ACR: AUTOMATIC CHECKPOINT/ RESTART FOR SOFT AND HARD ERROR PROTECTION.

XIANG NI, ESTEBAN MENESES, NIKHIL JAIN, SANJAY KALE

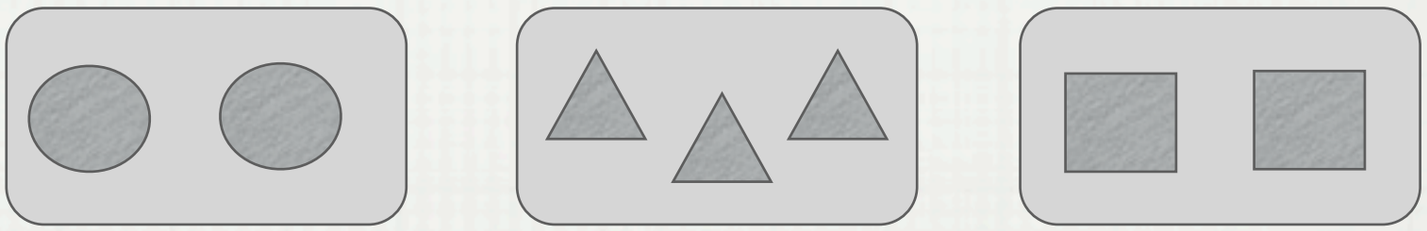
PARALLEL PROGRAMMING LAB, UIUC

CONTENTS

- ☐ MOTIVATION
- ☐ ACR FRAMEWORK
- ☐ OPTIMIZATION
- ☐ EXPERIMENTAL RESULTS
- ☐ CONCLUSION

BACKGROUND

TASK

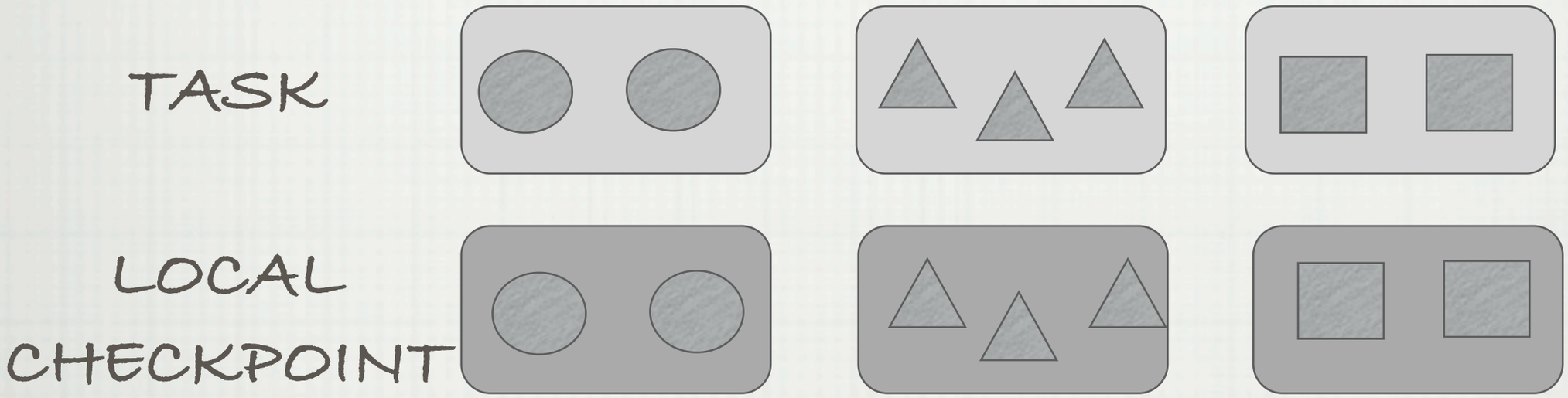


NODE A

NODE B

NODE C

BACKGROUND



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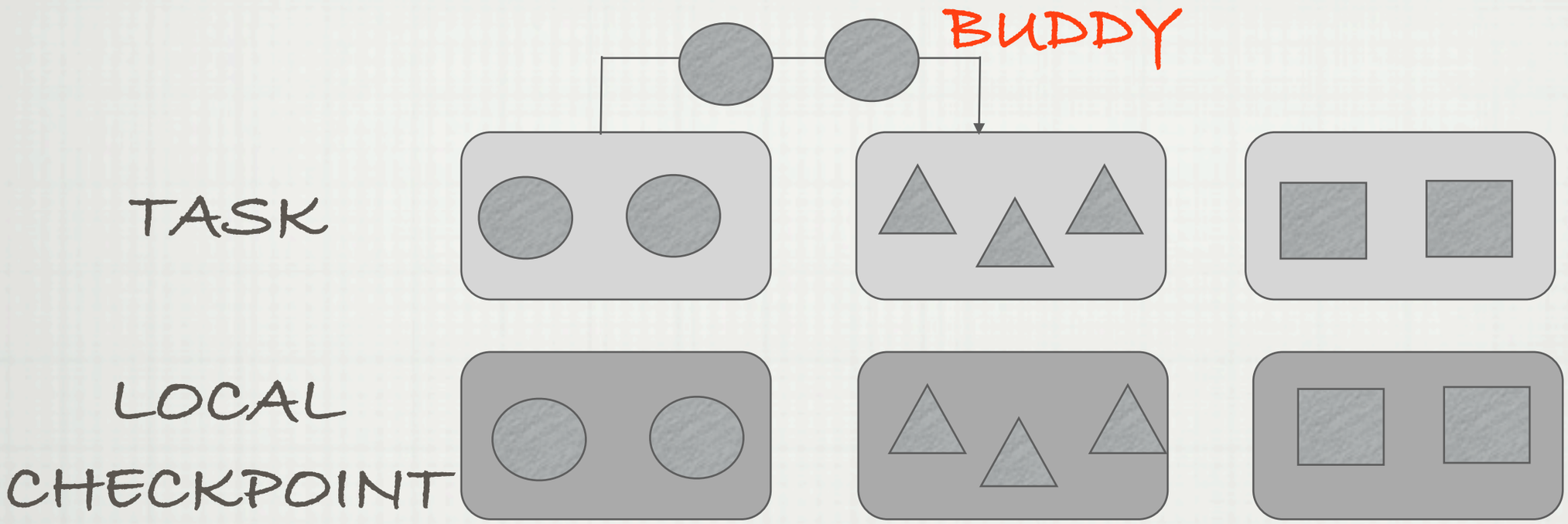

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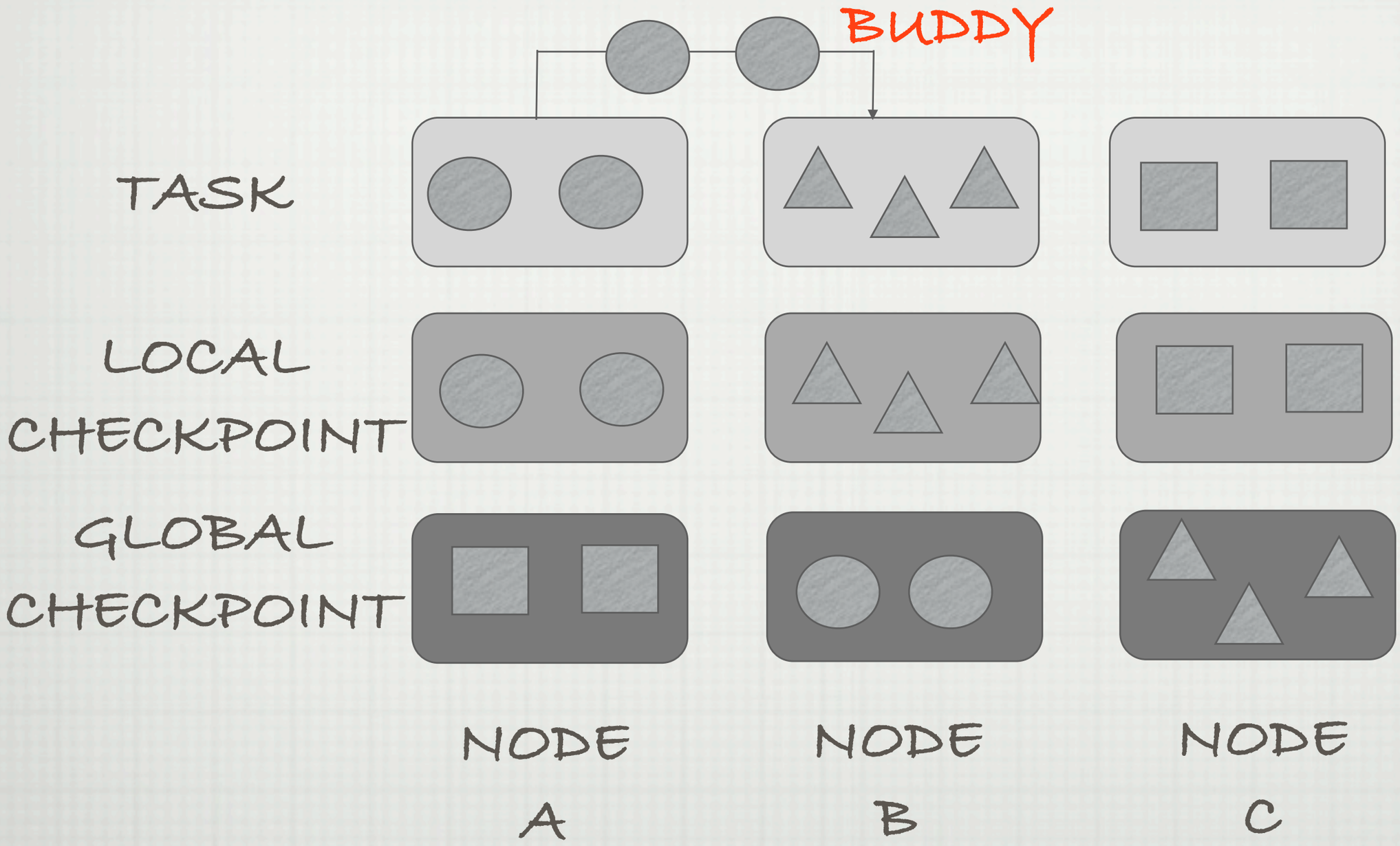

BUDDY
TASK
LOCAL CHECKPOINT
GLOBAL CHECKPOINT
NODE A
NODE B
NODE C

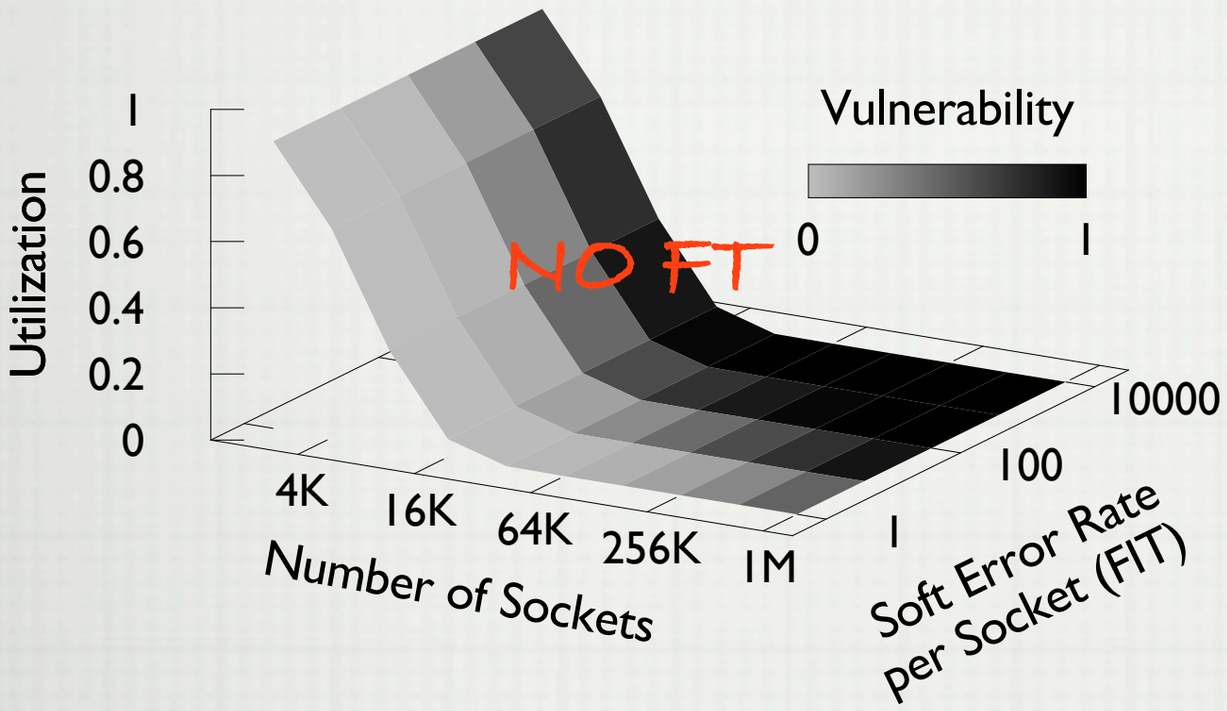
MOTIVATION

- New challenge: soft error.
- Computer electronic's sensitivity to radiation increases as their dimensions and operating voltage decreases
  - The requirements for high performance and low power.
- What may happen if soft failure rate keeps increasing?

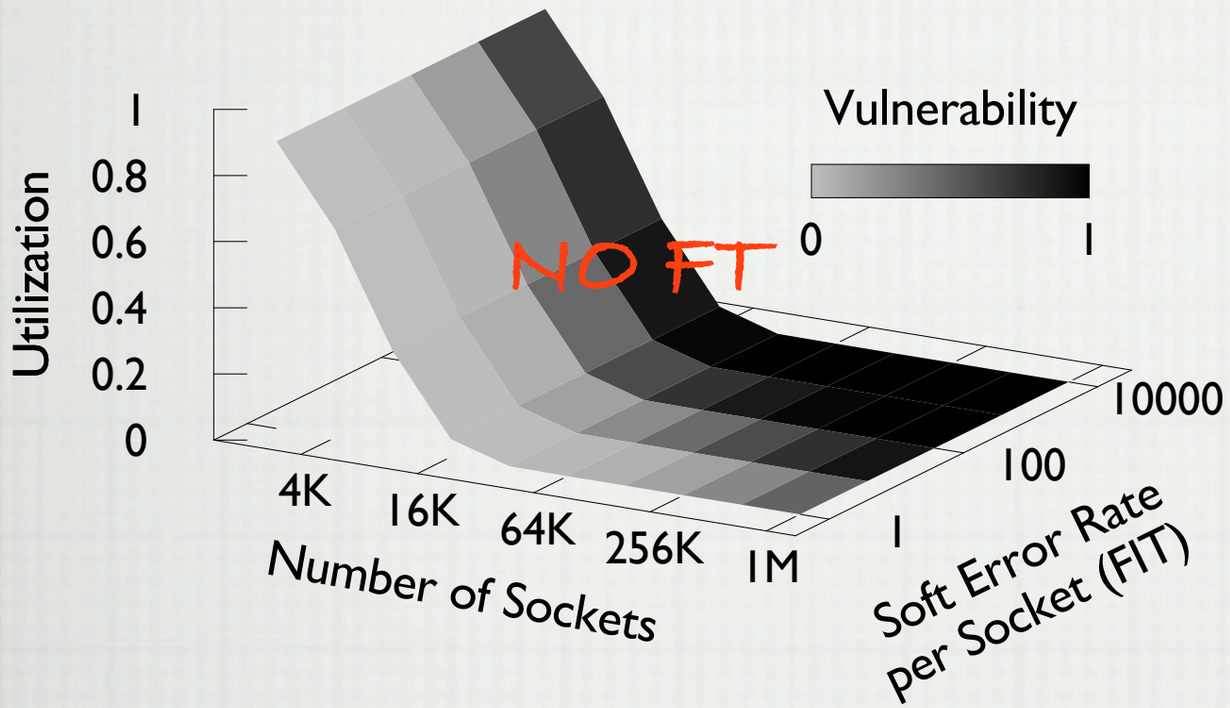
MOTIVATION

MOTIVATION

MOTIVATION


Utilization
1
0.8
0.6
0.4
0.2
0
Vulnerability
0
1
NO FT
4K
16K
64K
256K
1M
Number of Sockets
1
100
10000
Soft Error Rate
per Socket (FIT)

MOTIVATION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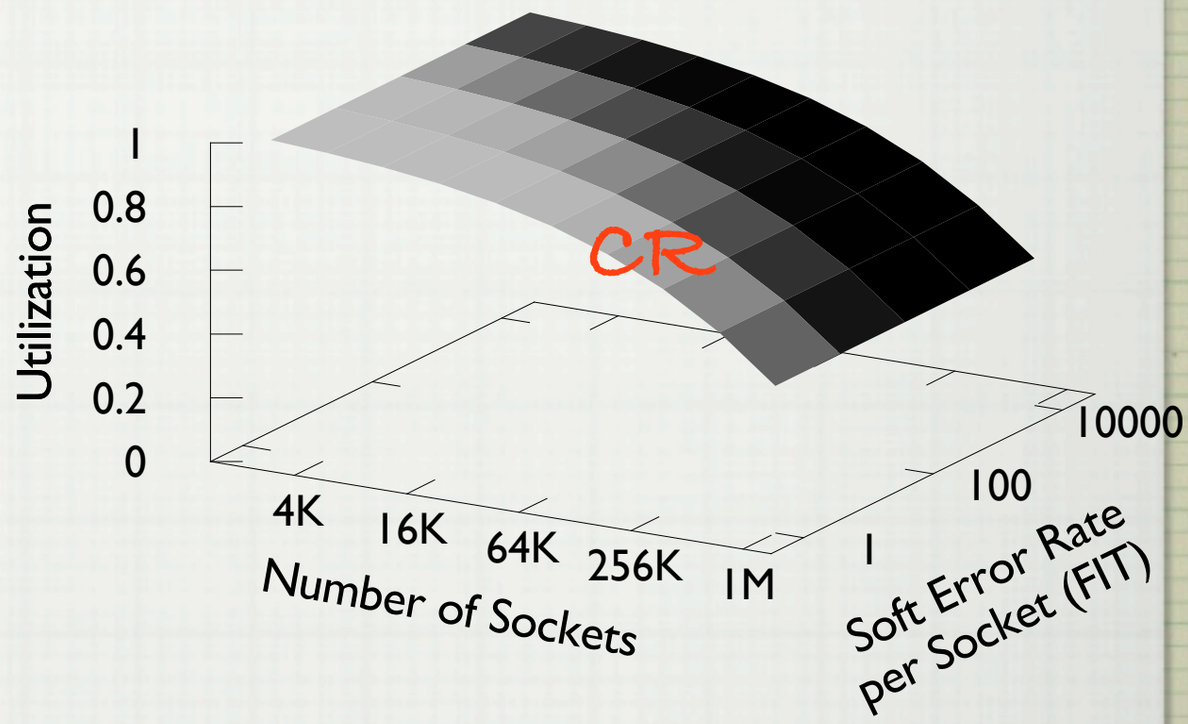
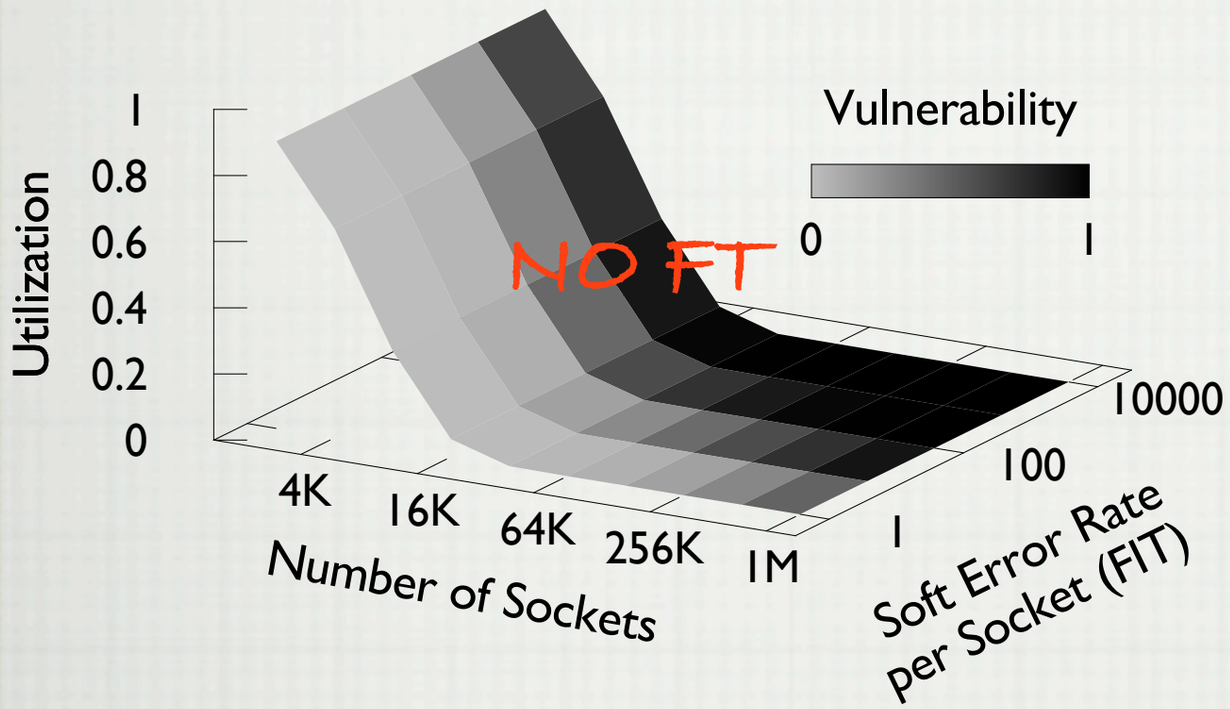

Utilization
1
0.8
0.6
0.4
0.2
0
CR
4K
16K
64K
256K
1M
Number of Sockets
1
100
10000
Soft Error Rate
per Socket (FIT)

MOTIVATION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Vulnerability
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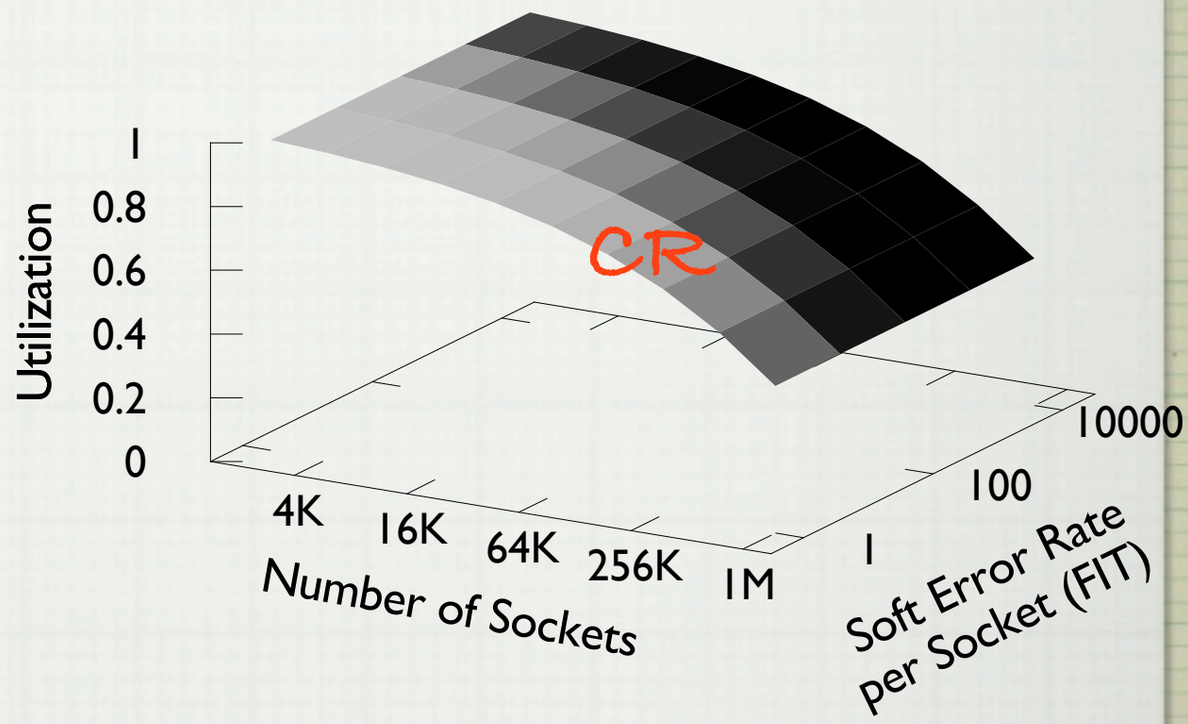
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0.8
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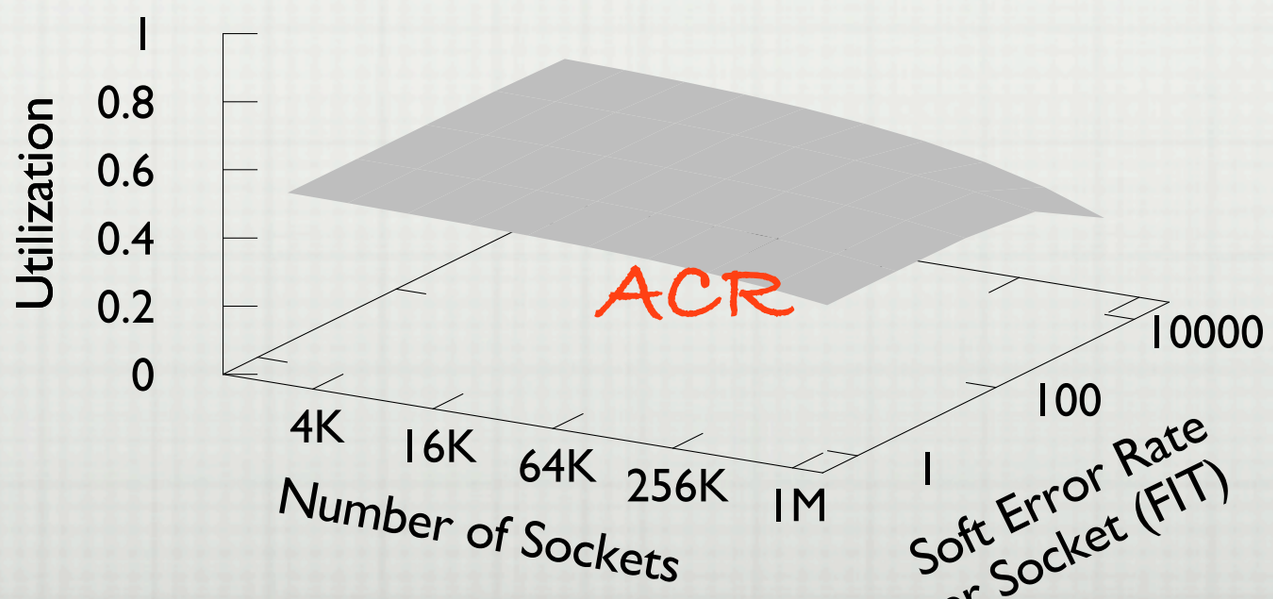
Utilization
1
0.8
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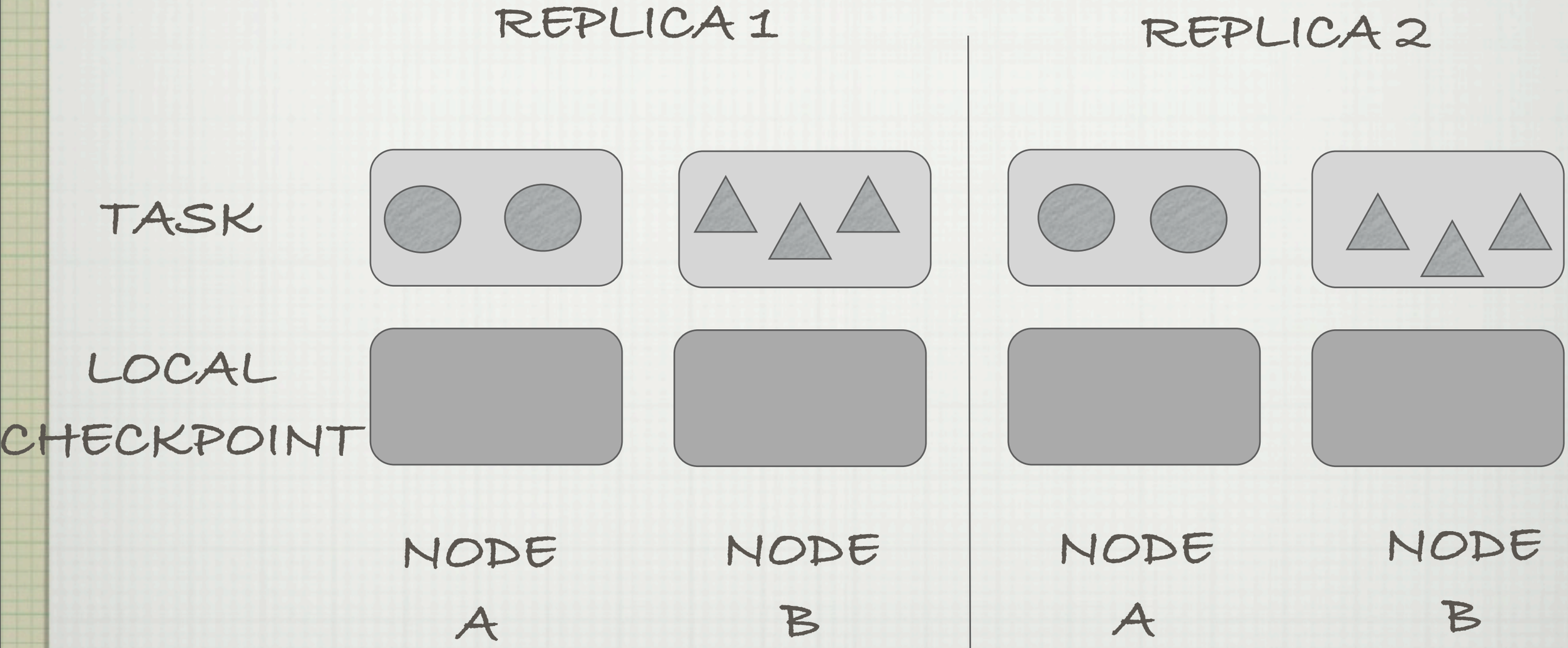
REPLICATION ENHANCED CHECKPOINTING



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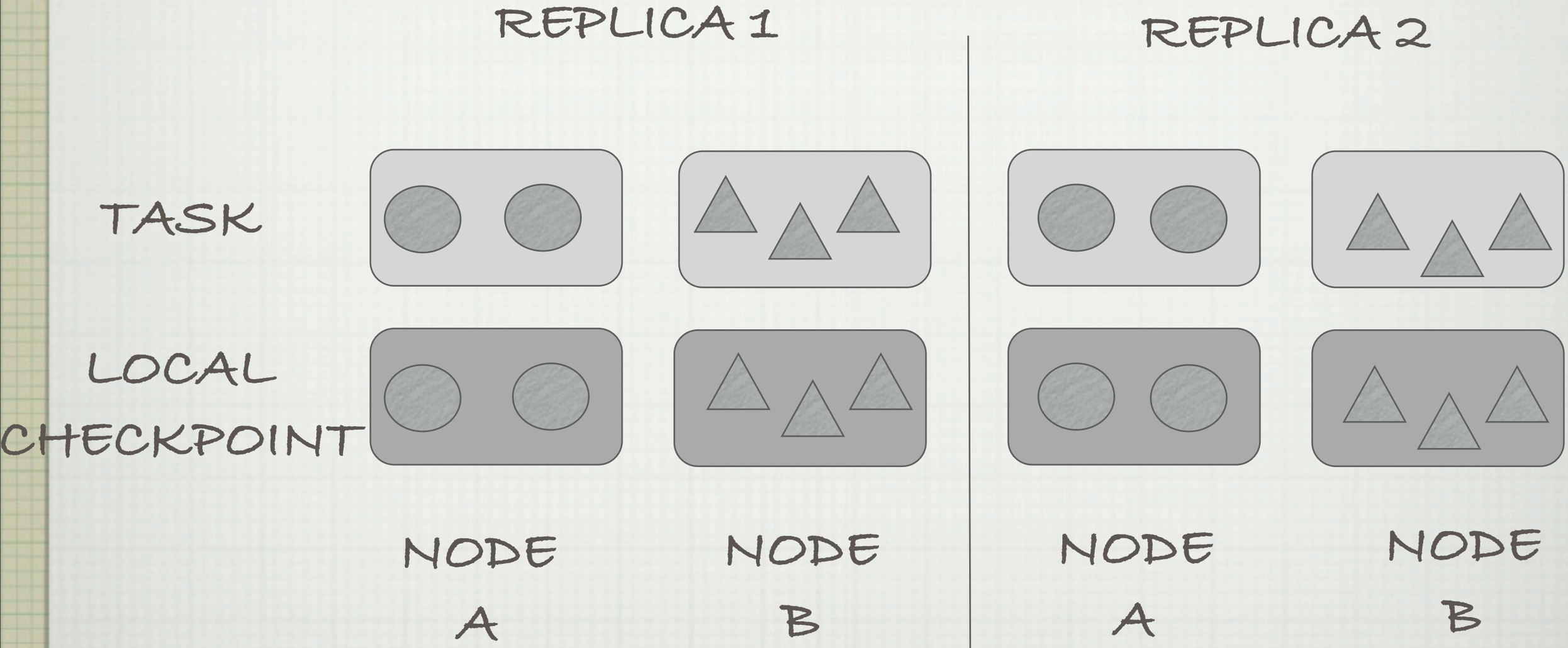

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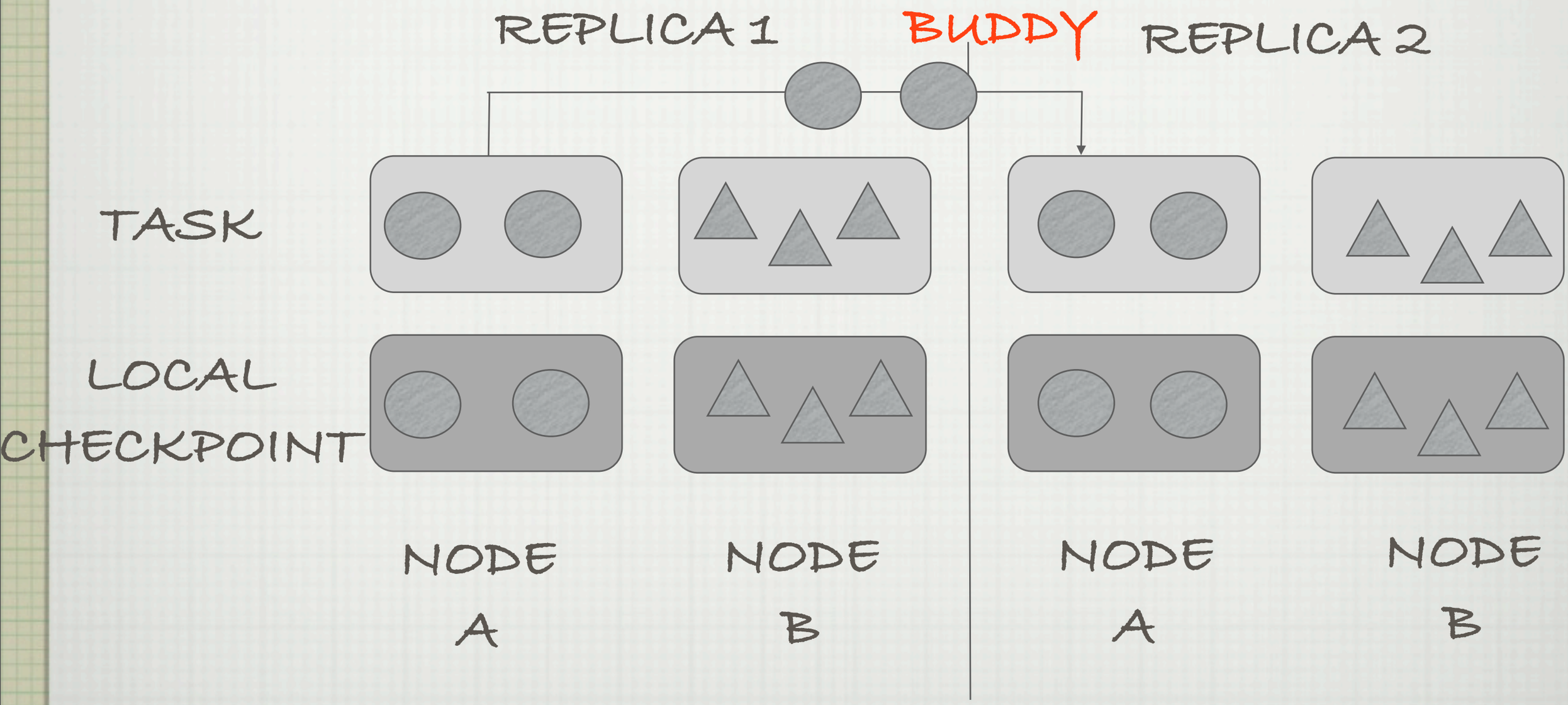

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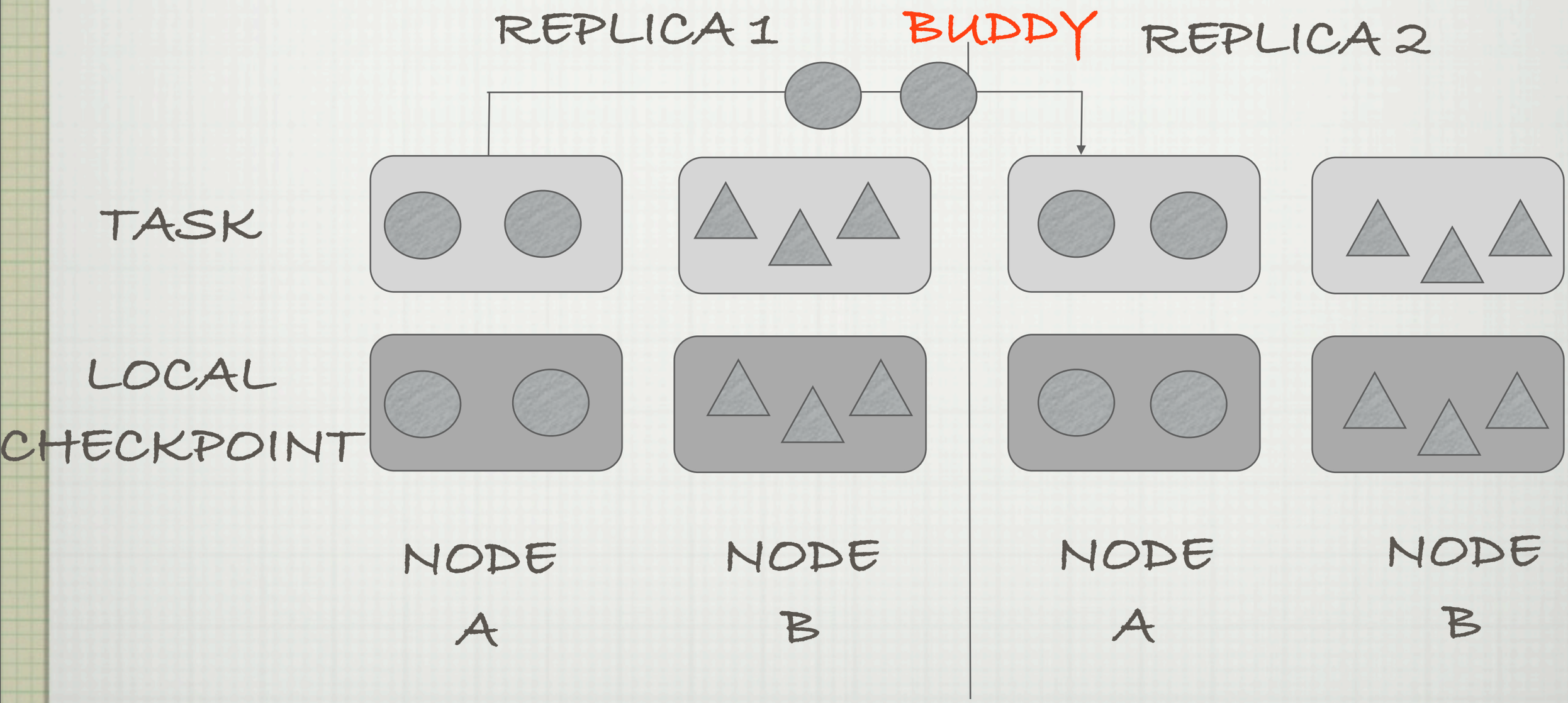
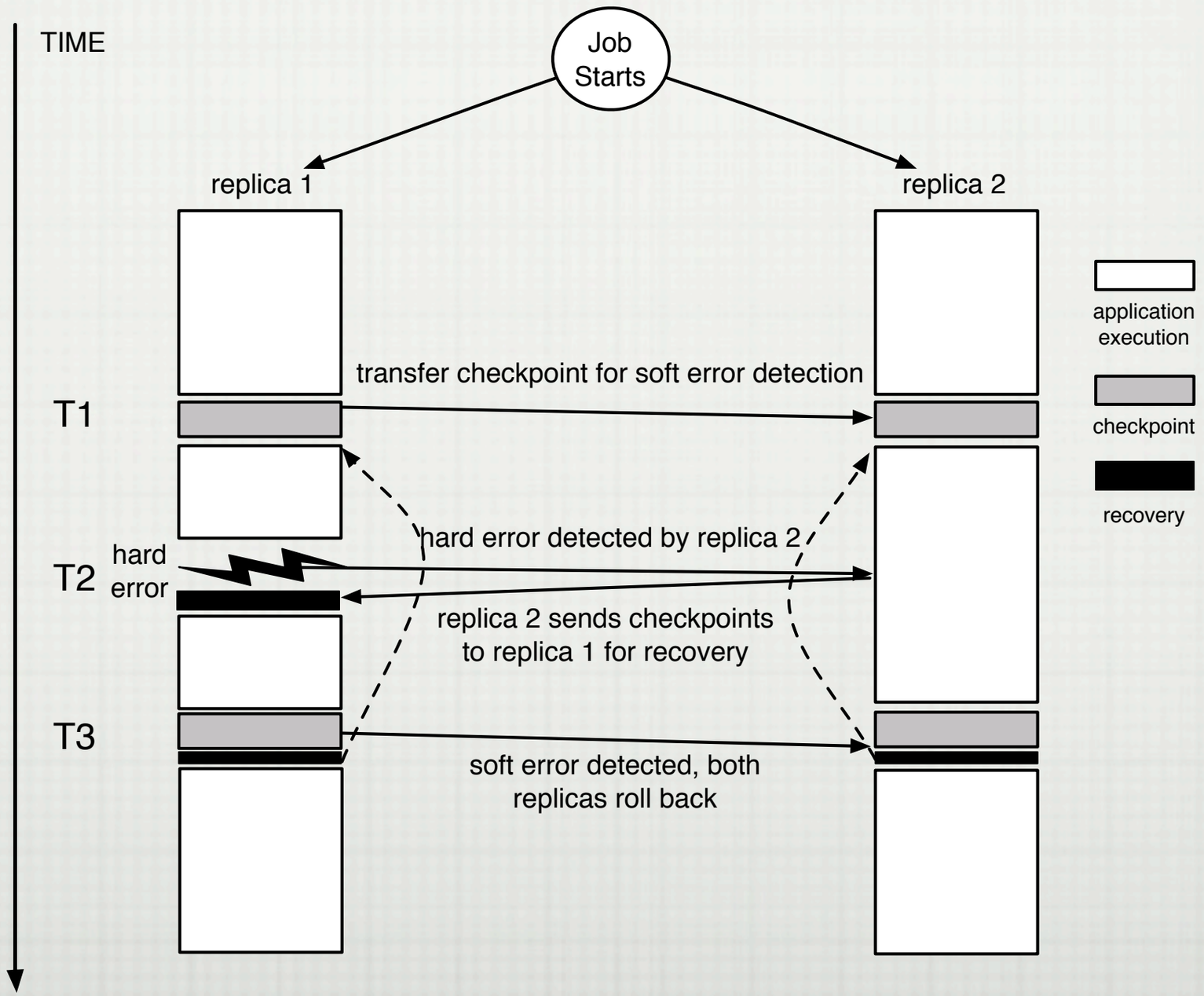


Comparison for soft data corruption

REPLICATION ENHANCED CHECKPOINTING



DIFFERENT WAYS TO RESTART FROM HARD ERROR

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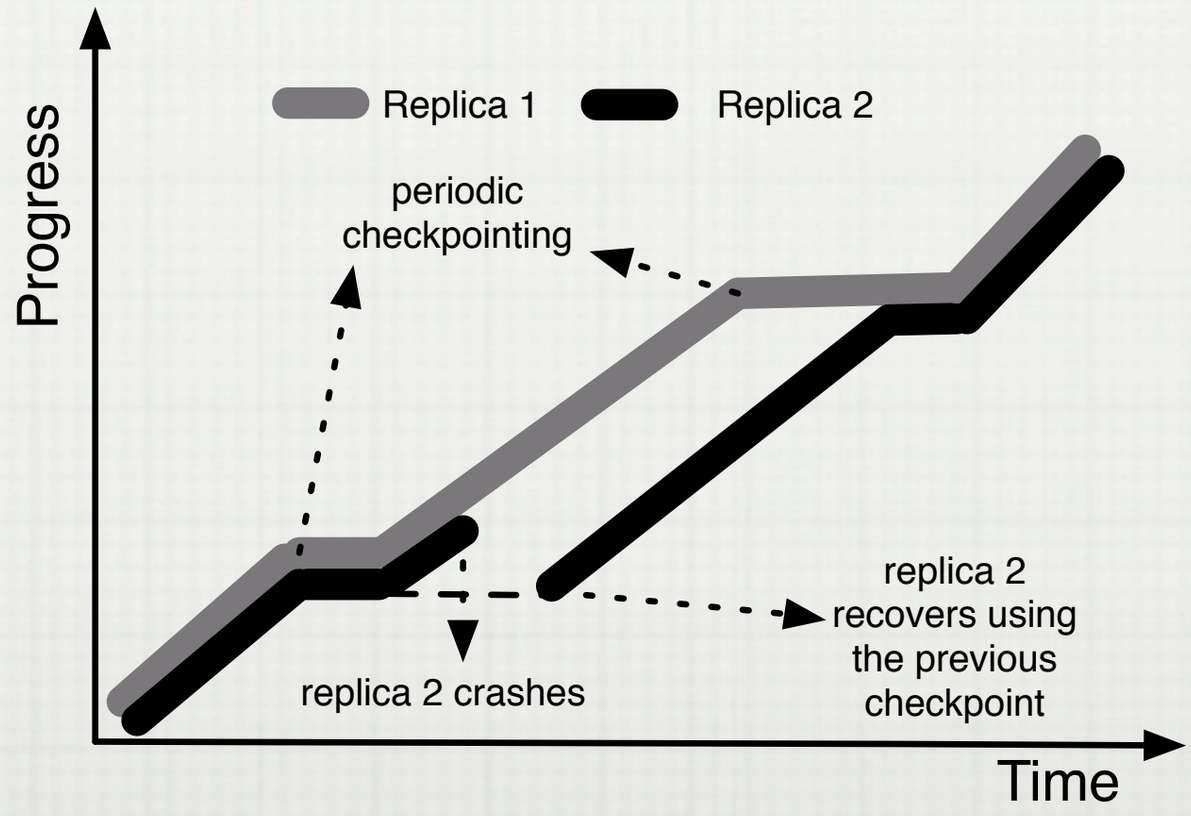

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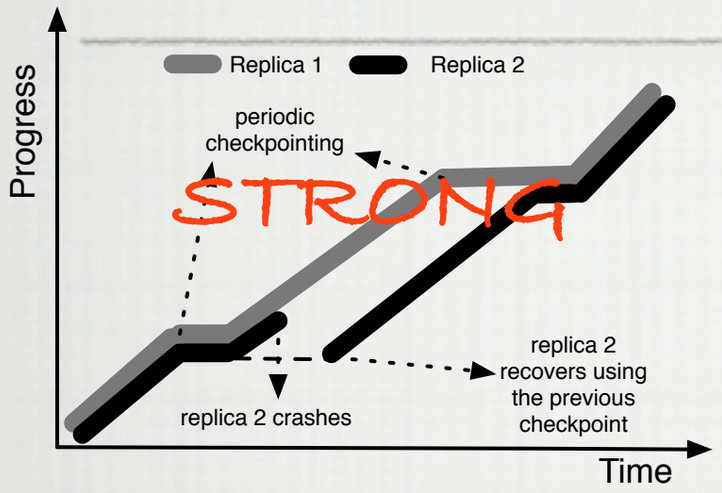

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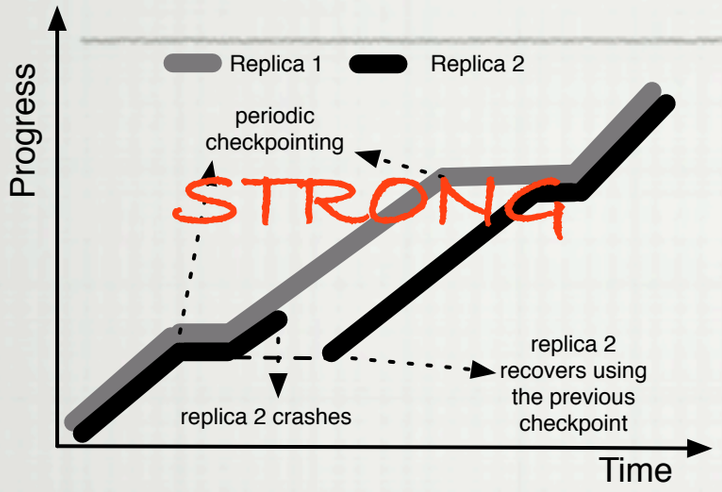

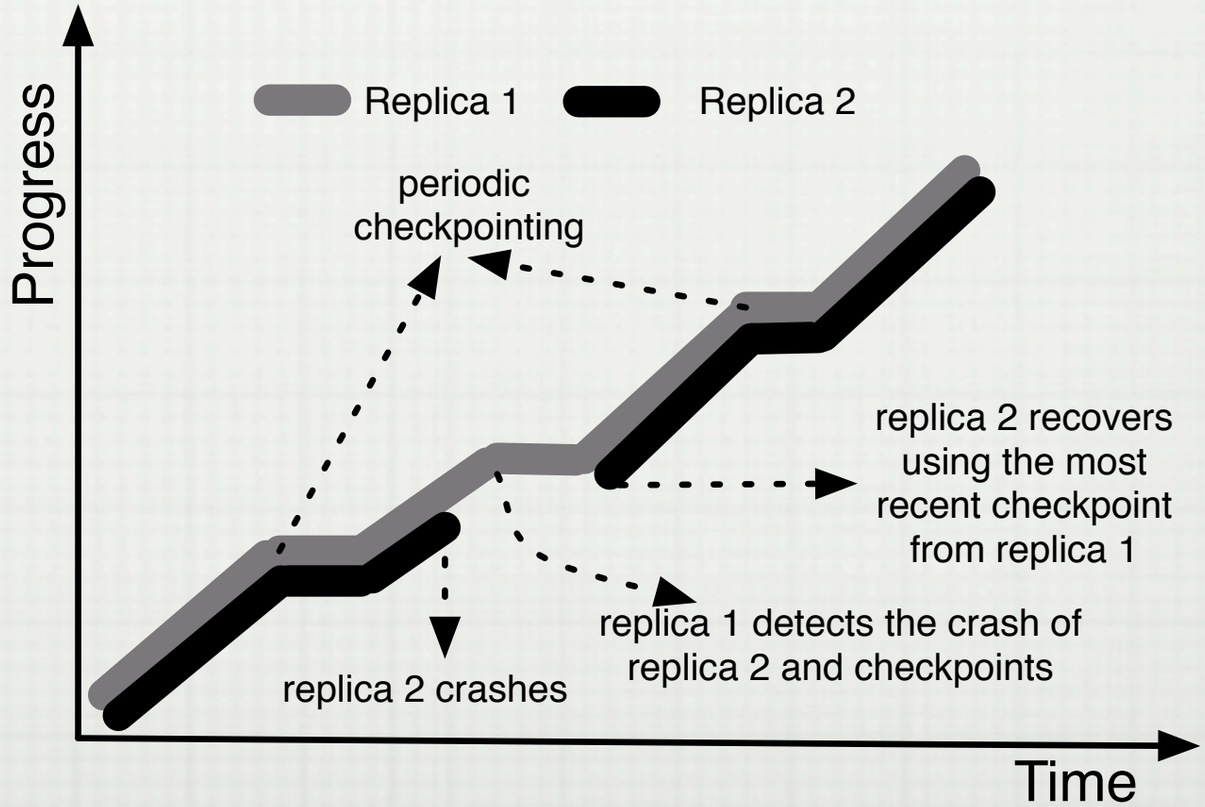

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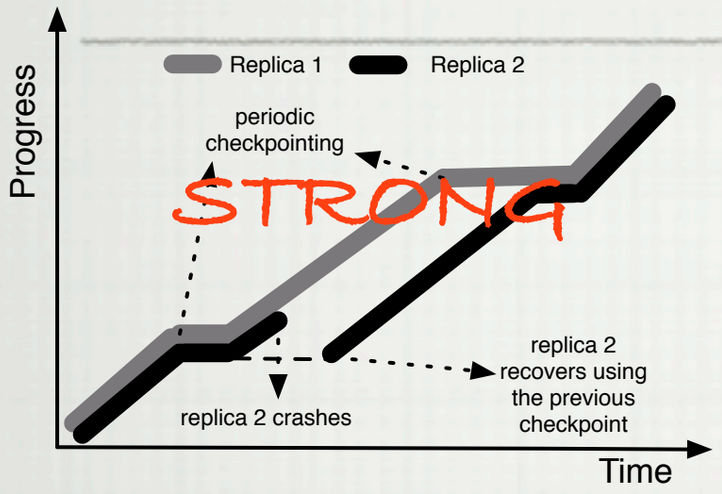

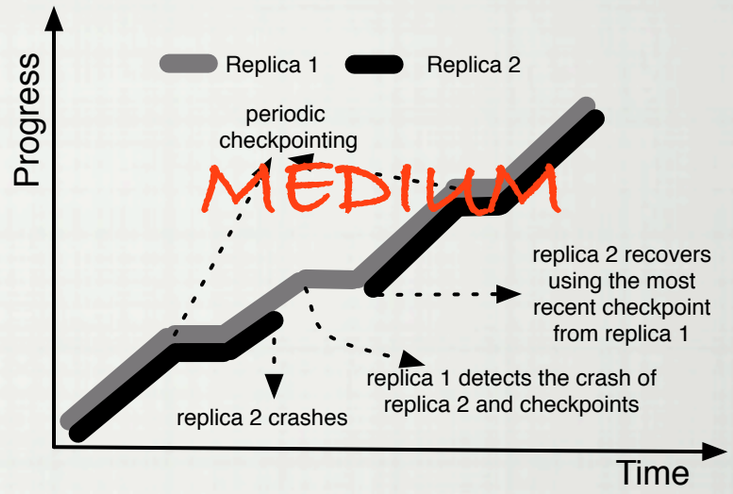

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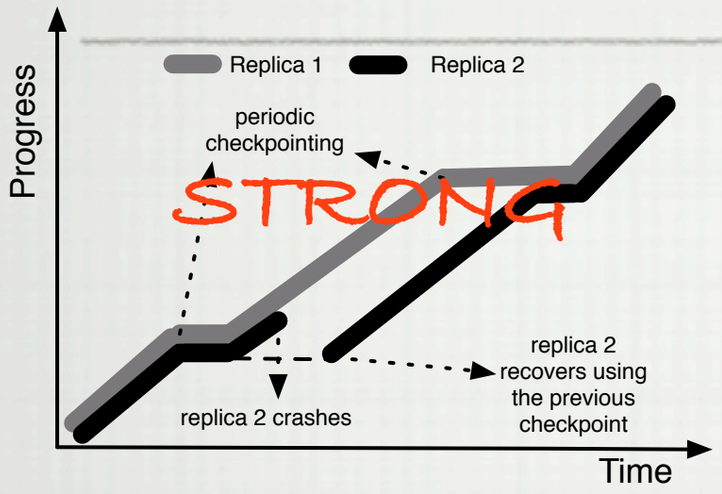
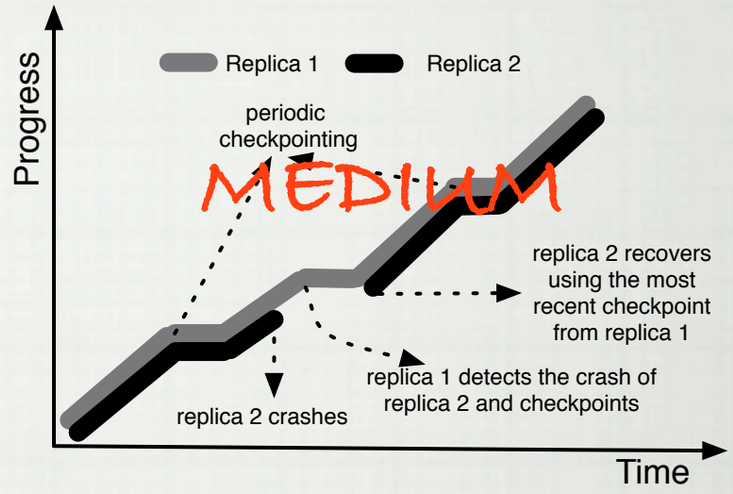
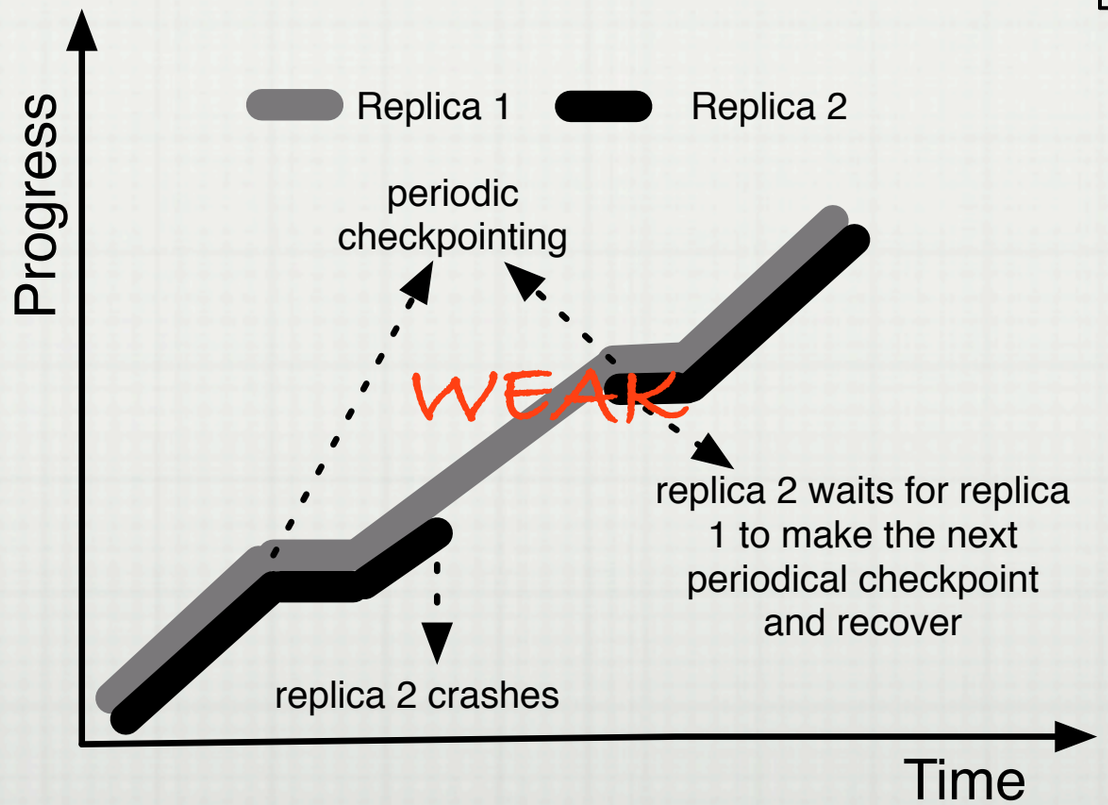


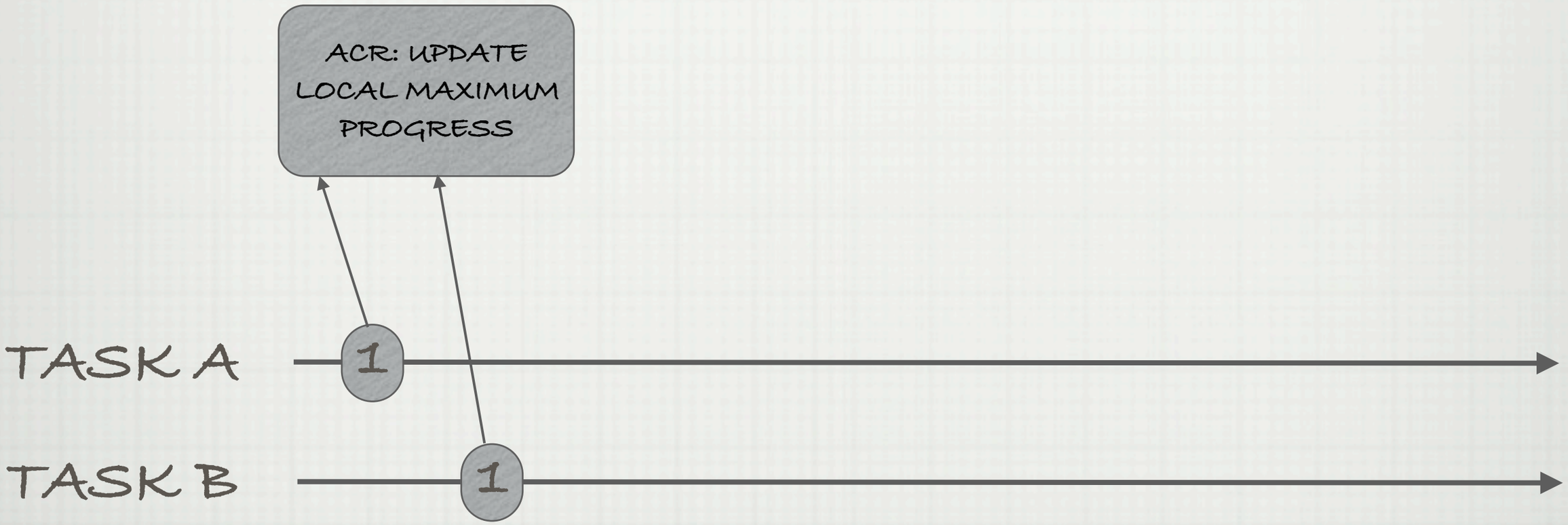




AUTOMATIC CHECKPOINT DECISION

ACR: UPDATE LOCAL MAXIMUM PROGRESS

AUTOMATIC CHECKPOINT DECISION



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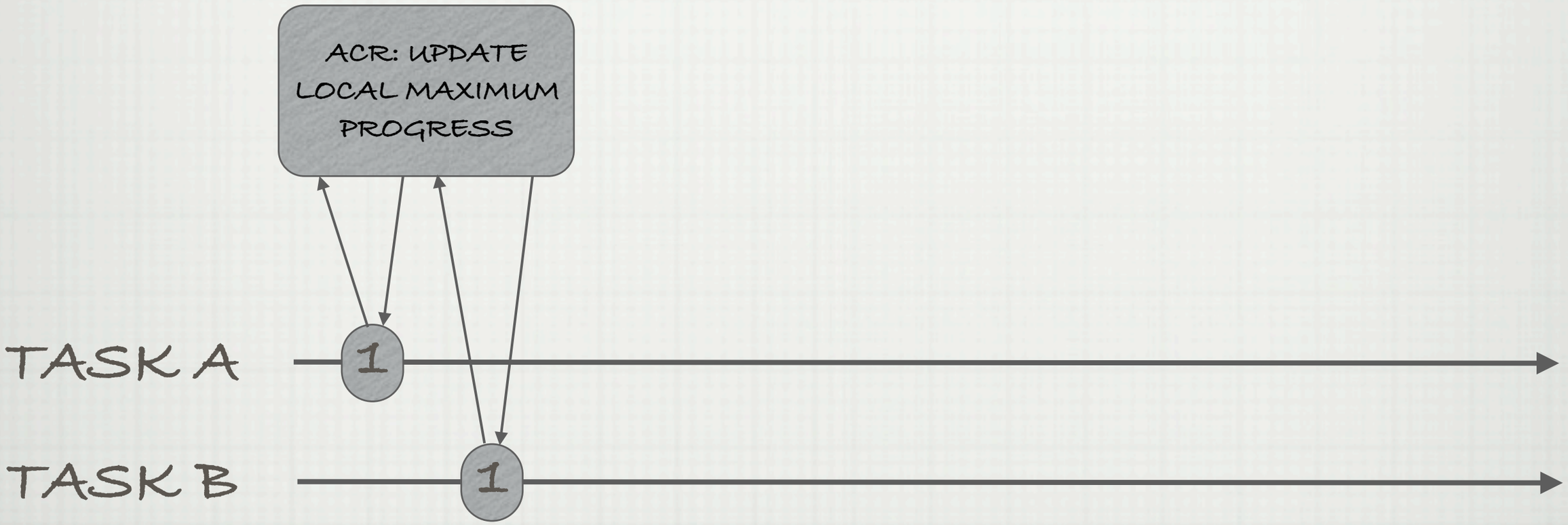

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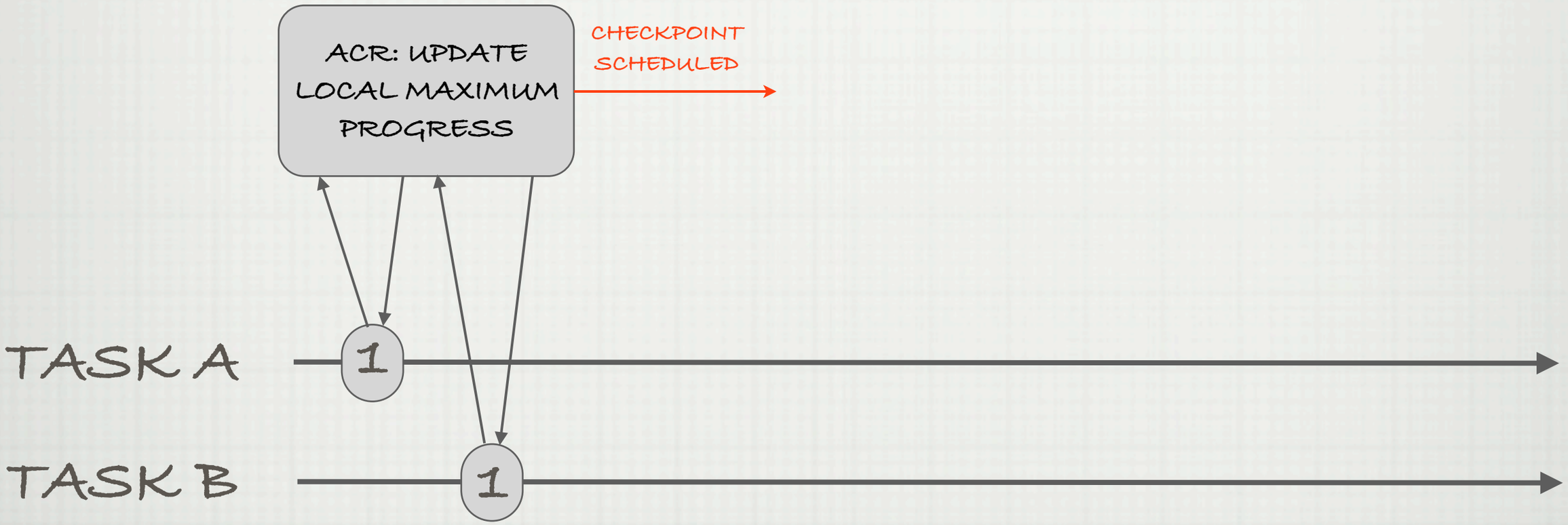

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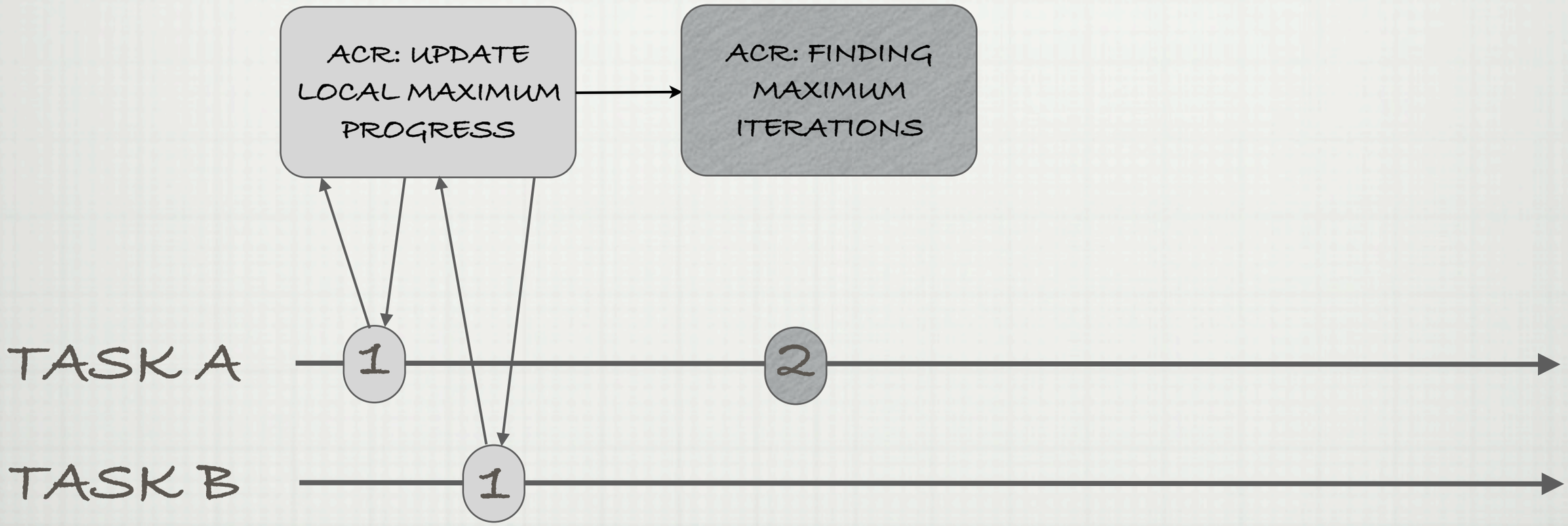

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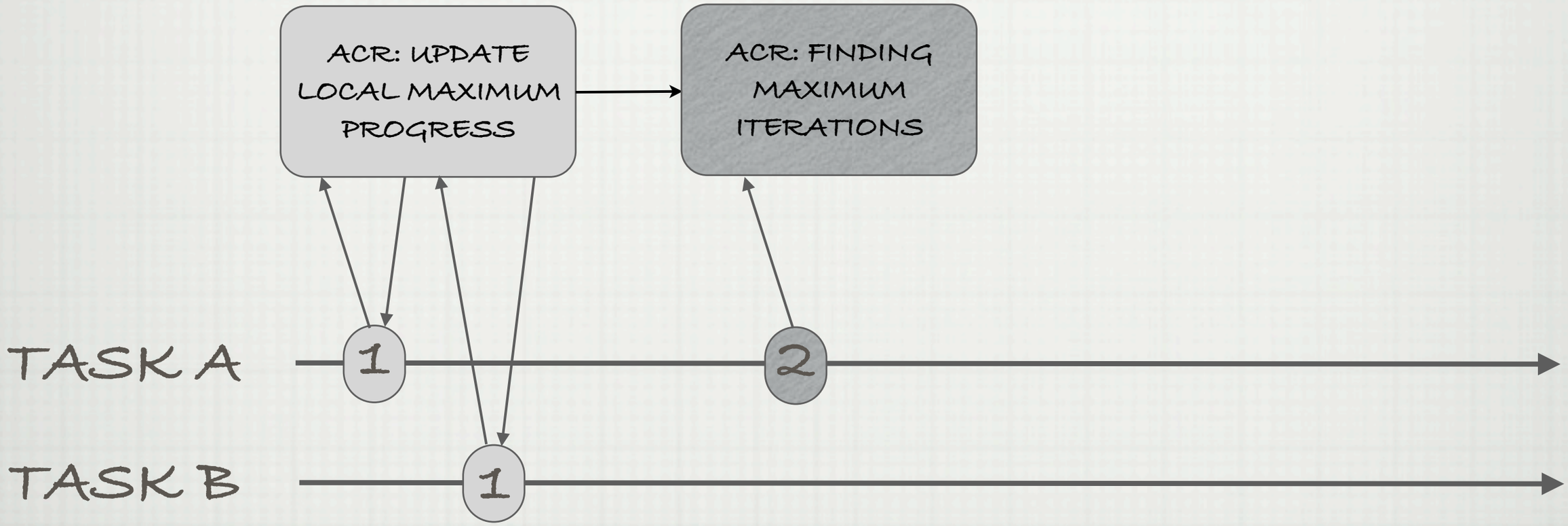

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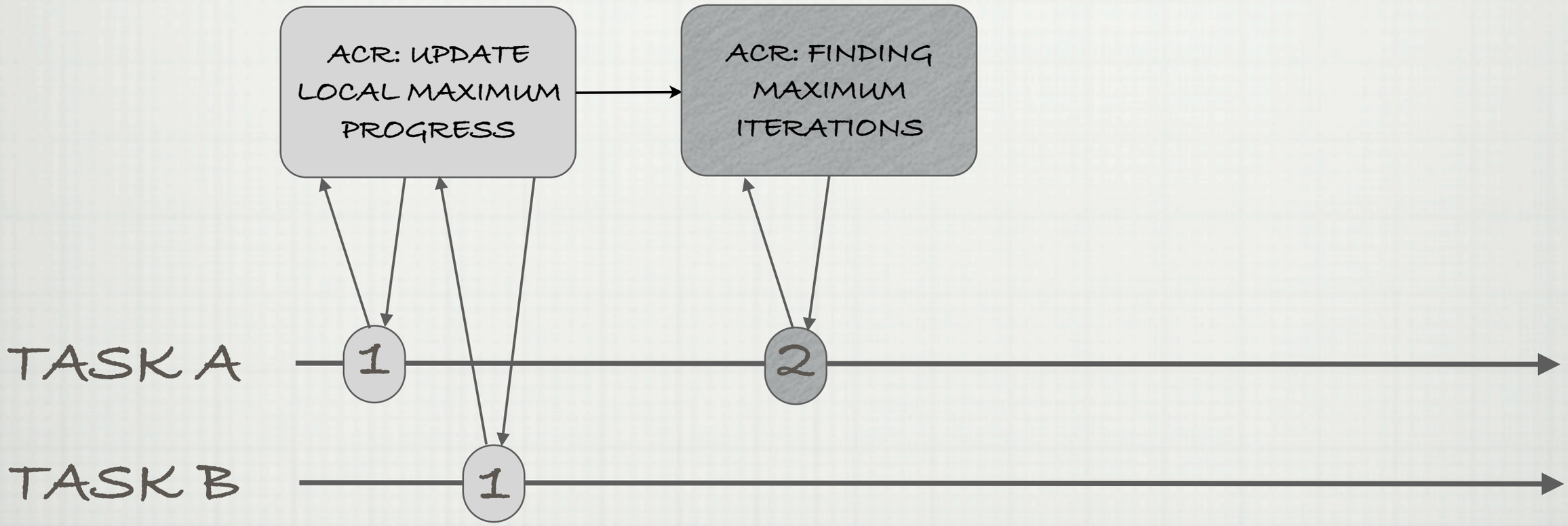

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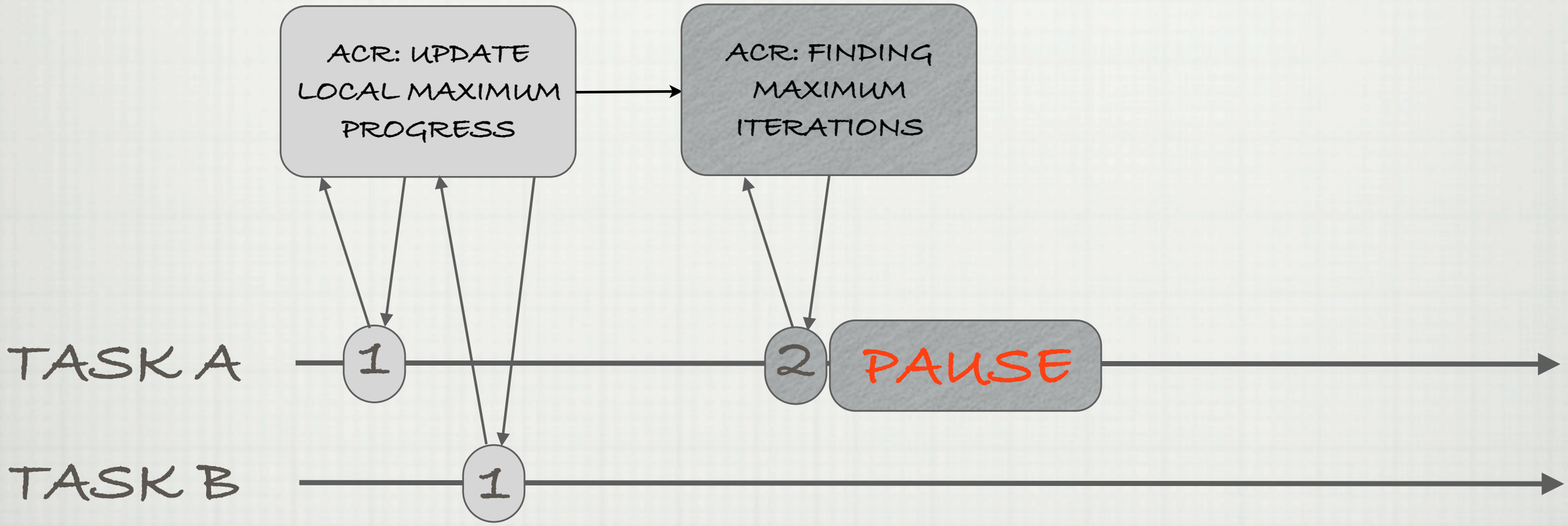

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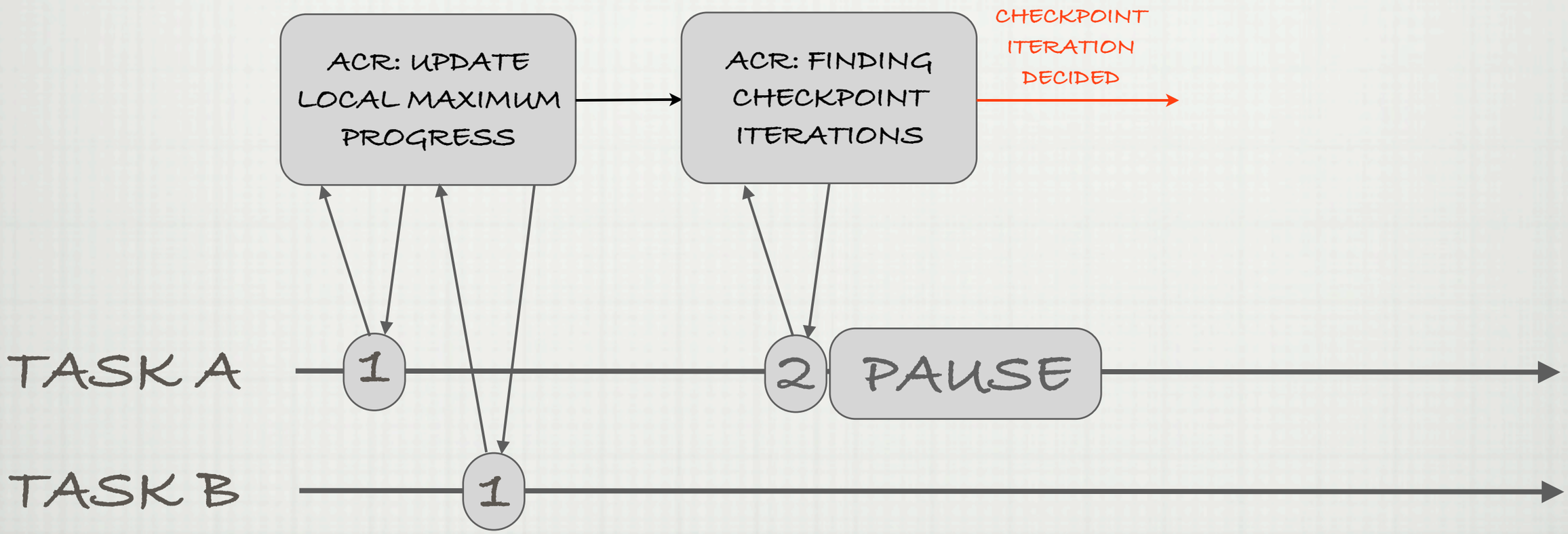

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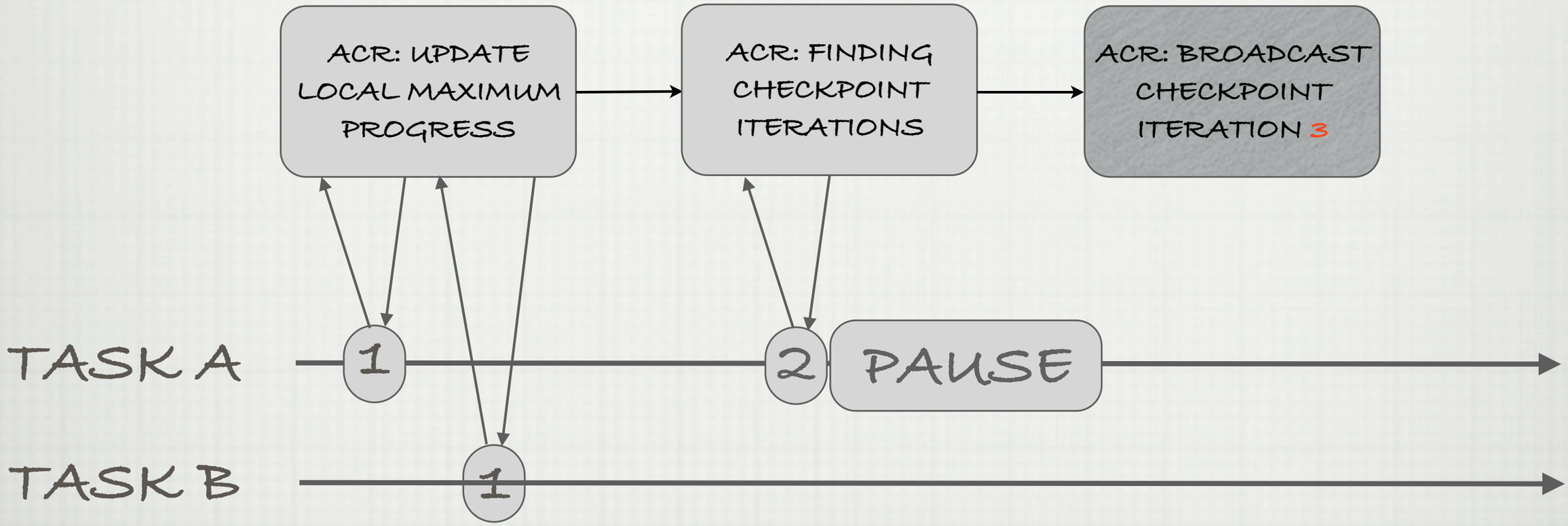

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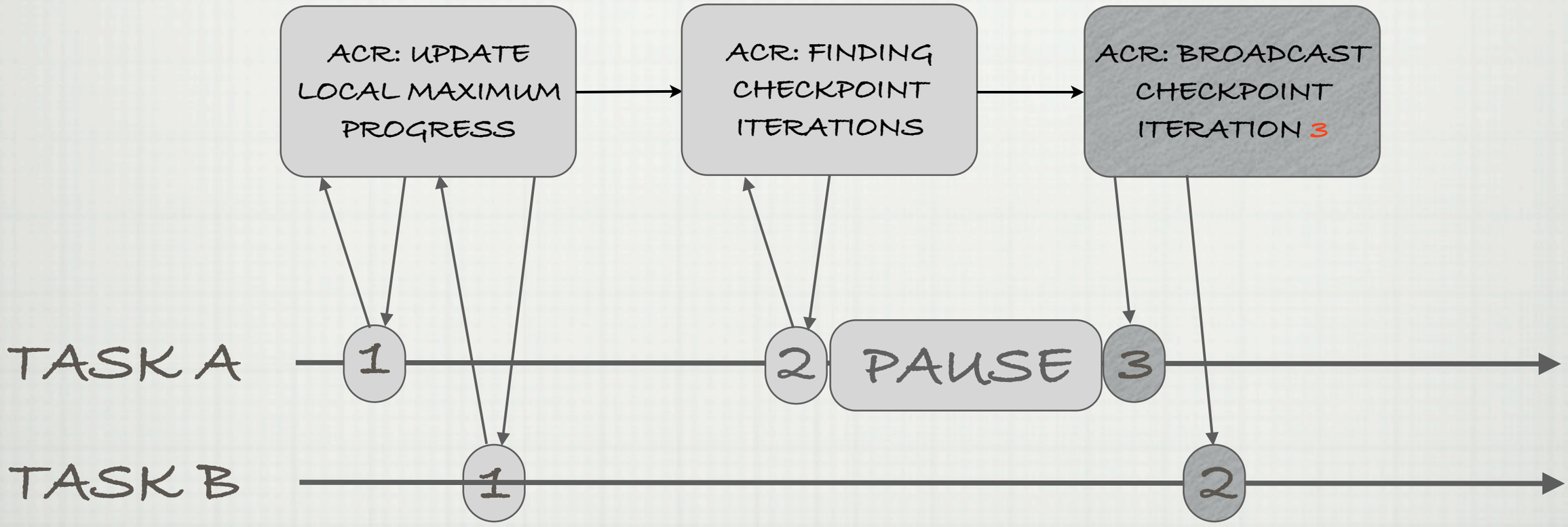

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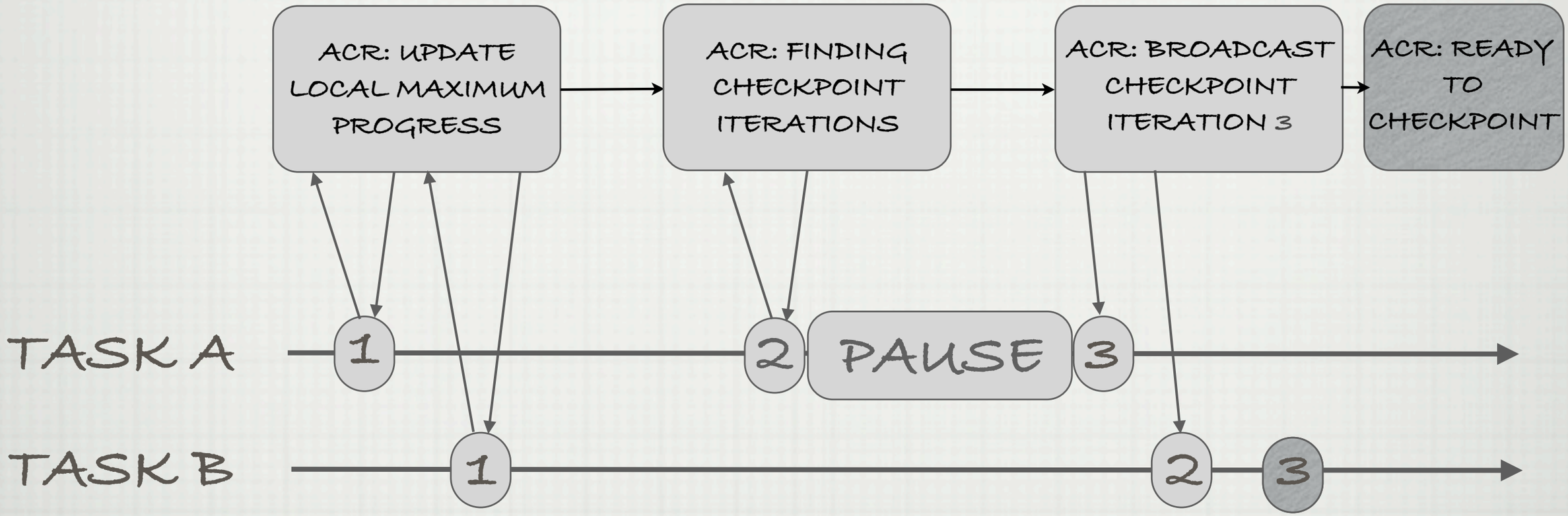

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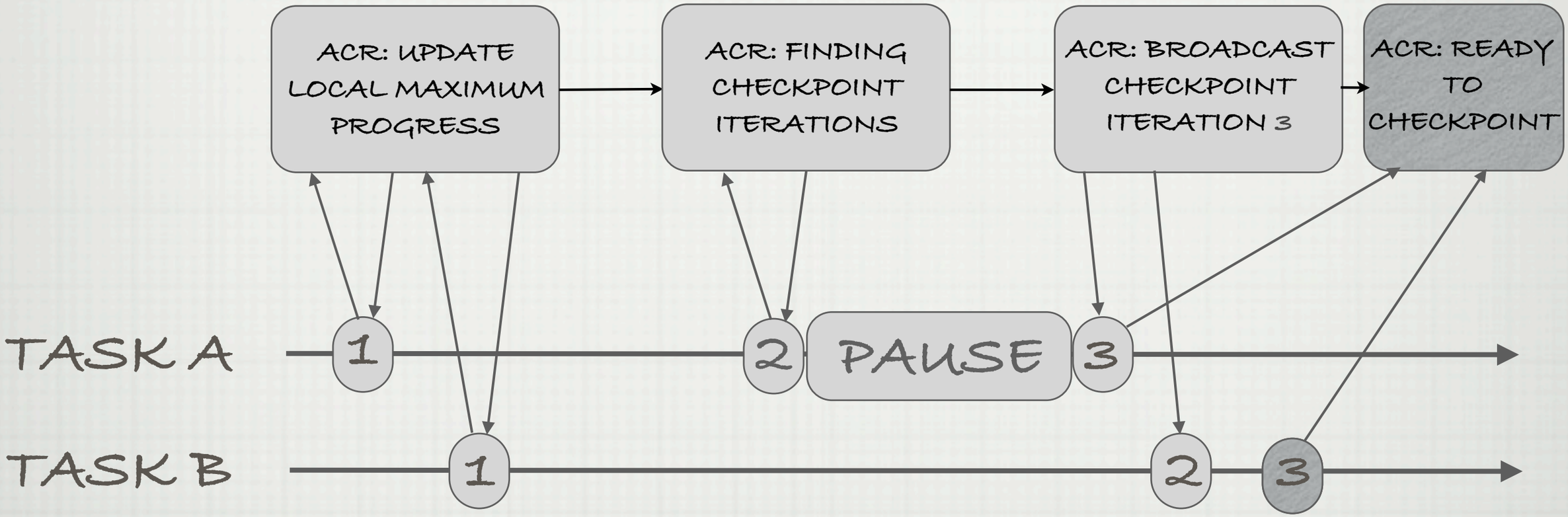
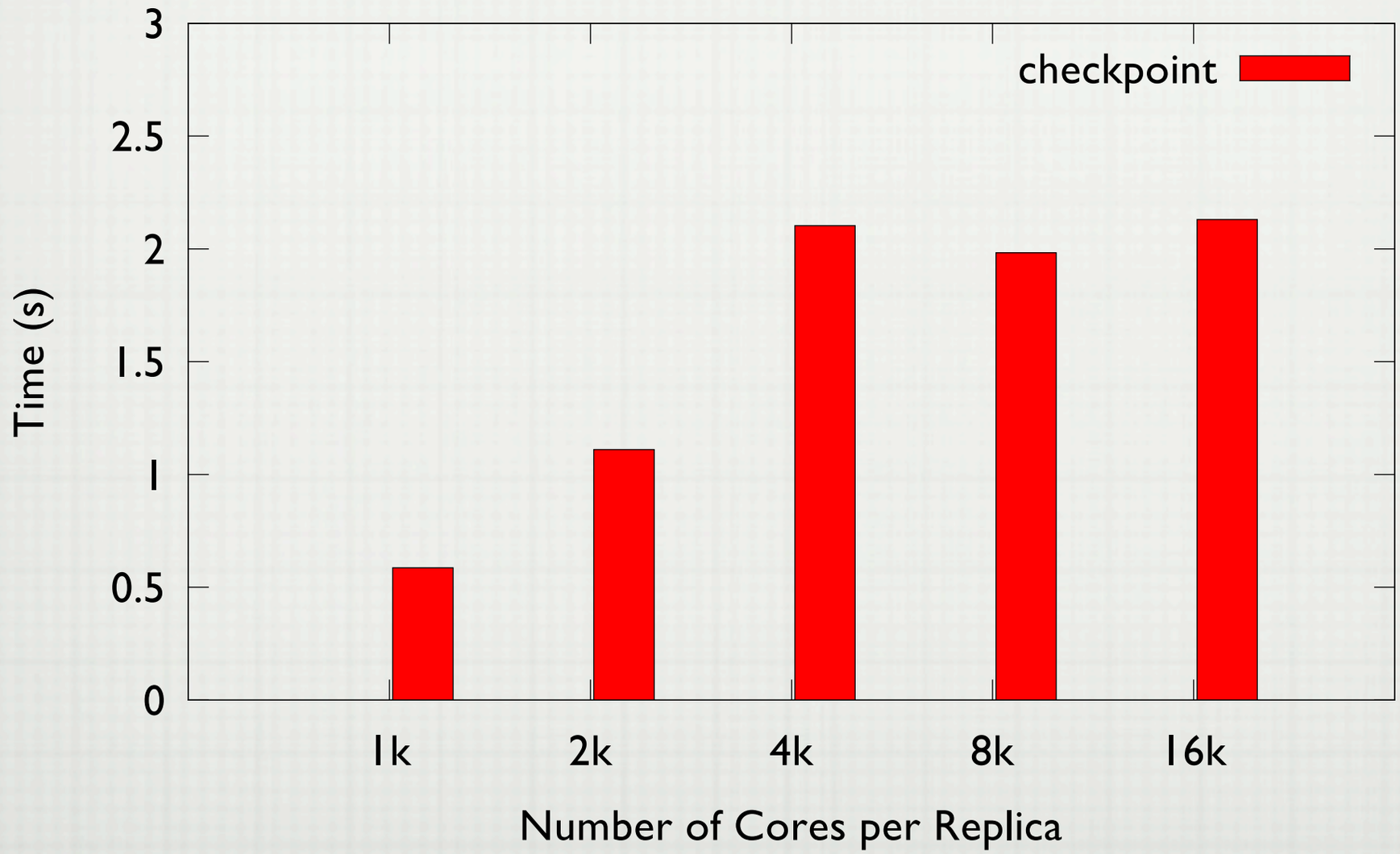
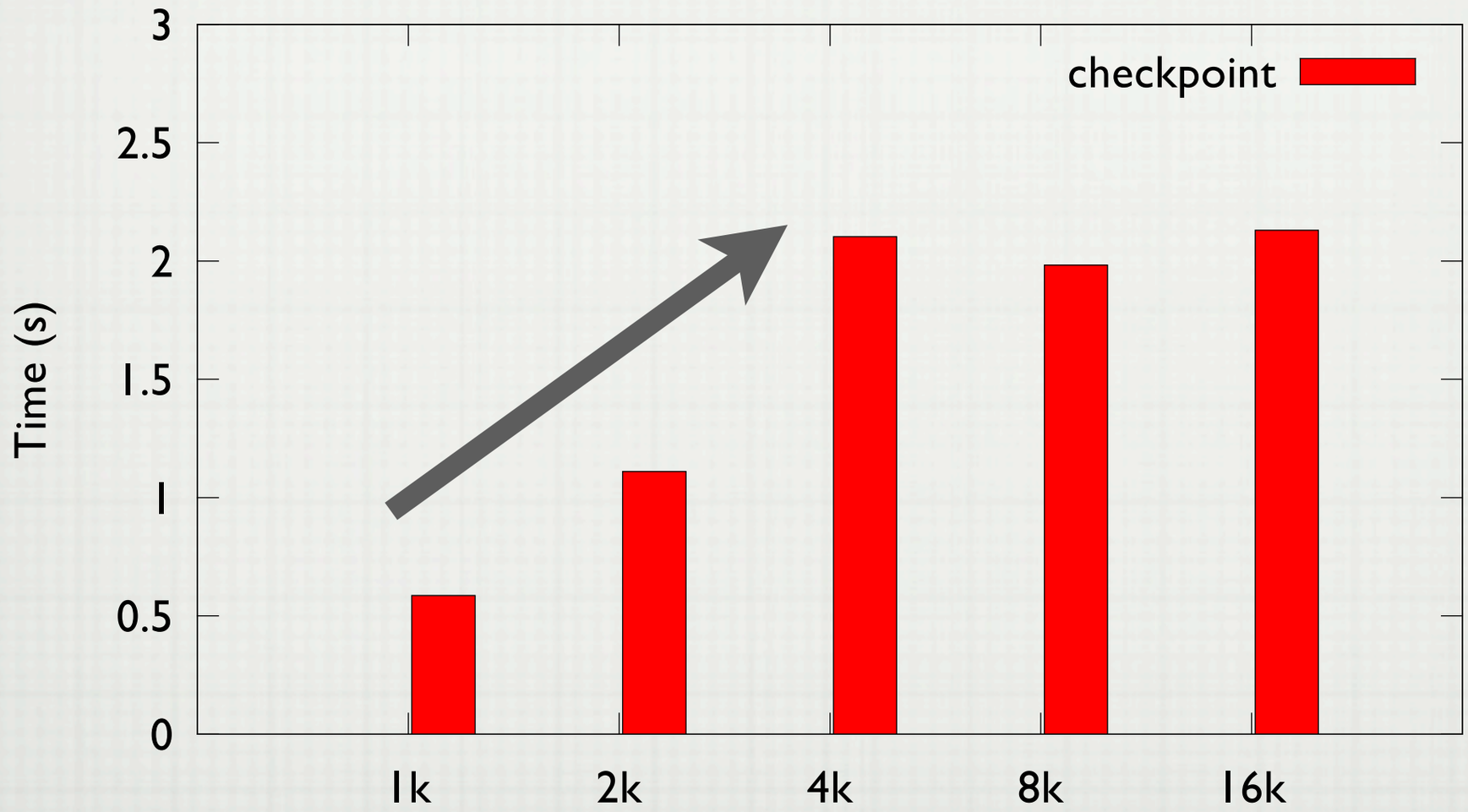


BASE PERFORMANCE



JACOBI3D BGP

BASE PERFORMANCE



JACOBI3D BGP

OPTIMIZATION: TOPOLOGY AWARE MAPPING

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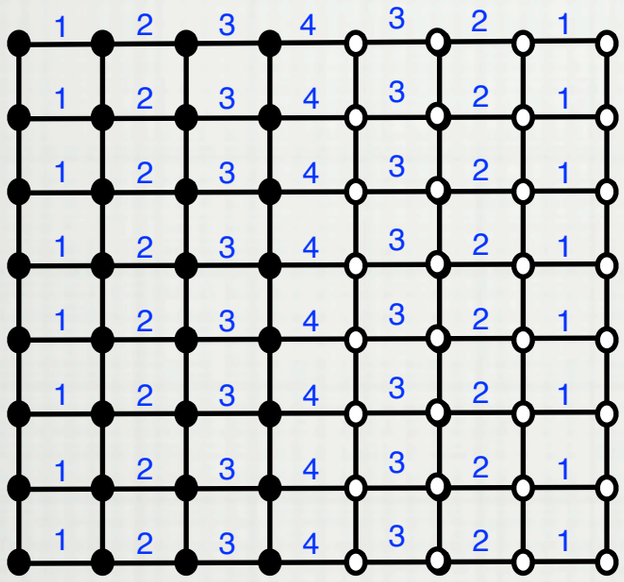
- Replica 1 nodes



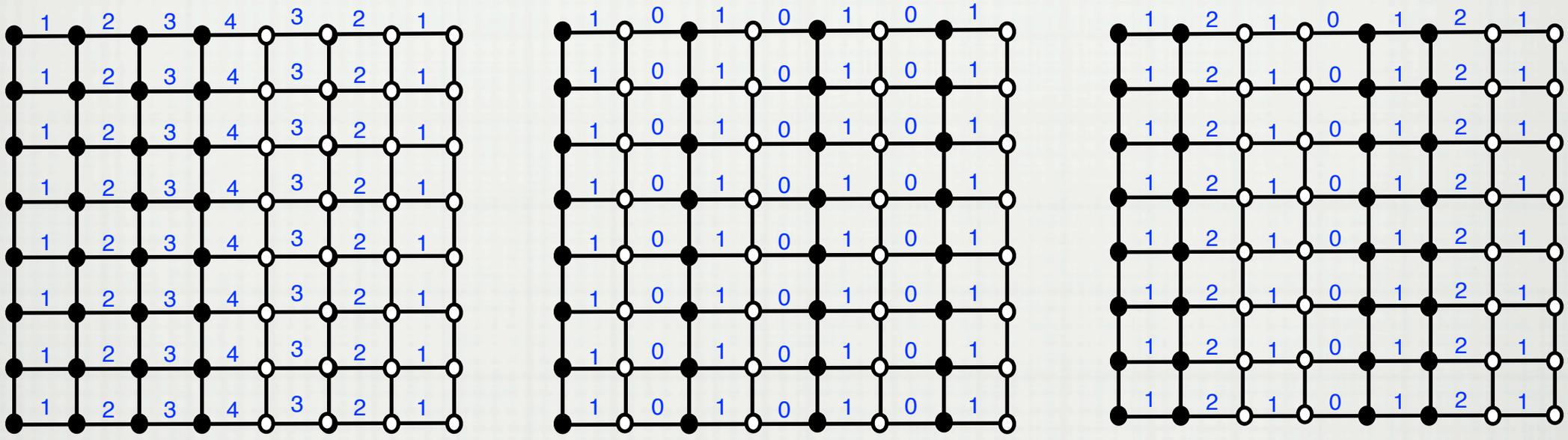
(a) Default-mapping

OPTIMIZATION: TOPOLOGY AWARE MAPPING

● Replica 1 nodes

o Replica 2 nodes

[0-4] # inter-replica messages



(a) Default-mapping

(b) Column-mapping

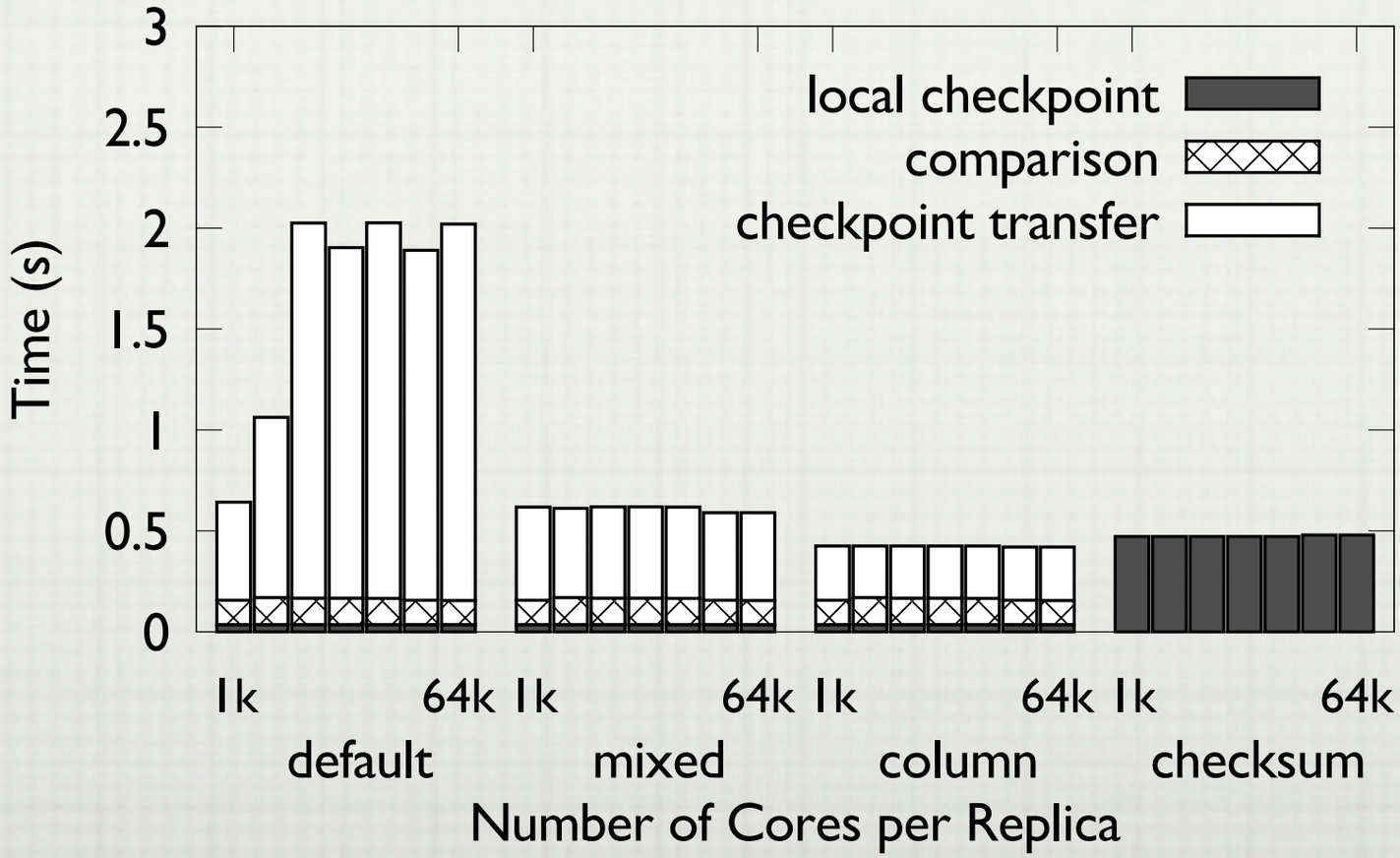
(c) Mixed-mapping

1) Reduce the inter-replica communication distance.

2) Trade-off between inter and intra replica communication.

OPTIMIZATION: CHECKSUM

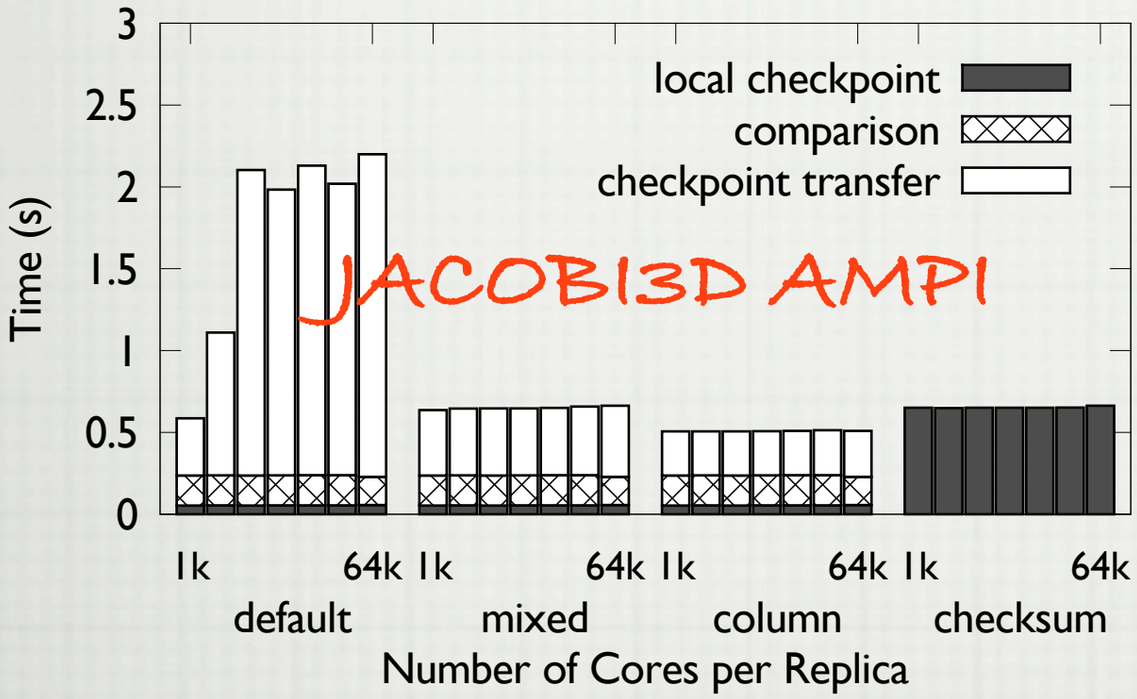
- ☐ TRANSFER THE CHECKSUM OF 1 INTEGER INSTEAD OF THE WHOLE CHECKPOINTS
- ☐ FLOATING POINT ROUND-OFF ERROR

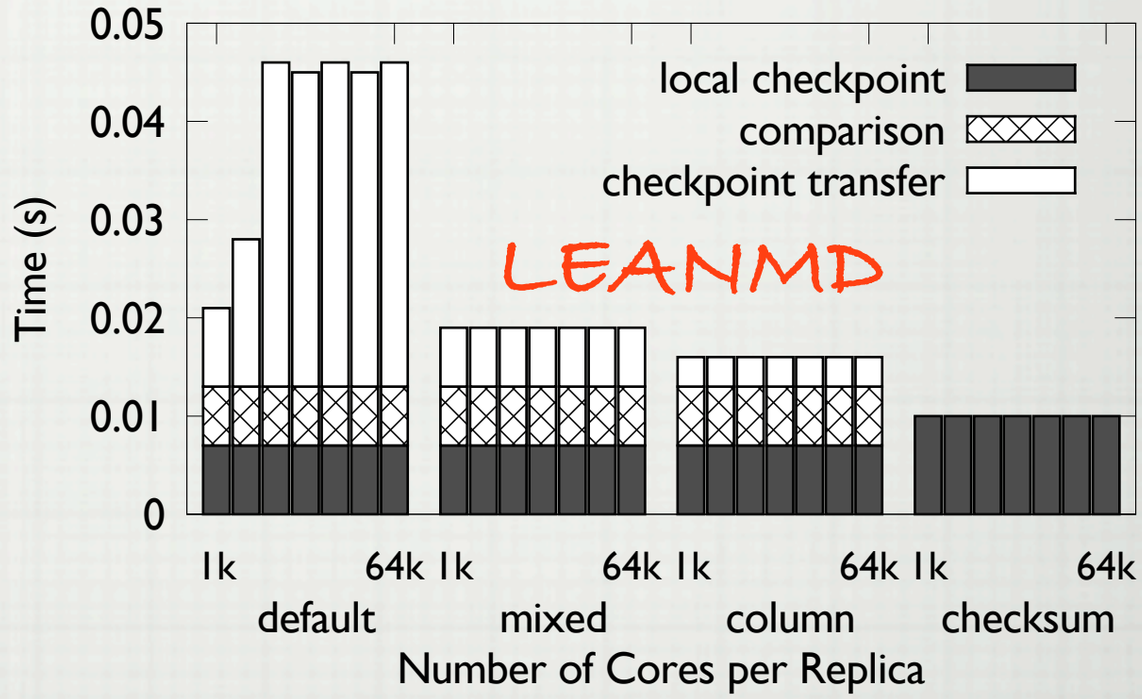


EXPERIMENTAL RESULTS: MINI-APPLICATIONS

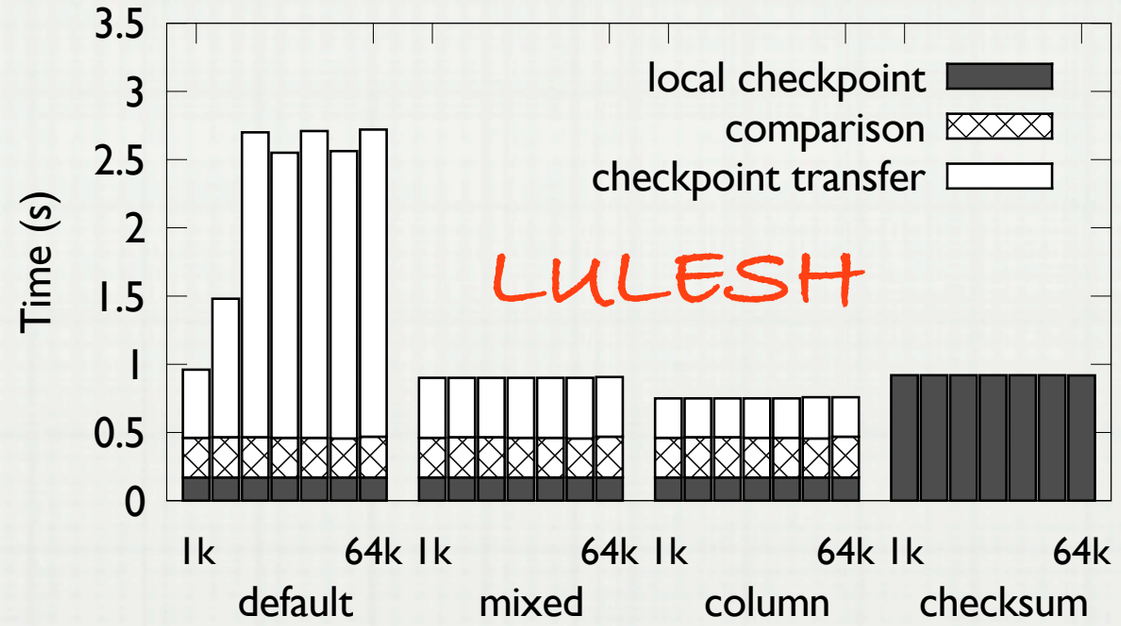
Benchmark	Description	Configuration per core	Memory Pressure
Jacobi3D	7-point stencil	64*64*128	High
HPCCG	Unstructured implicit finite element method	40*40*40	High
LULESH	Unstructured explicit mesh	32*32*64	High
LeanMD	Short-range non-bonded force calculation in NAMD	4000 atoms	Low
miniMD	Mimic the performance in LAMMPS	1000 atoms	Low

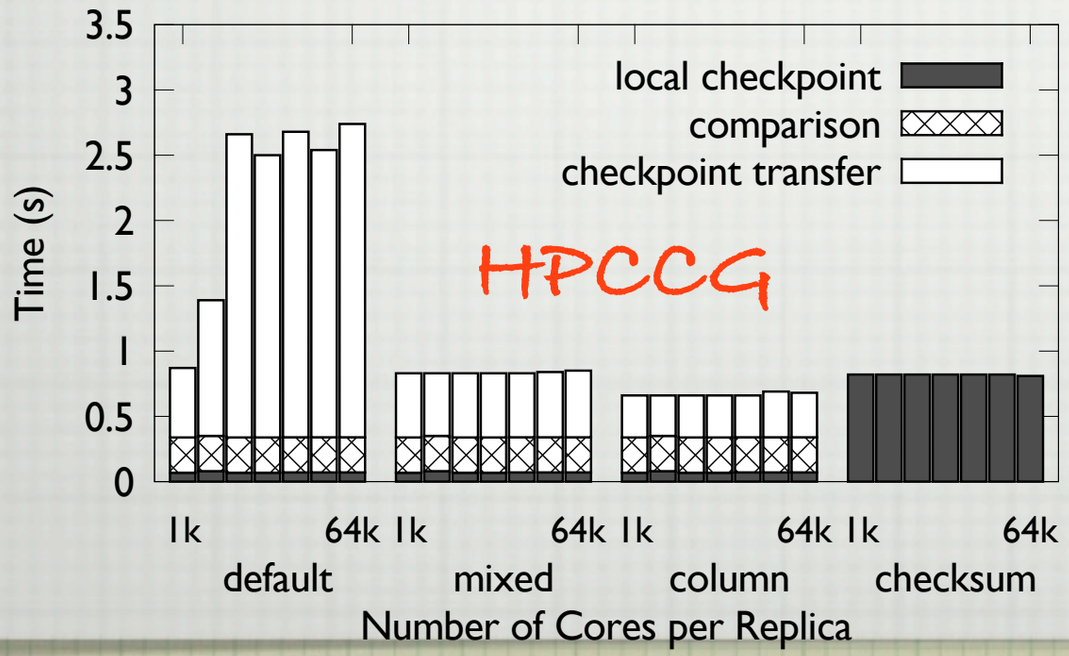
EXPERIMENTAL RESULTS: CHECKPOINT

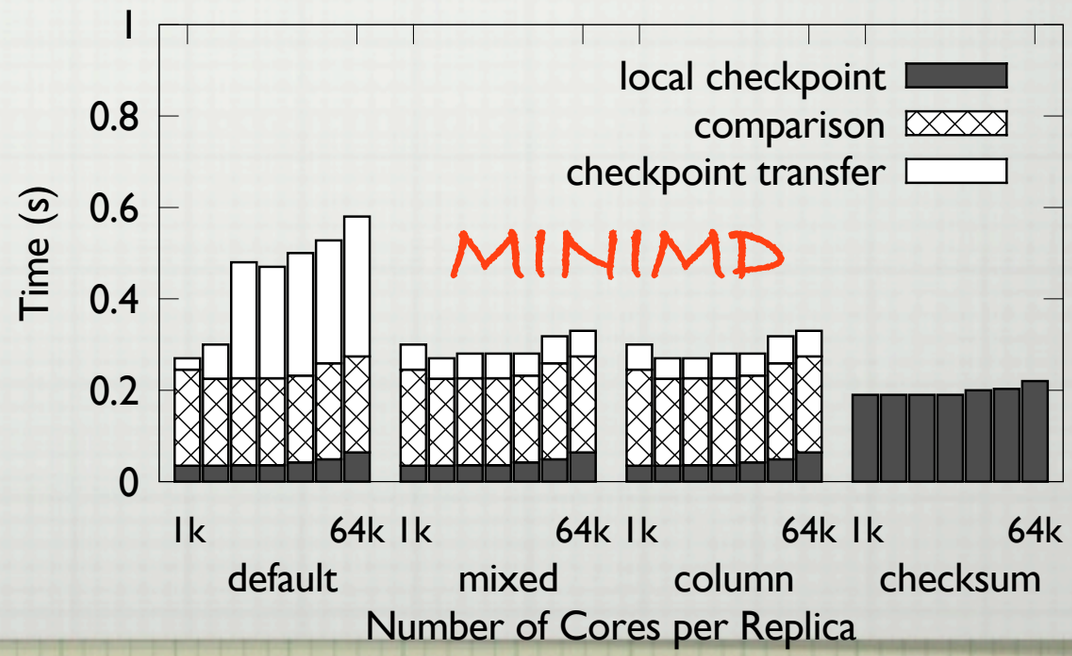




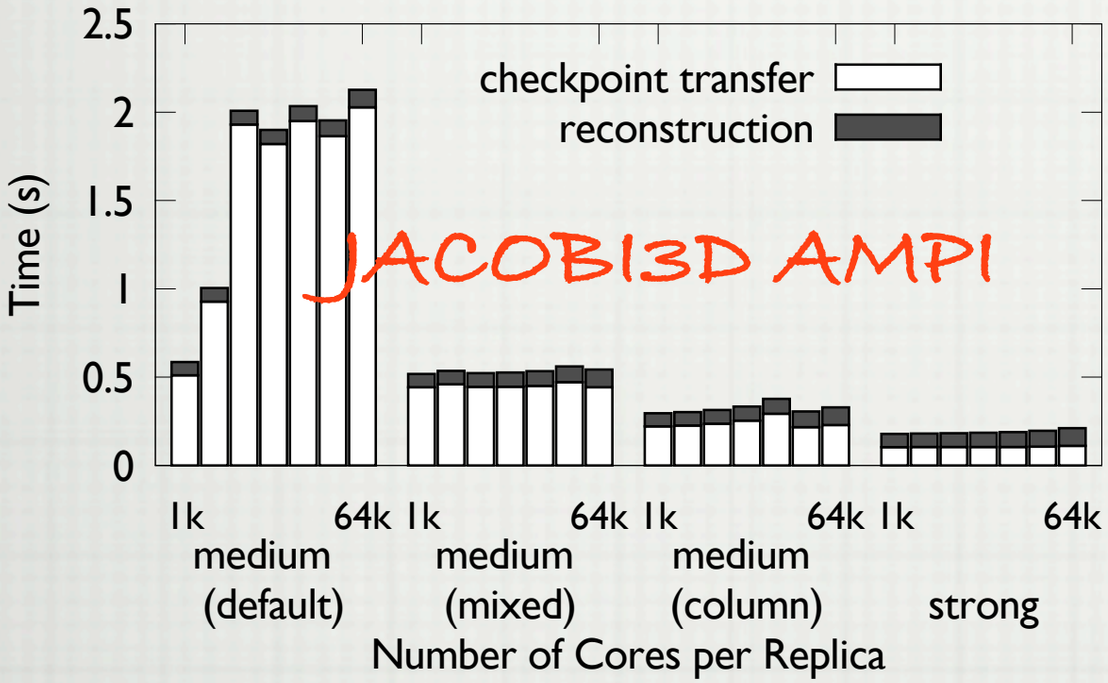
EXPERIMENTAL RESULTS: CHECKPOINT

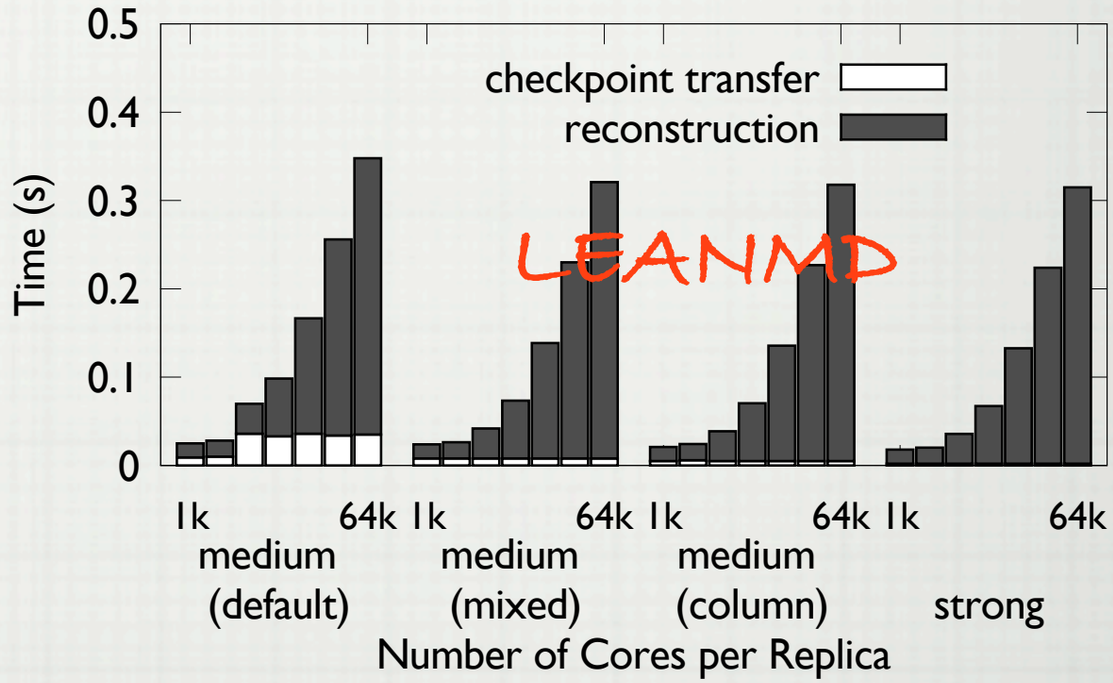






EXPERIMENTAL RESULTS: RESTART





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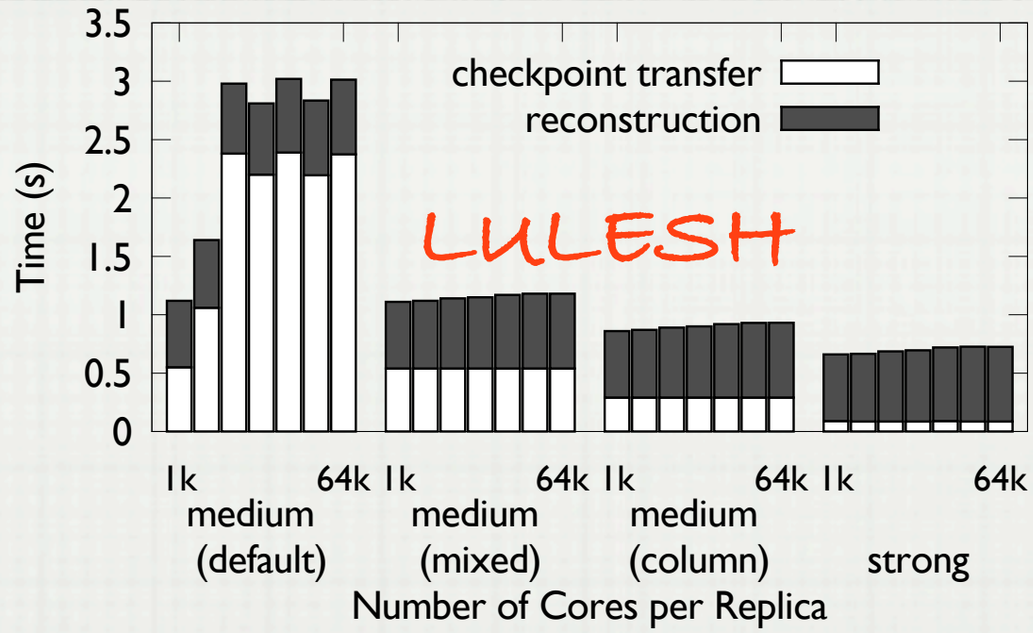
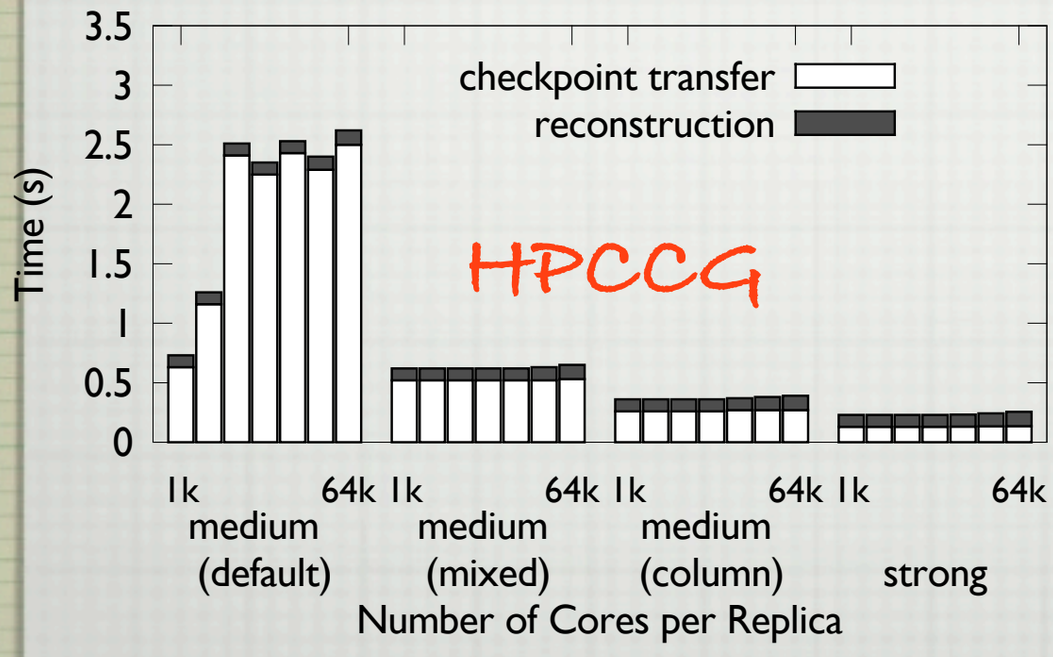
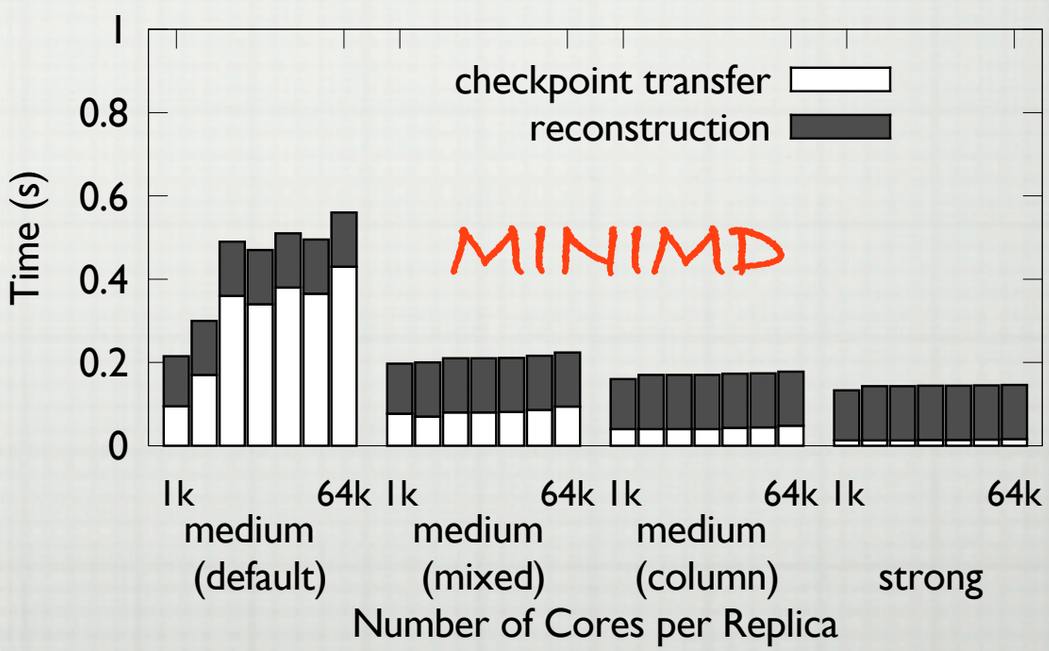
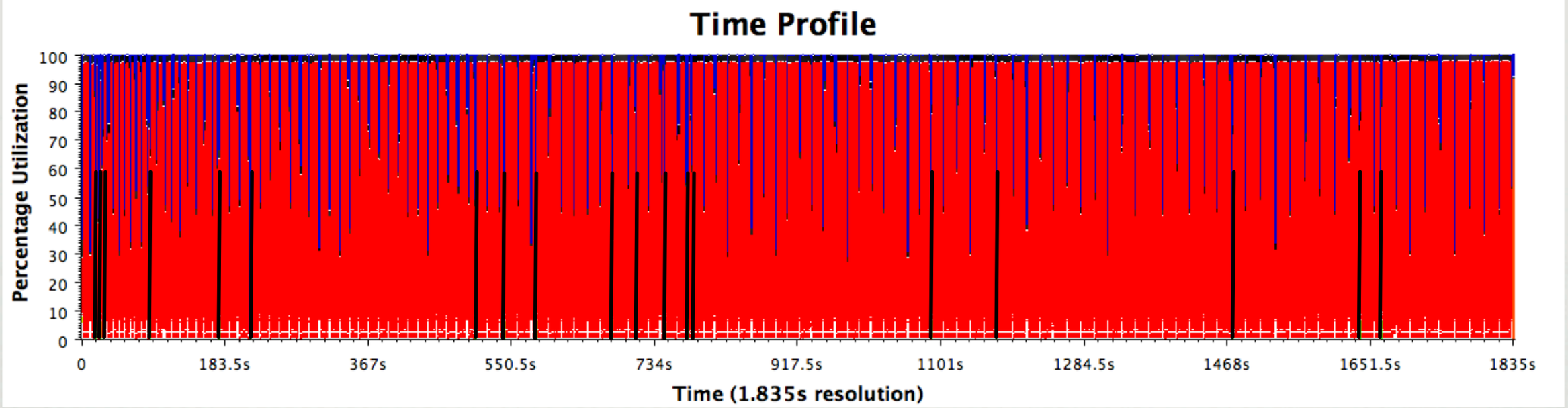




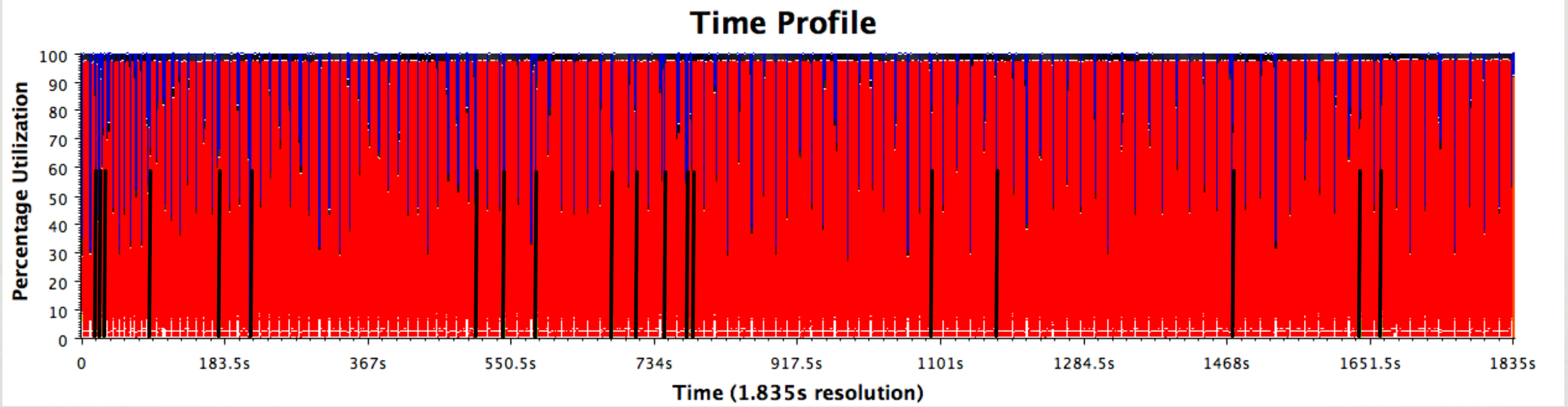


ADAPTING TO FAILURES



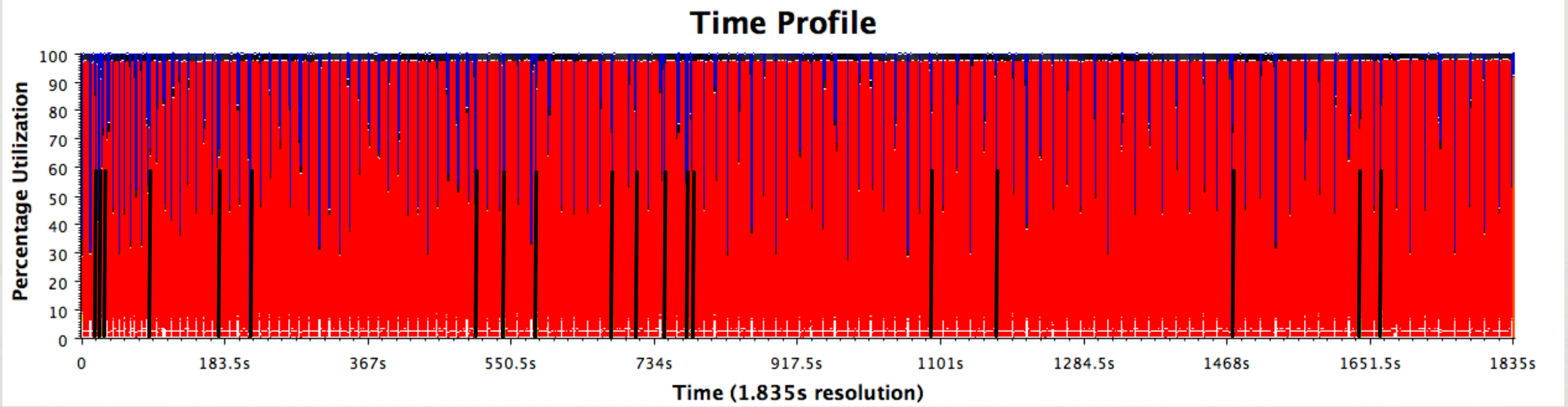
- Failures are injected according to Weibull process: shape parameter 0.6
- Changing Checkpoint period

ADAPTING TO FAILURES



- Failures are injected according to Weibull process: shape parameter 0.6
- Changing Checkpoint period

ADAPTING TO FAILURES



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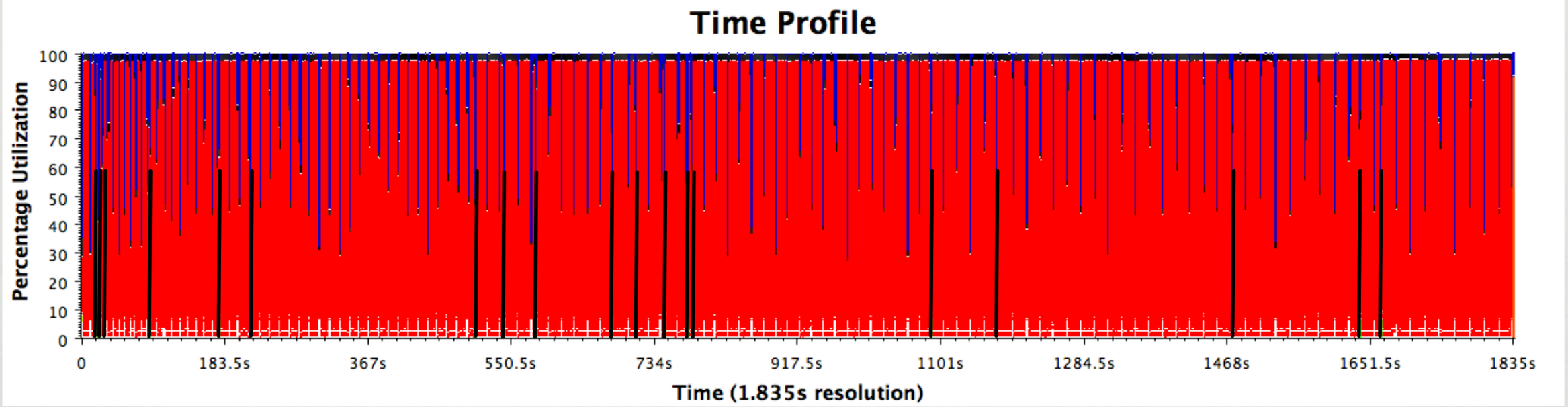
- Failures are injected according to Weibull process: shape parameter 0.6
- Changing Checkpoint period

175

ADAPTING TO FAILURES



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- Failures are injected according to Weibull process: shape parameter 0.6
- Changing Checkpoint period

175

- Real failures injected: node becomes irresponsive
- Automatic restart: with the support of spare nodes and thus no need to submit the job again

CONCLUSION

- Automatic checkpoint decision
  - Restart from hard errors
  - Adapting to different failure distributions
- Protection for both hard and soft errors
- Good scalability

THANKS!

- [ ] QUESTIONS?