



HAL
open science

Machine learning for timing estimation

Abderaouf Nassim Amalou, Elisa Fromont, Isabelle Puaut

► **To cite this version:**

Abderaouf Nassim Amalou, Elisa Fromont, Isabelle Puaut. Machine learning for timing estimation. D3 - Architecture séminaire: PhD days / Journées doctorants – 2022, Nov 2022, Rennes, France. <hal-04260161>

HAL Id: hal-04260161

<https://hal.science/hal-04260161v1>

Submitted on 26 Oct 2023

HAL is a multi-disciplinary open access archive for the deposit and dissemination of scientific research documents, whether they are published or not. The documents may come from teaching and research institutions in France or abroad, or from public or private research centers.

L'archive ouverte pluridisciplinaire HAL, est destinée au dépôt et à la diffusion de documents scientifiques de niveau recherche, publiés ou non, émanant des établissements d'enseignement et de recherche français ou étrangers, des laboratoires publics ou privés.



Distributed under a Creative Commons CC BY 4.0 - Attribution - International License

Machine learning for timing estimation

1. CONTEXT

The execution time is calculated in specific cases depending on the needed application domain, (e.g, worst case execution for realtime applications, average case for compiler optimization).

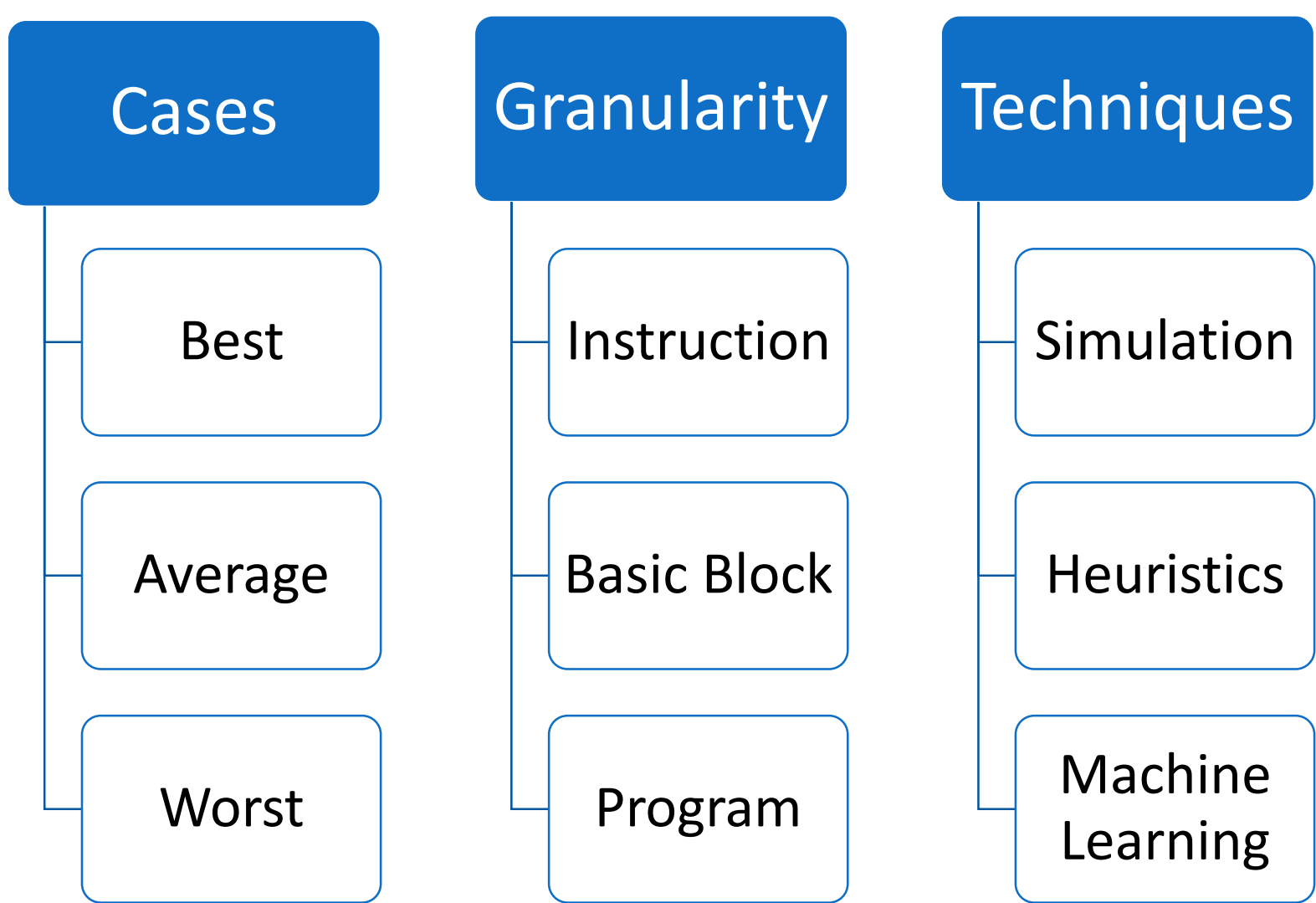


Figure 1 Execution time estimation classification

Challenges of using Machine Learning for timing estimation :

- Context-awareness (Cache and Pipeline).
- Representativity of training data.
- Reliability of the estimations.

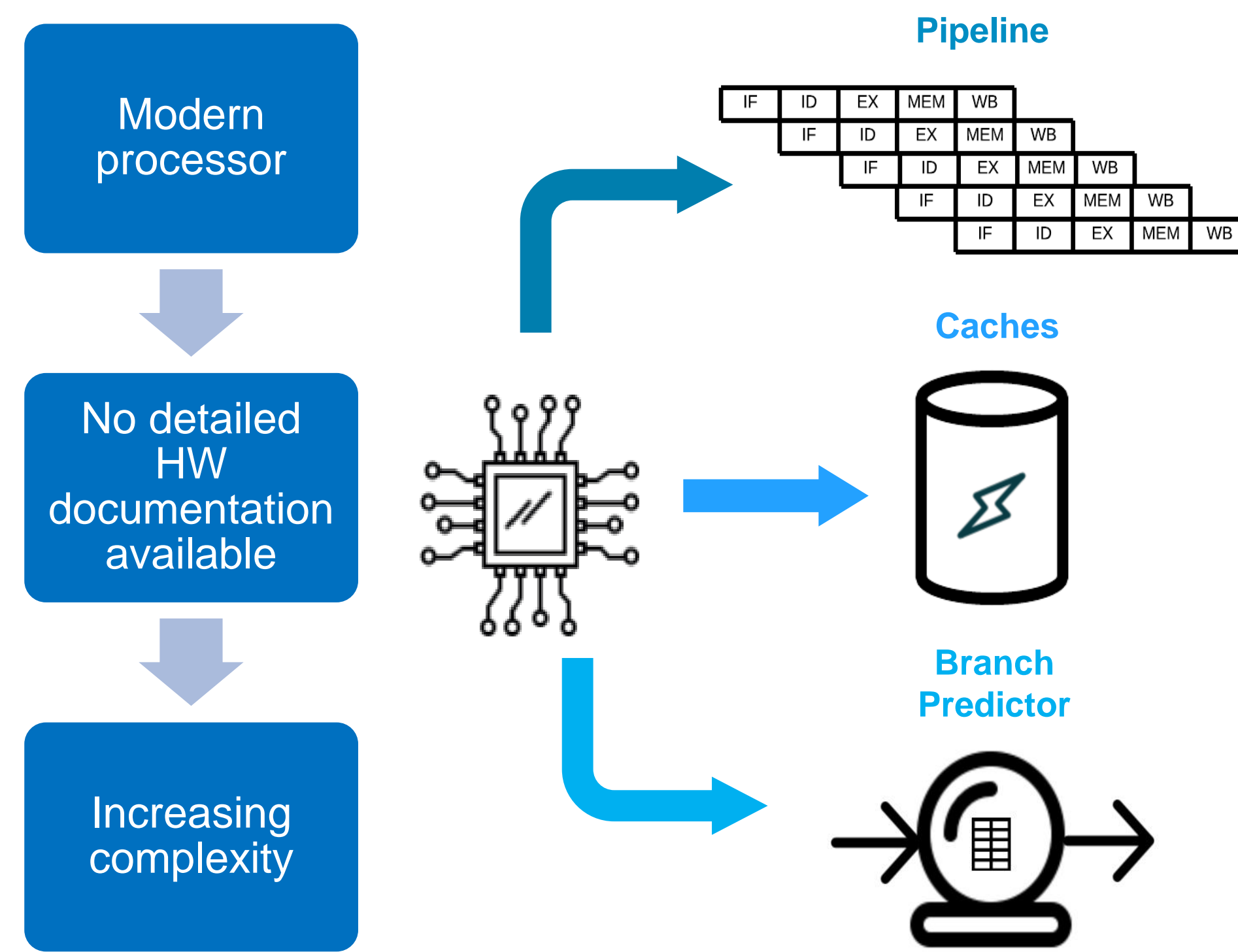
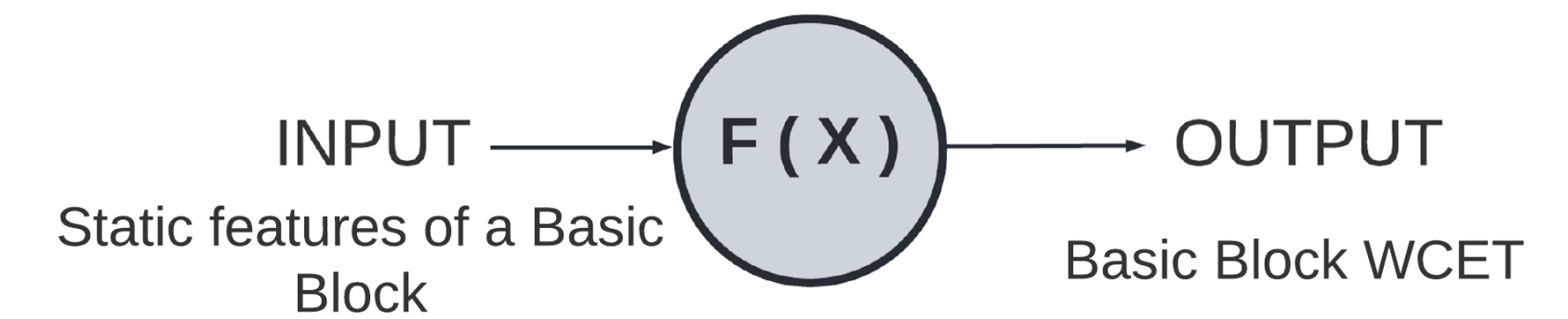


Figure 2 Challenges to estimate the execution time of modern processor

2. TIMING WORST CASE



WE-HML [1] (WCET Estimation using an Hybrid Machine-Learning based technique) estimates the WCET for processors that have caches.

- **Learning phase** : Training on Basic Block and WCET.
- **Estimation phase** : ILP for longest path combined with ML model.

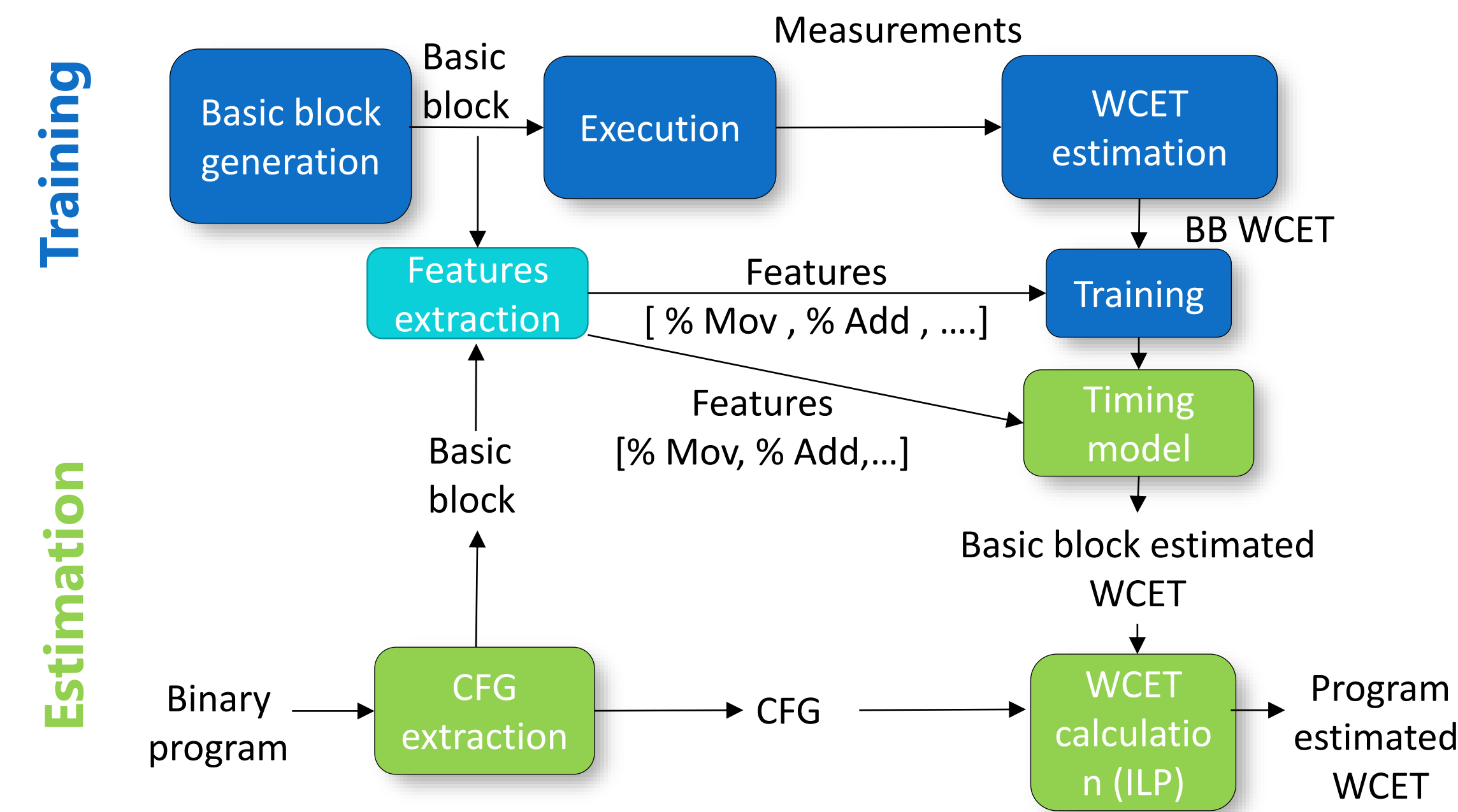
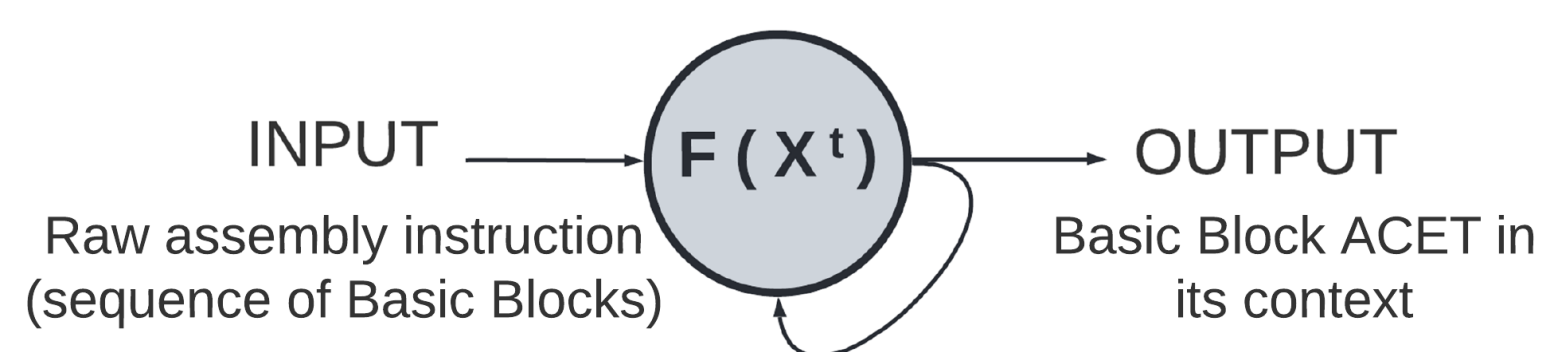


Figure 3 Training/Estimation workflow of WE-HML

3. TIMING AVERAGE CASE



- ITHEMAL [3] uses 2 stacked LSTMs layers to estimate the execution time for a BB in isolation.
- CATREEN [2] improves ITHEMAL to estimate the execution time of a BB in its context.
 - Instruction == Word.
 - Basic block == Sentence.
 - Sequence of basic blocks == Paragraph.

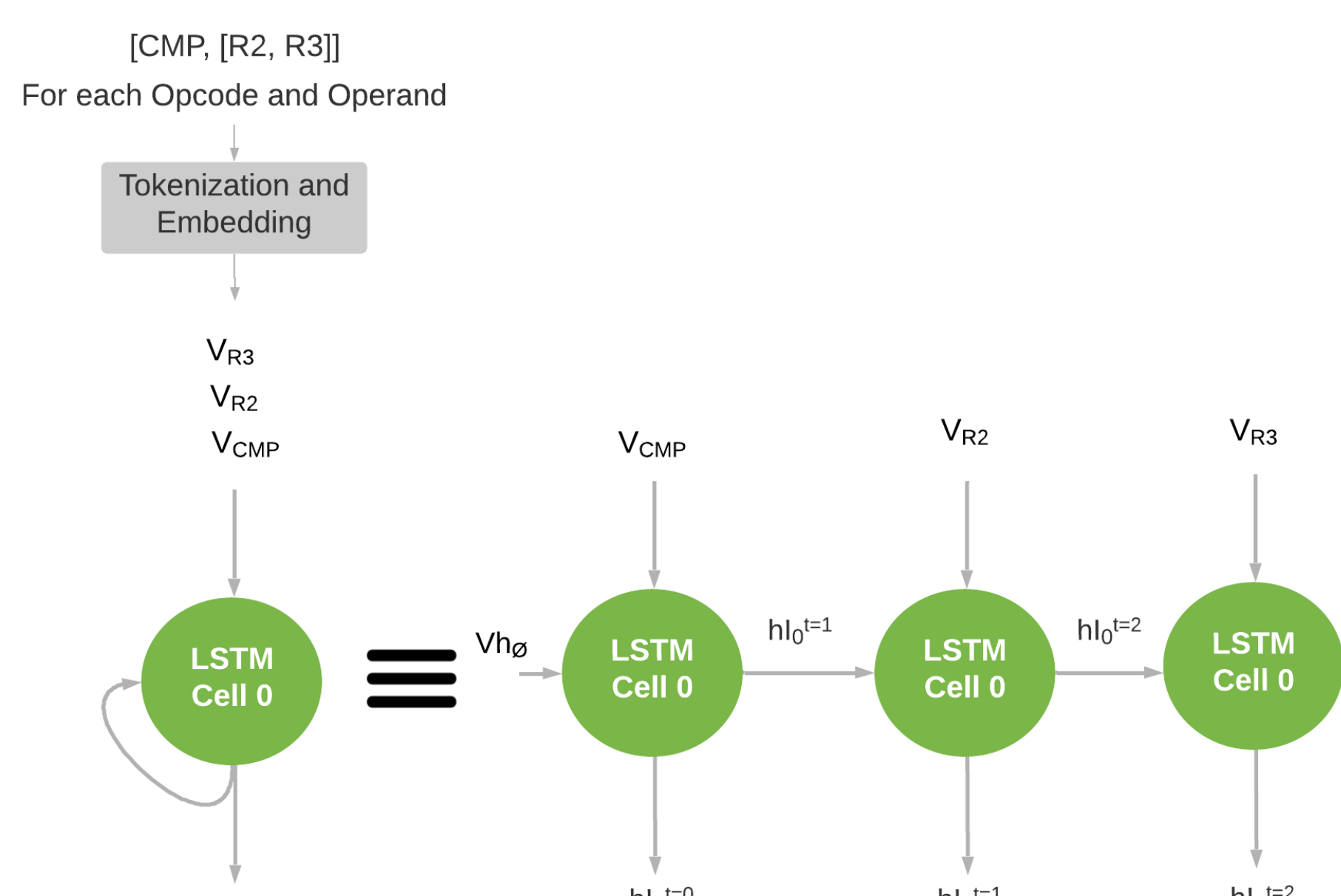


Figure 4 Unfolding of a LSTM cell of the instruction layer on a machine instruction

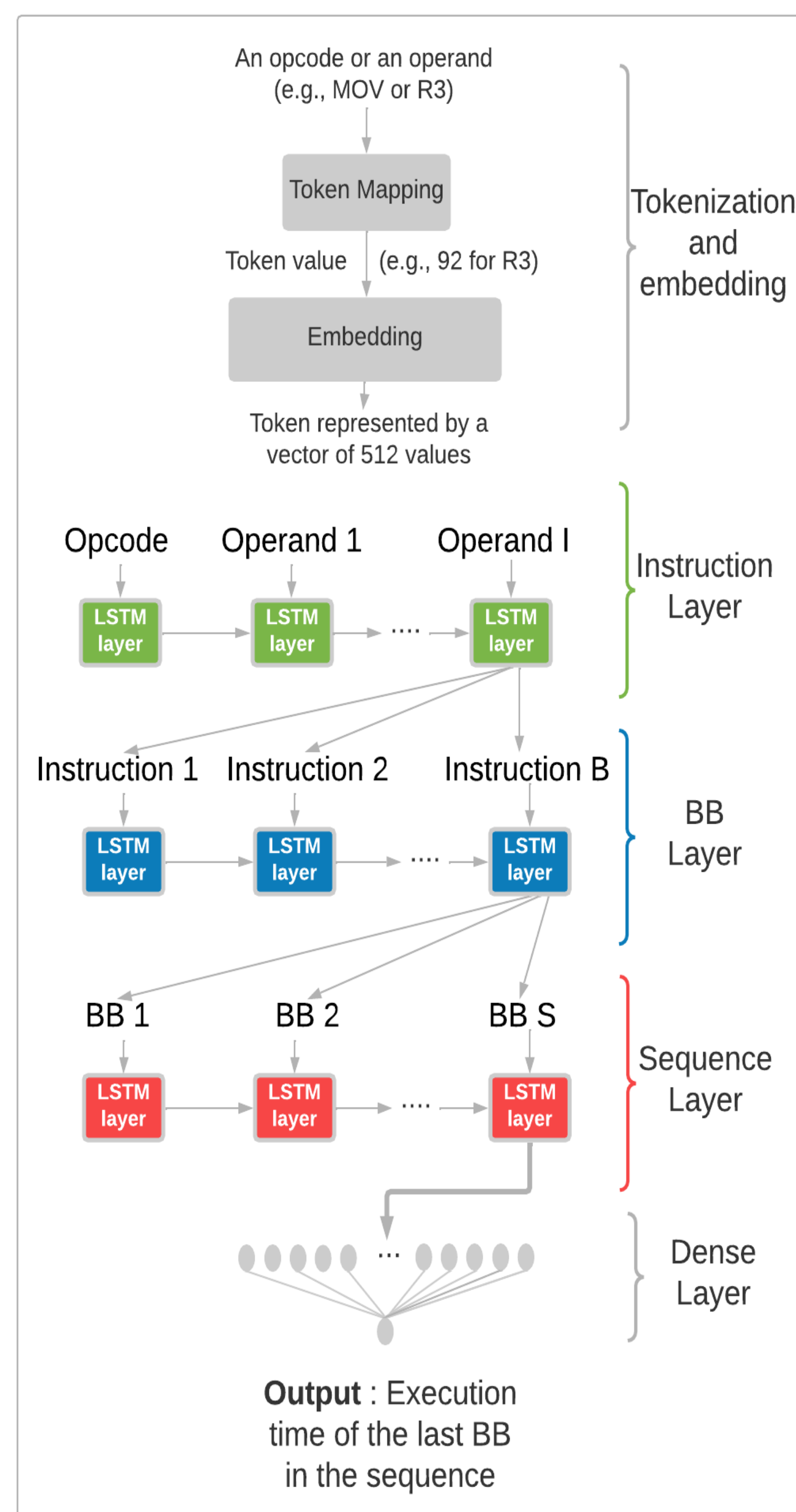


Figure 5 Architecture of CATREEN

4. RESULTS

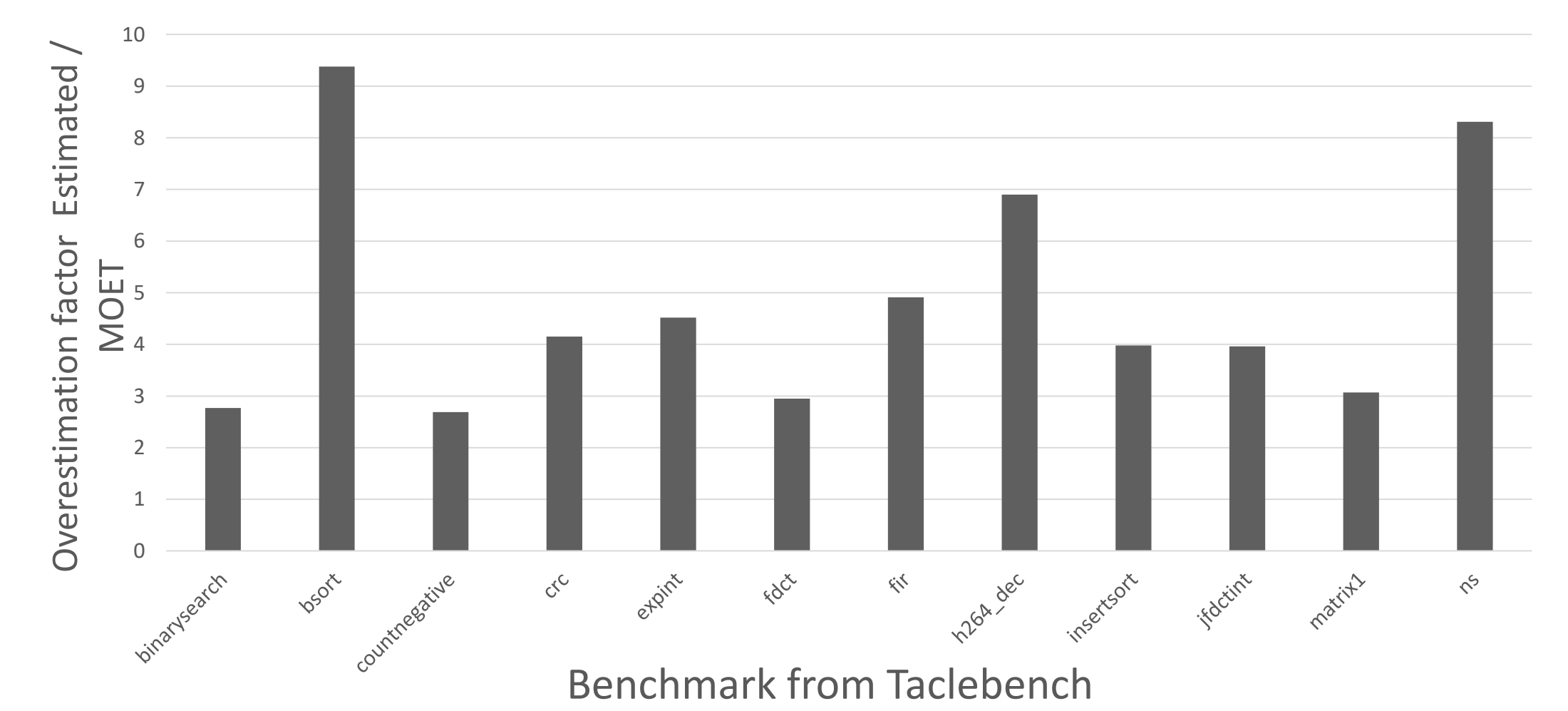


Figure 6 Estimated WCET WE-HML versus Maximum Observed Execution Time (MOET)

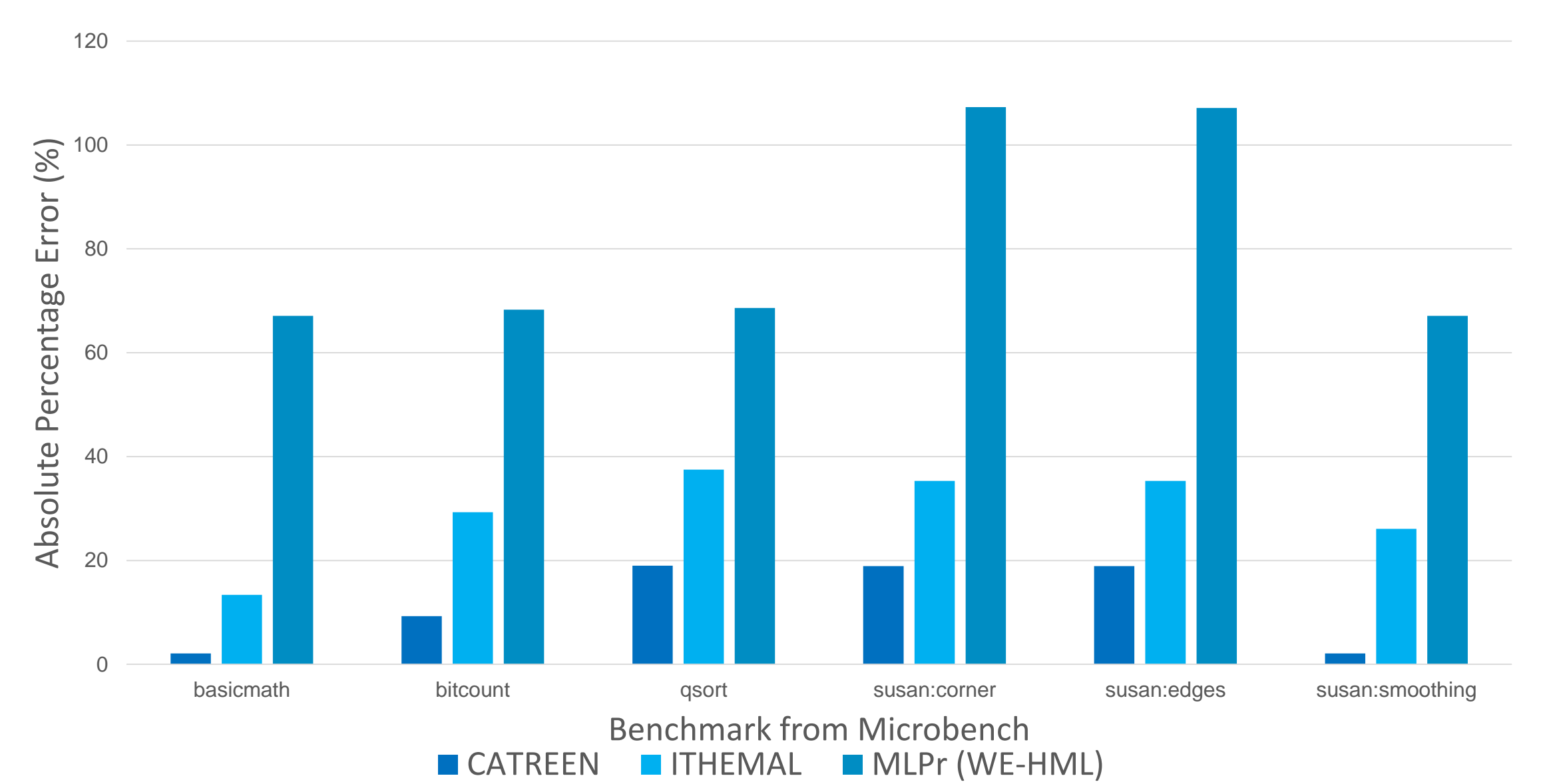
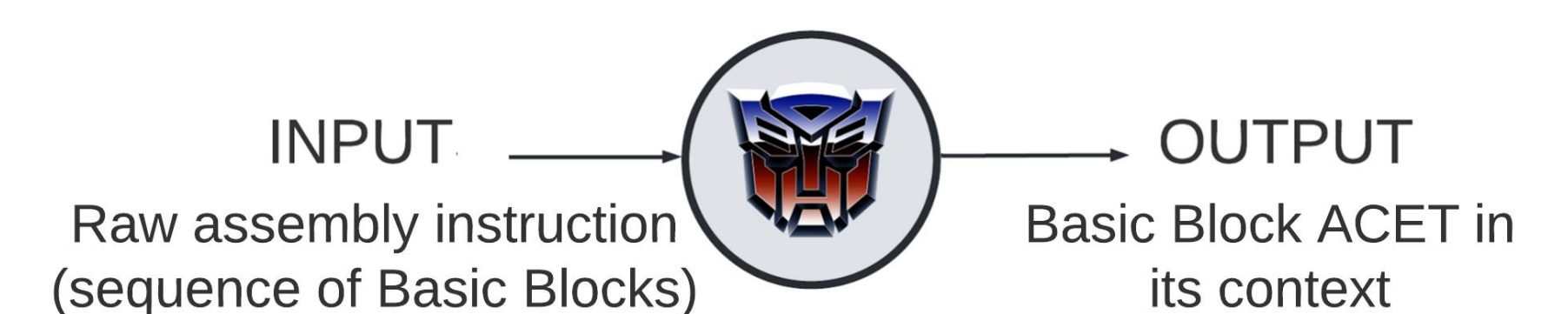


Figure 7 Absolute Percentage Error on MiBench for CATREEN, ITHEMAL and MLP regressor

5. PERSPECTIVE



- Transformers [4] are able to handle sequential data, but this is done in parallel, which drastically reduces both training and inference times.

Abderaouf Nassim AMALOU

PACAP/LACODAM

Pr. Isabelle PUAUT

PACAP

Pr. Elisa FROMONT

LACODAM

Contacts

abderaouf.amalou@irisa.fr

Bibliography

- [1] A. N. Amalou, I. Puaut, and G. Muller, "WE-HML: hybrid WCET estimation using machine learning for architectures with caches," in 27th IEEE International Conference on Embedded and Real-Time Computing Systems and Applications, RTCSA. IEEE, 2021, pp. 31–40.
- [2] Authors of this poster, "CATREEN: Context-Aware Code Timing Estimation with Stacked Recurrent Networks", 2022, submitted to ISPASS, under review.
- [3] C. Mendis, A. Renda, S. Amarasinghe, and M. Carbin, "Ithemal: Accurate, portable and fast basic block throughput estimation using deep neural networks," in International Conference on machine learning. PMLR, 2019, pp. 4505–4515.
- [4] A. Vaswani, N. Shazeer, N. Parmar, J. Uszkoreit, L. Jones, A. N. Gomez, Ł. Kaiser, and I. Polosukhin, "Attention is all you need," in Advances in neural information processing systems, 2017, pp. 5998–6008.