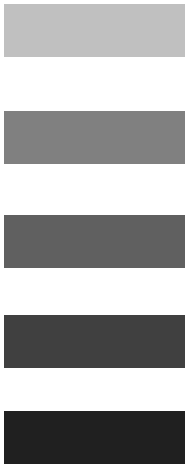
The Subconscious Mind of a Branch Predictor

Daniel A. Jiménez

Departments of Computer Science
The University of Texas at San Antonio
and
Rutgers, The State University of New Jersey

Branch Prediction

A *branch predictor* allows the processor to speculatively fetch and execute instructions down the predicted path.



Instruction fetch

Instruction decode

Execute

Memory access

Write back

Speculative execution

Branch Predictor Dreams

- In bed at night, a branch predictor has dreams
- Rather than accepting external input, the branch predictor dreams that all of its predictions are correct
- This talk illustrates a few branch predictor dreams with a somewhat surprising result

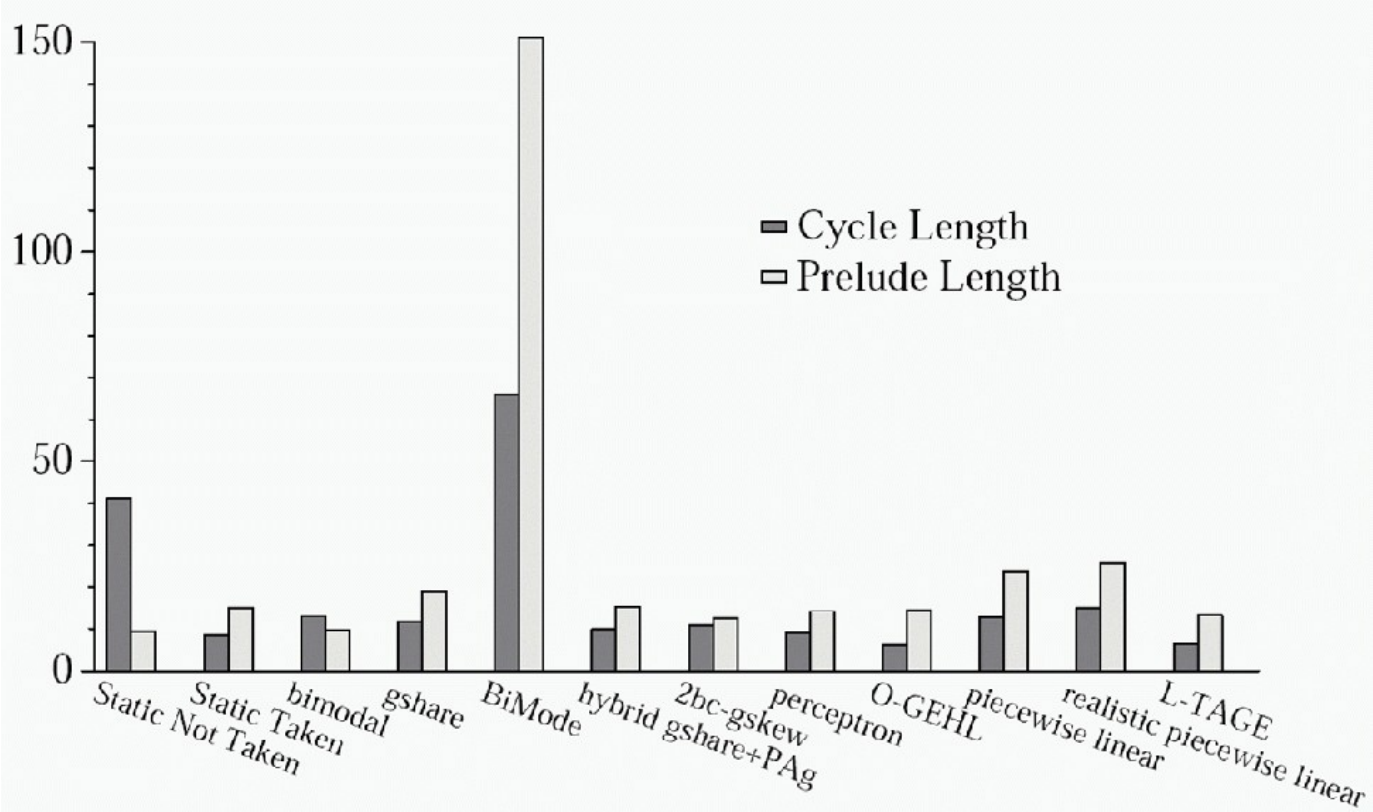
Methodology

- Used traces from the `403.gcc` benchmark on x86
- Simulated a wide variety of conditional branch predictors
- Simulated a perfect branch target buffer
- Run the benchmark a random number of branches, then begin recording a “dream” for 64K predictions where the branch predictor believes all of its predictions

Observations

- Dreams have two phases:
  - A *prelude* of apparently random behavior
  - A *period* that repeats a cycle over and over
- You might think that the lengths of the period and prelude would be correlated with the accuracy of the predictor
  - Not so much

Prelude and Period Lengths

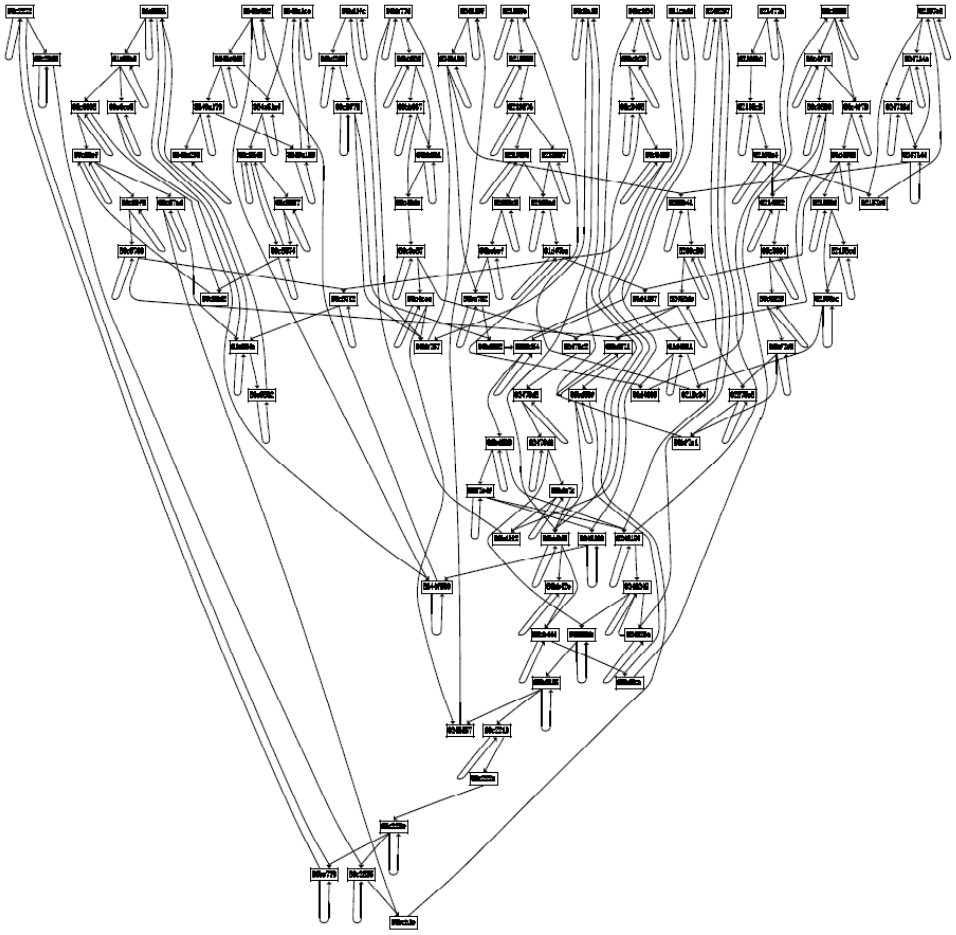


Ordered from least to most accurate

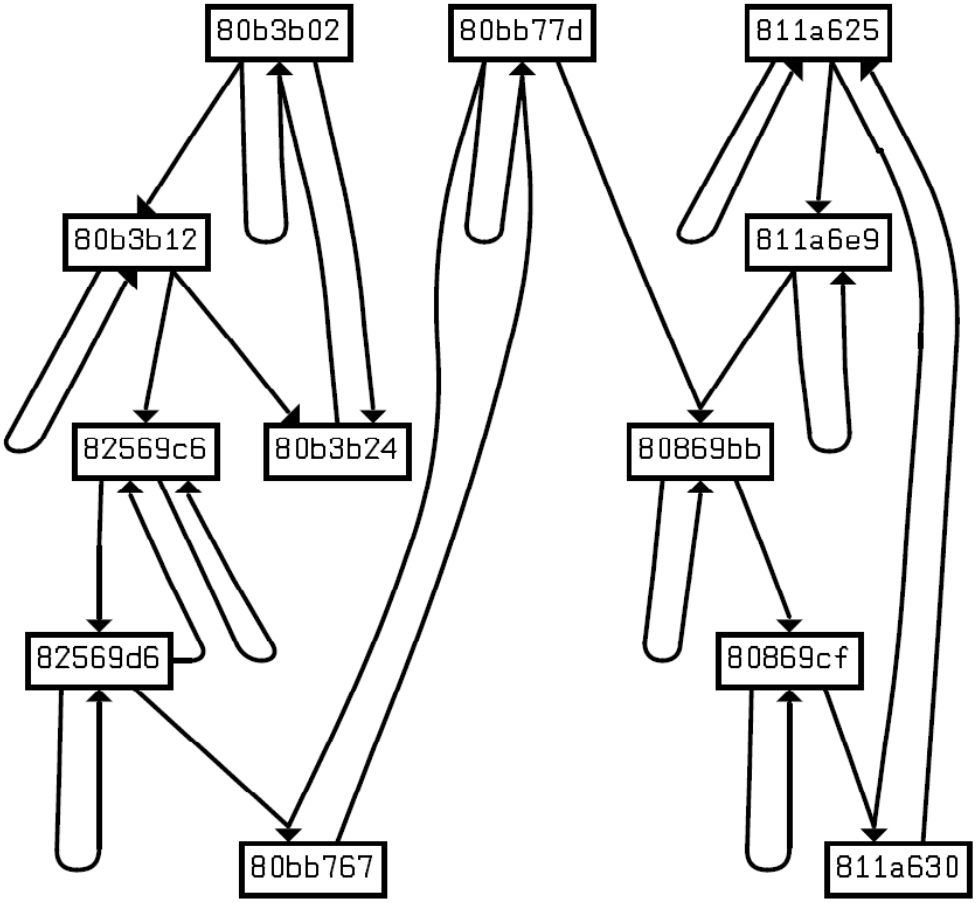
Dreamscapes

- Using the graph visualization tool VCG we can see the shapes of the control-flow graphs induced by branch predictor dreams
- The graphs have been compressed a bit to make them easier to draw – see me after the talk to find out how if you're really interested
- For each predictor, the most interesting dreamscapes are shown

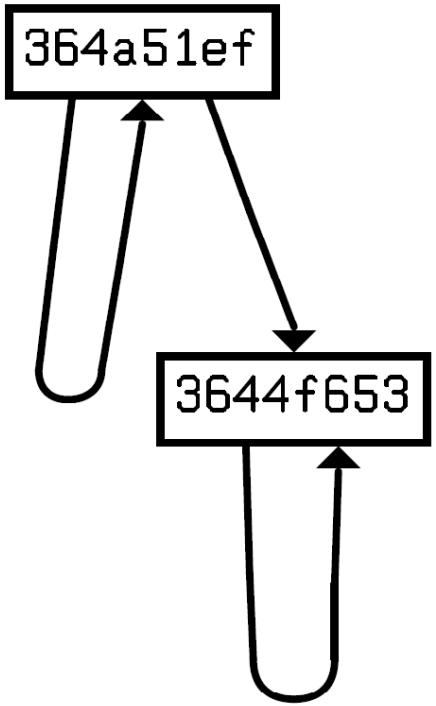
BiMode Predictor Dream



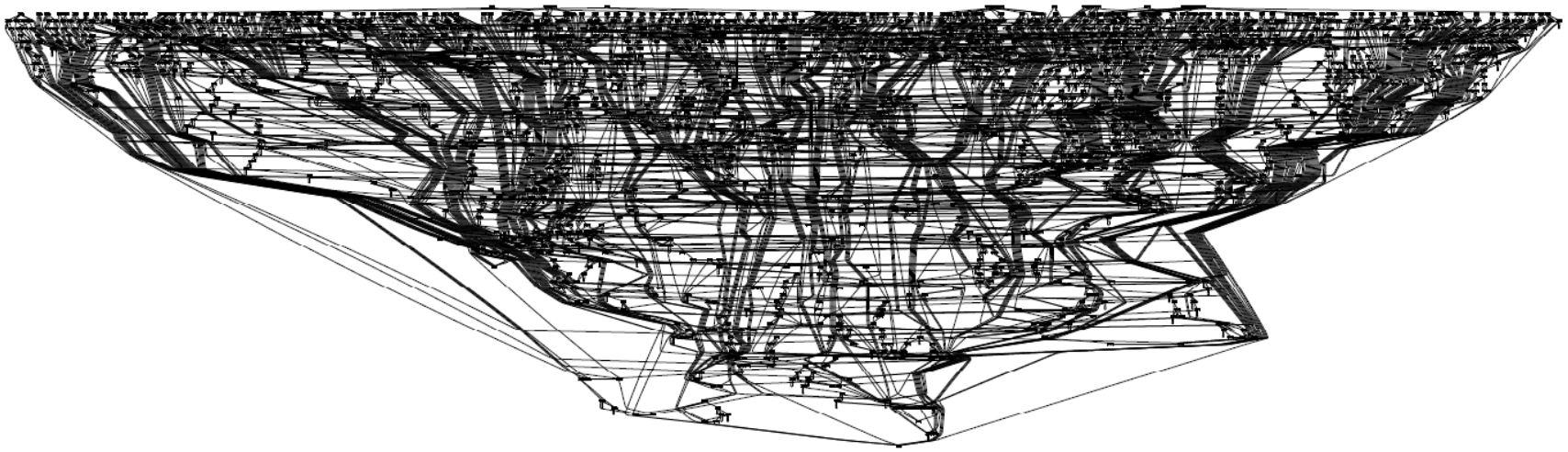
Piecewise Linear Branch Predictor Dream



L-TAGE Predictor Dream

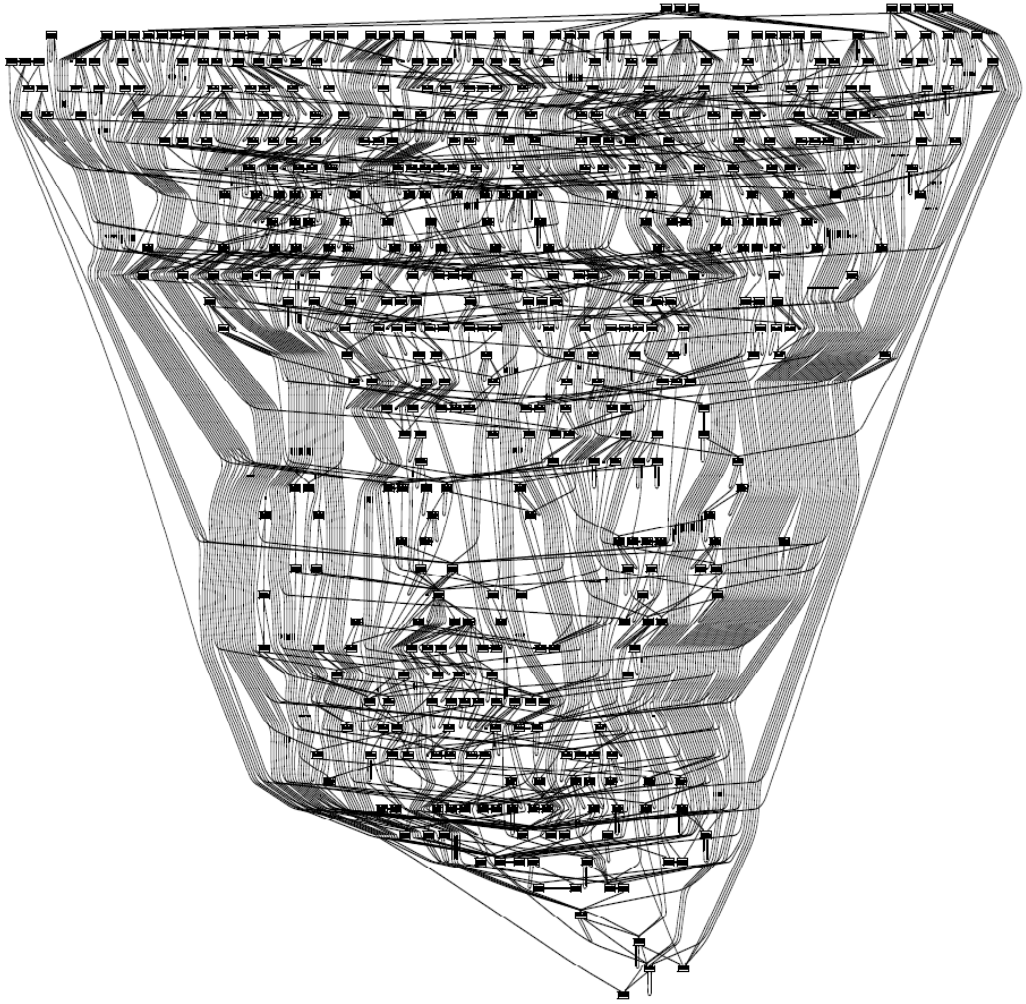


BiMode Nightmare



In a “nightmare,” all the predictions are wrong

Actual Control Flow Graph



Questions

- What can we learn from this?
- Can predictors learn something by dreaming in idle periods?
- Why do PLBP and L-TAGE, two very accurate predictors, dream so differently?
- Why does BiMode, not particularly accurate, have the most interesting dreams?

The End