BRANCH PREDICTION

BY ALEX ZIESMER

WHAT IS BRANCH PREDICTION

• A branch predictor guesses which way a branch will go.
• The proper branch cannot be known until the execute stage is completed.
• Modern pipelines are often 15 to 20 stages long, so lots of time is lost if no prediction or incorrect prediction occurs.
**STATIC PREDICTION**

- Simplest form of branch prediction
- Always predicts either taken or not taken
- Early versions of the SPARC and MIPS architectures used Static Prediction
- Some early Intel processors allowed the predictor to receive hints from the code to tell it to predict taken or not taken, but this is no longer used
- Static prediction is often the fallback for dynamic predictors when they don’t have the information required to make a decision

**SATURATING COUNTER**

- Every branch receives its own counter
- Saturates to 93.5% accuracy
TWO-LEVEL ADAPTIVE PREDICTOR

- Remembers what happened the last $n$ times for each branch
- Uses a saturating counter for each of the $2^n$ history patterns (right)
- Used in almost all modern processors

LOCAL BRANCH PREDICTOR

- Like a Two-Level Adaptive Predictor except it has a History Buffer for EACH conditional jump instruction
- Pattern History Table may or may not be shared
- Used in many Intel Pentium processors (4-bit buffer, 16 entry pattern table)
- Saturates to 97.1% accuracy
GLOBAL BRANCH PREDICTOR

• Like the Local Branch Predictor, except it does not keep a separate history for each conditional jump
• This shared history allows it to recognize correlation between separate branches
• Requires a very large table size to be useful

AGREE PREDICTOR

• Combination of Saturating Counter, Two-Level Adaptive, and Global Branch Predictors
• Uses Two-Level Adaptive Prediction, A Globally Shared History Buffer and Pattern History Table, and a local Saturating Counter
• Outputs are XORed together to give the final prediction
• Developed by Intel, but eventually abandoned
HYBRID PREDICTOR

• Combination of multiple prediction methods
• Either remembers which predictor has been correct the most, or it has a voting system where each predictor makes its prediction and it chooses whichever one got the most votes

LOOP PREDICTOR

• Best used for conditional jumps that control loops
• If at the bottom of a loop, it repeats n times and will be taken n-1 times and not taken 1 time
• If at the top of a loop, it will be not taken n-1 times and taken 1 time
• Useful for any jump that goes one way many times and then the other way once
• Often used in modern processors
OVERRIDING BRANCH PREDICTOR

• Most accurate branch predictors are slow, and most fast branch predictors are inaccurate, but we want fast and accurate
• Overriding Branch Predictors are a combination of two branch predictors, one that is very fast, and another that is accurate
• The fast branch predictor’s prediction will be taken while the slower predictor is deciding
• The slower predictor will override the fast predictor if it predicts differently
• Used in almost all modern processors

QUESTIONS?
INDIRECT JUMP PREDICTOR

• Chooses between more than two branches
• Uses a two level adaptive predictor, but each branch contributes more than one bit to the history buffer
• If a processor does not have indirect jump prediction, it will predict an indirect jump to go to the same target it has previously