Use of machine learning for timing estimation: from single-core processors to multi-cores

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Timing estimation of the WCET
The Worst-Case Execution Time

Distributions of the execution time

WCET techniques

Static Timing Analysis (STA)
Measurement-Based Timing Analysis (MBTA)
Hybrid Timing Analysis (HTA)

Motivation (1/2)

- Modern processor
- No detailed HW documentation available
- Increasing complexity
Motivation (2/2)

Pipeline

Caches

Branch Predictor

Instructions
sequence impact

Loops and information reusing
Machine Learning for WCET estimation

Program

Control flow graph (CFG)

Implicit path enumeration technique (IPET)

Machine Learning

\[ \text{MAX } T = \sum x_i \cdot t_i \]

execution time of block \(i\)

execution count of block \(i\) on that path

execution time on a given path

?
Preliminary work
WE-HML: Hybrid WCET estimation using Machine Learning for architectures with caches
Training workflow of regression models

Basic block generation → Execution + measurements under cache pollution → Measurements → WCET estimation

Features extraction → [ % Mov , % Add , ....] → Features

Training

Supervised learning :

\[ F(X) = Y \]

X is [ %Mov , %Add , ... ]

Y is BB WCET

F is { Linear regression, Random Forest, Multilayer perceptron...}

A. Amalou, I. Puaut, and G. Muller, ‘WE-HML: hybrid WCET estimation using machine learning for architectures with caches’, 2021, RTCSA.
First attempt on context awareness: Cache pollution

A. Amalou, I. Puaut, and G. Muller, ‘WE-HML: hybrid WCET estimation using machine learning for architectures with caches’, 2021, RTCSA.
WCET prediction of a program

A. Amalou, I. Puaut, and G. Muller, ‘WE-HML: hybrid WCET estimation using machine learning for architectures with caches’, 2021, RTCSA.
Challenges

Context-awareness

Representativity of training data

Comparison with reference tools
Ongoing work ML technique inspired by ITHEMAL
ITHEMAL : Instruction THroughput Estimator using MAchine Learning

Reccurent Neural Network that predicts the BCET of a basic block (In isolation)

Context-awareness of the basic blocks execution
Extension to multi-cores

- Single-core
- Multi-cores
Thank you for your attention

Questions ?