     R1,R1,#16
```

Load/Store : 2 cc

Add.d : 4 cc

2-way Superscalar with explicit RR and Branch Prediction (cycle 6)

F0	F2	F4	F6	F8	F10	F12	F14	F16	F18	F20	F22	F24	F26	F28	F30
P32	P2	P36	P34	P38	P10	P12	P14	P16	P18	P20	P22	P24	P26	P28	P30

Current Map Table

Dest. Val. IS EX Done

				SUBI R1, R1, #16	6	
				BNEZ R1, LOOP	5	6
				S.D -8 (R1), P38	4	
				S.D 0 (R1), P36	3	
F8	P8			ADD.D P38, P34, P2	3	6
F4	P4			ADD.D P36, P32, P2	2	4
F6	P6	M[R1-8]		L.D P34, -8 (R1)	2	4 6
F0	P0	M[R1]		L.D P32, 0 (R1)	1	2 4

1
4
1
3
1
2
11
1
0
9
8
7
6
5
4
3
2
1

P40	P42	P44	P46	...	P62	P0
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Freelist

L.D F0,0 (R1)
 L.D F6,-8 (R1)
 ADD.D F4,F0,F2
 ADD.D F8,F6,F2
 S.D 0 (R1) ,F4
 S.D -8 (R1) ,F8
 BNEZ R1,LOOP
 SUBI R1, R1, #16

Load/Store : 2 cc
 Add.d : 4 cc

2-way Superscalar with explicit RR and Branch Prediction (cycle 7)

F0	F2	F4	F6	F8	F10	F12	F14	F16	F18	F20	F22	F24	F26	F28	F30
P40	P2	P36	P34	P38	P10	P12	P14	P16	P18	P20	P22	P24	P26	P28	P30

Current Map Table

Dest. Val. IS EX Done

	Dest.	Val.	IS	EX	Done
F0	P32	L.D P40,0(R1)	7		
		SUBI R1, R1, #16	6	7	
		BNEZ R1, LOOP	5	6	7
-	-	S.D -8(R1), P38	4		
-	-	S.D 0(R1), P36	3		
F8	P8	ADD.D P38, P34, P2	3	6	
F4	P4	ADD.D P36, P32, P2	2	4	
F6	P6	L.D P34, -8(R1)	2	4	6
F0	P0	L.D P32, 0(R1)	1	2	4

1
4
1
3
1
2
11
1
0
9
8
7
6
5
4
3
2
1

P42	P44	P46	P48	...	P0	P6
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Freelist

- L.D F0, 0(R1)
- L.D F6, -8(R1)
- ADD.D F4, F0, F2
- ADD.D F8, F6, F2
- S.D 0(R1), F4
- S.D -8(R1), F8
- BNEZ R1, LOOP
- SUBI R1, R1, #16

Load/Store : 2 cc

Add.d : 4 cc

2-way Superscalar with explicit RR and Branch Prediction (cycle 8)

F0	F2	F4	F6	F8	F10	F12	F14	F16	F18	F20	F22	F24	F26	F28	F30
P40	P2	P44	P42	P38	P10	P12	P14	P16	P18	P20	P22	P24	P26	P28	P30

Current Map Table

Dest.	Val.	IS	EX	Done
F4	P36			
F6	P34			
F0	P32			
F4	P4	V1		
F6	P6	M[R1-8]		
F0	P0	M[R1]		

1
4
1
3
1
2
11
1
0
9
8
7
6
5
4
3
2
1



Freelist

```

L.D   F0,0(R1)
L.D   F6,-8(R1)
ADD.D F4,F0,F2
ADD.D F8,F6,F2
S.D   0(R1),F4
S.D   -8(R1),F8
BNEZ  R1,LOOP
SUBI  R1,R1,#16
    
```

Load/Store : 2 cc

Add.d : 4 cc

2-way Superscalar with explicit RR and Branch Prediction (cycle 9)

F0	F2	F4	F6	F8	F10	F12	F14	F16	F18	F20	F22	F24	F26	F28	F30
P40	P2	P44	P42	P46	P10	P12	P14	P16	P18	P20	P22	P24	P26	P28	P30

Current Map Table

Dest. Val. IS EX Done

Dest.	Val.	IS	EX	Done		
-	-					
-	-	S.D	0 (R1) , P44	9		
F8	P38	ADD.D	P46 , P42 , P2	9		
F4	P36	ADD.D	P44 , P40 , P2	8		
F6	P34	L.D	P42 , -8 (R1)	8		
F0	P32	L.D	P40 , 0 (R1)	7	8	
		SUBI	R1 , R1 , #16	6	7	8
		BNEZ	R1 , LOOP	5	6	7
-	-	S.D	-8 (R1) , P38	4		
-	-	S.D	0 (R1) , P36	3	8	
F8	P8	ADD.D	P38 , P34 , P2	3	6	
F4	P4	V1	ADD.D P36 , P32 , P2	2	4	8
F6	P6	M[R1-8]	L.D P34 , -8 (R1)	2	4	6
F0	P0	M[R1]	L.D P32 , 0 (R1)	1	2	4

1
4
1
3
1
2
11
1
0
9
8
7
6
5
4
3
2
1

P48	P50	P52	P54	...	P6	P4
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Freelist

```

L.D    F0,0 (R1)
L.D    F6,-8 (R1)
ADD.D  F4,F0,F2
ADD.D  F8,F6,F2
S.D    0 (R1) ,F4
S.D    -8 (R1) ,F8
BNEZ   R1,LOOP
SUBI   R1, R1, #16
    
```

Load/Store : 2 cc
Add.d : 4 cc

2-way Superscalar with explicit RR and Branch Prediction (cycle 10)

F0	F2	F4	F6	F8	F10	F12	F14	F16	F18	F20	F22	F24	F26	F28	F30
P40	P2	P44	P42	P46	P10	P12	P14	P16	P18	P20	P22	P24	P26	P28	P30

Current Map Table

Dest.	Val.	IS	EX	Done	
-	-	S.D -8 (R1) , P46	10		
-	-	S.D 0 (R1) , P44	9		
F8 P38		ADD.D P46 , P42 , P2	9		
F4 P36		ADD.D P44 , P40 , P2	8	10	
F6 P34		L.D P42 , -8 (R1)	8	10	
F0 P32	M[R1-12]	L.D P40 , 0 (R1)	7	8	10
		SUBI R1 , R1 , #16	6	7	8
		BNEZ R1 , LOOP	5	6	7
-	-	S.D -8 (R1) , P38	4	10	
-	-	S.D 0 (R1) , P36	3	8	
F8 P8	V2	ADD.D P38 , P34 , P2	3	6	10
F4 P4	V1	ADD.D P36 , P32 , P2	2	4	8
F6 P6	M[R1-8]	L.D P34 , -8 (R1)	2	4	6
F0 P0	M[R1]	L.D P32 , 0 (R1)	1	2	4

1
4
1
3
1
2
11
1
0
9
8
7
6
5
4
3
2
1

P48	P50	P52	P54	...	P6	P4
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Freelist

L.D F0,0 (R1)
 L.D F6,-8 (R1)
 ADD.D F4,F0,F2
 ADD.D F8,F6,F2
 S.D 0 (R1) ,F4
 S.D -8 (R1) ,F8
 BNEZ R1,LOOP
 SUBI R1, R1, #16

Load/Store : 2 cc
 Add.d : 4 cc