ECE M116C / CS 151B: Week 5 Section

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Branch Target Buffer

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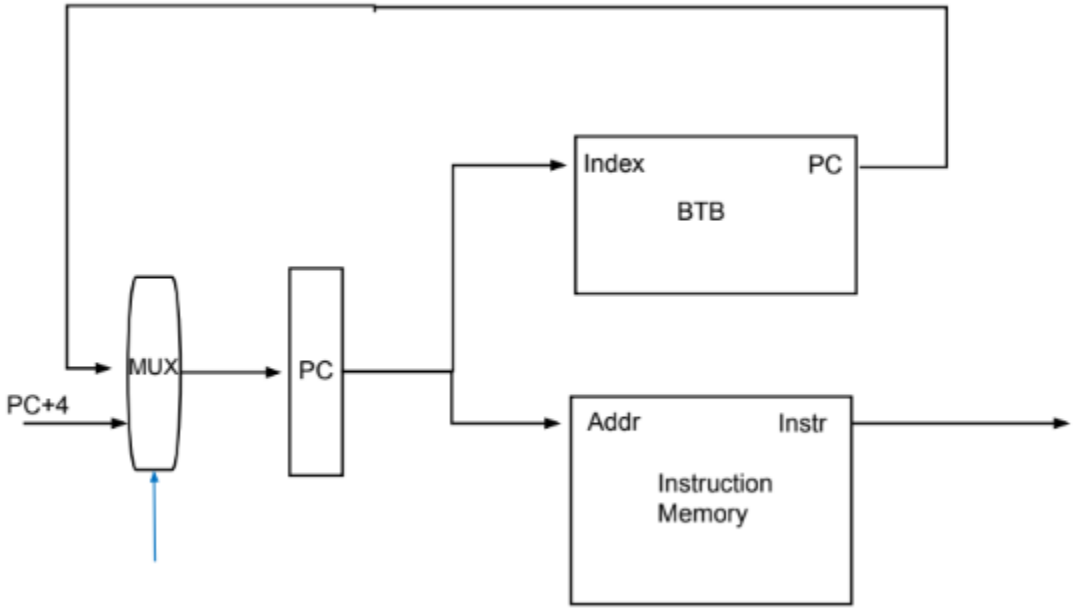


-Goal: improve accuracy by predicting always taken. But, need to know where to go to!

Branch Target Buffer

- Used to store predictions for different branch instructions (“always taken as alternative to always “not taken”)
- Address: PC (lower bits -> because of locality)
- Data: addresses to branch to
- Algorithm:
  - If PC exists, grab address stored as next PC
  - Else, record target address in the table
- Update BTB after realize instruction is control flow, and target address is known (in the decode stage!)

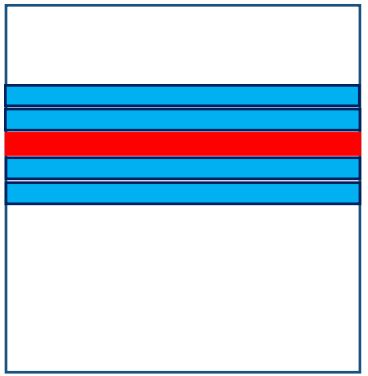
Locality

- **Temporal Locality**: if just used something, will likely use it again soon
- **Spatial Locality**: if used something, will likely need similar/related things

Order of execution

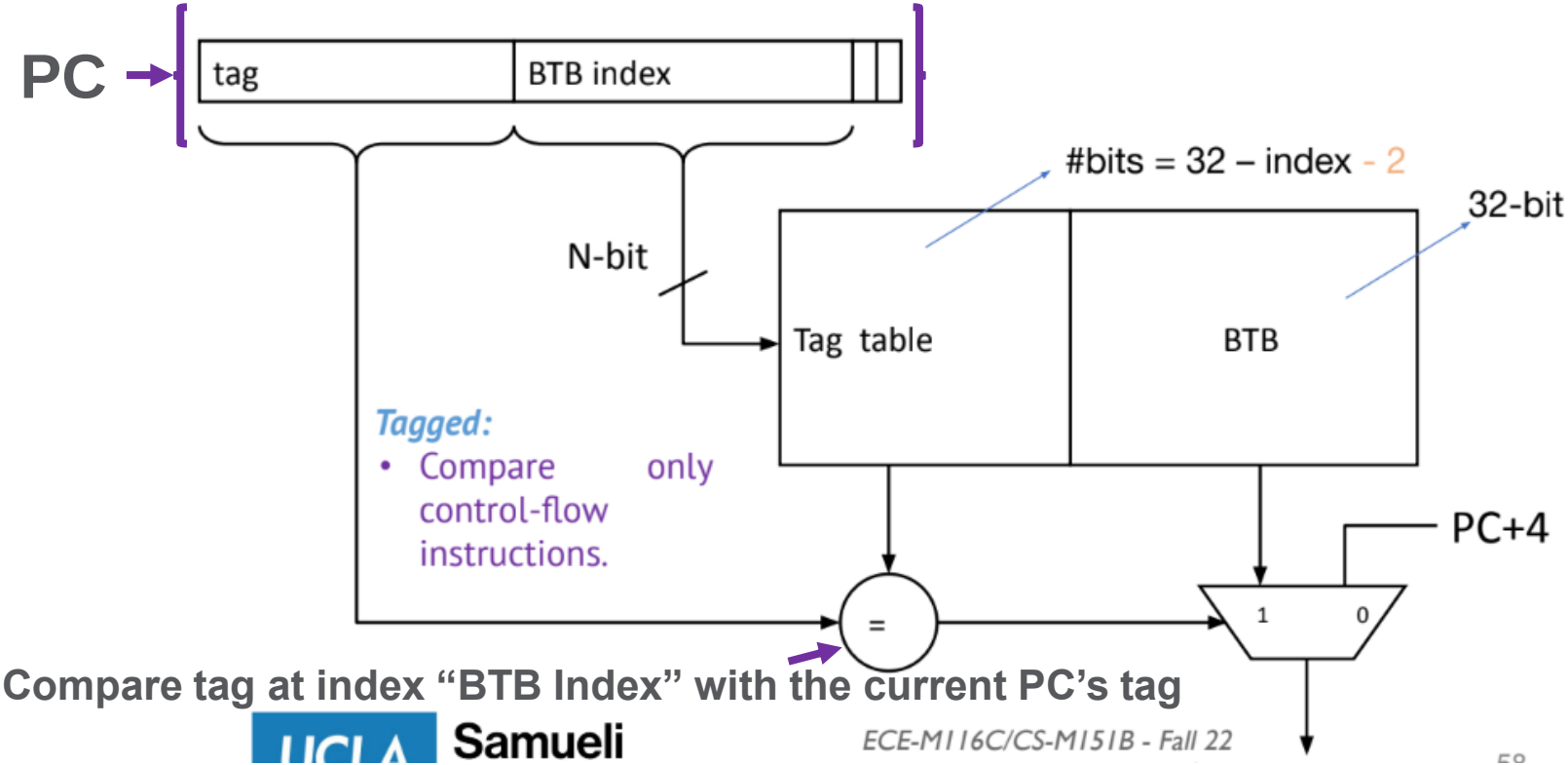
```
20    addi
24    beq (goes to 20)
20    addi
24    beq (goes to 20)
20    addi
24    beq (goes to 20)
…
```

Temporal Locality



Spatial Locality

Branch Target Buffer



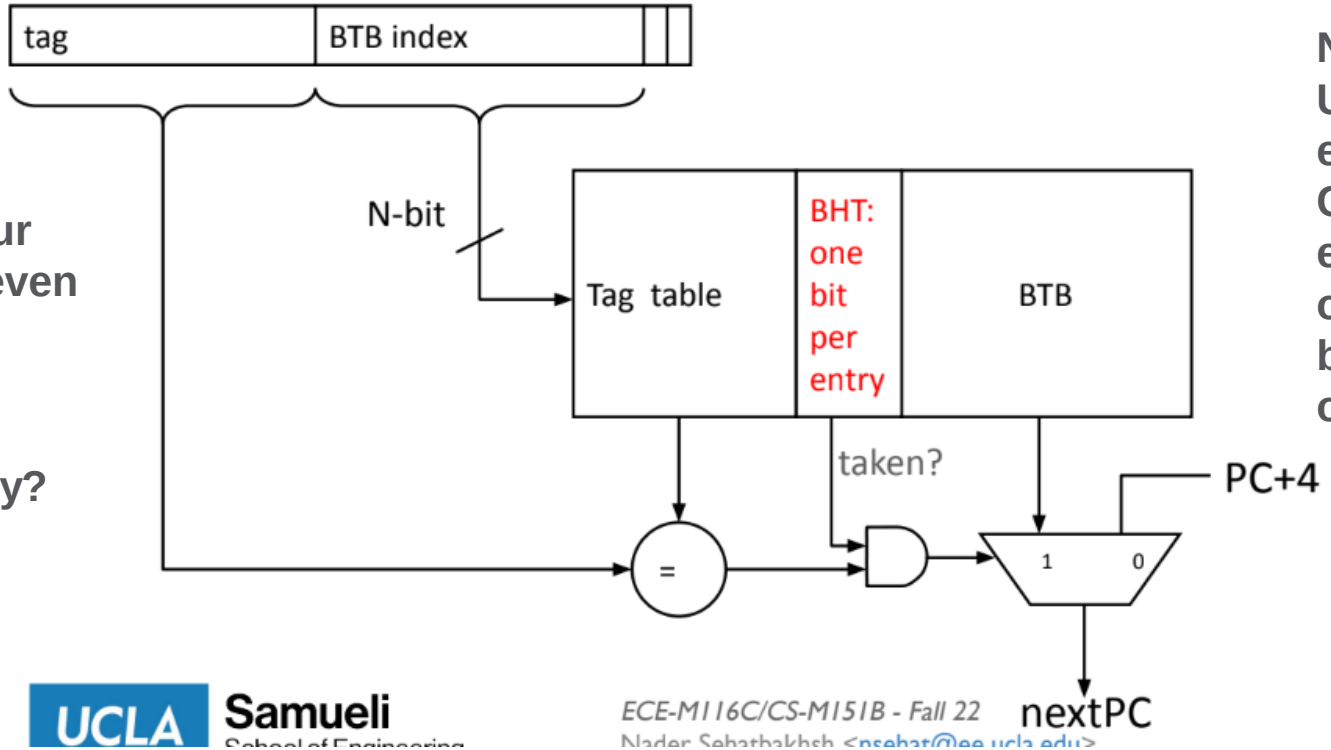
Compare tag at index "BTB Index" with the current PC's tag

Note: utilize locality to decrease lookup time by reducing number of bits stored. Downside: might have misses

Branch Prediction

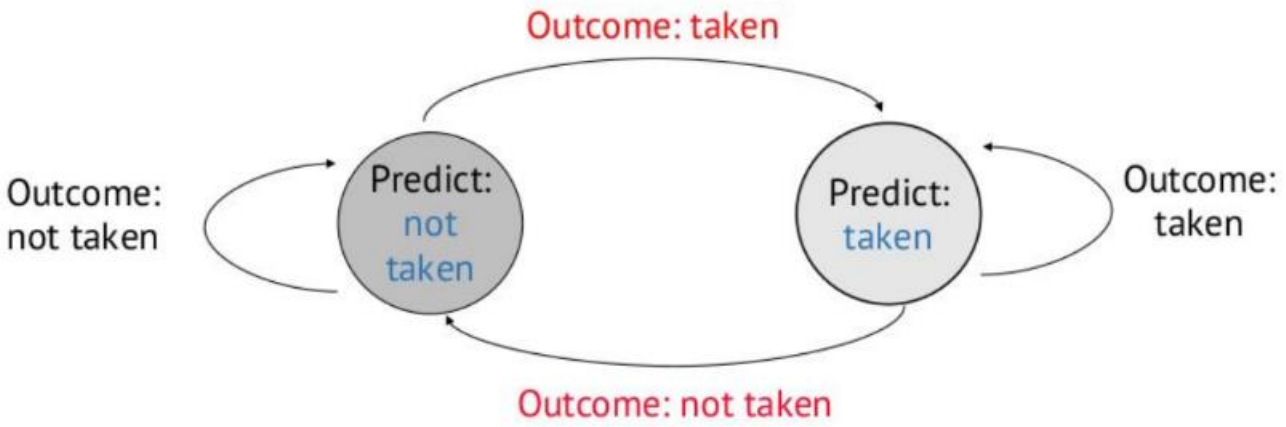
Branch Predictor

Can we improve our accuracy even more by predicting more intelligently?

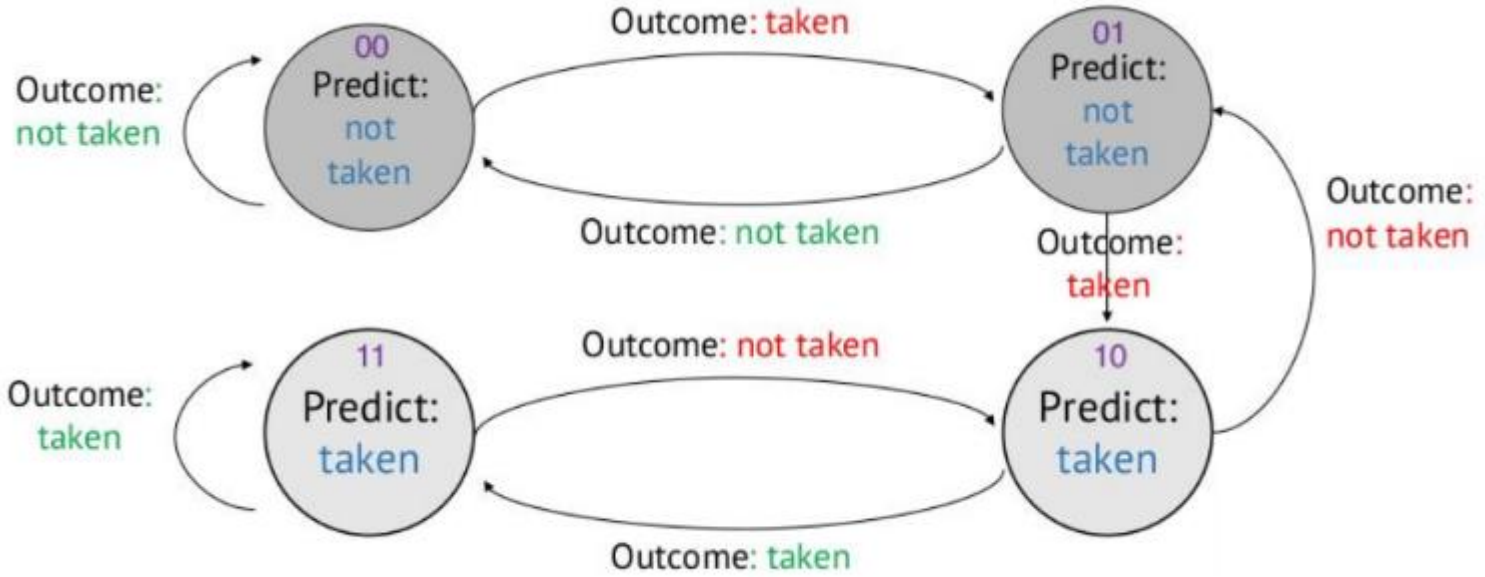


Note: Unconditional entries = 1. Conditional entries: based on latest branch outcome

Branch Predictor FSM: 1 bit



Branch Predictor FSM: 2 bit



Ex) Branch Predictor FSM (1 bit)

Pattern: T N T N N N N T N

What are the predictions? Assume start at 1 (predict taken)

What is the prediction accuracy?

Ex) Branch Predictor FSM (1 bit)

Pattern: T N T N N N N T N

What are the predictions? Assume start at 1 (predict taken)

What is the prediction accuracy?

Answer: T T N T N N N N T

Accuracy: 4/9 = 44.4%

Ex) Branch Predictor FSM (2 bit)

Pattern: T N T N N N N T N

What are the predictions? Assume start at 11 (predict taken)

What is the prediction accuracy?

Ex) Branch Predictor FSM (2 bit)

Pattern: T N T N N N N T N

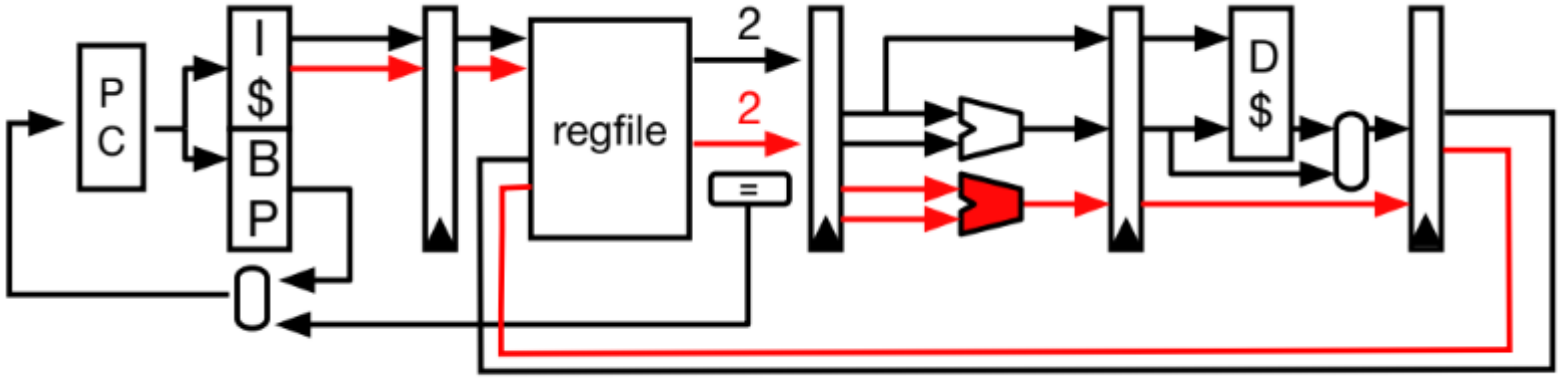
What are the predictions? Assume start at 11 (predict taken)

What is the prediction accuracy?

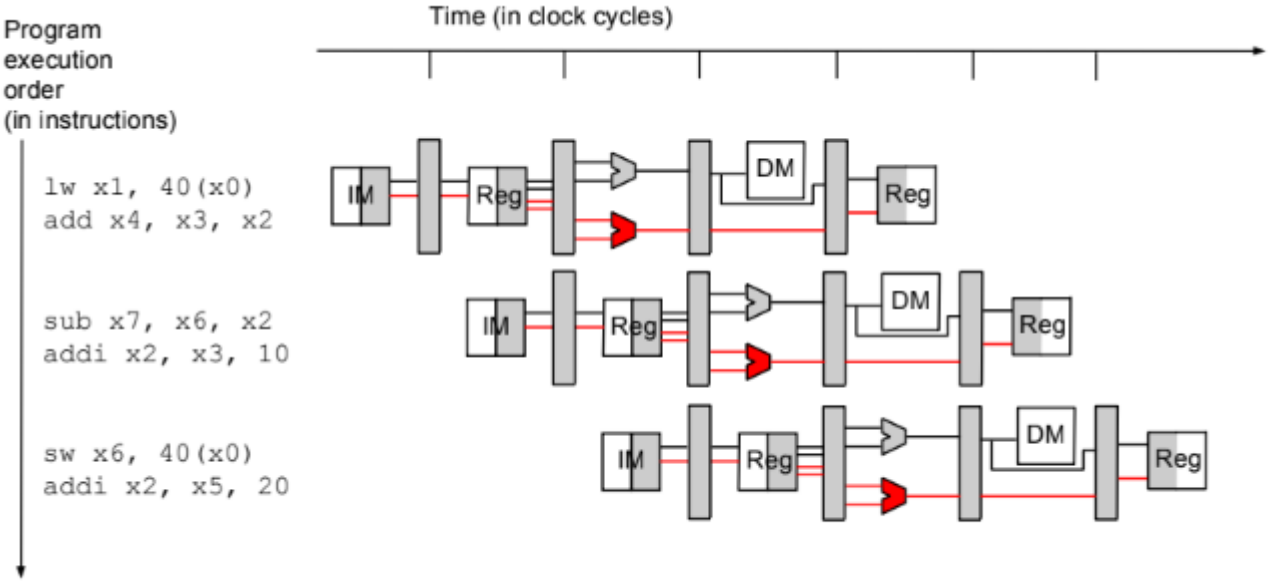
Answer: T T T T T N N N N

Accuracy: 5/9 = 55.6%

Superscalar



Superscalar



Note: must not have a RAW dependency in instructions issued at same time