COSC 6385
Computer Architecture
- Correlated Branch Predictors

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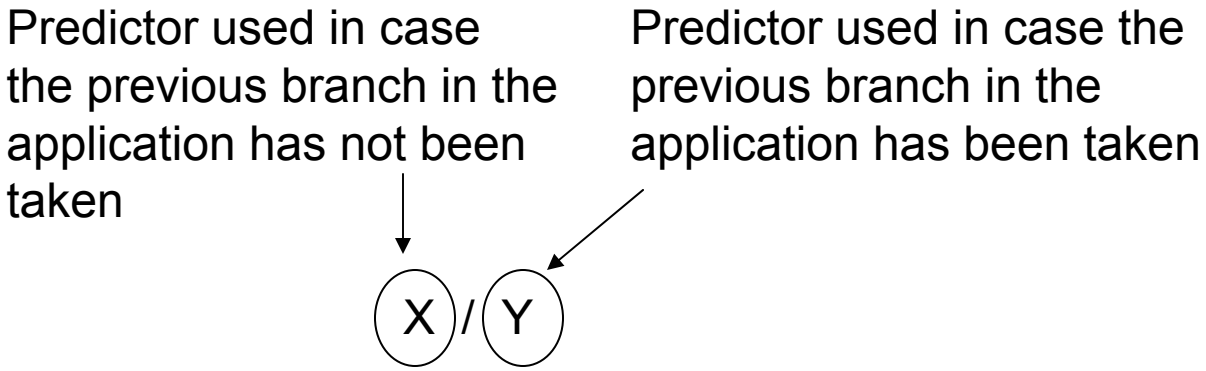
Correlated branches

- For a (1,1) predictor: each branch has two different branch prediction buffers:

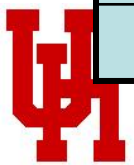


- The content of the two branch prediction buffers are determined by the branch to which they belong
- Which of the two branch prediction buffers are used is depending on the outcome of the previous branch in the application

Correlated branches - example

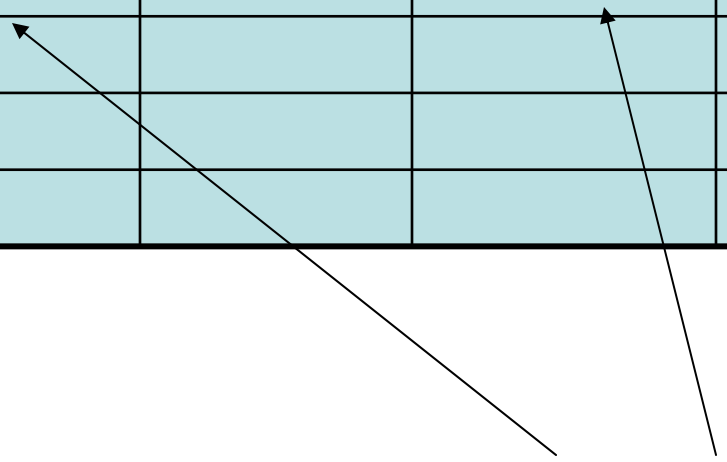
```
if ( d==0 )              BNEZ  R1, L1          !branch b1
  d = 1;                 DADDIU R1, R0, #1
if ( d==1 )        L1:   DADDIU R3, R1, #-1
  …                      BNEZ R3, L2           !branch b2

                          …
                   L2:
```

Initial value of d	d==0?	b1	Value of d before b2	d==1?	b2
2	No	Taken	2	No	Taken
0	Yes	Not taken	1	Yes	Not taken
2	No	Taken	2	No	Taken
0	Yes	Not taken	1	Yes	Not taken



Correlated branches - example

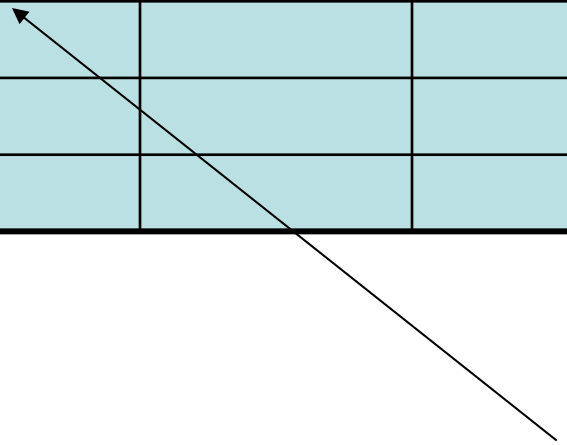
d=?	BPB b1	b1 act.	BPB b2	B2 act.
2	NT/NT		NT/NT	



- the branch prediction buffers for the branches b1 and b2 are assumed to hold the prediction ‘Not taken’ for both option (previous branch not taken/taken)

Correlated branches - example

d=?	BPB b1	b1 act.	BPB b2	B2 act.
2	**NT**/NT		NT/NT	



• assuming BPB for b1 uses the 'Not Taken' predictor because the previous branch in the application has not been taken
→ BPB for b1 predicts that b1 will not be taken

Correlated branches - example

d=?	BPB b1	b1 act.	BPB b2	B2 act.
2	**NT**/NT	T	NT/NT	

→ BPB for b1 predicts that b1 will not be taken
→ b1 is taken (see table for d=2)

Initial value of d	d==0?	b1	Value of d before b2	d==1?	b2
2	No	**Taken**	2	No	Taken
0	Yes	Not taken	1	Yes	Not taken

Correlated branches - example

d=?	BPB b1	b1 act.	BPB b2	B2 act.
2	**NT**/NT	T	NT/**NT**	
	T/NT			

→ updating the 'Previous branch has not been taken' part of BPB for b1 to Taken
→ because b1 has been taken, the 'last branch has been taken' part of BPB b2 will be used
→ BPB b2 predicts, that b2 will not be taken

Correlated branches - example

d=?	BPB b1	b1 act.	BPB b2	B2 act.
2	**NT**/NT	T	NT/**NT**	T
	T/**NT**		NT/T	

→ b2 is taken (see table for d=2)
→ updating the 'Previous branch has been taken' part of BPB for b2 to Taken
→ because b2 has been taken, the 'last branch has been taken' part of BPB b1 will be used
→ BPB b1 predicts, that b1 will not be taken

Initial value of d	d==0?	b1	Value of d before b2	d==1?	b2
2	No	Taken	2	No	**Taken**
0	Yes	Not taken	1	Yes	Not taken

Correlated branches - example

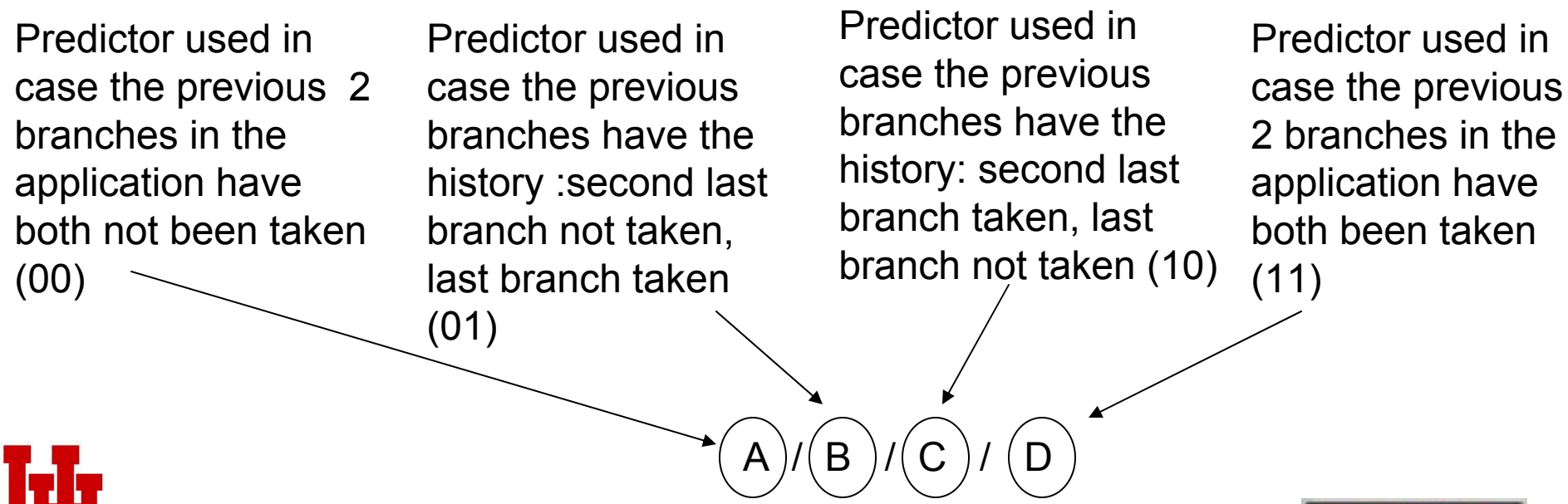
d=?	BPB b1	b1 act.	BPB b2	B2 act.
2	**NT**/NT	T	NT/**NT**	T
0	T/**NT**	NT	**NT**/T	

→ b1 is not taken (see table for d=0) → matches prediction!
→ update of BPB b1 does not modify any entry taken
→ because b1 has not been taken, the 'last branch has not been taken' part of BPB b2 will be used
→ BPB b2 predicts that b2 will not be taken

Initial value of d	d==0?	b1	Value of d before b2	d==1?	b2
2	No	Taken	2	No	Taken
0	Yes	**Not taken**	1	Yes	Not taken

Correlated branches

- A (2,1) correlated branch predictor
  - Uses the behavior of the last 2 branches to choose from 2^2 different predictions
  - Uses a 1 bit predictor for each of the 4 prediction buffers



Correlated branches

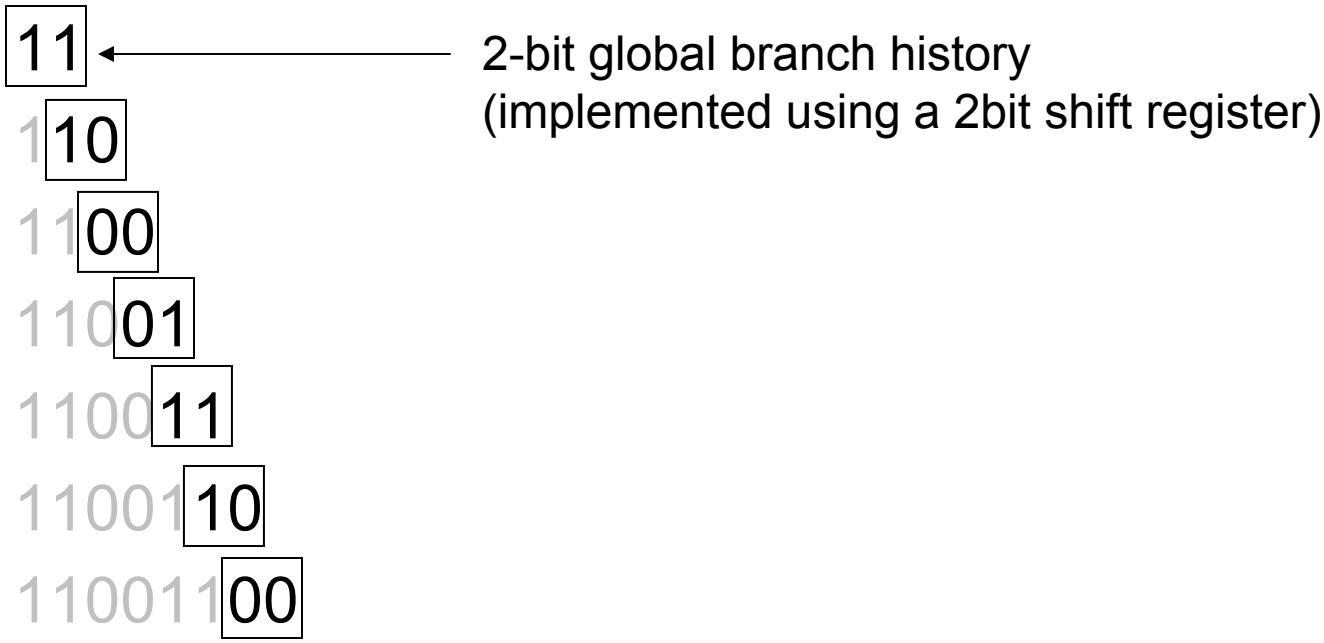
- How do we know which of the four sections of our branch predictor to use
  - Need to record the behavior of all branches in the application

Initial value of d	d==0?	b1	Value of d before b2	d==1?	b2
2	No	Taken	2	No	Taken
0	Yes	Not taken	1	Yes	Not taken
2	No	Taken	2	No	Taken
0	Yes	Not taken	1	Yes	Not taken

- e.g. 110011001100 11

Correlated branches

- For a (2,n) branch predictor, the last two branches are relevant



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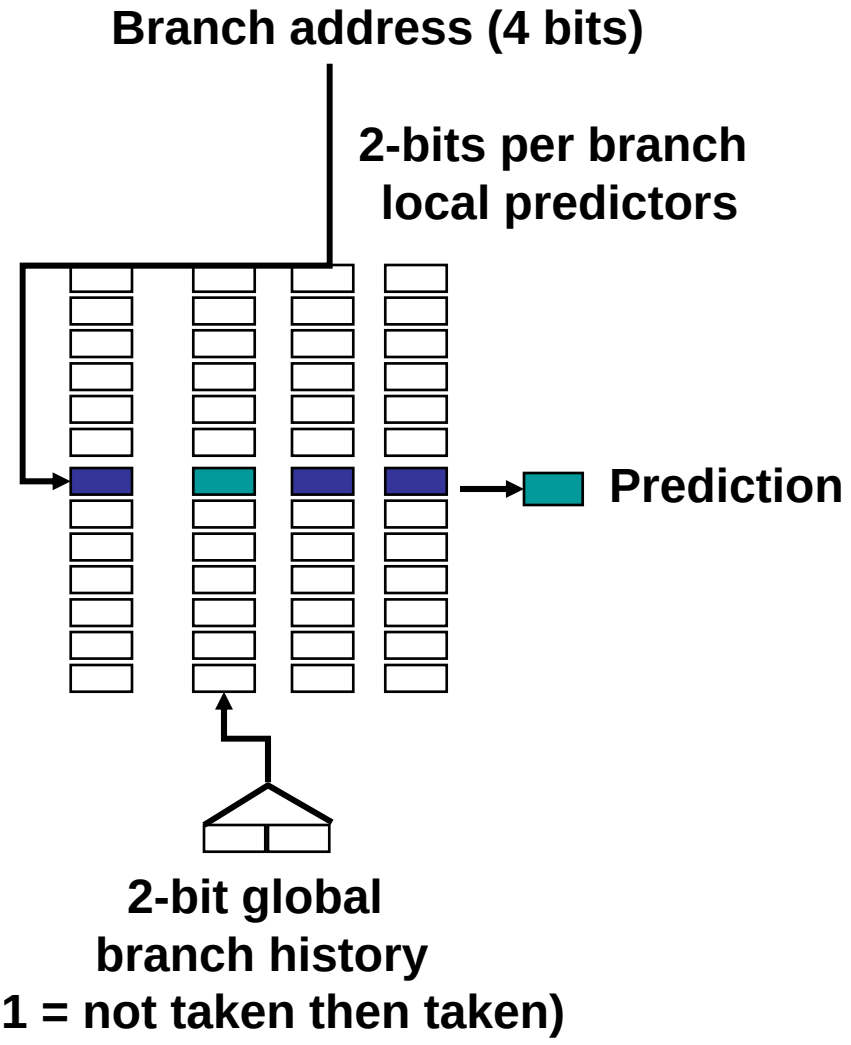
Correlating Branches

Idea: taken/not taken of recently executed branches is related to behavior of next branch (as well as the history of that branch behavior)

- Then behavior of recent branches selects between, say, 4 predictions of next branch, updating just that prediction

- (2,2) predictor: 2-bit global, 2-bit local



Slide based on a lecture by David A. Patterson, University of California, Berkley
http://www.cs.berkeley.edu/~pattrsn/252S01