Branch Prediction

This Set: How to predict branch direction targets.

Review Material
McFarling 93, a concise description of basic branch prediction techniques.
EE 4720 Lecture Set 12

References at end of set.

Branch Prediction Techniques

Basic Techniques (Covered in EE 4720)
- Bimodal (Two-Bit Counter, don’t confuse with bi-mode)
- gshare (Global History ⊕ PC)
- Local History

Advanced Techniques
Variant on one or more basic techniques.

Performance of Basic Techniques

Bimodal (Don’t confuse with bi-mode.)
- Accuracy: 93% on SPEC89. (McFarling 93)
- Advantage: Fast warmup.
- Limitation: Only works for highly biased branches.

gshare (Global History ⊕ PC)
- Accuracy: 96% on SPEC89. (McFarling 93)
- Advantage: Handles a wide variety of branches.
- Limitation: Slow warmup, large table needed to avoid collisions.

Local History
- Accuracy: 97% on SPEC89. (McFarling 93)
- Advantage: Can precisely predict short loops.
- Limitation: Cannot predict one branch based on another.
Advanced Techniques

Each makes better use of basic techniques.

*Hybrid Predictor:* Choose best predictor for each branch.

*Skewed:* Avoid collisions by storing counter in multiple places.

*Bias Filtering:* Avoid collisions by accounting for bias.

*History Filtering:* Use a subset of history appropriate for branch.

Hybrid Branch Predictors

Primary Reference: McFarling 93. Early work on hybrid predictors, also provides good summary of basic predictors.

Other references: Chang 94, Evers 96.

*Hybrid Branch Predictor:* A branch predictor that predicts a branch by choosing a prediction made by one of several predictors. The choice might be based on a chooser table, or by using the majority prediction.

Status: Used in existing processors, including Alpha 21264.

Skewed Predictors

Primary Reference: Michaud 97.

Problem: Collisions in PHT.

Solution: Predict using counters stored in several places within PHT.

Details:

Use three PHTs.

Hash (combine) global history with PC three different ways …

… creating three different indices (index 1, index 2, index 3, one per PHT) …

…and use these to lookup one counter in each PHT.

Use majority prediction.
Bias Filtering

Problem: Collisions by highly biased branches.

Solutions:
- Use separate PHTs for taken and not-taken branches. (Bi-Mode, Lee 97)
- Use PHTs only for branches not predicted by bimodal predictor (YAGS, Eden 98).
- If bit in instruction cache set invert prediction. (Agree Sprangle 97)

Details covered in class.

History Filtering

Problem: Global history has irrelevant outcomes.

Solutions:
- Adjust length of global history. Juan 98
- Take a weighted combination of outcomes, with weights chosen for branch.

Details to be added. (13 September 2003, 16:06:57 CDT)

Branch Prediction References

Hybrid predictors.

Skewed predictor.

Bias Filtering Predictors


History Filtering