DyPO: Dynamic Pareto-Optimal Configuration Selection for Heterogeneous MpSoCs

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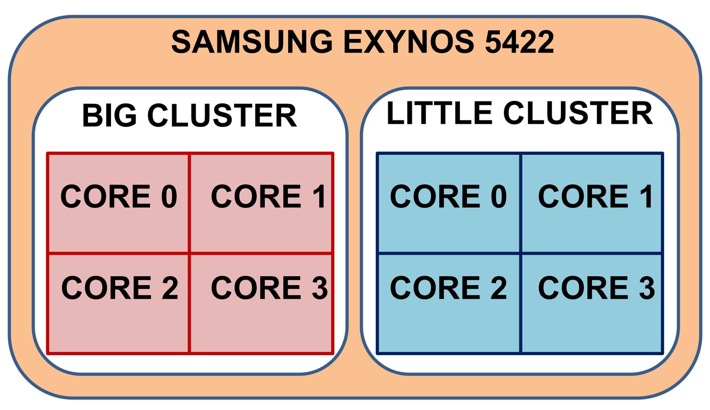
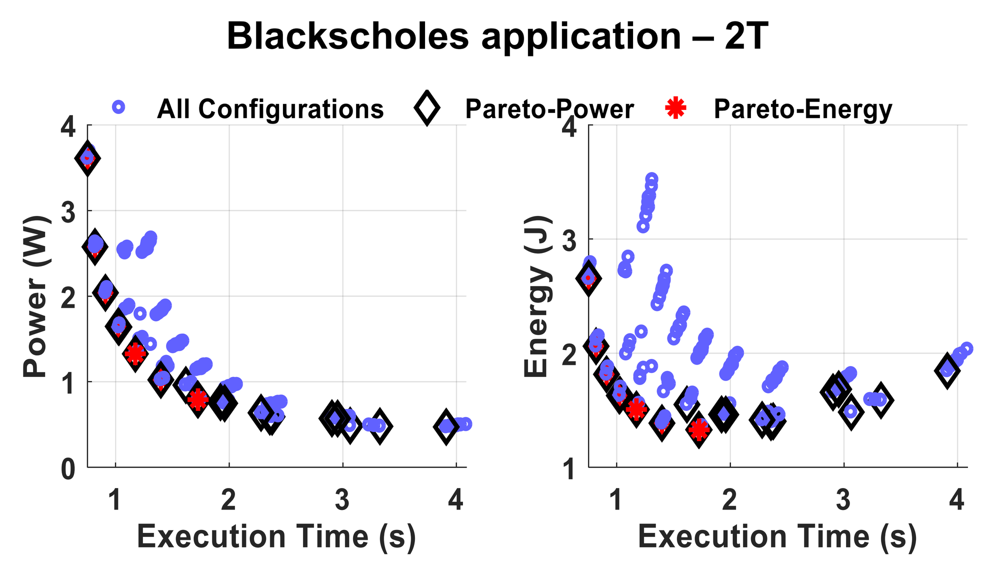
1. Motivation

- Smart phones have a highly heterogeneous processor
- Power and performance change as a function of:
  1. **Configurations**
  2. **Workloads**

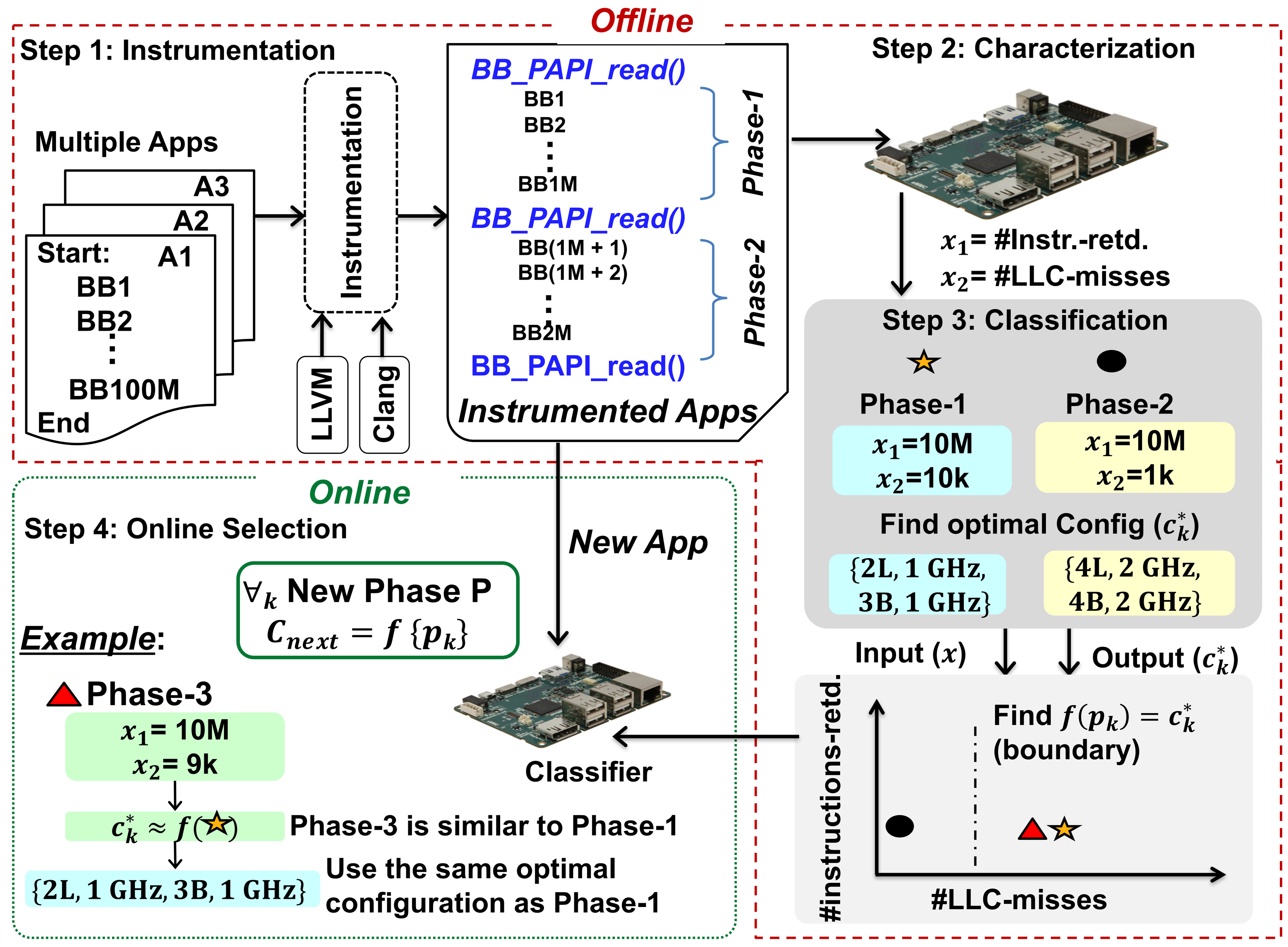


Number of configuration knobs
4004 for Samsung Exynos 5422

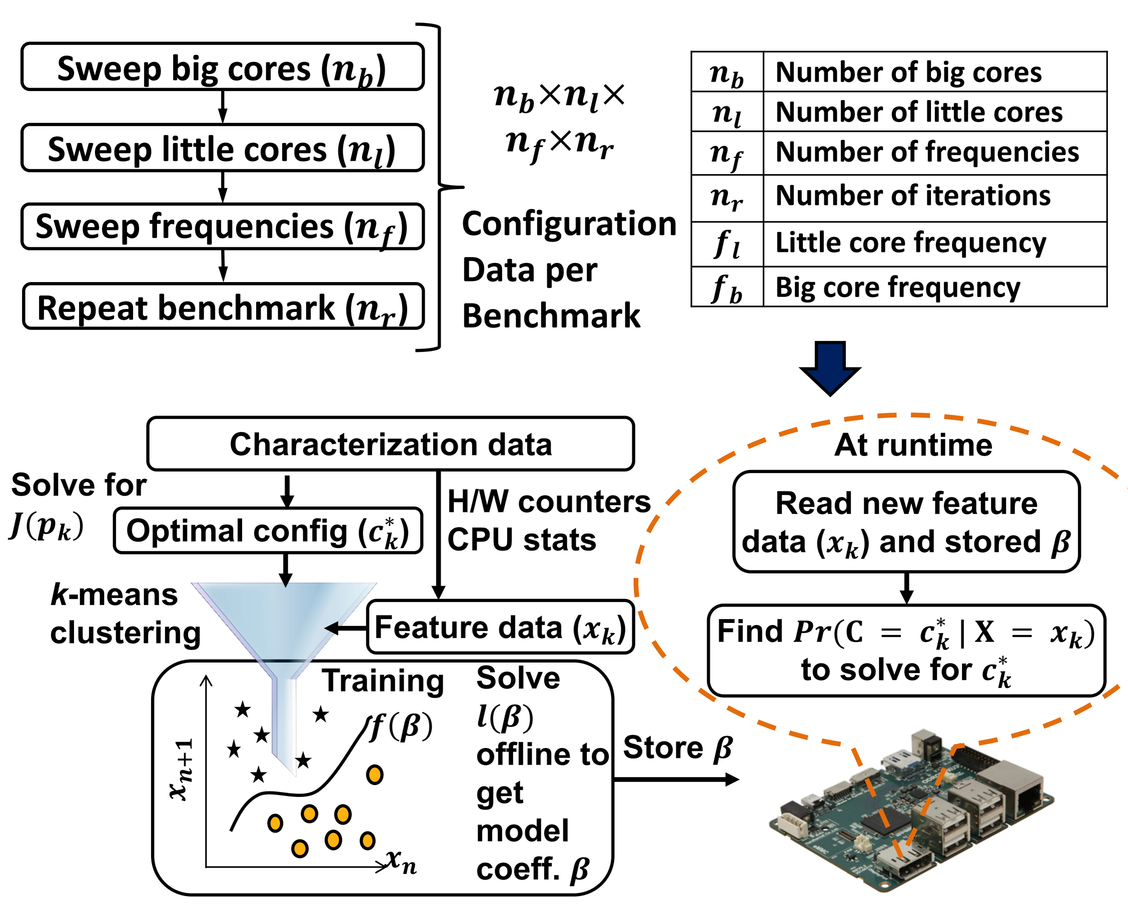


- Good Power-Performance tradeoff does not mean good Energy-Performance tradeoff
- Dynamically selecting the optimal config is challenging

2. DyPO Overview and Illustration



3. Characterization and Classification



- 3 iterations of each benchmark at different configuration
- Profile **18 benchmark**, leading to **4467 distinct workload** snippets
- Time spent for **one benchmark is about 1-2 hours**

Objective

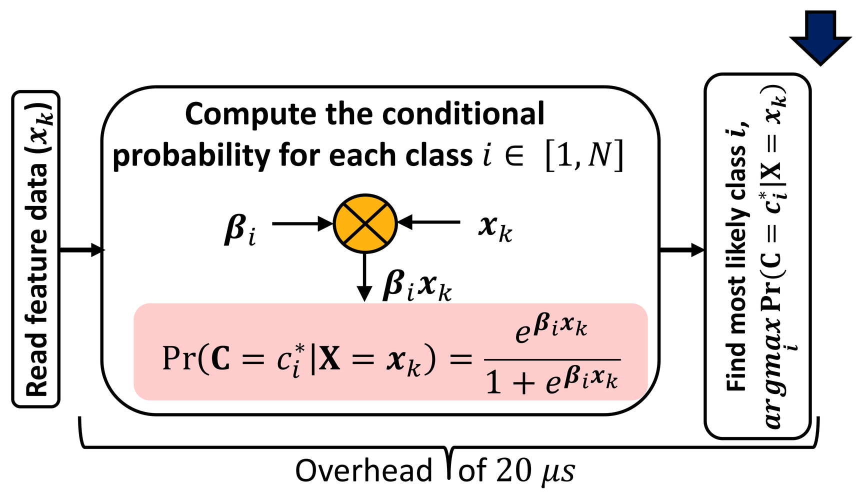
$$J(p_k) = \min_{c_k}\left[E(c_k, p_k) + \mu t_{exe}(c_k, p_k)\right]$$

Likelihood

$$l(\beta) = \prod_{k=1}^{M} \Pr(\mathrm{C} = c_k^* \mid \mathrm{X} = x_k)$$

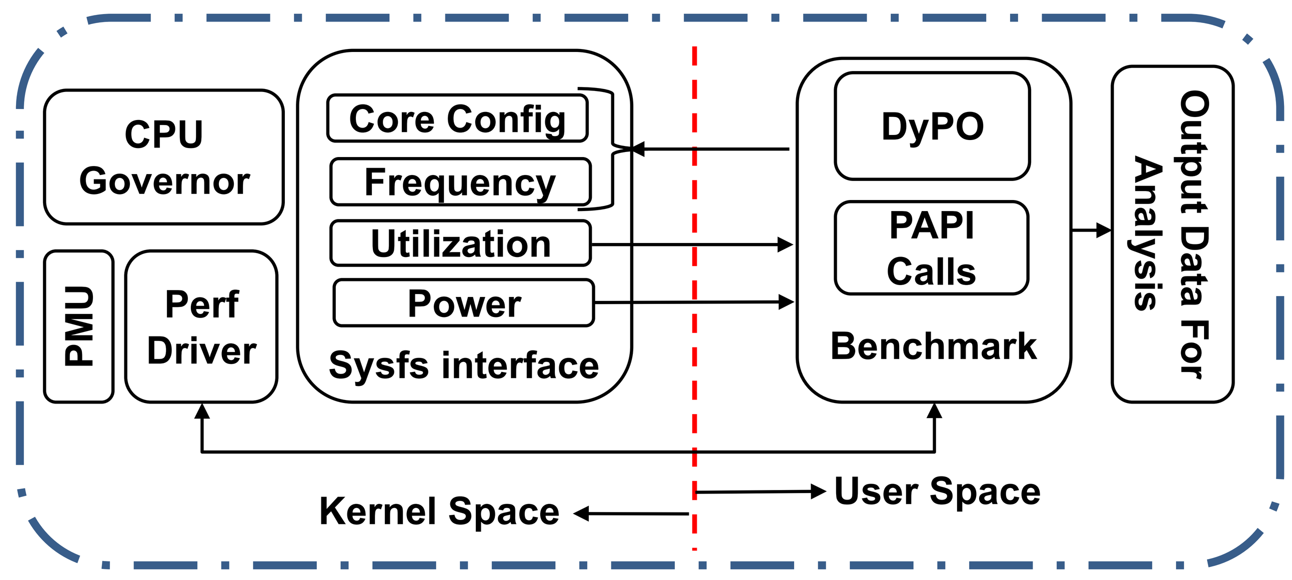
Conditional Probability

$$\Pr(\mathrm{C} = c_k^* \mid \mathrm{X} = x_k) = \frac{e^{\beta x_k}}{1 + e^{\beta x_k}}$$



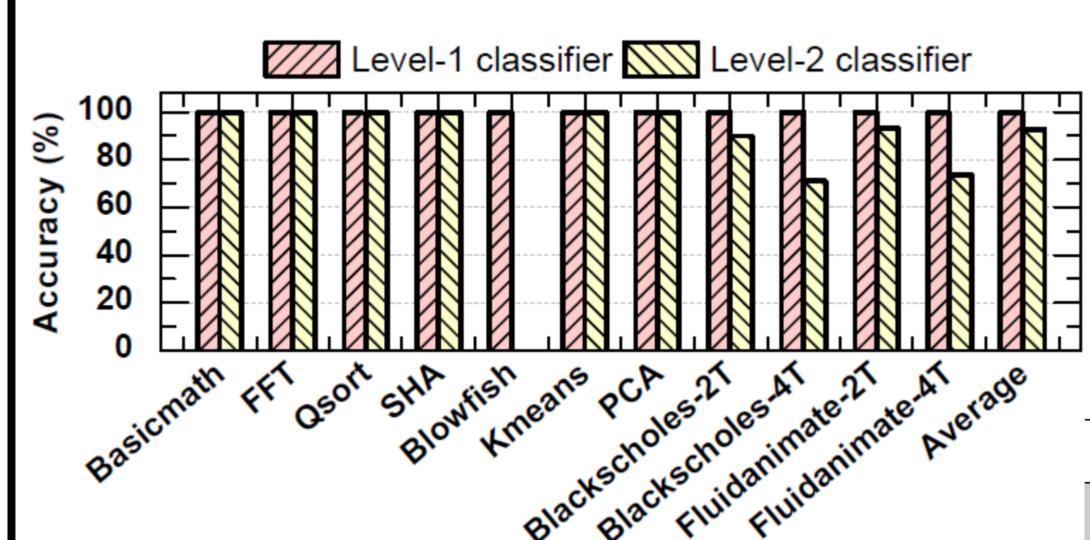
- Use the model coefficient matrix β **stored in the platform (~282 bytes)**
- **The conditional probability is computed at runtime for each of the N classes**
- The class with the highest probability is assigned to the system

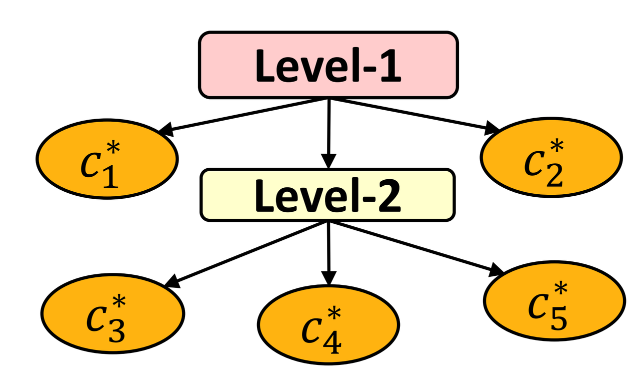
4. Experiment Setup



- **Odroid-XU3 board**
- **Exynos 5422**
- **Octa-core CPU**
- **Ubuntu OS**
- **Linux Kernel v3.10**
- **18 Applications**

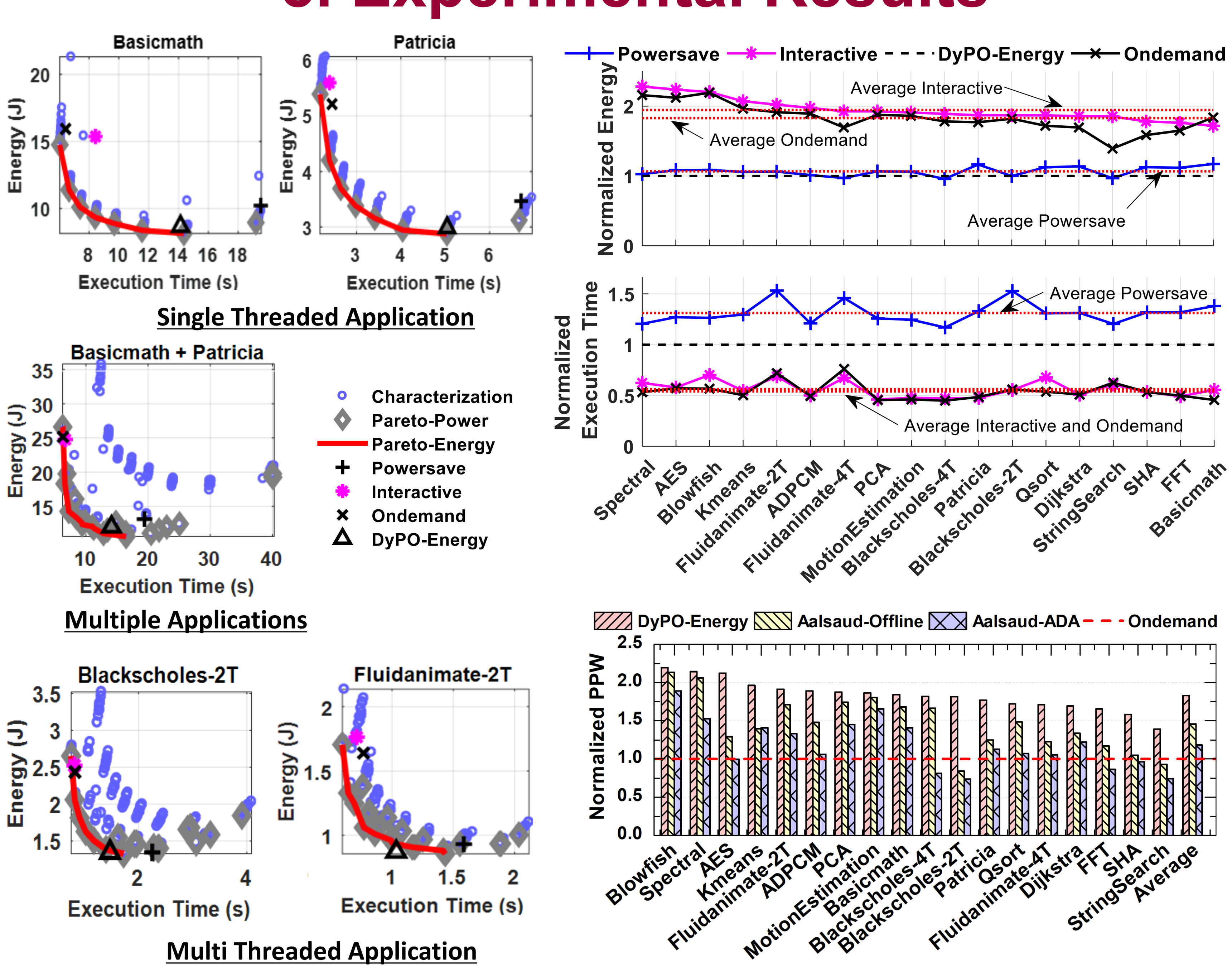
Application Level Parameters	System Level Parameters
Instructions Retired	Per Core CPU Frequency
CPU Cycles	Per Core CPU Utilization
Branch Miss Prediction	little, big, GPU and DRAM Power Consumption
Level 2 Cache Misses	Number of Active Cores
Data Memory Access	Execution Time
Noncache External Memory Request	





Classifier Accuracy	Level 1	Level 2
60% Training Validation	99.9 %	92.7 %
5-Fold Cross Validation	99.9 %	80.5 %

5. Experimental Results



6. Conclusions

- **Our technique successfully finds the Pareto-optimal configurations at runtime as a function of the workload [1]**
- **DyPO-Energy achieves 25% and 55% gain in PPW compared to Aalsaud*-Offline and Aalsaud*-ADA [2], respectively**
- **Experiments show 93%, 81% and 6% larger performance per watt (PPW) compared to the interactive, ondemand and powersave governors**
- **The details can be found in [1].**

References

[1] Ujjwal Gupta, Chetan Arvind Patil, Ganapati Bhat, Prabhat Mishra, and Umit Y. Ogras. "DyPO: Dynamic Pareto Optimal Configuration Selection for Heterogeneous MpSoCs," in ACM Tran. on Embedded Comp. Sys. (ESWEEK Special Issue), October 2017

[2] A. Aalsaud et al., "Power–Aware Performance Adaptation of Concurrent Applications in Heterogeneous Many-Core Systems," in Proc. of the Intl. Symp. on Low Power Elec. and Design, 2016, pp. 368–373.

Acknowledgement

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