MEANTIME: Achieving Both Minimal Energy and Timeliness with Approximate Computing

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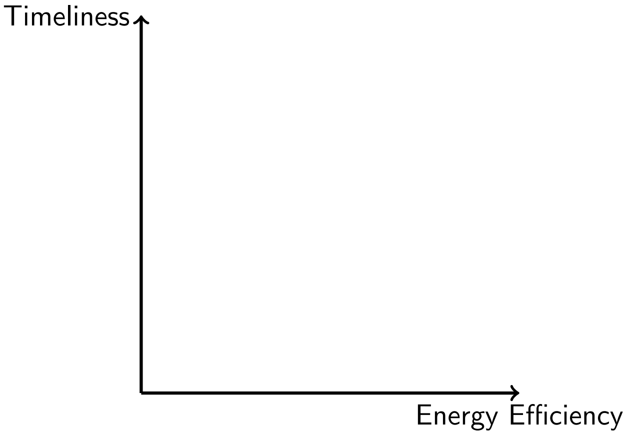
University of Chicago

USENIX ATC 2016

Problem



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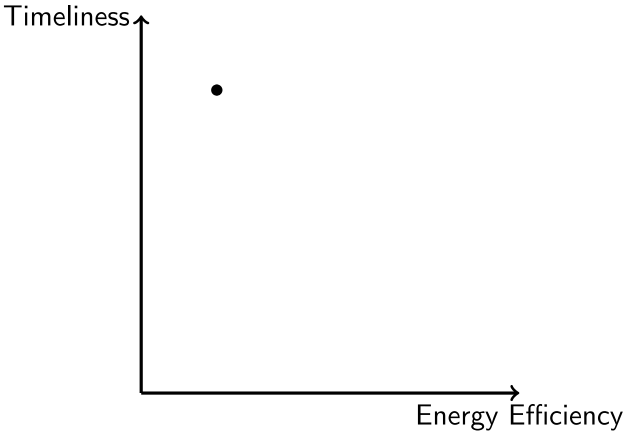

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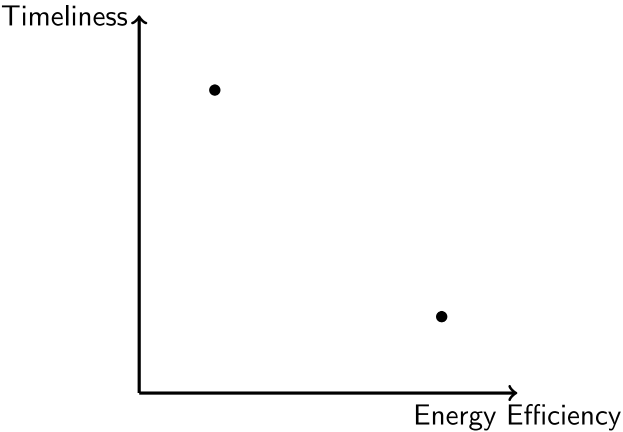

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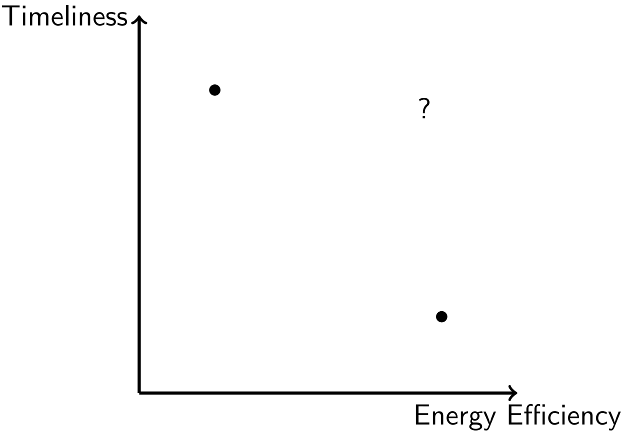

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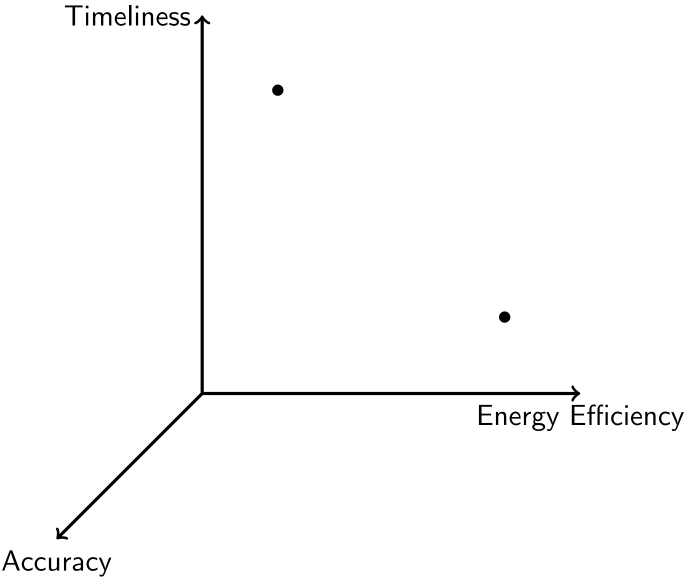

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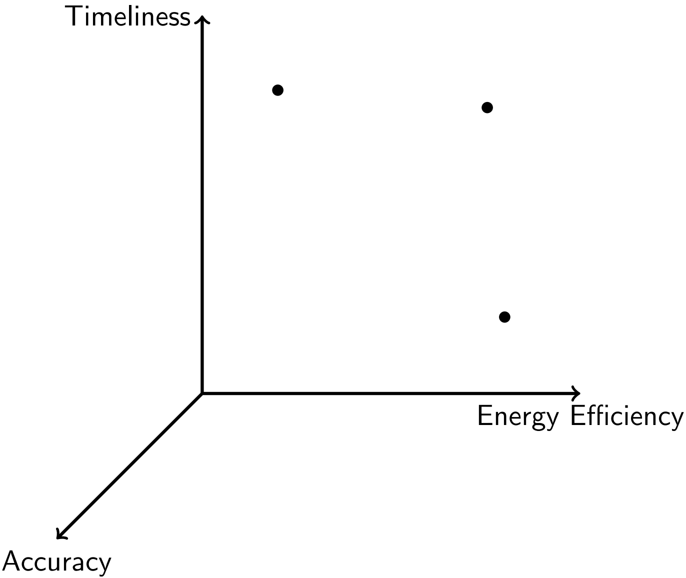

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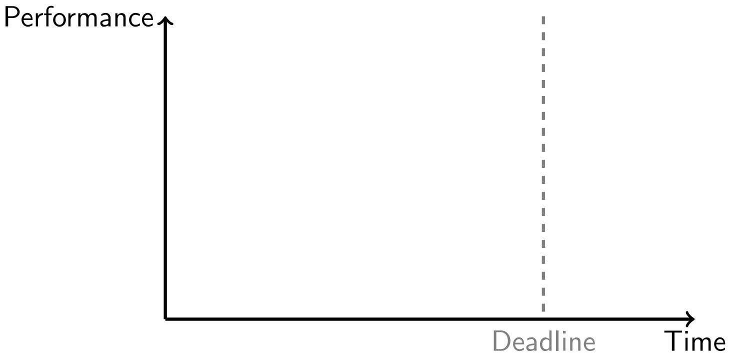
Techniques



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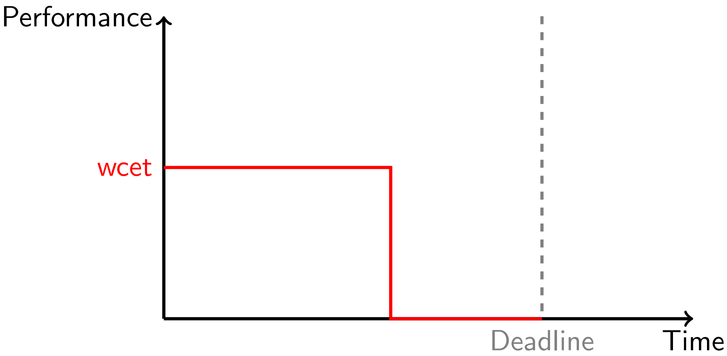

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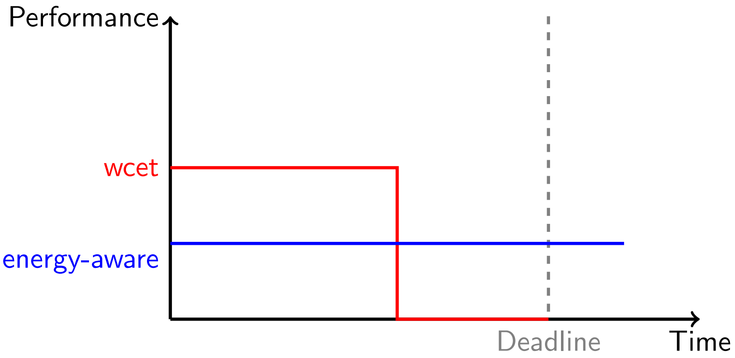

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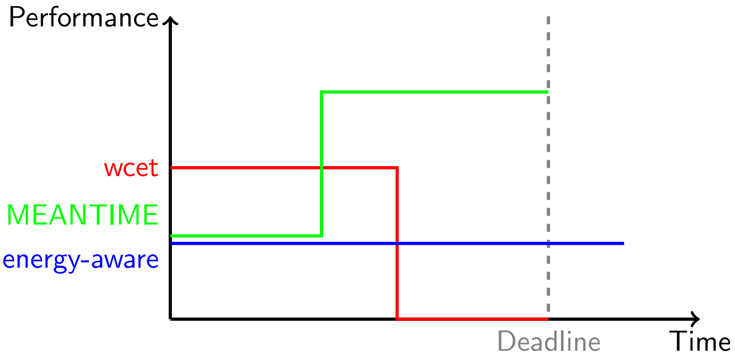

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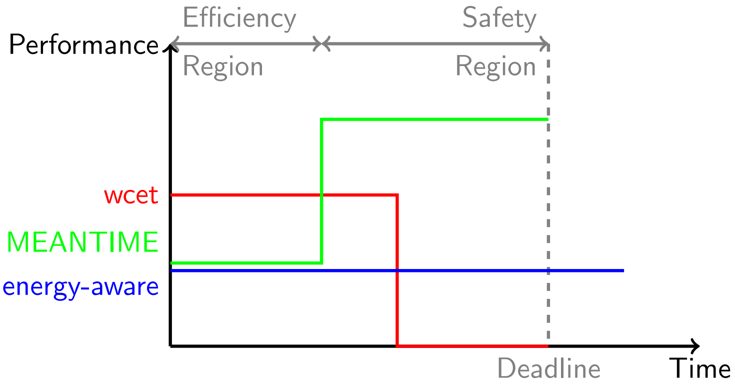

Efficiency
Region
Safety
Region
Performance
wcet
MEANTIME
energy-aware
Deadline
Time

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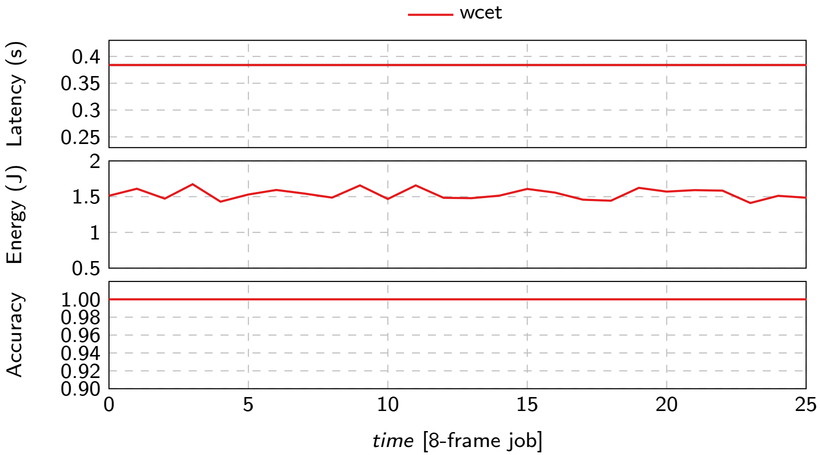
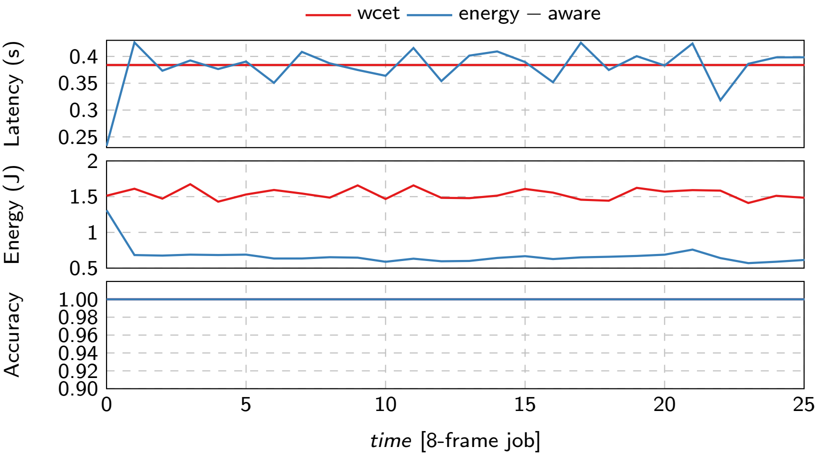
Radar



wcet
Latency (s)
0.4
0.35
0.3
0.25
Energy (J)
2
1.5
1
0.5
Accuracy
1.00
0.98
0.96
0.94
0.92
0.90
0
5
10
15
20
25
time [8-frame job]

Radar



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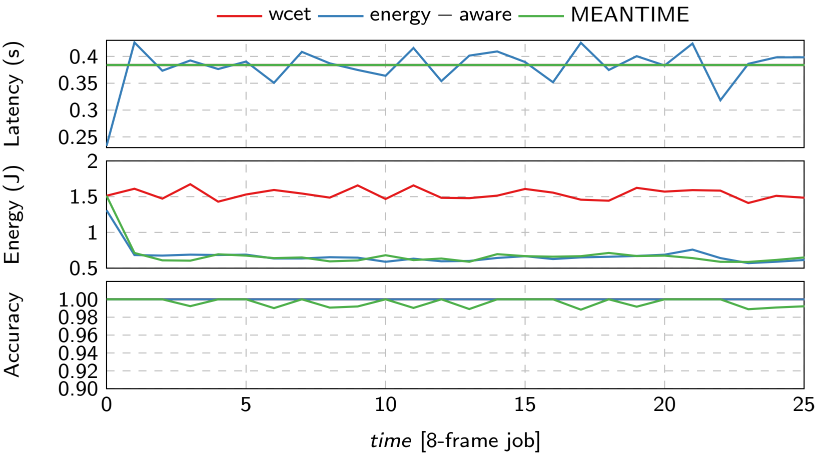
Radar



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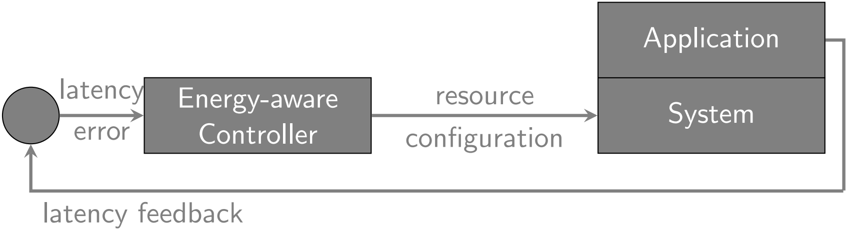

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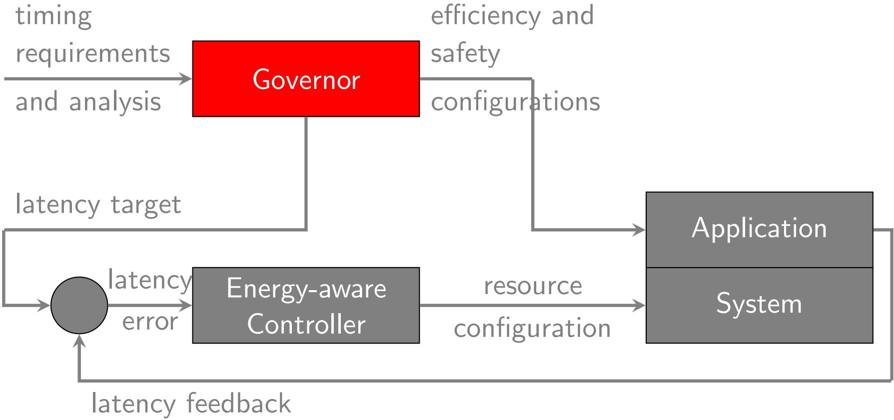

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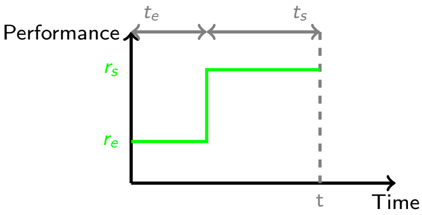
Governor



$$t_s \cdot r_s + t_e \cdot r_e = W$$

$$t_s + t_e + t_{switch} = t$$

$$t_s, t_e \geq 0$$

Variable	Meaning
W	job workload in worst case
t_{switch}	worst case time to switch app. and sys. config.
s_0	minimum speedup from approximation
t_{wc}	worst case latency

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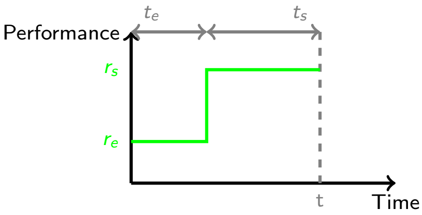

$$t_s \cdot r_s + t_e \cdot r_e = W$$

$$t_s + t_e + t_{switch} = t$$

$$t_s, t_e \geq 0$$

$$t_e = \frac{t_{wc} - s_0 \cdot (t - t_{switch})}{1 - s_0}$$

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Experimental Setup

Hardware:

- Platform
  - ODROID-XU3
- Processor
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- big.LITTLE
  - 8 cores
    - 4 big A15 cores
    - 4 LITTLE A7 cores
- Configurations
  - 128

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Applications:

- x264
- bodytrack
- swaptions
- ferret
- streamcluster
- radar

Approaches Evaluated

- wcet
  - reserve resources for worst case and then sleep
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- energy-aware
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  - [PowerDial ASPLOS 2011] [2]

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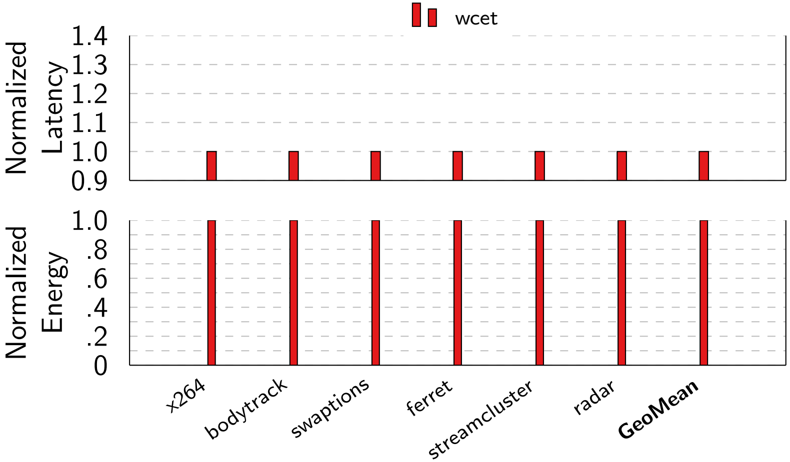
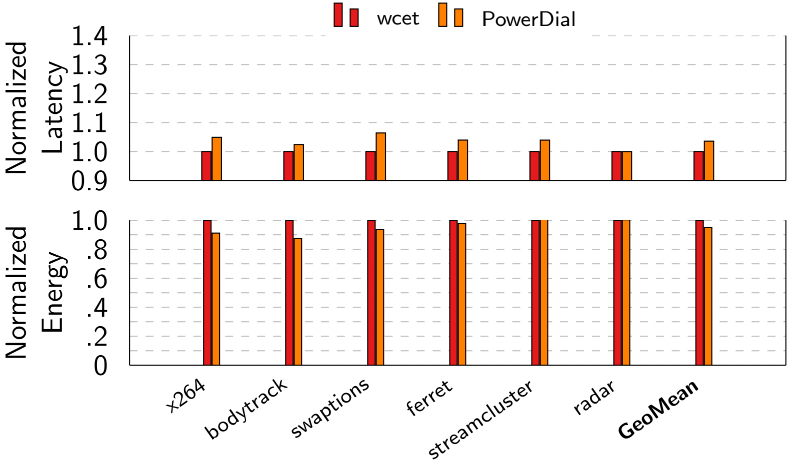
- optimal
  - found by running every configuration

Results



wcet
Normalized Latency
1.4
1.3
1.2
1.1
1.0
0.9
Normalized Energy
1.0
.8
.6
.4
.2
0
x264
bodytrack
swaptions
ferret
streamcluster
radar
GeoMean

Results



wcet
PowerDial
Normalized Latency
1.4
1.3
1.2
1.1
1.0
0.9
Normalized Energy
1.0
.8
.6
.4
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0
x264
bodytrack
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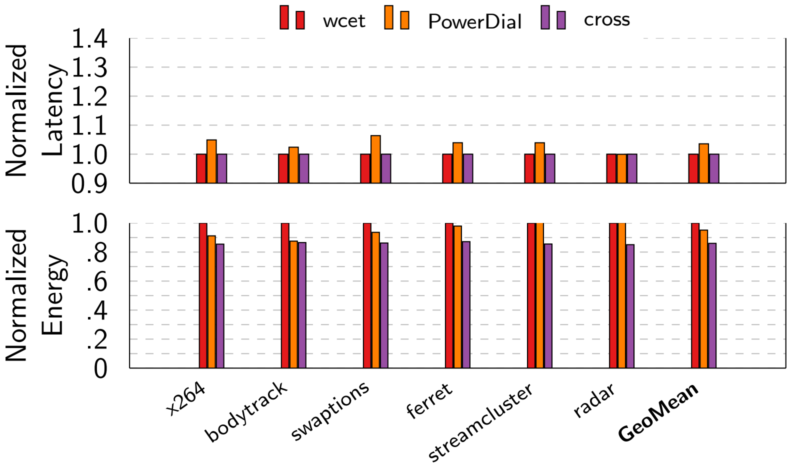
Results



wcet
PowerDial
cross
Normalized Latency
1.4
1.3
1.2
1.1
1.0
0.9
Normalized Energy
1.0
.8
.6
.4
.2
0
x264
bodytrack
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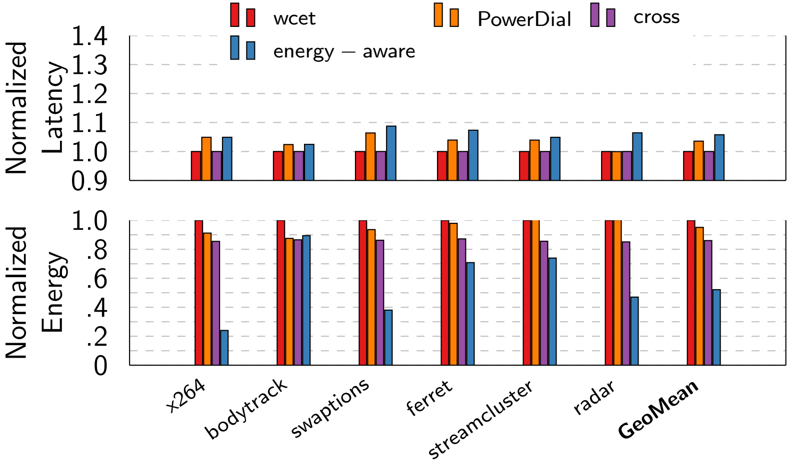
Results



wcet
PowerDial
cross
energy − aware
Normalized Latency
1.4
1.3
1.2
1.1
1.0
0.9
Normalized Energy
1.0
.8
.6
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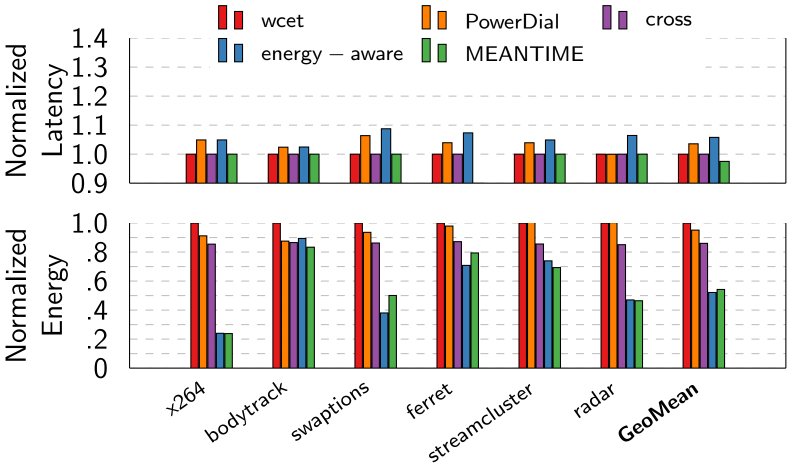

wcet
PowerDial
cross
energy — aware
MEANTIME
Normalized Latency
1.4
1.3
1.2
1.1
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0.9
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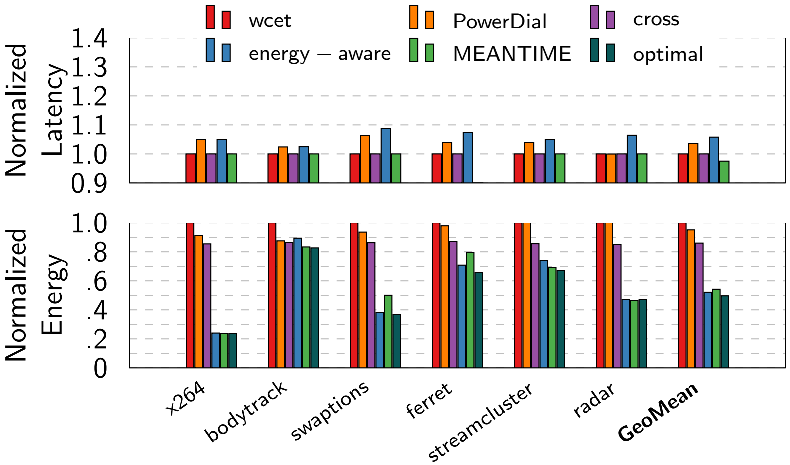

wcet
PowerDial
cross
energy − aware
MEANTIME
optimal
Normalized Latency
1.4
1.3
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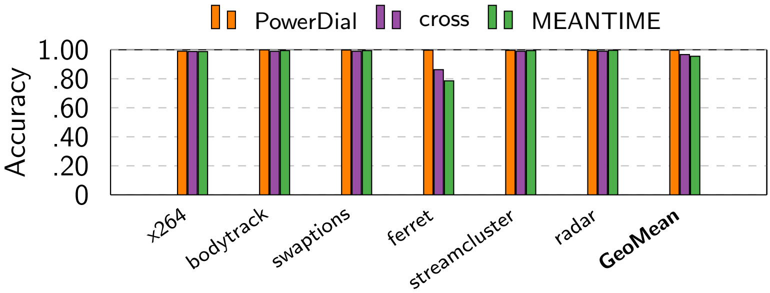
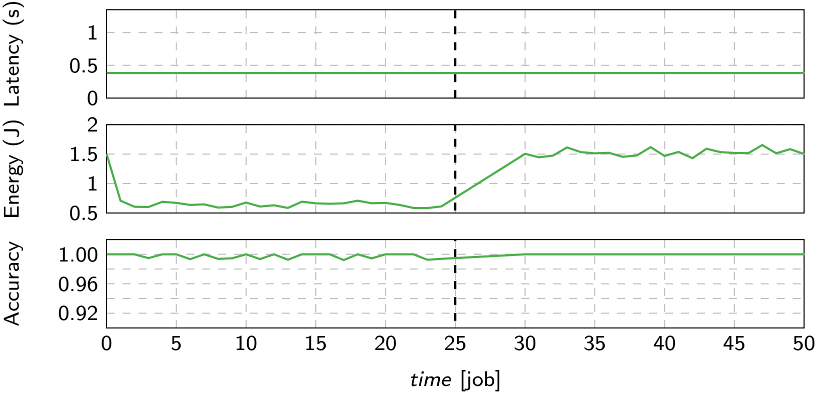
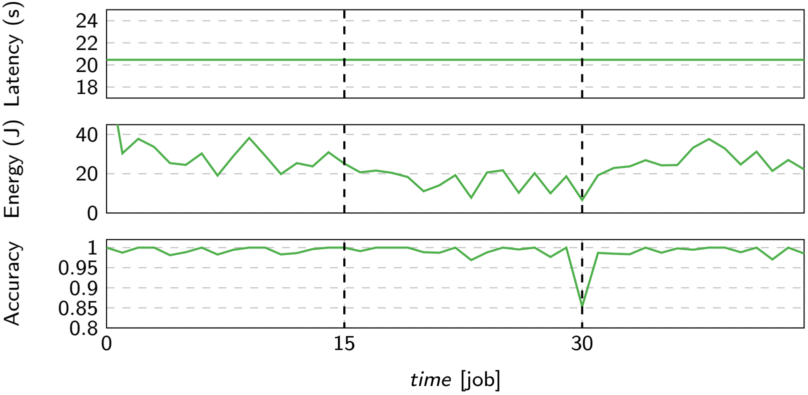


PowerDial
cross
MEANTIME
Accuracy
1.00
.80
.60
.40
.20
0
x264
bodytrack
swaptions
ferret
streamcluster
radar
GeoMean

Changing accuracy goals



Phases



Latency (s)
24
22
20
18
Energy (J)
40
20
0
Accuracy
1
0.95
0.9
0.85
0.8
0
15
30
time [job]

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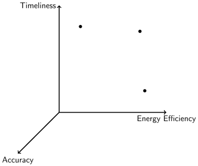

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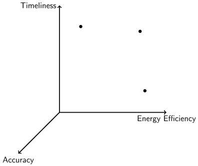

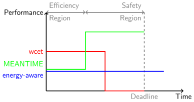

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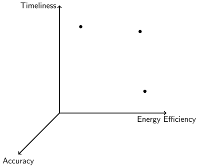

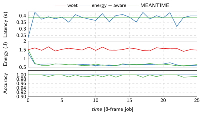

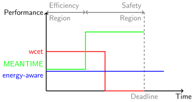

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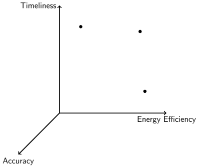

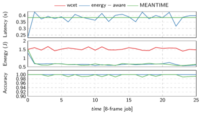

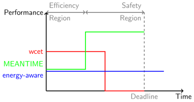

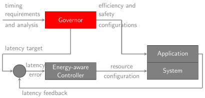

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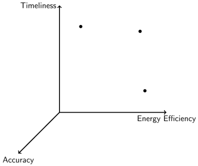

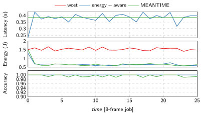

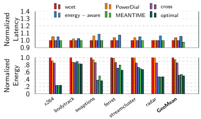

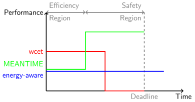

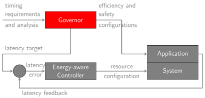

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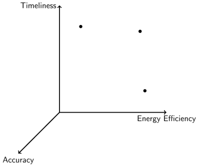

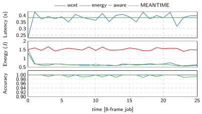

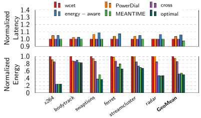

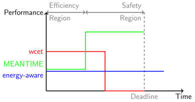

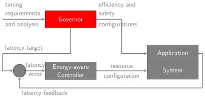

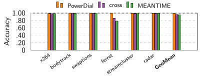

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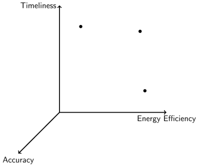
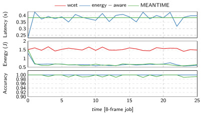
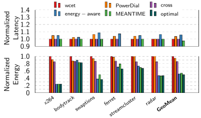
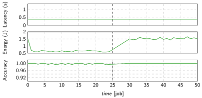
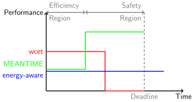
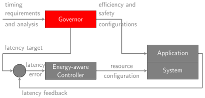


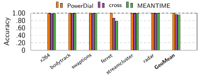




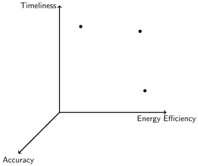


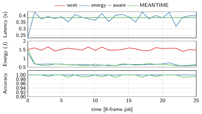


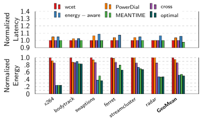


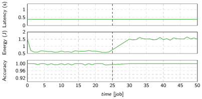


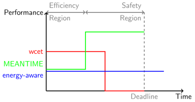
MEANTIME: Achieving Both Minimal Energy and Timeliness with Approximate Computing

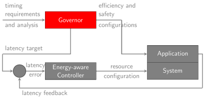


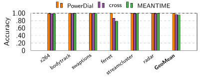


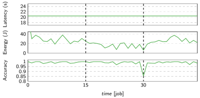












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