# ACR:

# Amnesic Checkpoint and Recovery

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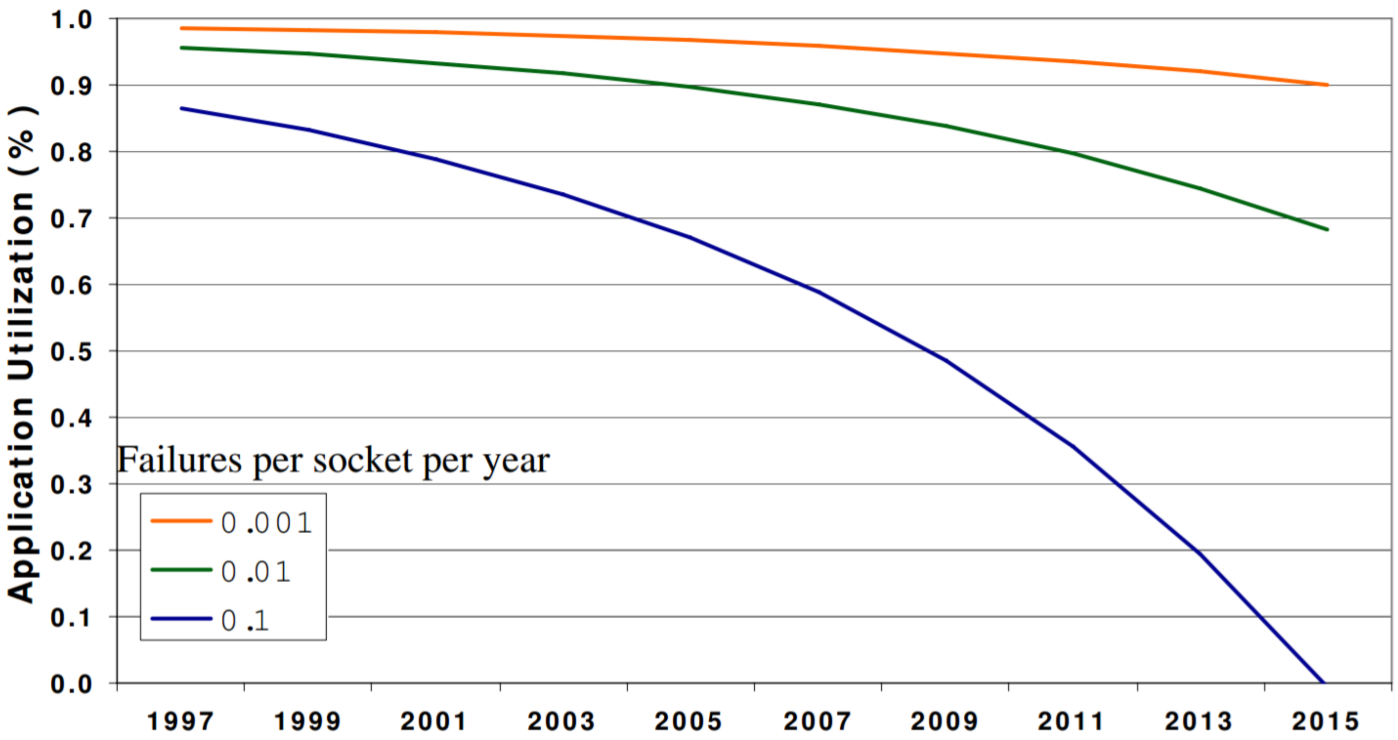
# Motivation




P. Kogge, et al., “Exascale computing study: Technology challenges in achieving exascale systems,” 2008.

# Amnesic Checkpointing and Recovery

- **Challenge:**
  - Checkpoint &rollback/recovery overheads quickly dominates as the failure rate increases
  - Need to find ways to mitigate Checkpoint &rollback/recovery overheads
- **Idea:** reduce the volume of data to be checkpointed by relying on cost-effective **recomputation**
  - Eliminate values from checkpoint set if they are recomputable (cost effectively)
  - Recomputation of eliminated values is necessary only on recovery (which is less frequent than checkpointing)

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$$o_{recovery,ACR} \leq o_{recovery} \quad \textbf{\textit{iff}} \quad (o_{rollback,ACR} + o_{recomp,ACR}) \leq o_{rollback}$$

# Baseline Checkpointing

- Global checkpointing
- In-memory
- Log-based

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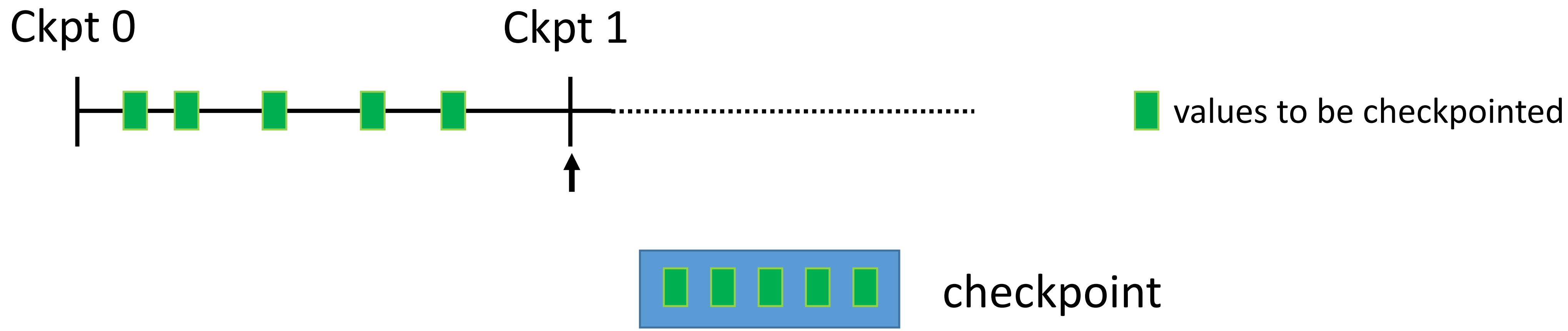

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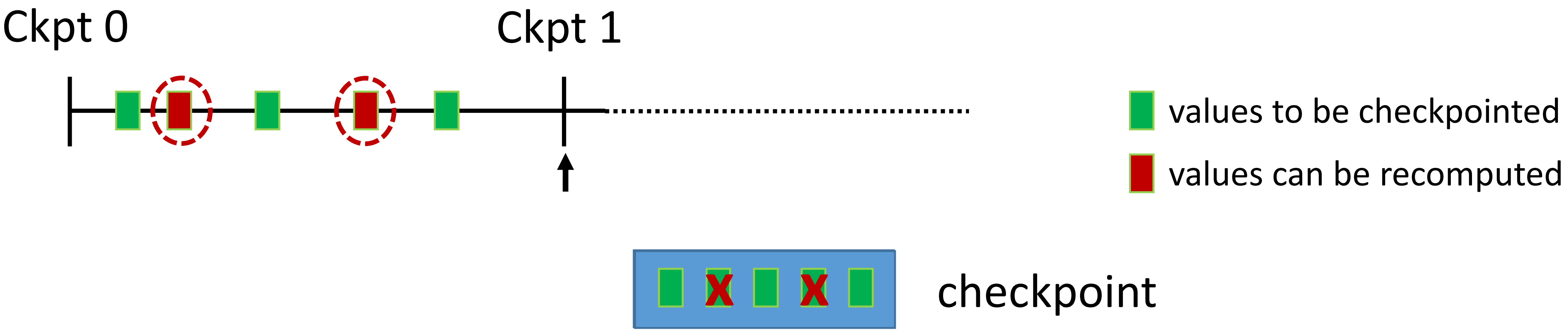

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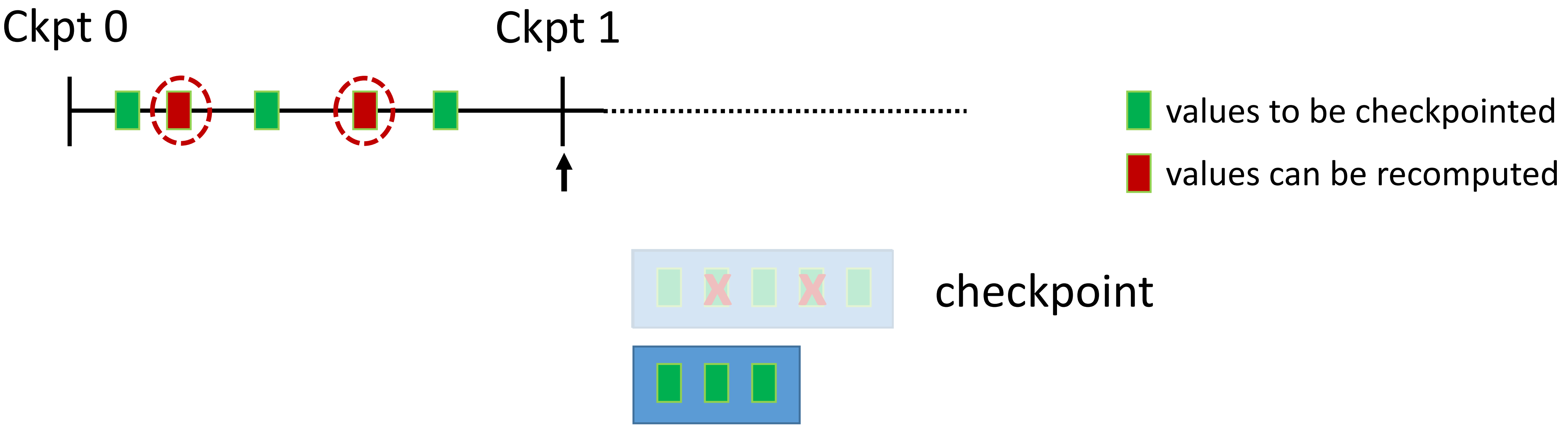

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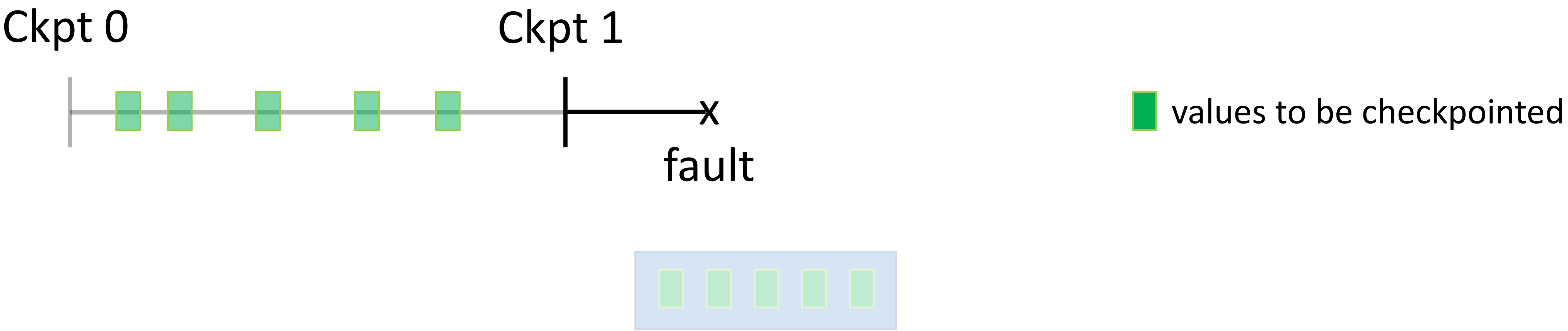

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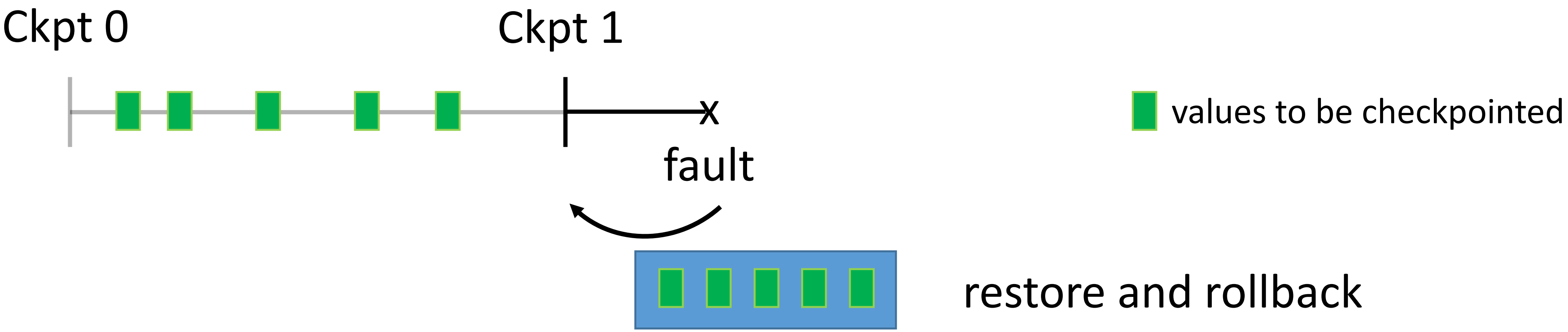

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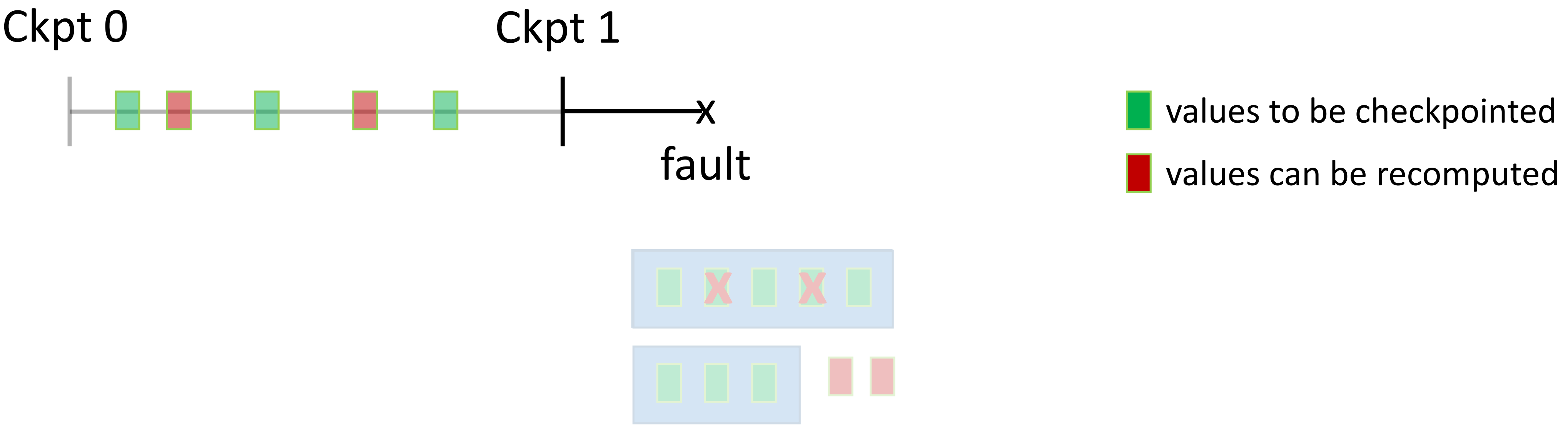

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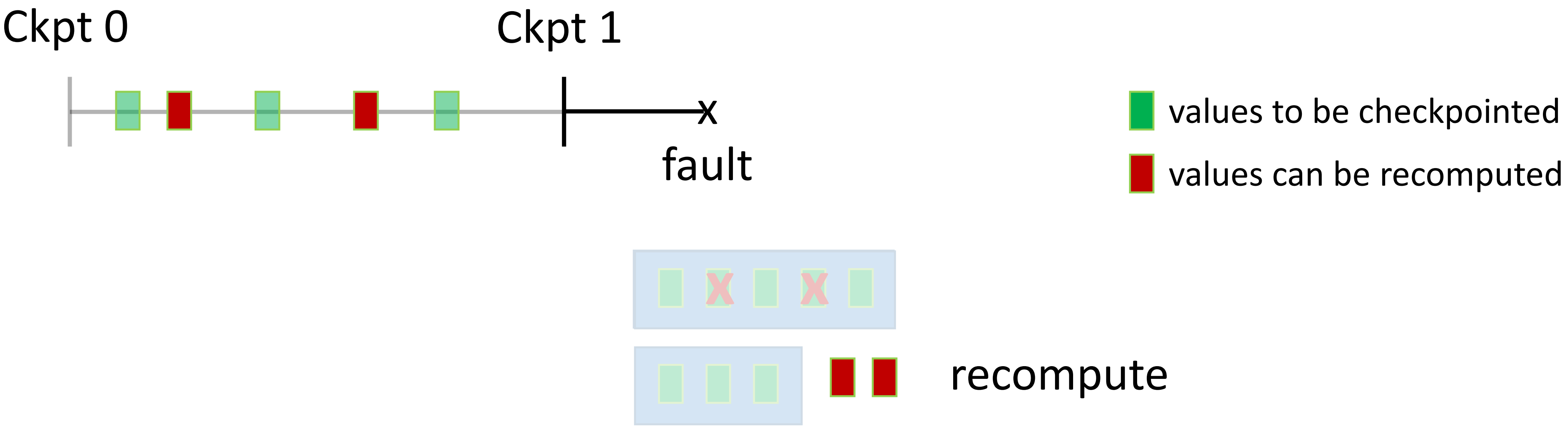

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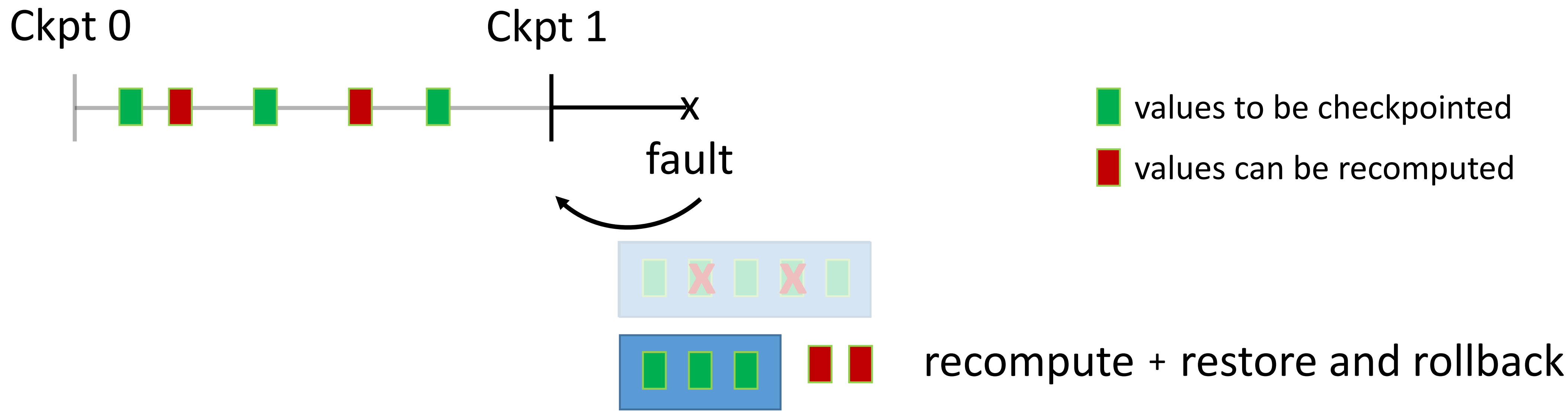

# How to Recompute a Value?

```
int sumArr[10]
load (i)
load (j)
load (k)
k = i / j
while ( i <= 10 )
    sumArr[i] = i +j
    j = i * j
    incr i
    if (k > 1 )
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store (sumArr)
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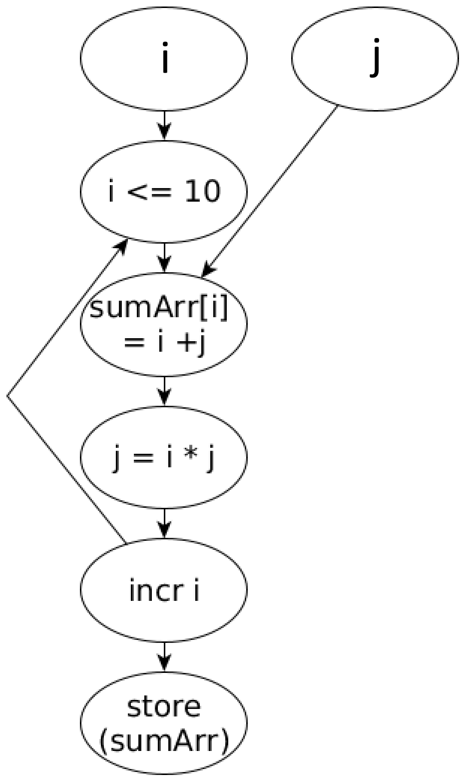

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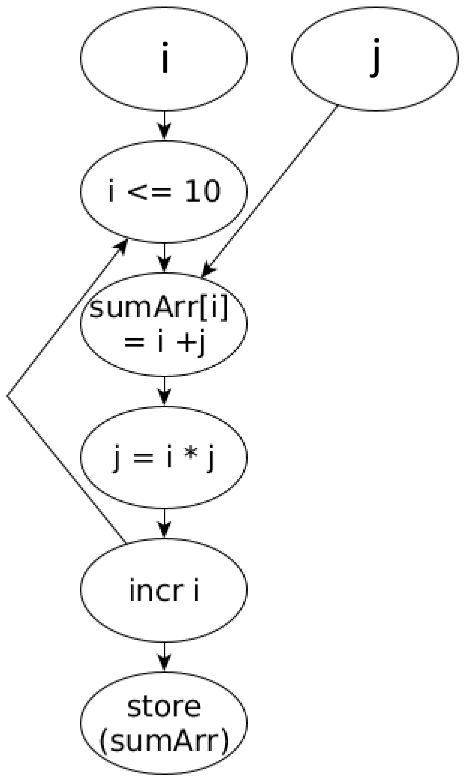


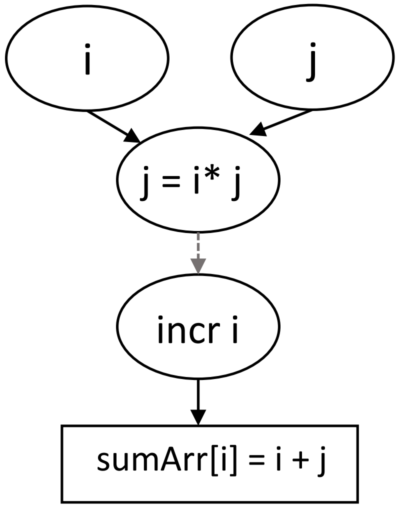

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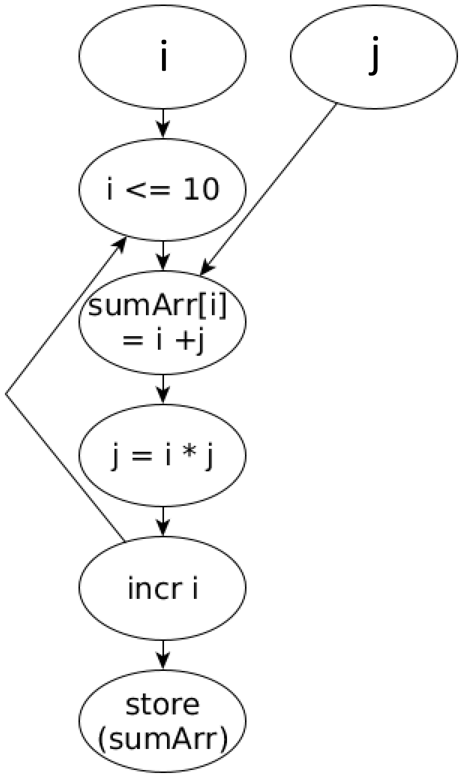
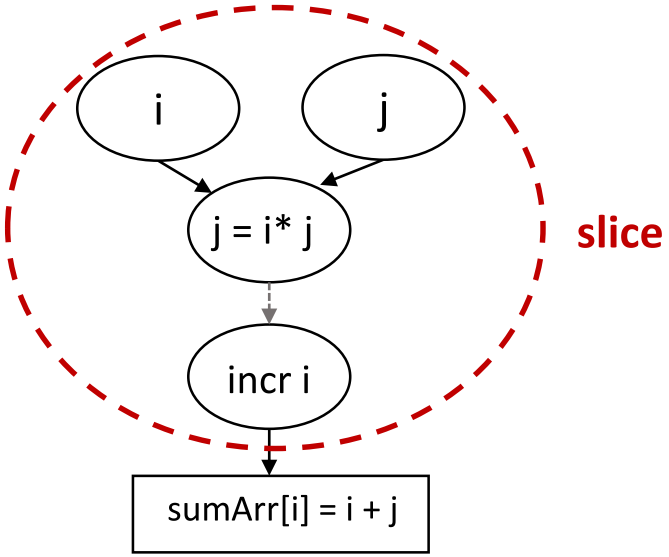
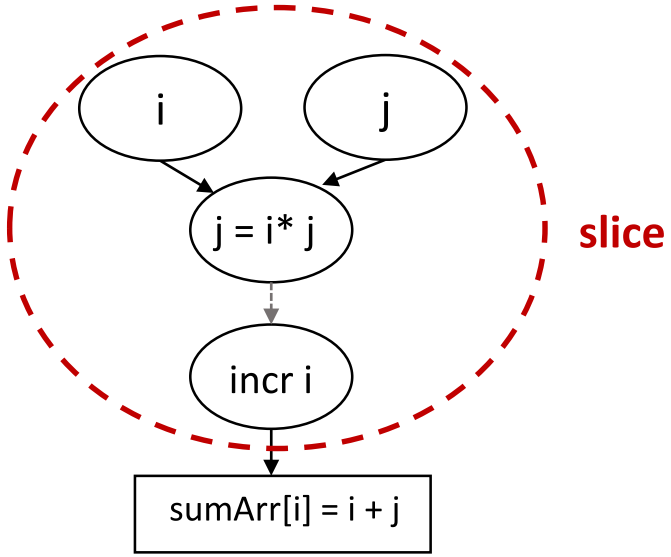


# How to form Slices?

- Compiler identifies them
  - Select cost-effective ones (i.e., short ones)

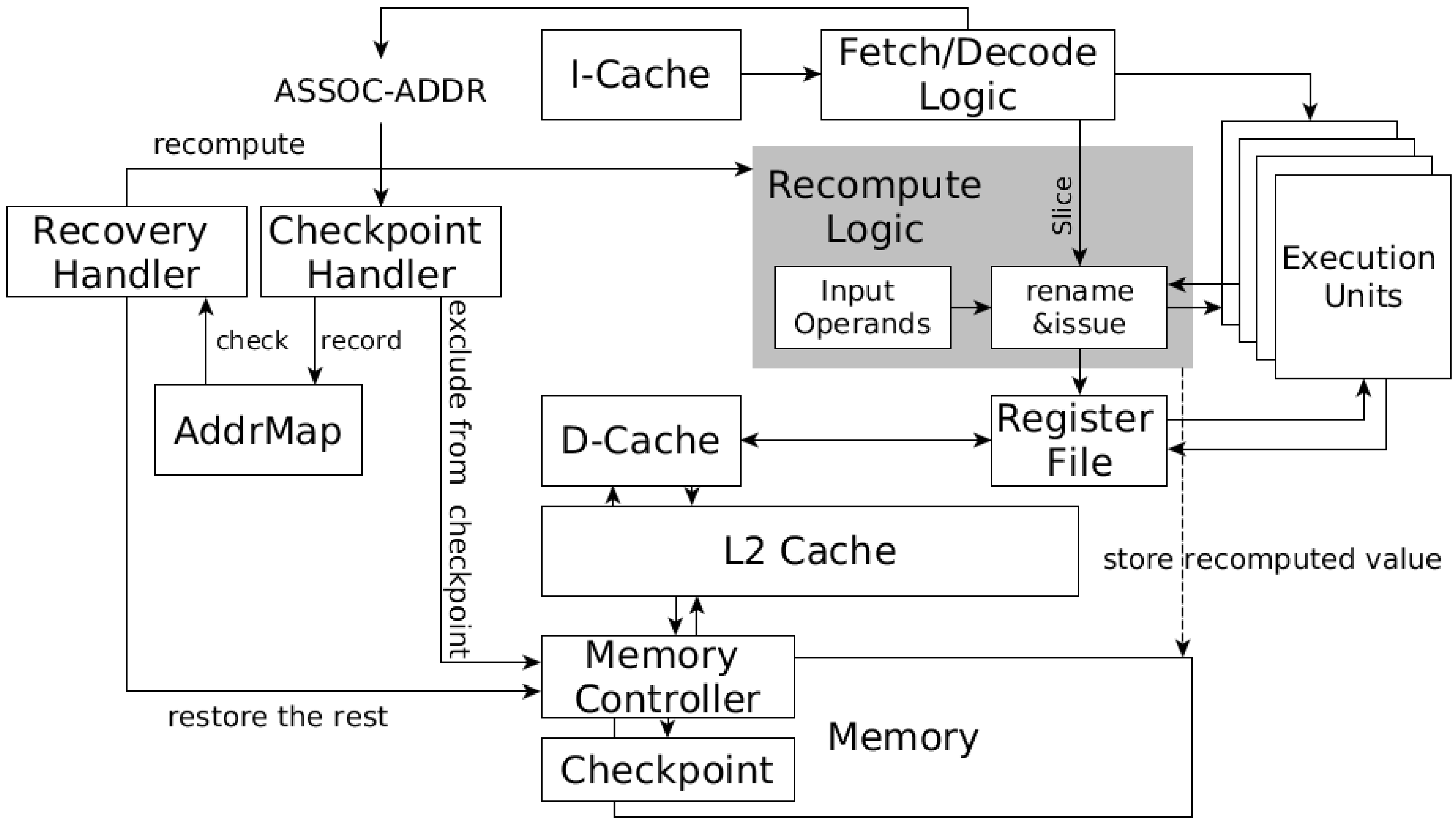
$$(o_{rollback,ACR} + o_{recomp,ACR}) \leq o_{rollback}$$



# How to use Slices?

- Need to know start address of the slice
- Need to communicate it to runtime
  - **ASSOC-ADDR:** <memory address,  slice address>
    - automatically executed with the corresponding store
    - <memory address,  slice address> is recorded in buffer: **AddrMap**
- If recovery needed
  - Look into AddrMap for active Slices
  - Recompute values whose Slices are recorded in AddrMap

# Amnesic Checkpoint and Recovery




ACR: Amnesic Checkpointing and Recovery

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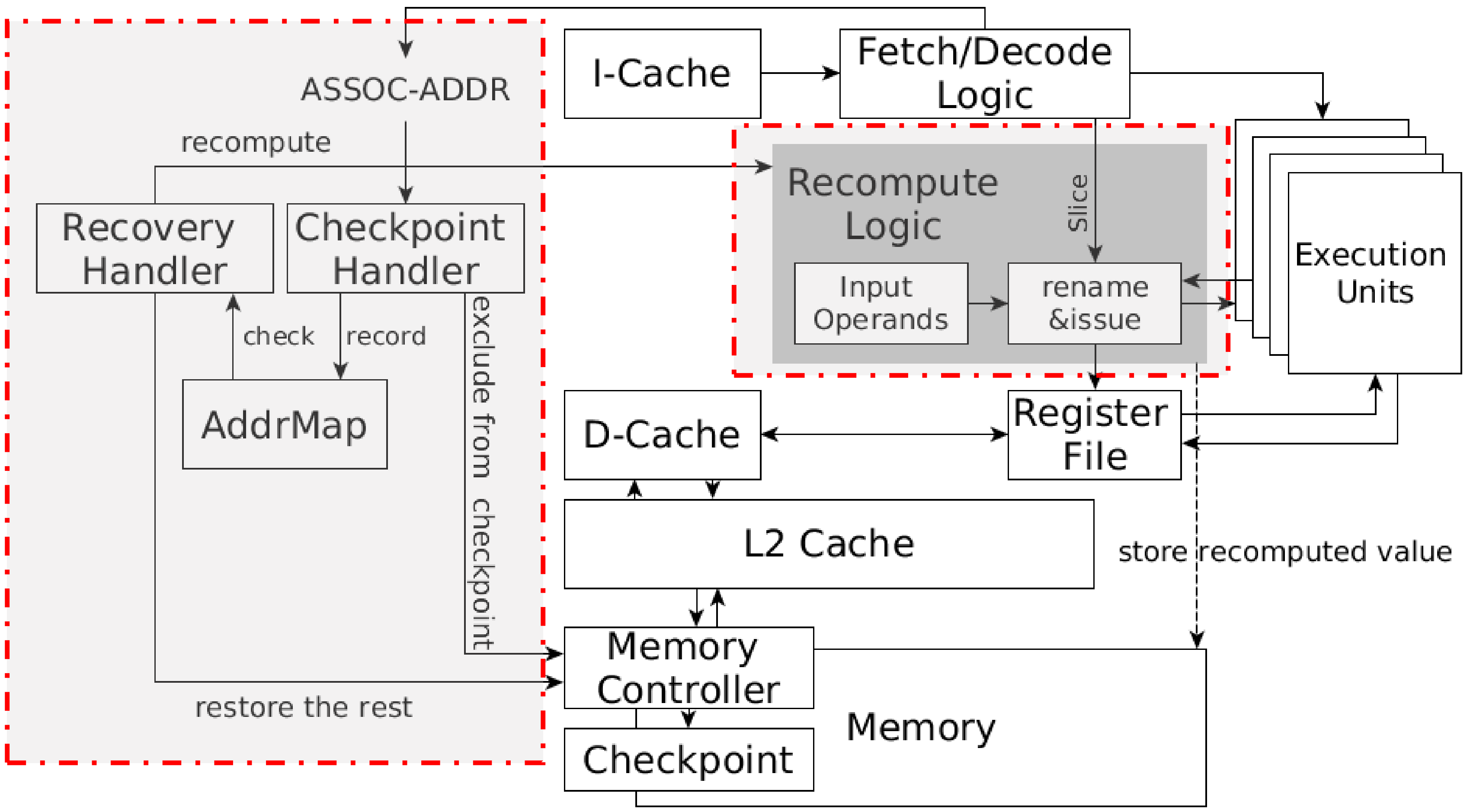


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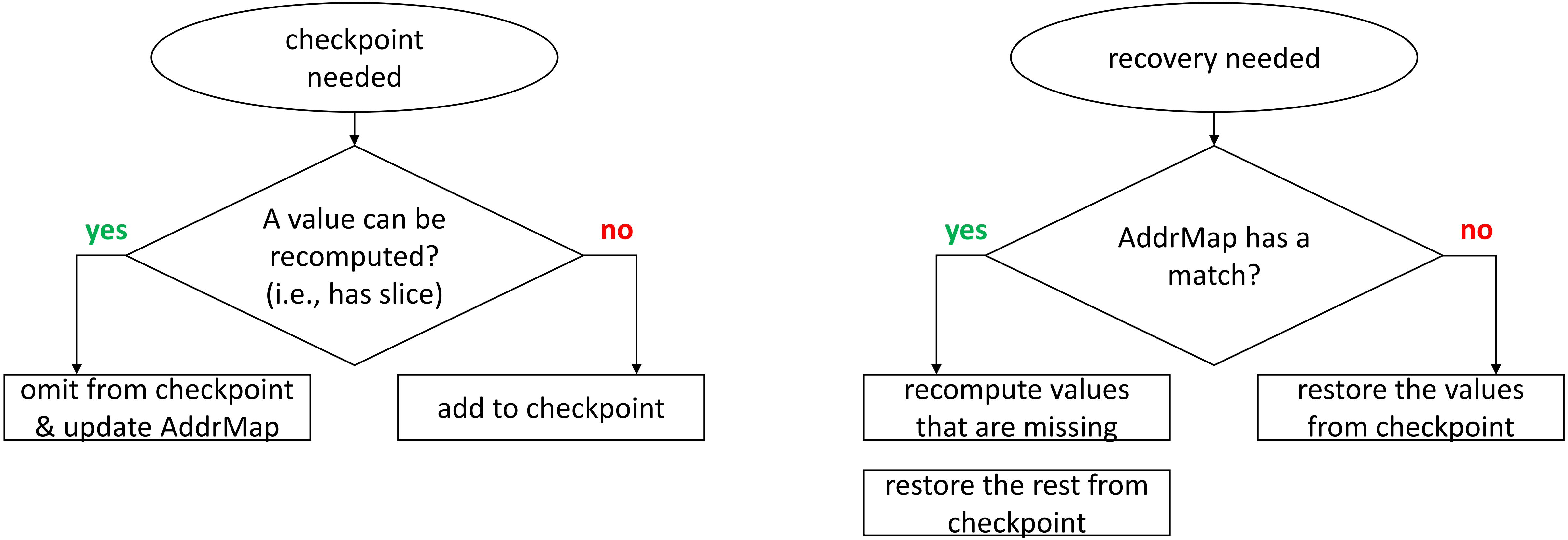


# Evaluation

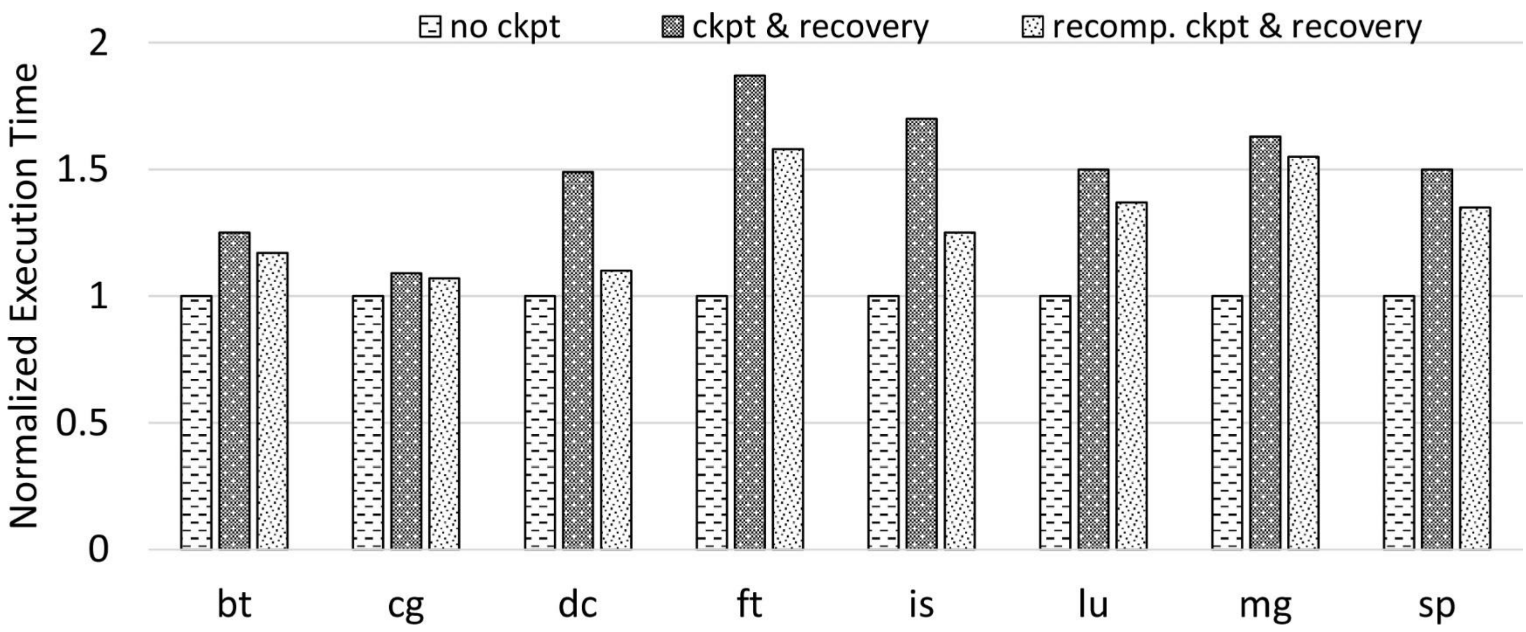
# Recomputation Enabled Checkpointing – Setup

- NAS benchmarks
- Amnesic compiler pass mimicked by binary instrumenting Pintool
- Microarchitecture and scheduler implemented in Snipersim

- 1.09 GHz, 4-issue, inorder core: 8/16/32 cores and 8/16/32 threads
- L1: 32KB, 4-way
- L2: 512KB, 8-way

- Ideal Baseline (no checkpoint, no recovery)
- Global coordinated
- Local coordinated

# Performance Overhead – Checkpoint and Recovery



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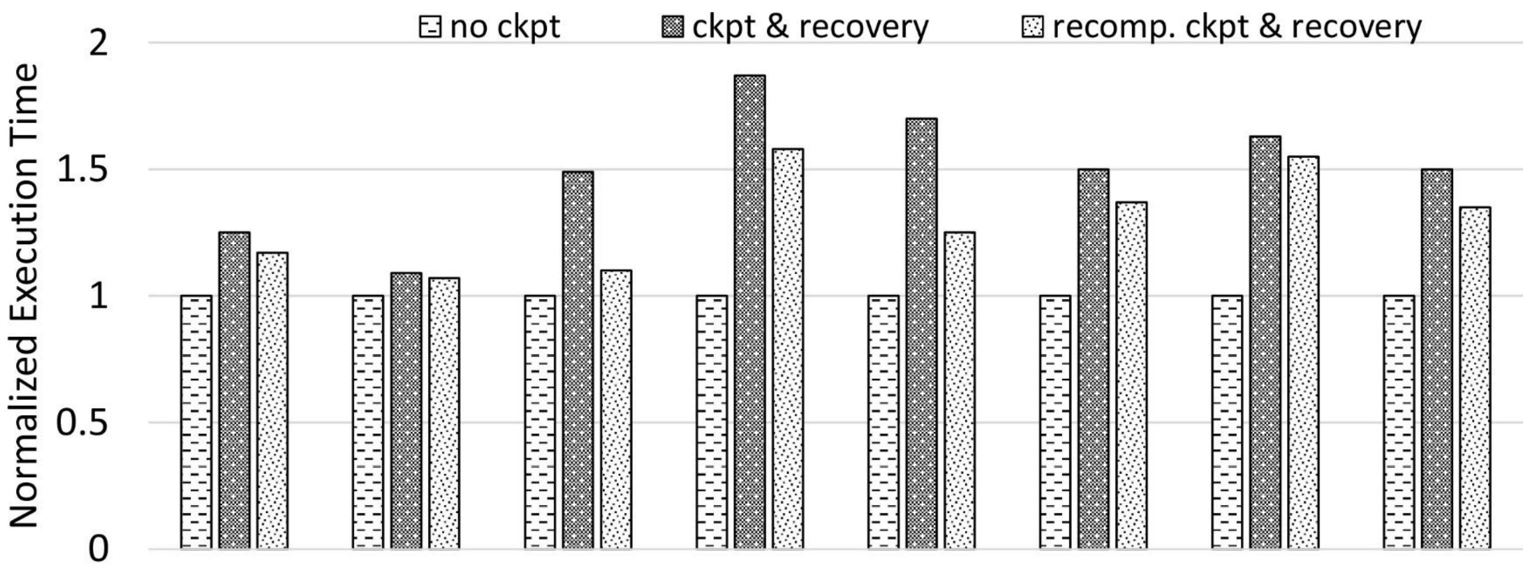
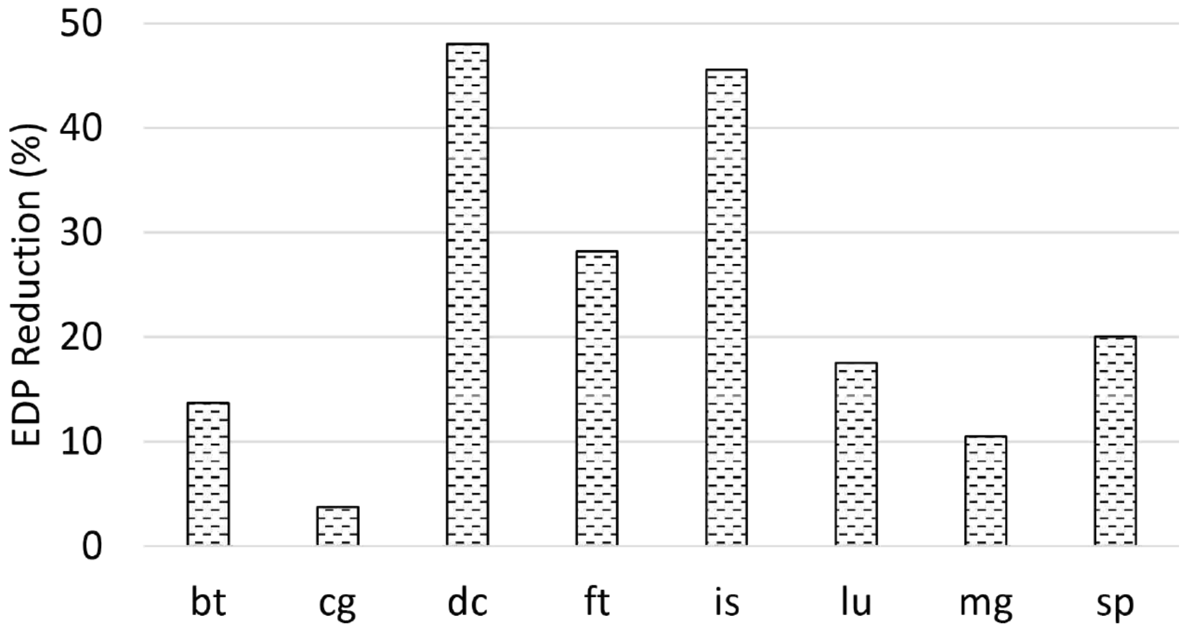



**up to 26.68% (12.39% on average) reduction on checkpoint and recovery overhead**

# EDP Reduction – Recovery



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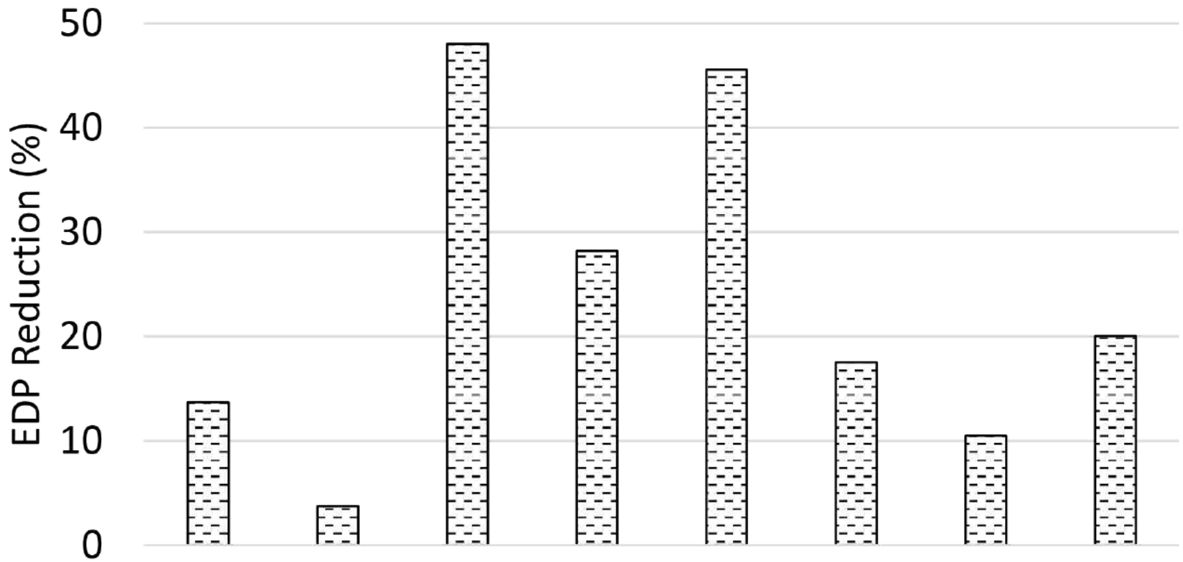
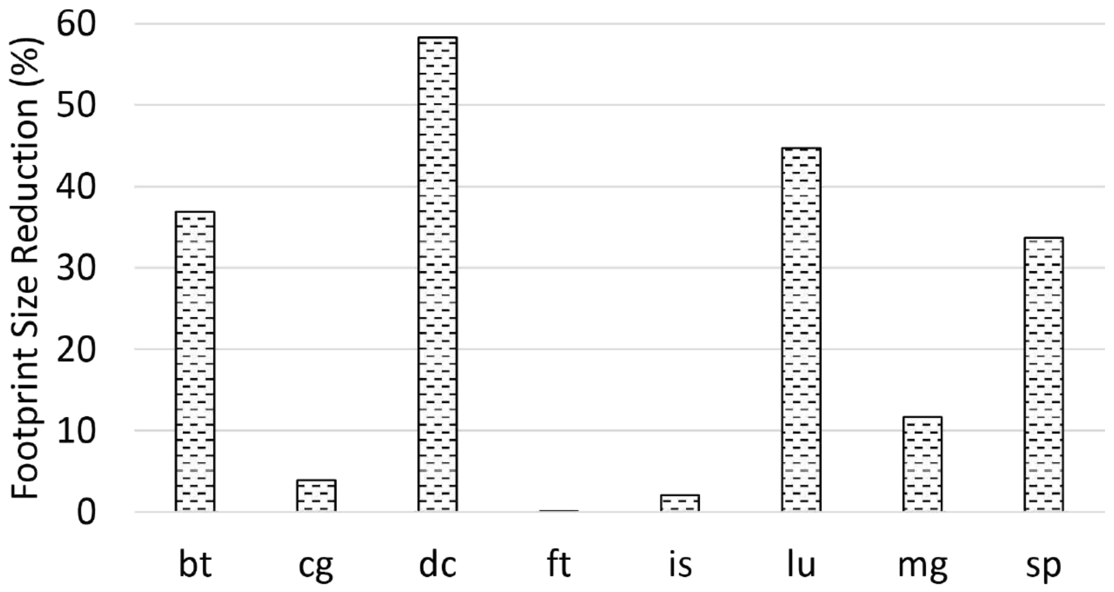



**up to 48.07% (23.41% on average) EDP gain**

# Footprint Size Reduction



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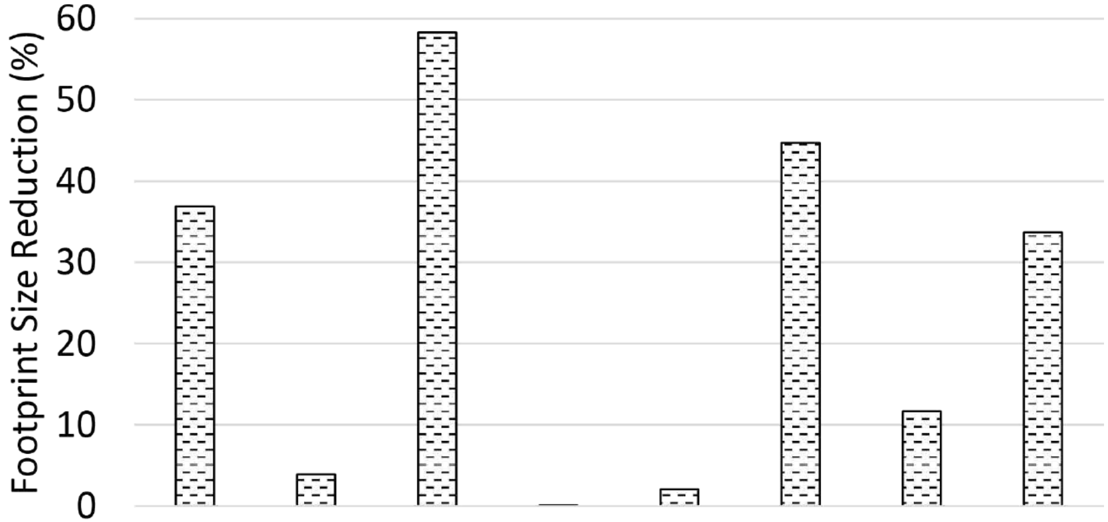
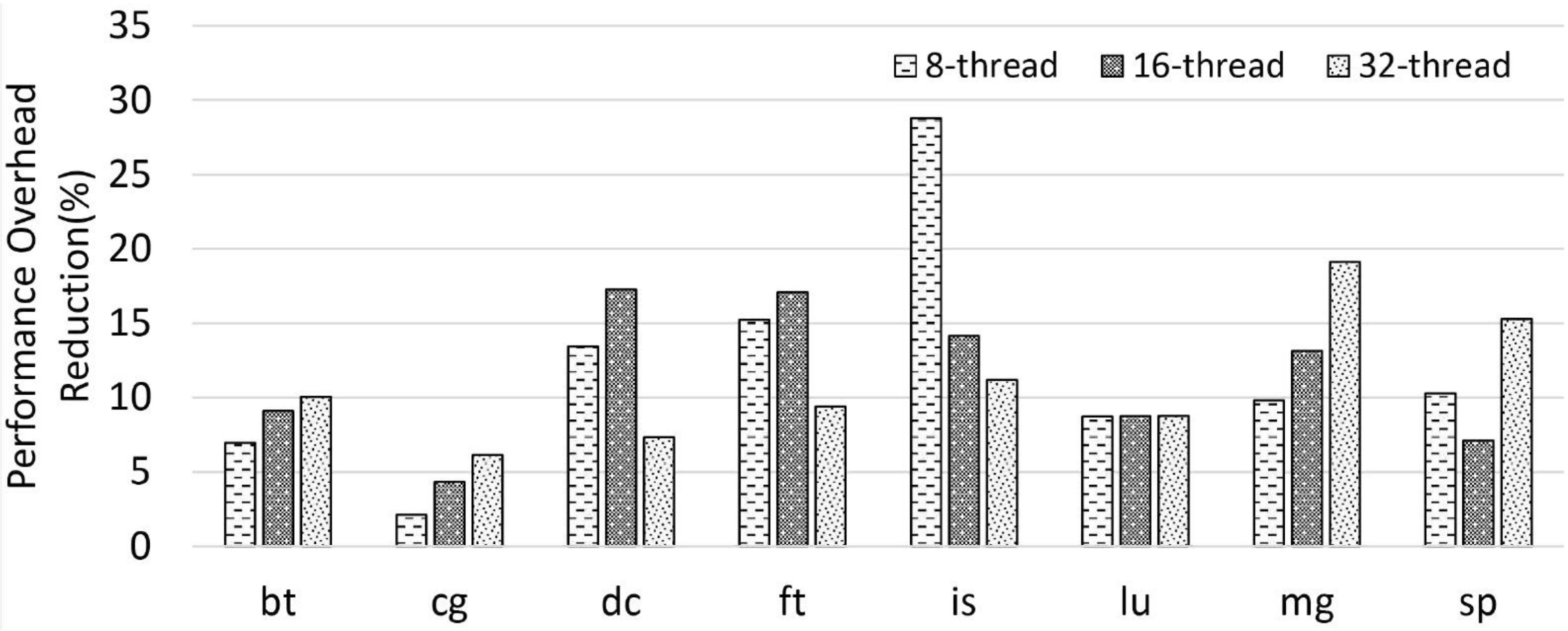



**up to 58.3% (23.91% on average) memory footprint size reduction**

# Thread Count



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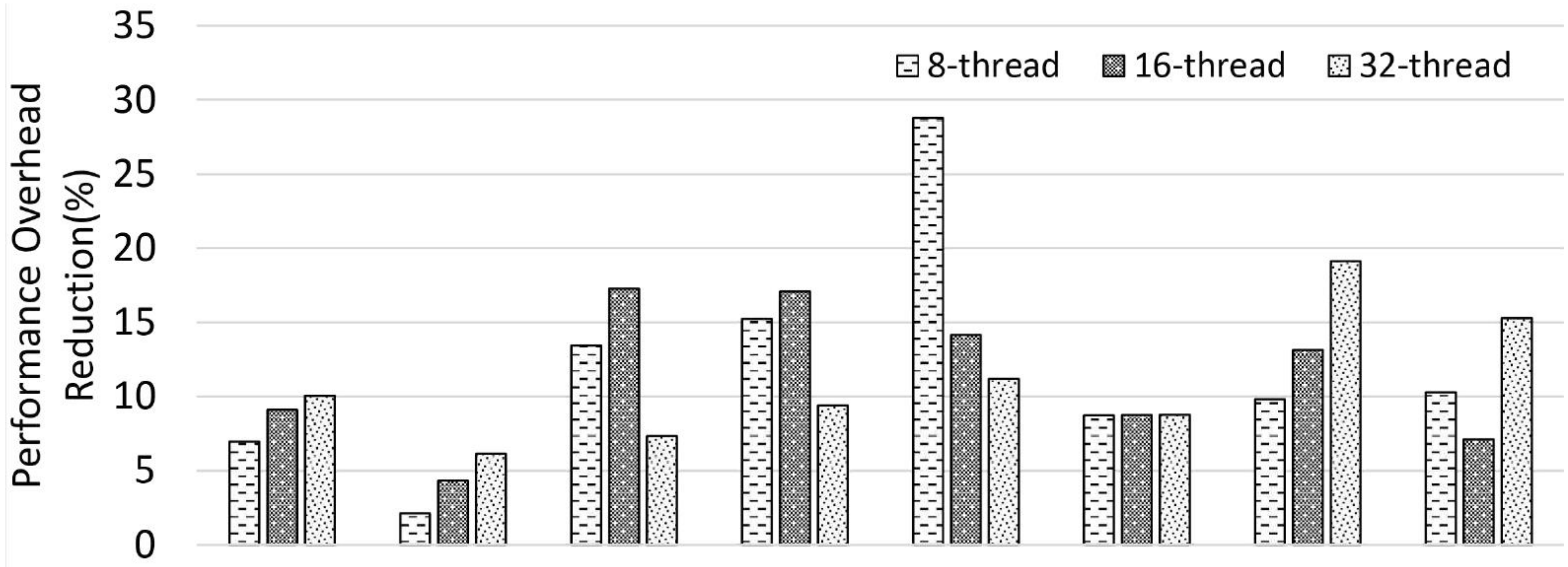
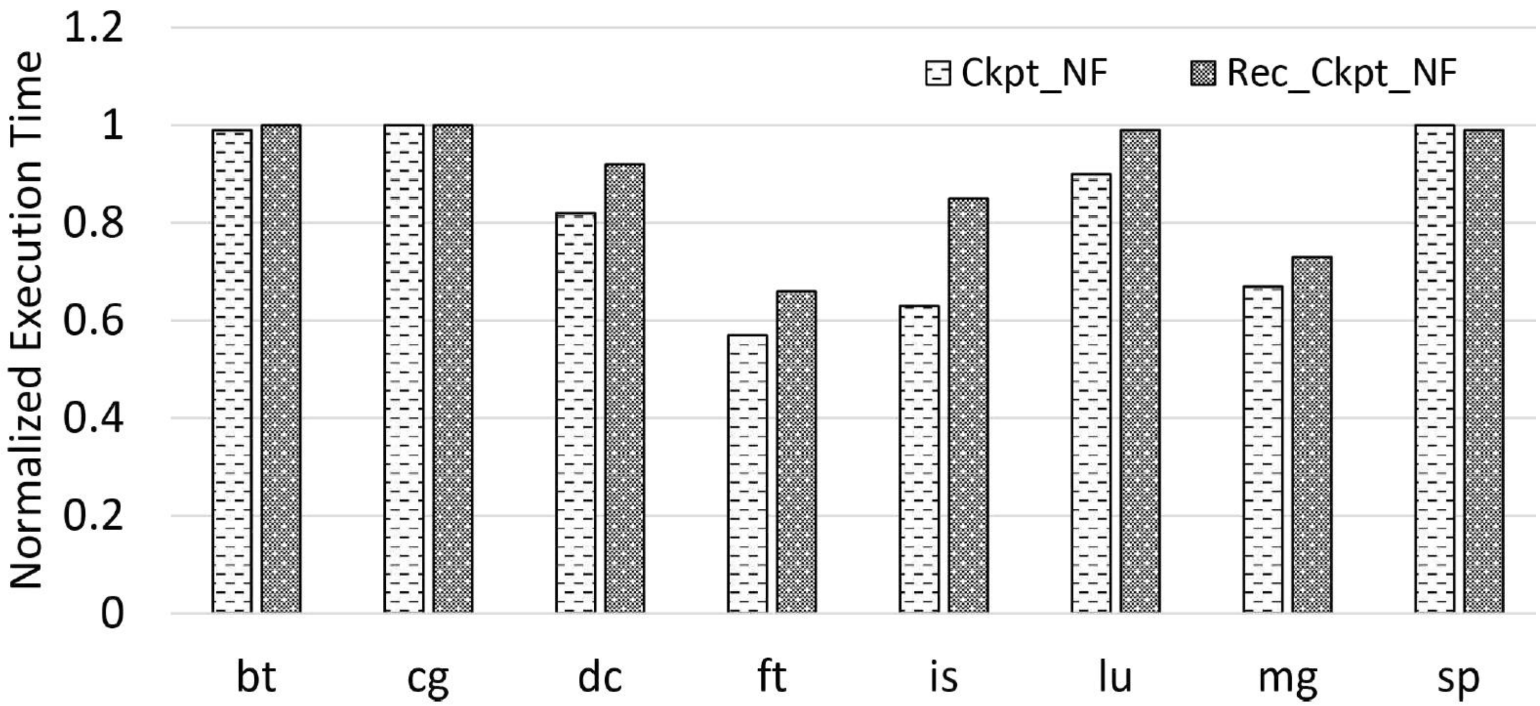



**up to 28%, 17% (is), and 19% (mg) reduction for 8-, 16-, 32-threads,respectively**

# Global vs Coordinated Local Checkpointing



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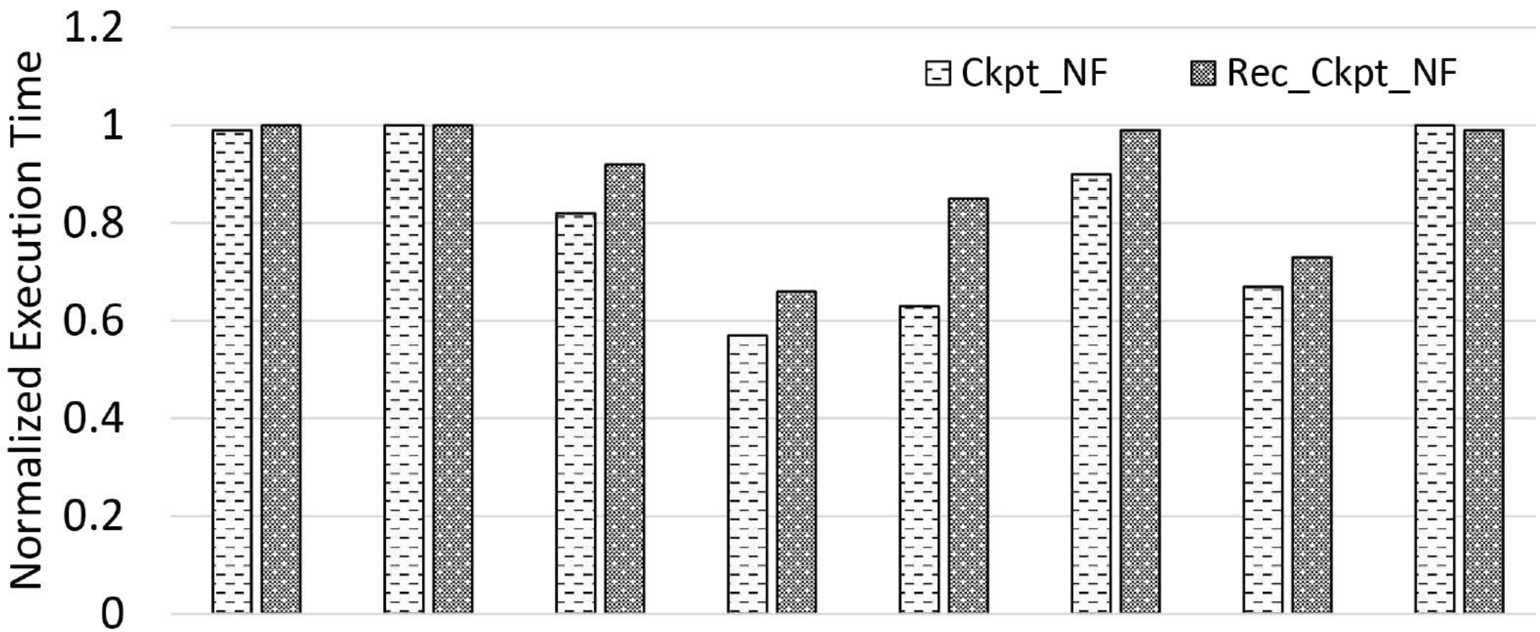
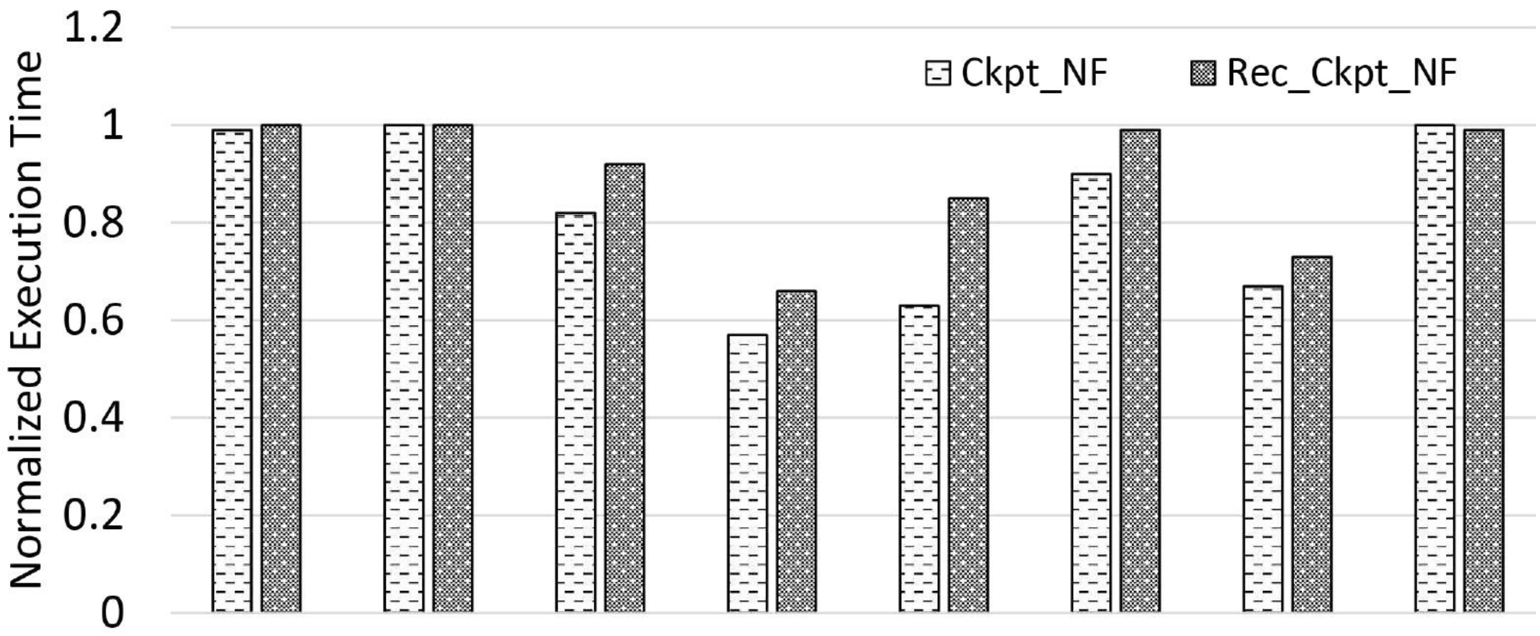



**up to 42% (ft) reduction w.r.t. Ckpt_NF of global checkpointing**

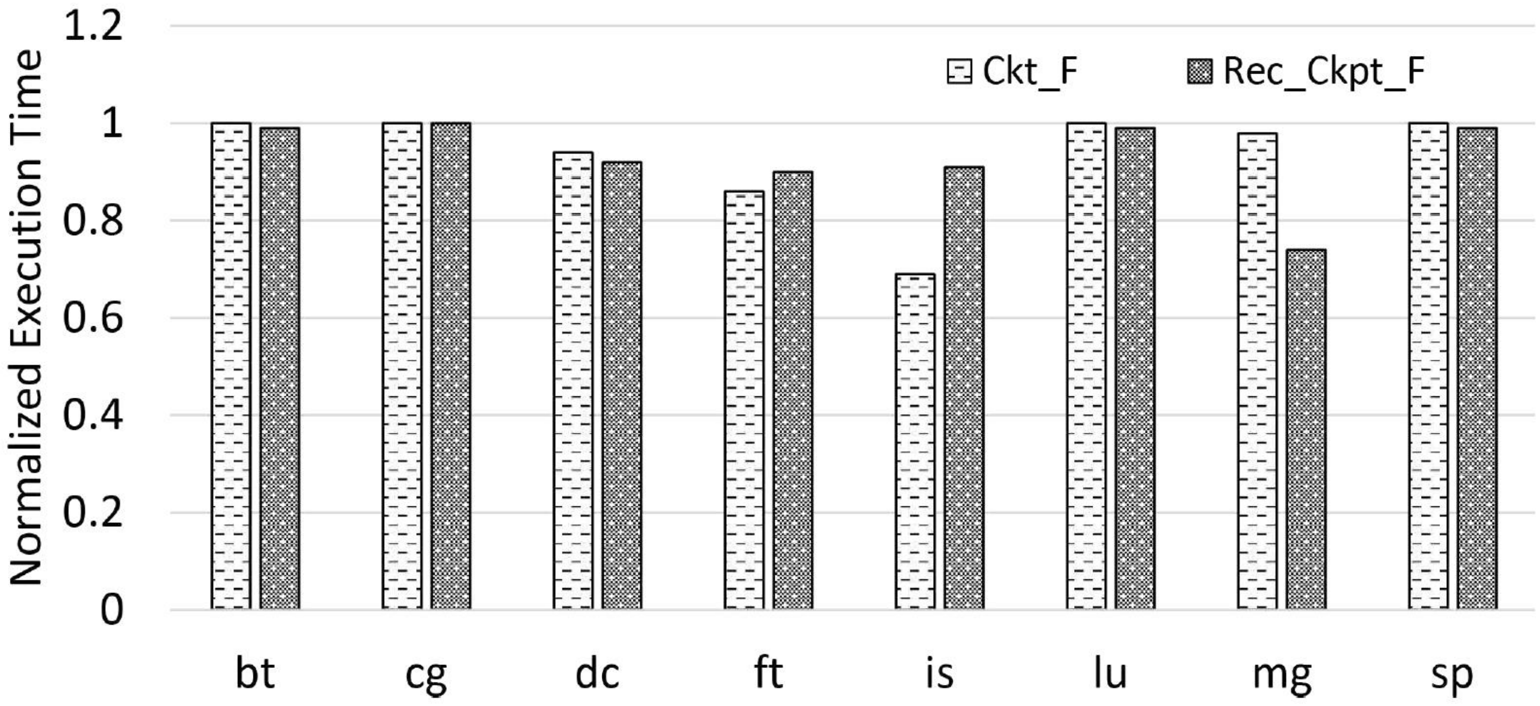
# Global vs Coordinated Local Checkpointing




**up to 42% (ft) reduction w.r.t. Ckpt_NF of global checkpointing**

**up to 33% (ft) reduction w.r.t. Rec_Ckpt_NF of global checkpointing**

# Global vs Coordinated Local Checkpointing



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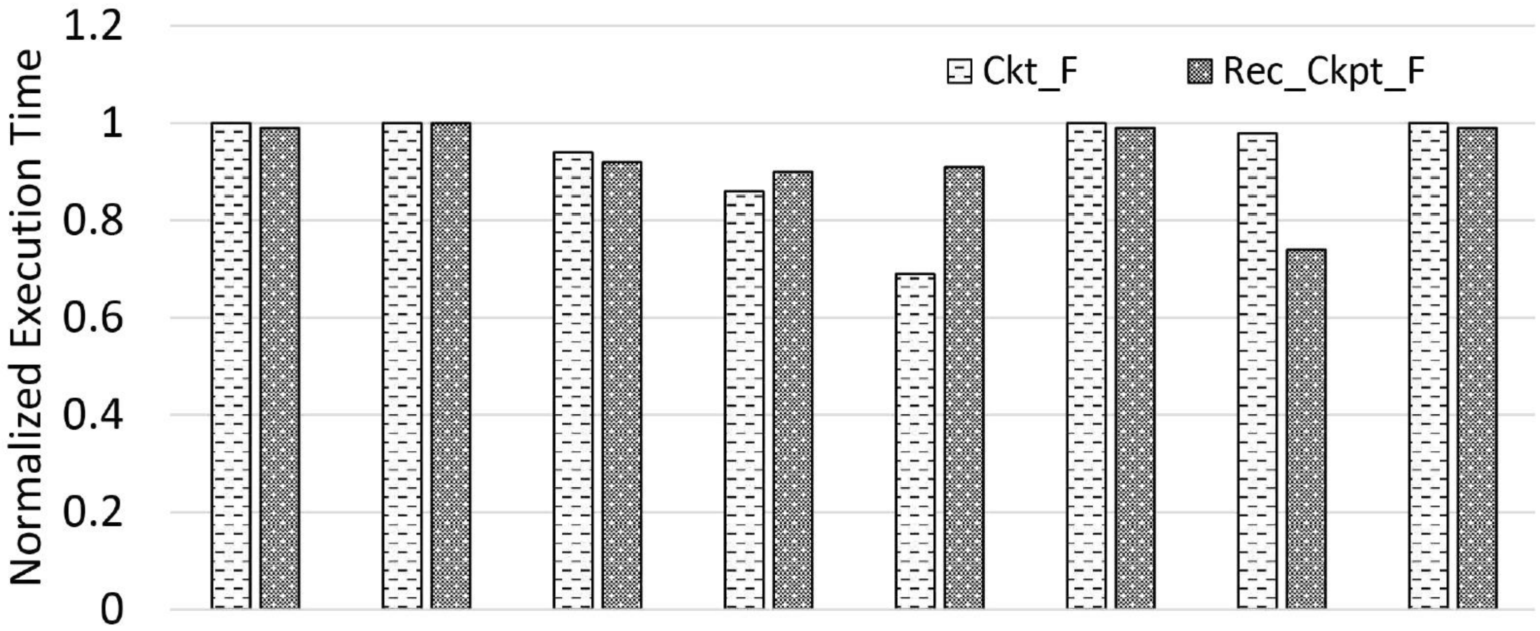
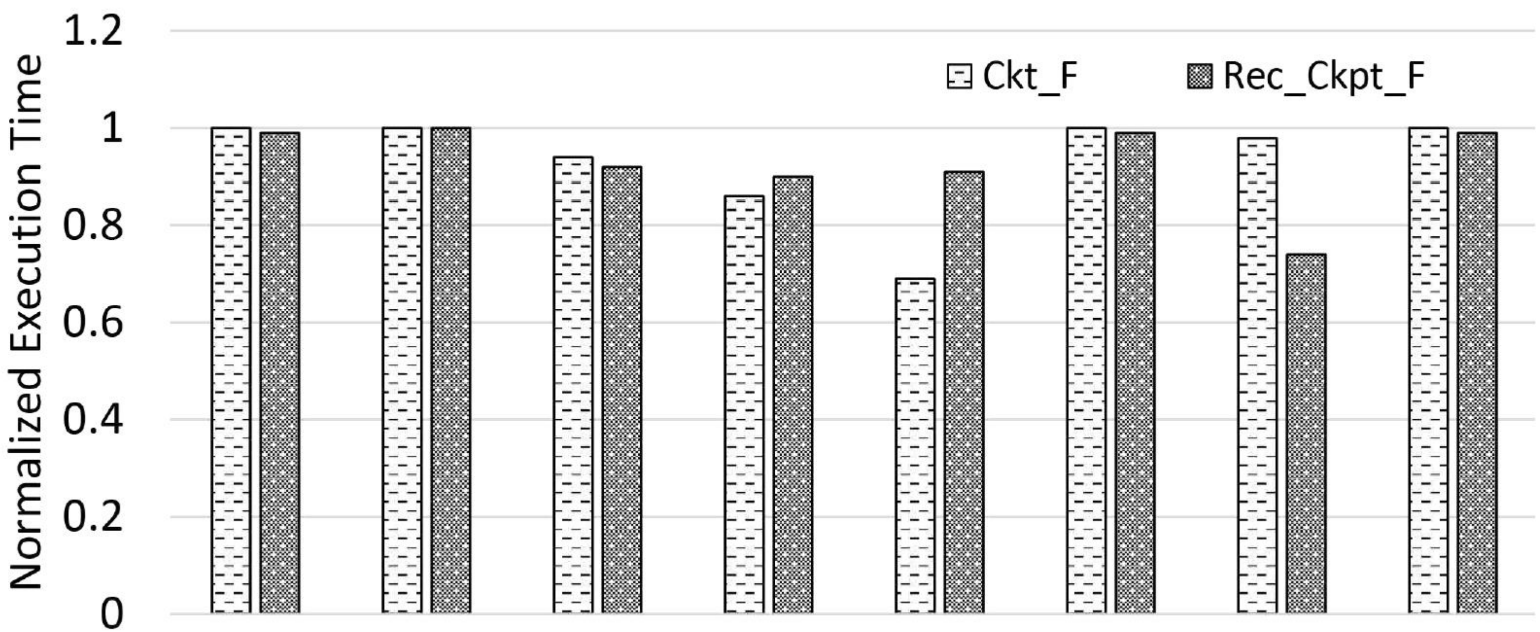



**up to 31% (is) reduction w.r.t. Ckpt_F of global checkpointing**

# Global vs Coordinated Local Checkpointing




up to 31% (is) reduction w.r.t. Ckpt_F of global checkpointing

up to 26% (mg) reduction w.r.t. Rec_Ckpt_F of global checkpointing

# Summary

- Effective in reducing checkpoint overhead
  - Power and performance
- Reduces checkpoint footprint size (i.e., storage reduction)
- Low-cost recovery

# Questions and Comments

???