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## ► To cite this version:

Matthieu Rodet, Jean-Luc Béchenec, Mikaël Briday, Sébastien Faucou, Isabelle Puaut, et al.. Circadia: Checkpointing for Intermittent Computing in AI Driven Applications. ACACES 2025 - 21st International Summer School on Advanced Computer Architecture and Compilation for High-performance Embedded Systems, Jul 2025, Salerno, Italy. 2025. ⟨hal-05340610⟩

**HAL Id: hal-05340610**

**<https://hal.science/hal-05340610v1>**

Submitted on 31 Oct 2025

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# Circadia: Checkpointing for Intermittent Computing in AI Driven Applications



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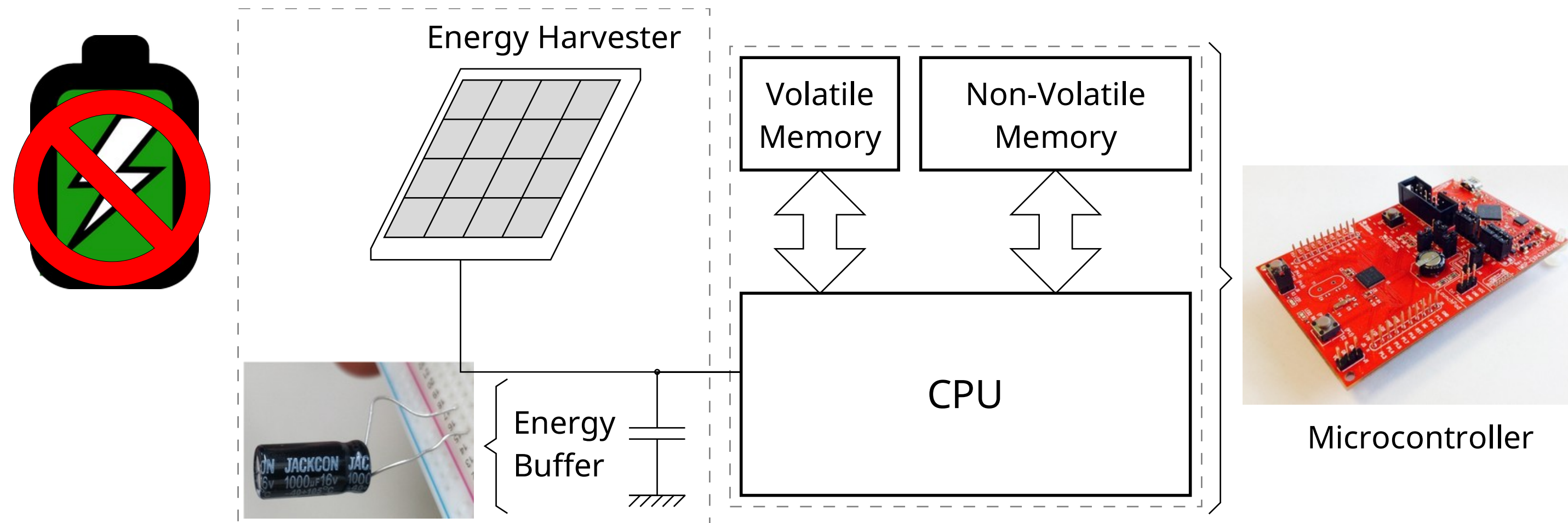
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## 1. Intermittent Computing

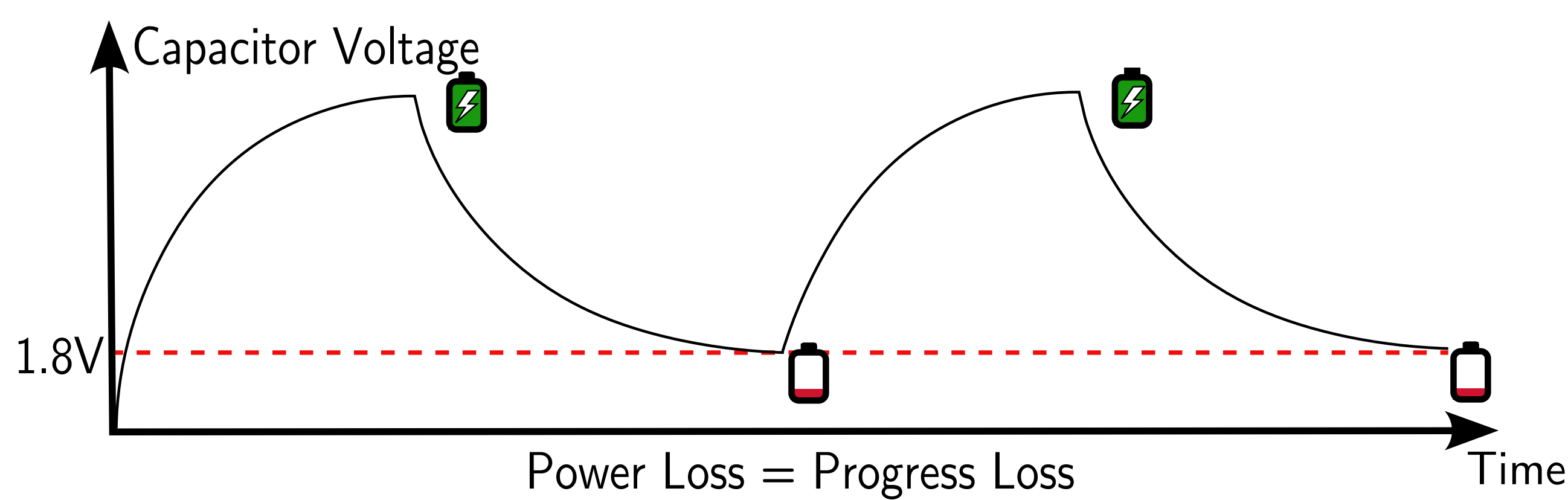
Battery-less sensors: Replacing battery by

- energy harvester (*solar panel, RF harvester*)
- energy buffer (*(super-)capacitor*)



- lower maintenance needs
- deployed in remote locations (*space, forest*)

**Problem:** frequent and unexpected shutdowns → volatile state reset (register, volatile memory) → progress loss



**Solution:** Checkpoints to save progress

## 3. Circadia's Algorithm

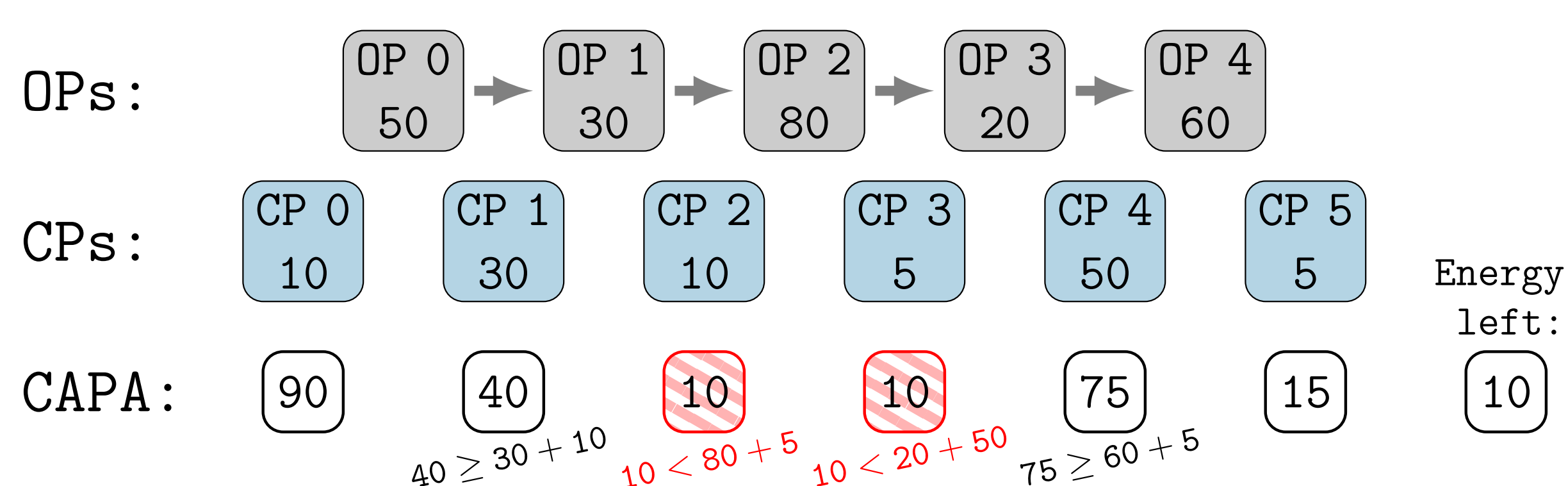
### • Inputs

- elementary operations (OPs)
- Worst Case Energy Consumption (WCEC) of OPs
- WCEC of checkpoints (CPs)
- System's capacitor energy capacity (CAPA)

### • Output

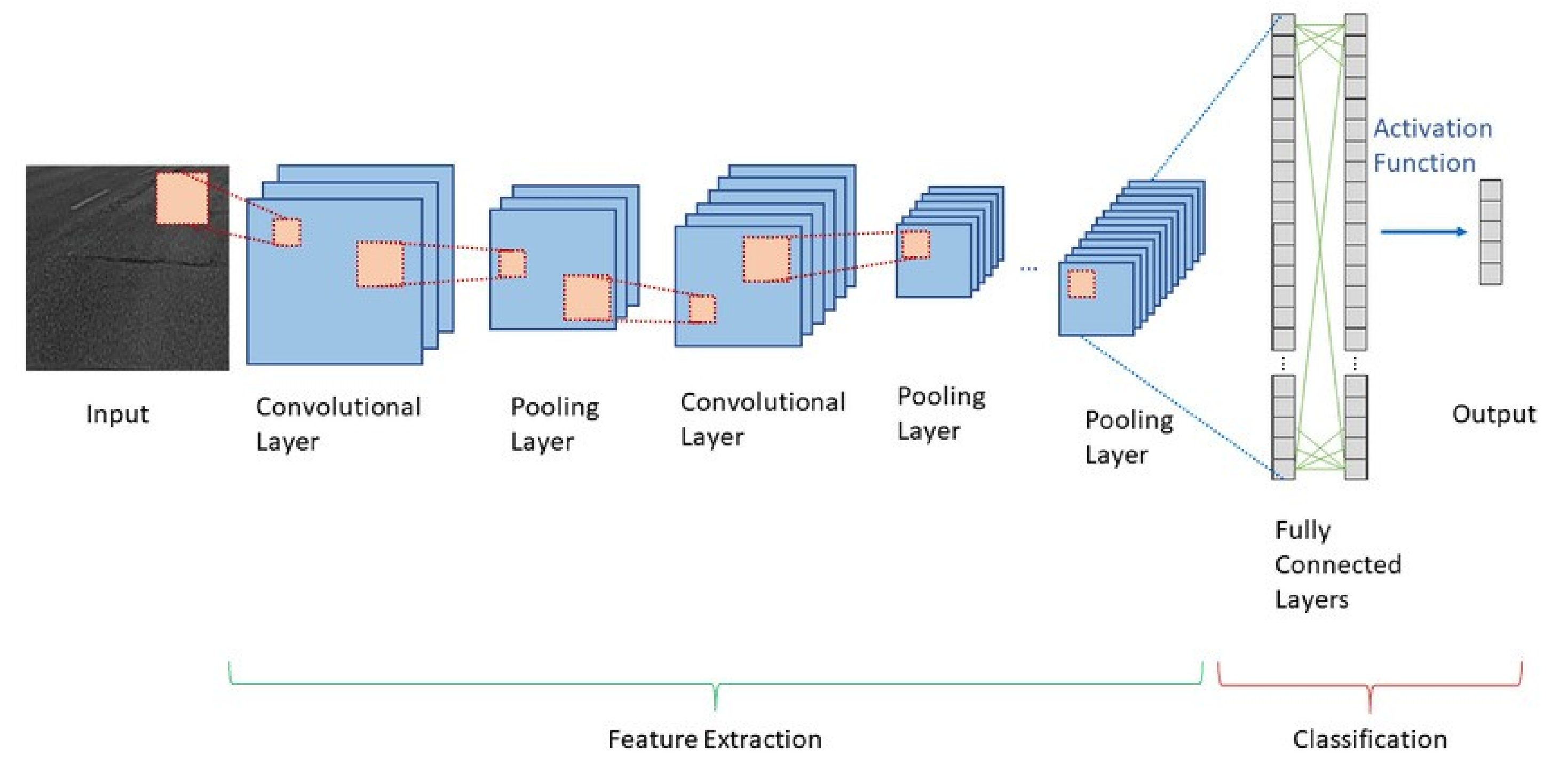
- Indexes of selected checkpoints

**Execution scheme:** checkpoint = halt to collect energy  
**Circadia:** greedy approach, start with full CAPA, decreased for each OP until not enough. Places checkpoint and restart with full CAPA. Example with CAPA=100:



## 2.1 CNN Architecture

Convolution Neural Networks: sequence of layers



- Convolutional + Pooling to extract patterns
- Dense (fully connected) to classify the input

## 2.2 CNN division

Where can we place checkpoints?

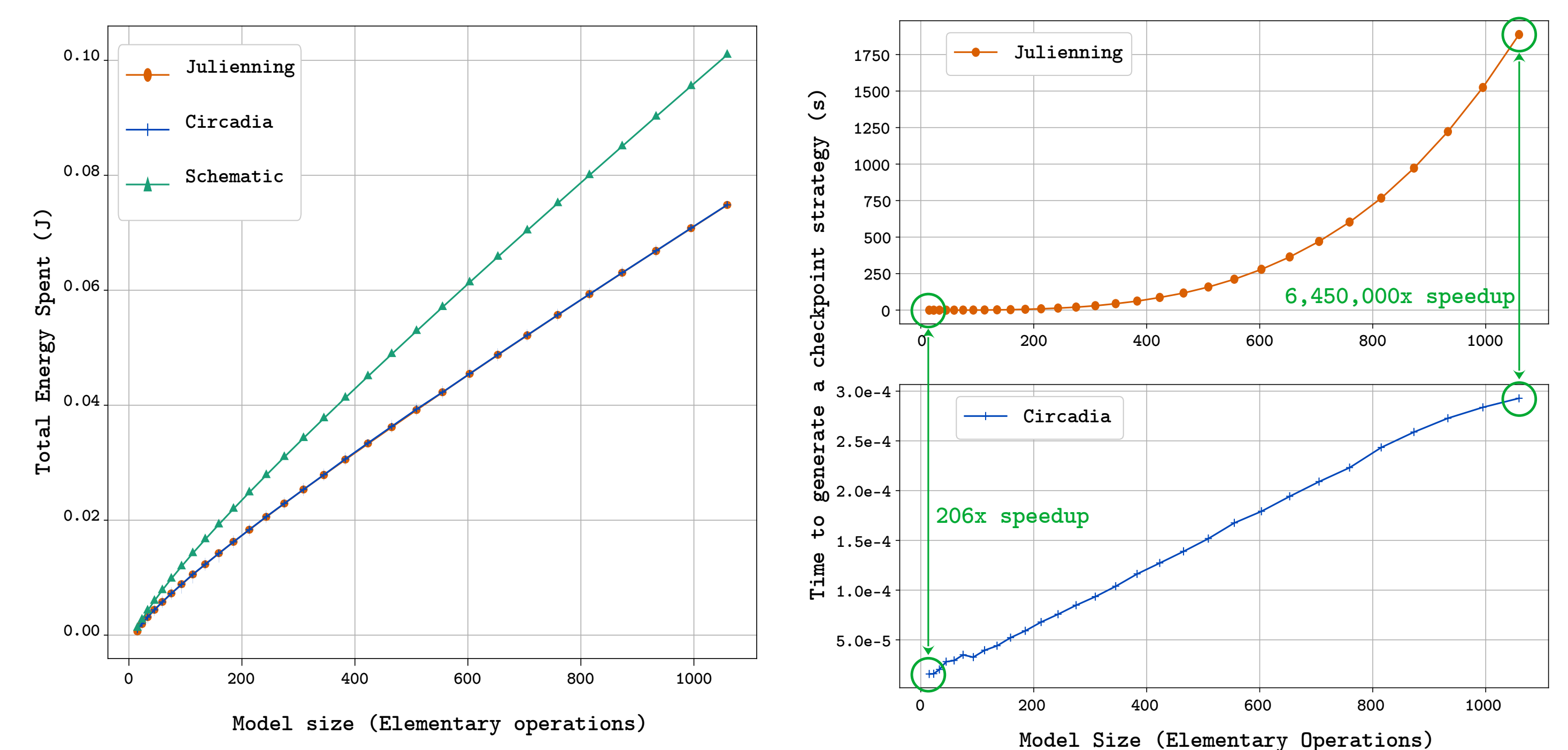
- Layer division into elementary operations:

- Convolutional layer: sequence of matrix convolutions (application of a small kernel over a bigger matrix)
- Pooling: sequence of matrix local maximum/average
- Dense: unique matrix multiplication

## 4. Experimental Results

Baselines:

- Schematic: general-purpose approach
- Juliënning: energy-optimal CNN-dedicated approach



- Dedicated algorithms reduce energy spent by 35%
- Circadia is nearly as energy efficient as Juliënning
- Circadia is way faster and scalable than Juliënning

## Funding Project: ANR-23-IAS3-0003

The authors acknowledge the ANR – FRANCE (French National Research Agency) for its financial support of the OWL project n°ANR-23-IAS3-0003. The OWL ANR project proposes a new model of computation for more frugal intelligent autonomous sensors: circadian artificial intelligence. The targeted applications are in the field of environmental monitoring, especially bioacoustic and its application in conservation ecology. This model is well suited for sensors without batteries that are intermittently powered by ambient energy.

