



# Dynamic Branch Prediction

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# About Me: Mark

- Grad Student, BS/MS program
- Research: Computer Architecture *saiipa*
  - Approximate Computing
  - Novel Architectures & HW/SW Co-Design
- Work:
  - Lockheed Martin Aeronautics – Flight Test (F-35, etc.)
  - Amazon – SDE
  - Microsoft Research – Architectures for Quantum Computers
- Personal:
  - Soccer / Sounders FC
  - Food (cooking & eating)
  - Bicycling, Skiing/Snowboarding, Golf



# About Me: Teddy

- Undergrad Student, Senior, CE
  - Minors in Physics & Math
- Research: Indolence Maximization
  - Sleep >> Work
- Work:
  - Clean Power Research – Software Engineer Intern
  - Qumulo – Software Engineer (next fall)
- Personal:
  - Music (piano, singing, experimental, classical, jazz)
  - Videa Gaemz
  - Skateboarding (recently)



# Control Hazards

- Instruction Fetch occurs before Branch Resolution
  - What does the CPU do on a Conditional Branch?
- A few options:
  - Stall
  - Branch Delay Slot
  - Predict the Branch



# Branch Prediction

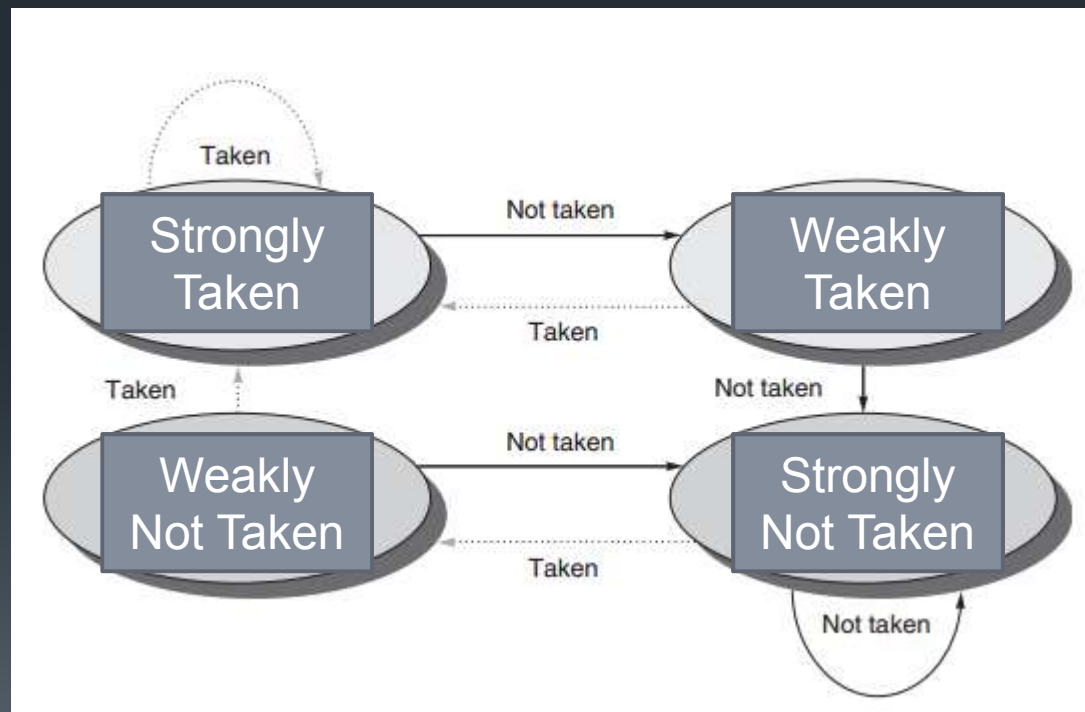
- Predict which branch is taken
- Speculatively execute instructions at branch target
- Eventually, resolve the branch
  - On misprediction occurs, flush speculative instructions and jump to correct path



# Branch Prediction Performance

- Depends on:
  - Accuracy of prediction
  - Frequency of branches
  - Time between prediction and resolution

# Saturating Counters / Two-bit Predictors





# Local Predictors

- Branch Prediction Buffer (BPB) / Branch History Table (BHT)
  - Memory indexed by instruction address during Fetch stage
    - Low order  $m$  address bits
  - Each entry is 2-bit predictor
  - $2^m$  2-bit predictors
- Extra bits in Instruction Cache (I\$)
  - Alternate implementation
  - Bits attached to each block in I\$ and fetched with the instruction
- But, sometimes behavior is not predictable by a single branch





# Correlating Predictors

- Use the behavior of previous branches to make a prediction
- Global History Register (GHR)
  - Shift register (m bits), last m branch results
  - i.e. 0 = not taken, 1 = taken
- Pattern History Table (PHT)
  - $2^m$  2-bit predictors
- To make a prediction, index the PHT using the GHR, read the predictor
- On branch resolution, update the PHT entry used, then update the GHR (shift in a new bit)



# Homework #1 – Branch Prediction Demo!