MORE THAN YOU EVER WANTED TO KNOW ABOUT SYNCHRONIZATION

by Vincent Gramoli

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Concurrency & Memory Management Seminar 2015

Department of Computer Sciences

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SYNCHRONIZATION

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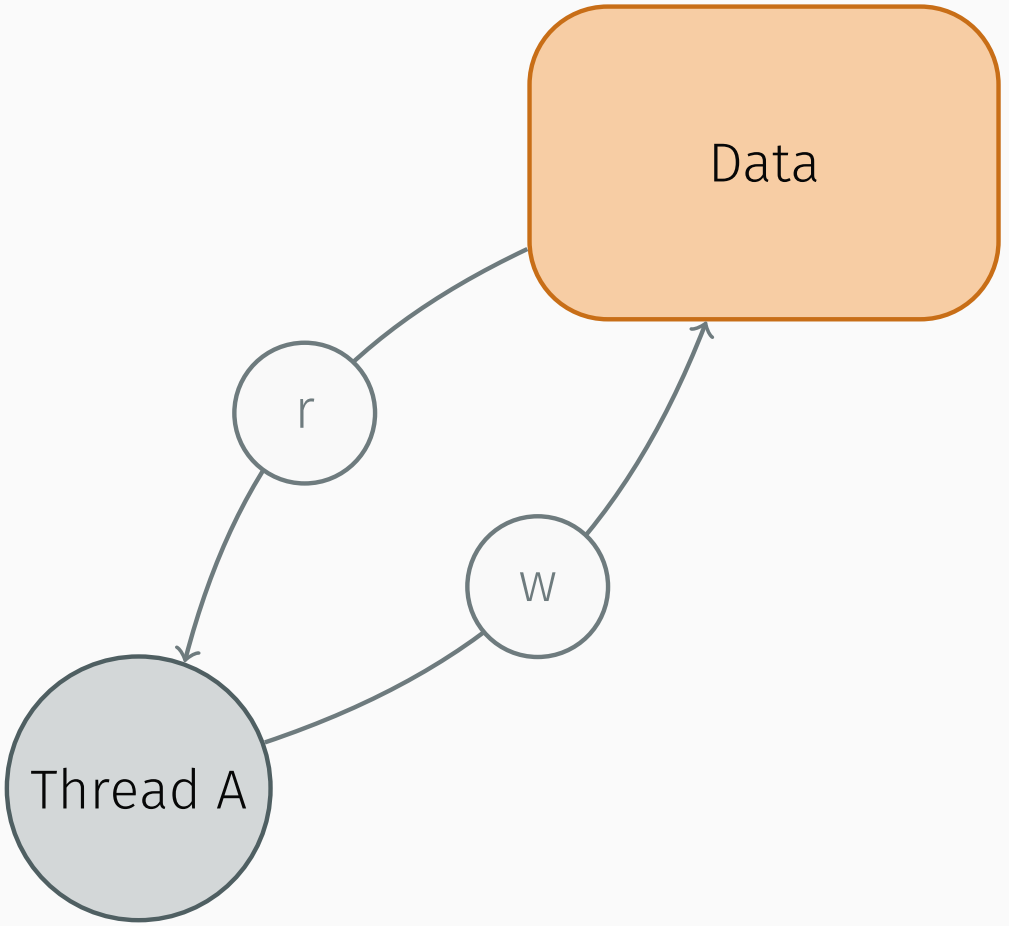

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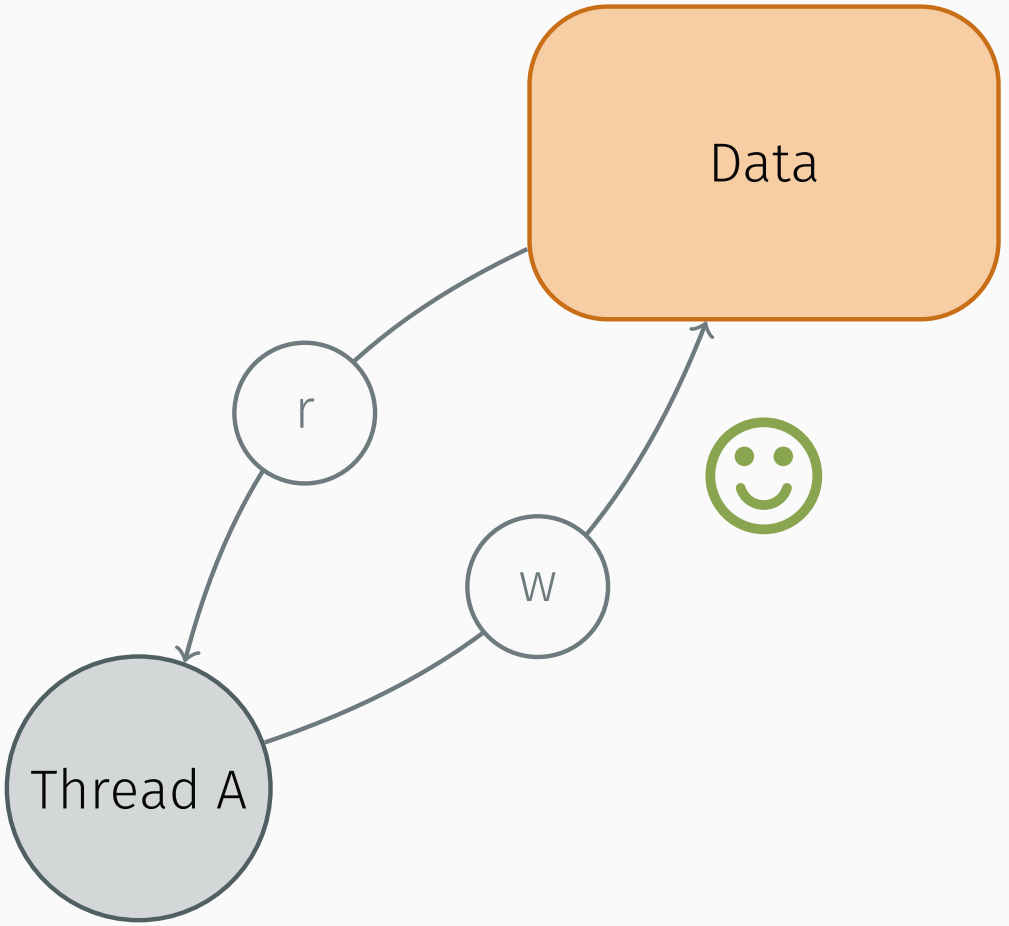

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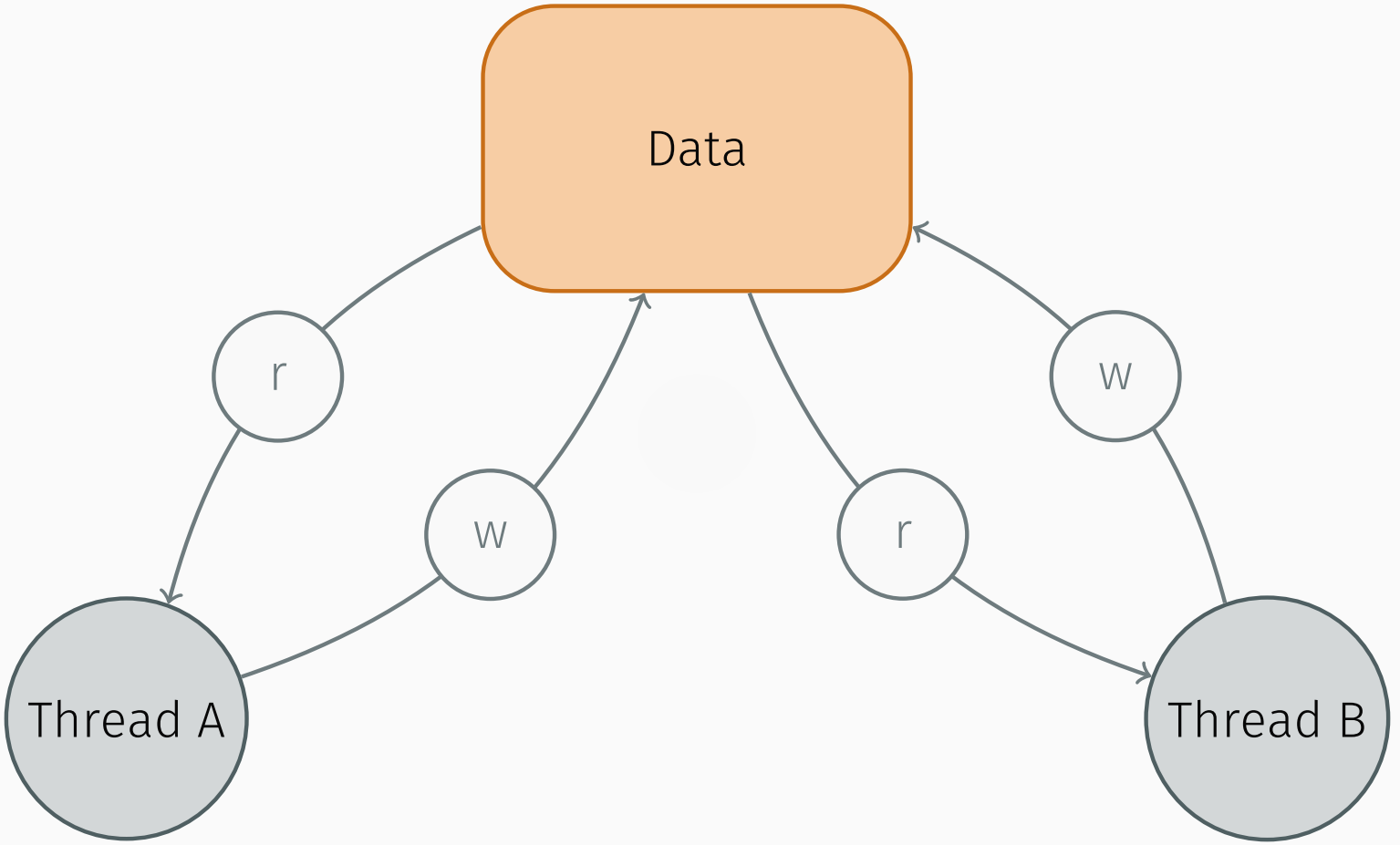

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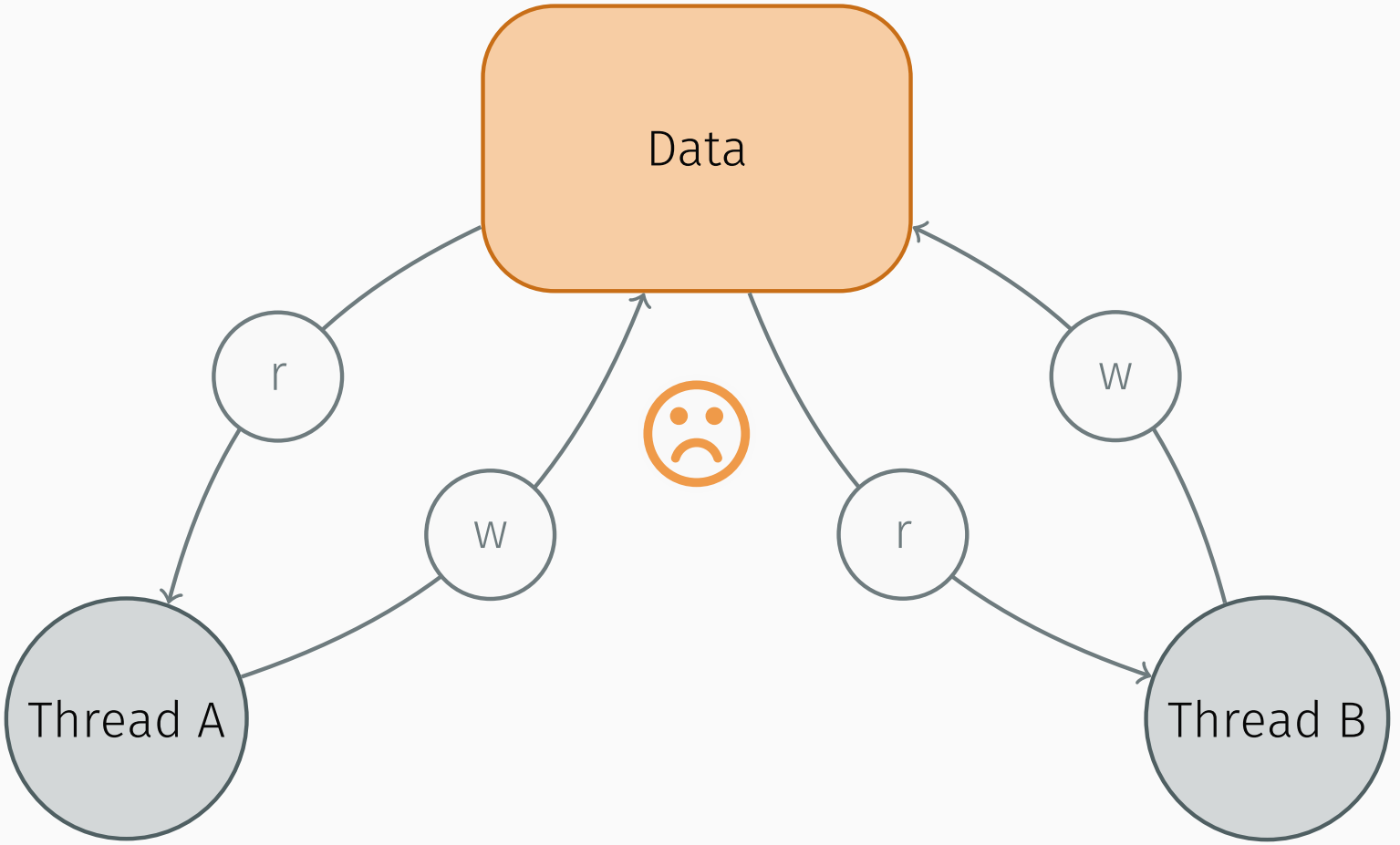

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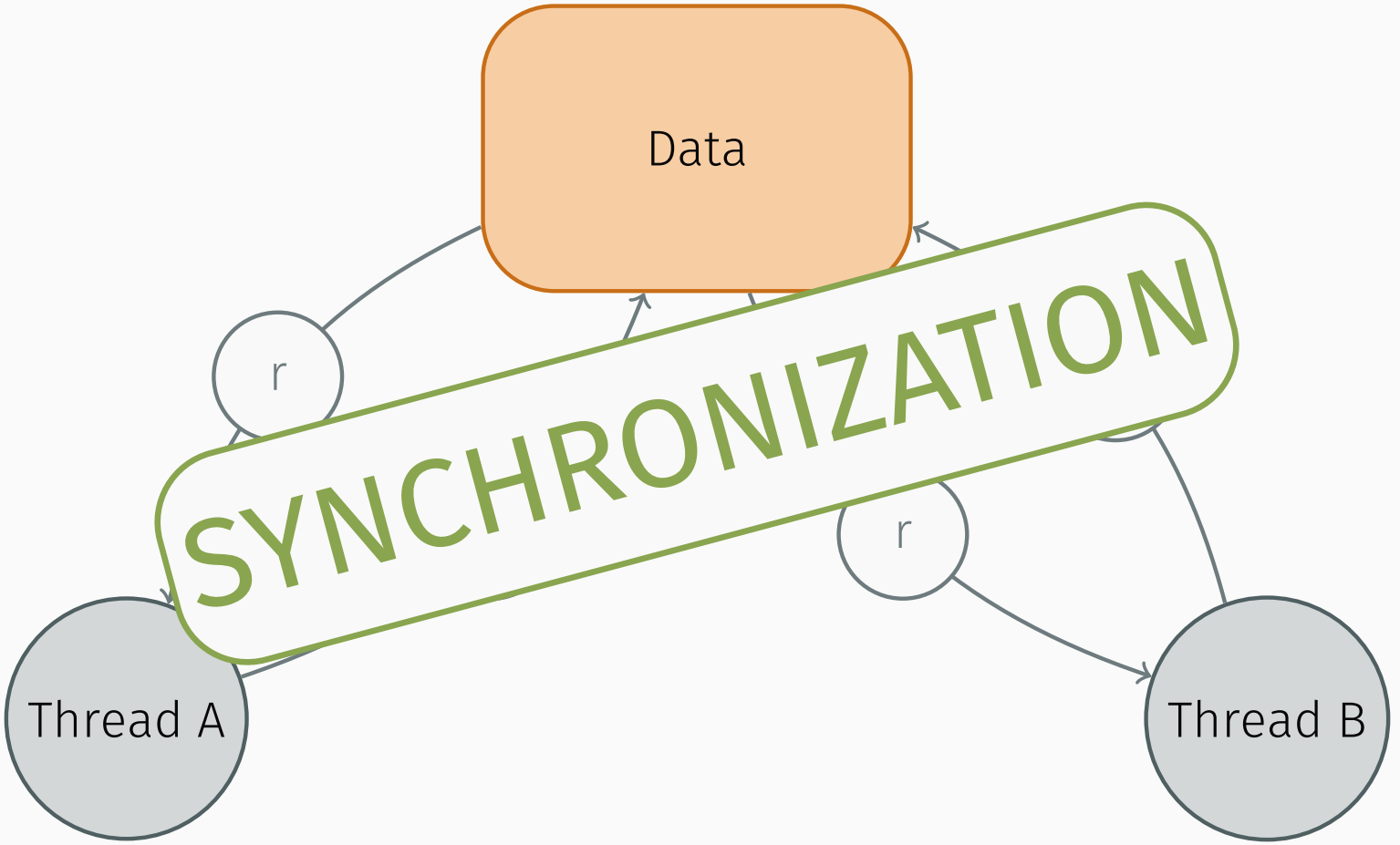

MUTUAL EXCLUSION

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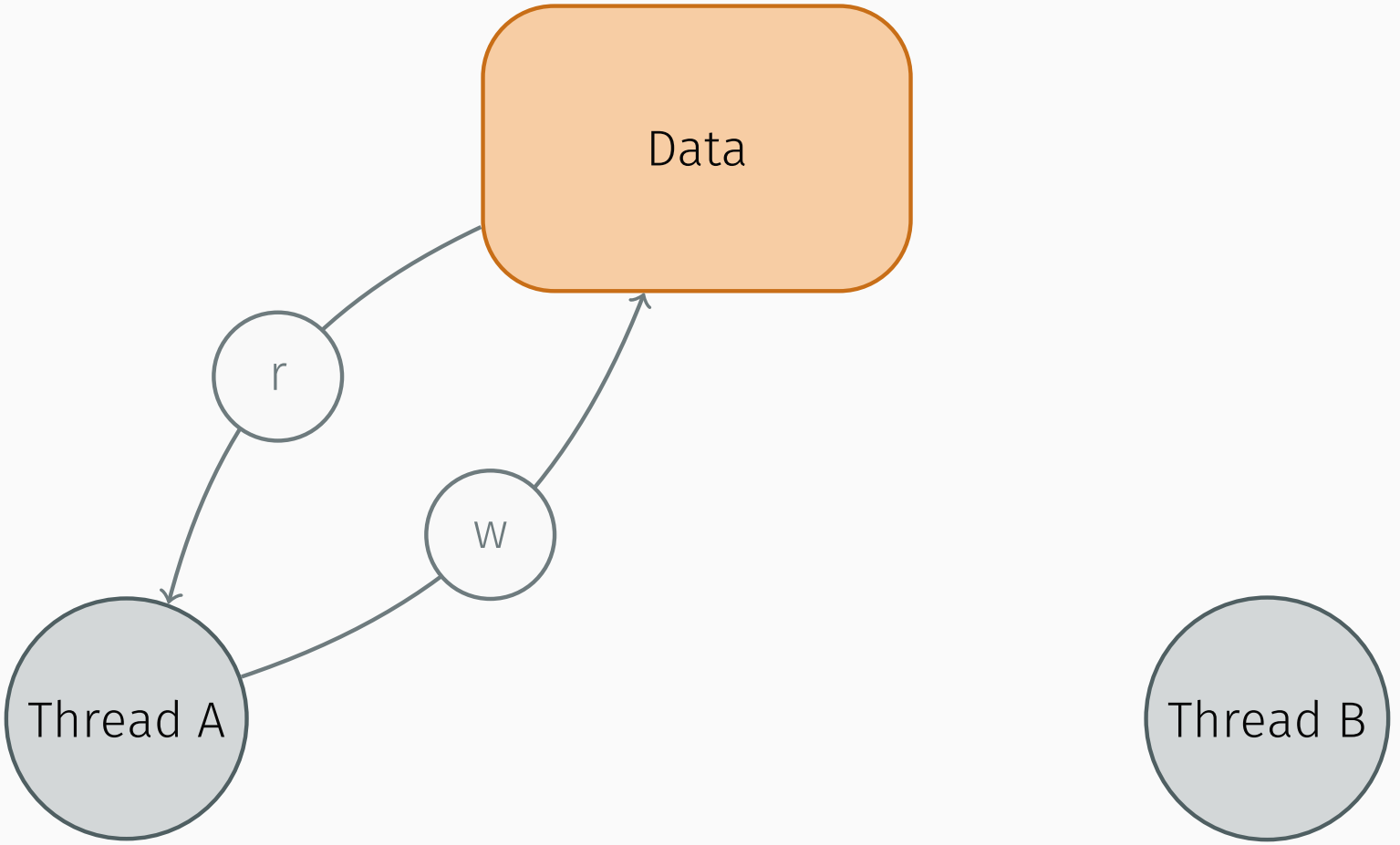

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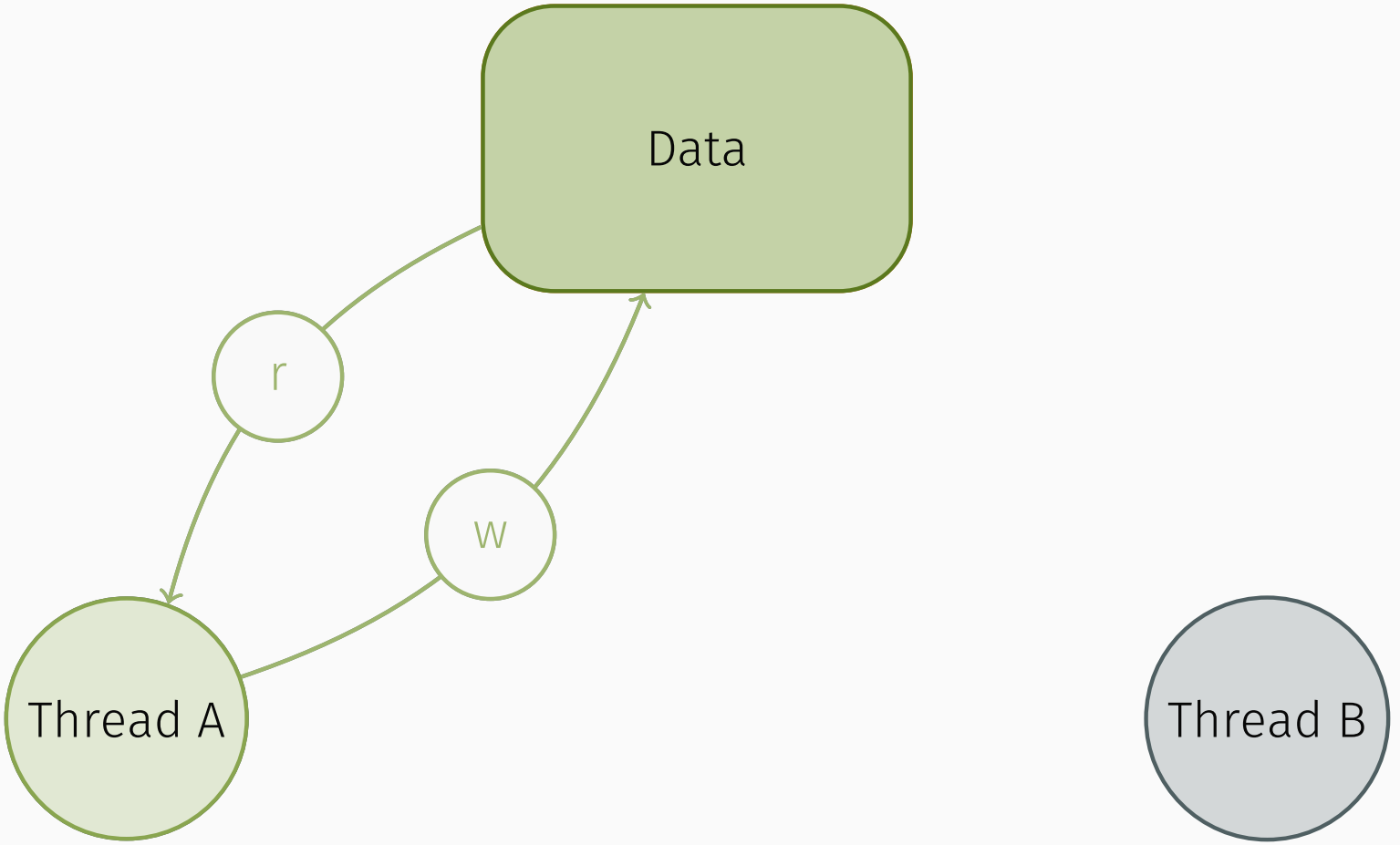

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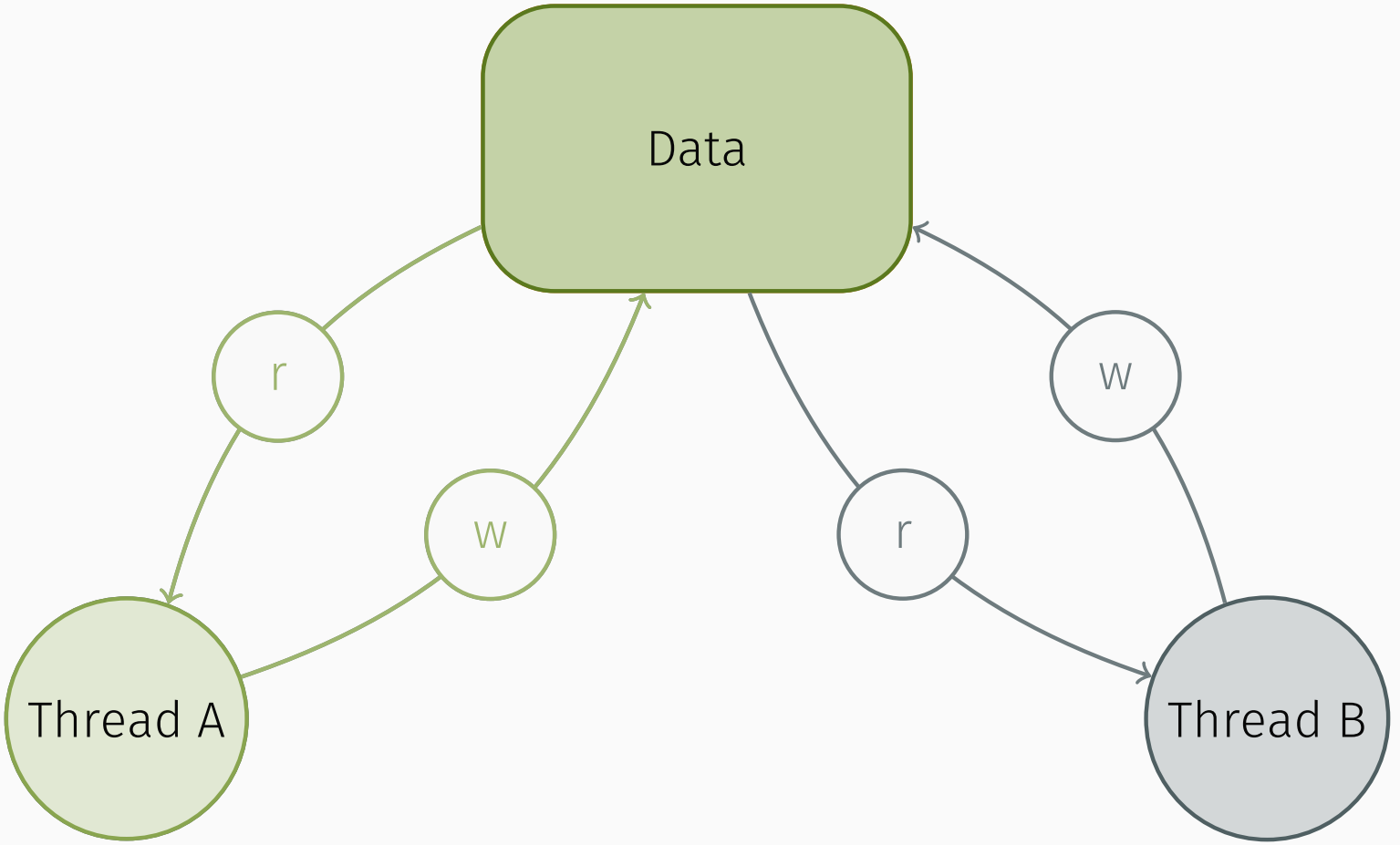

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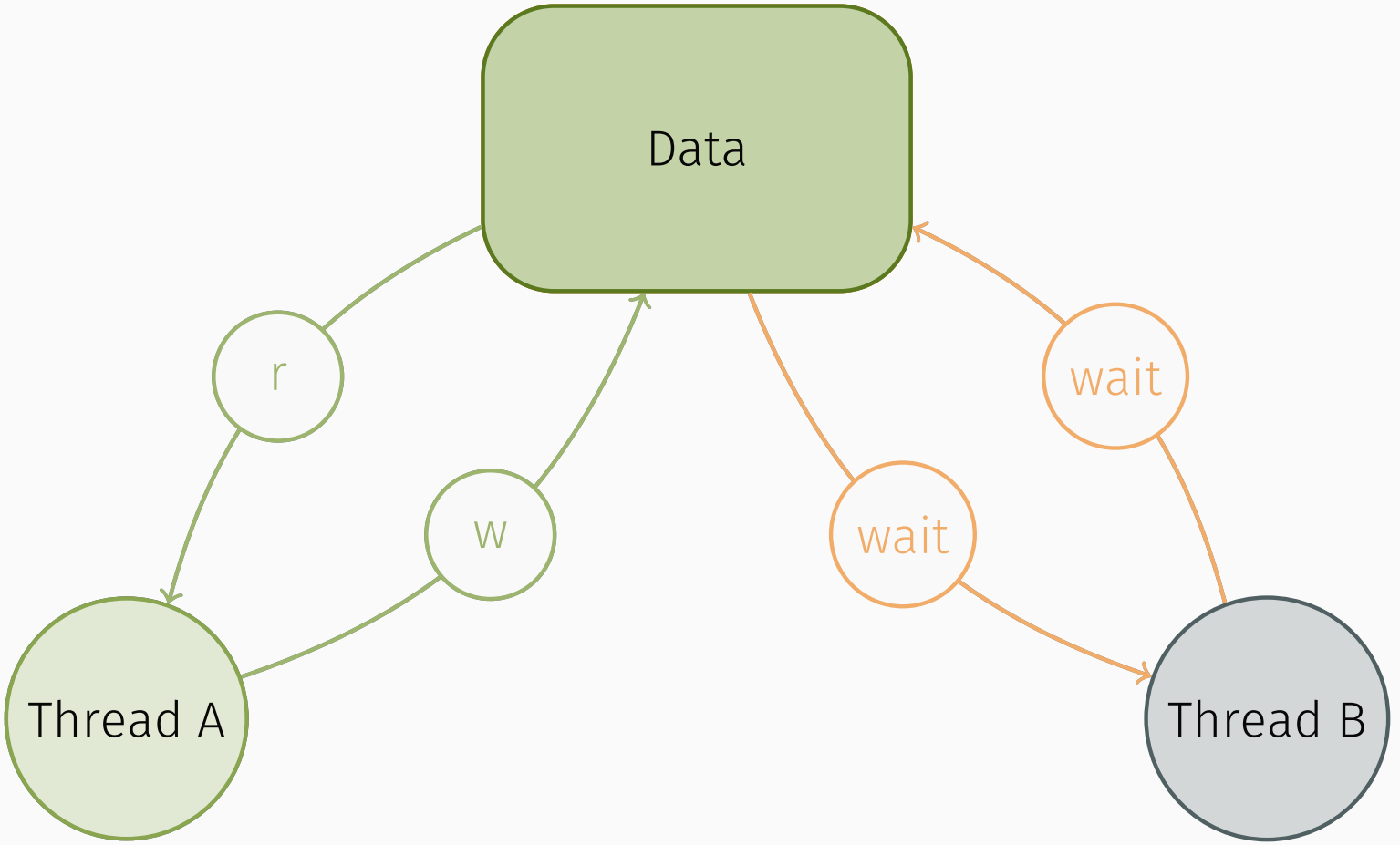

READ-MODIFY-WRITE

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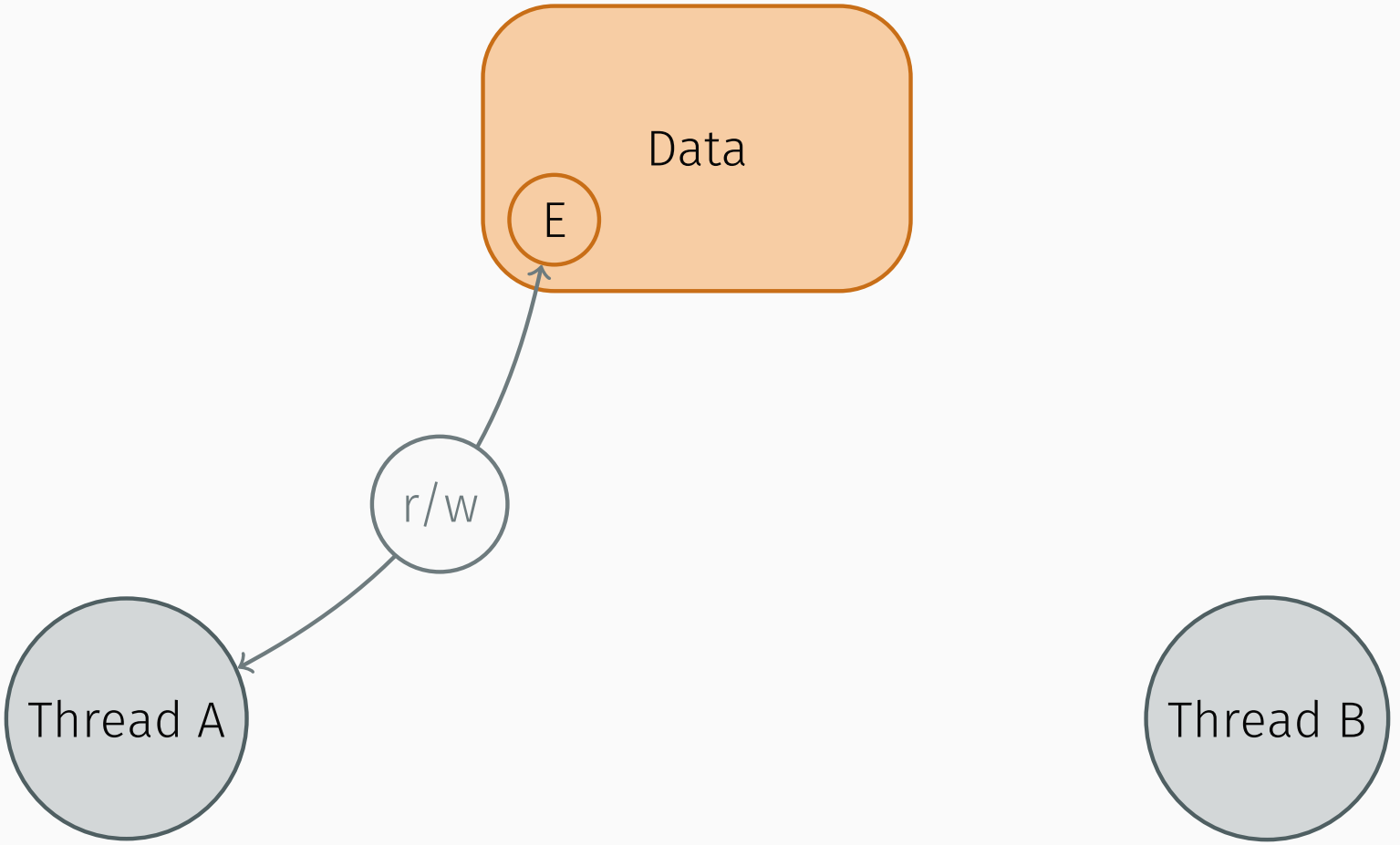

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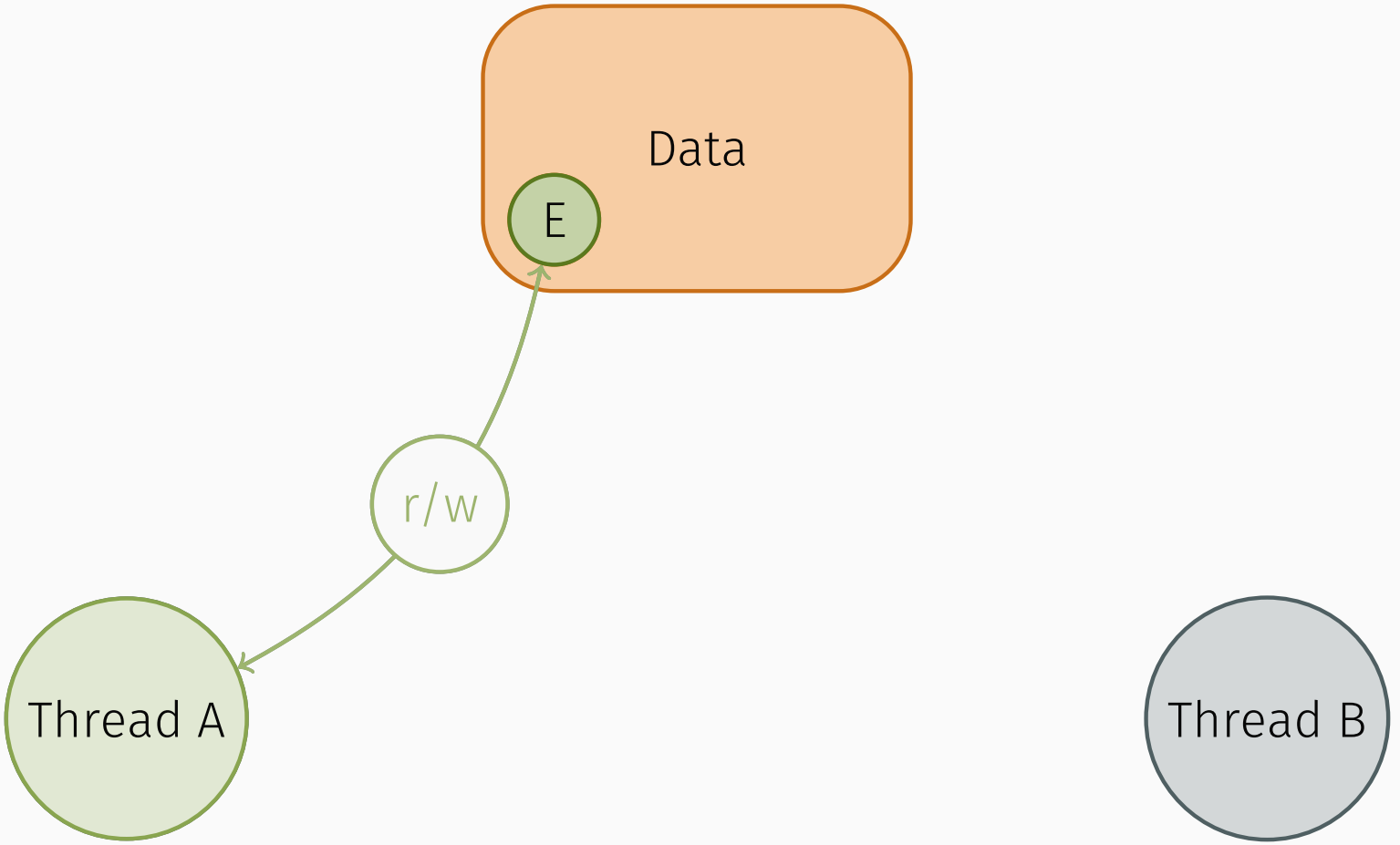

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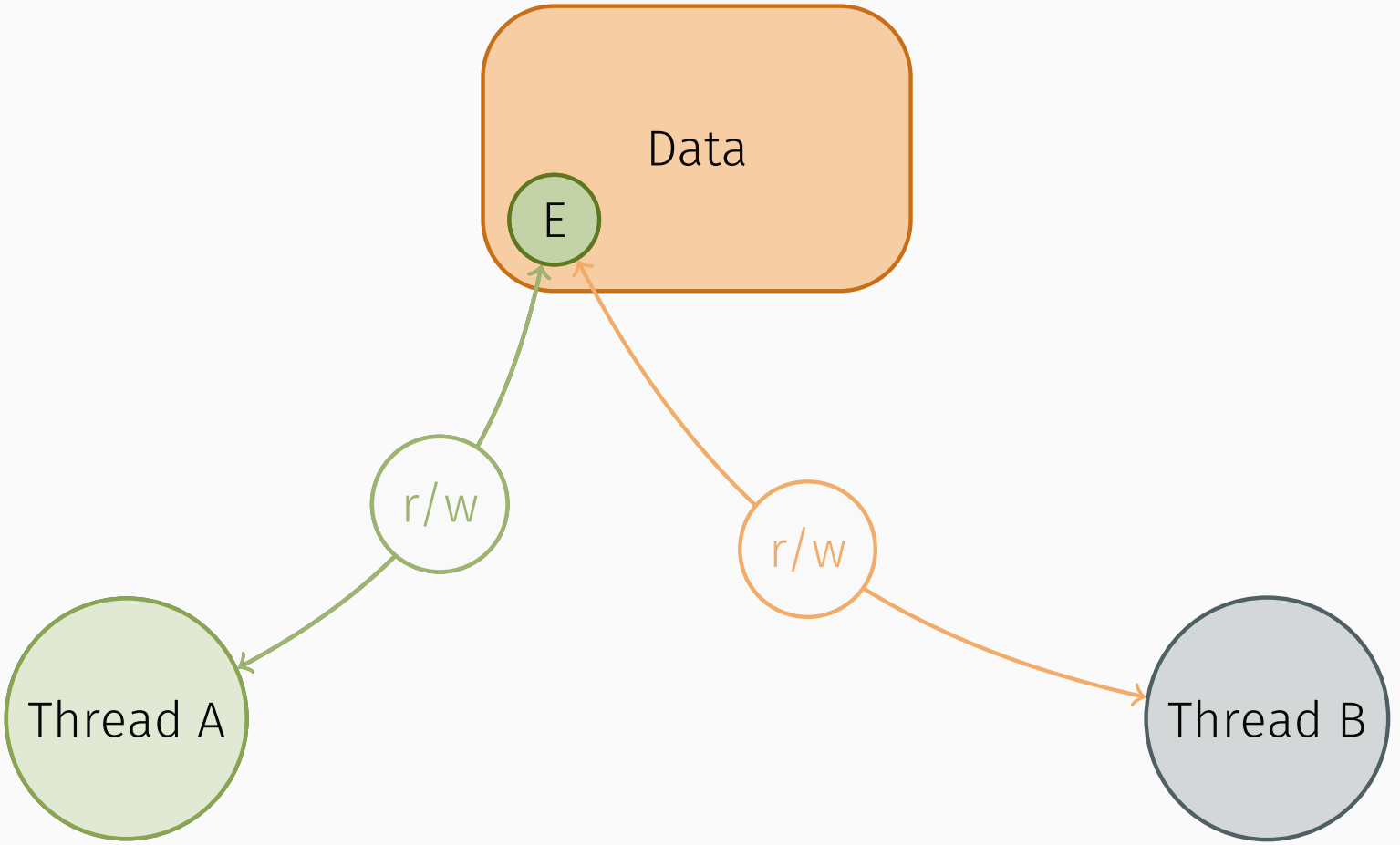

COPY-ON-WRITE

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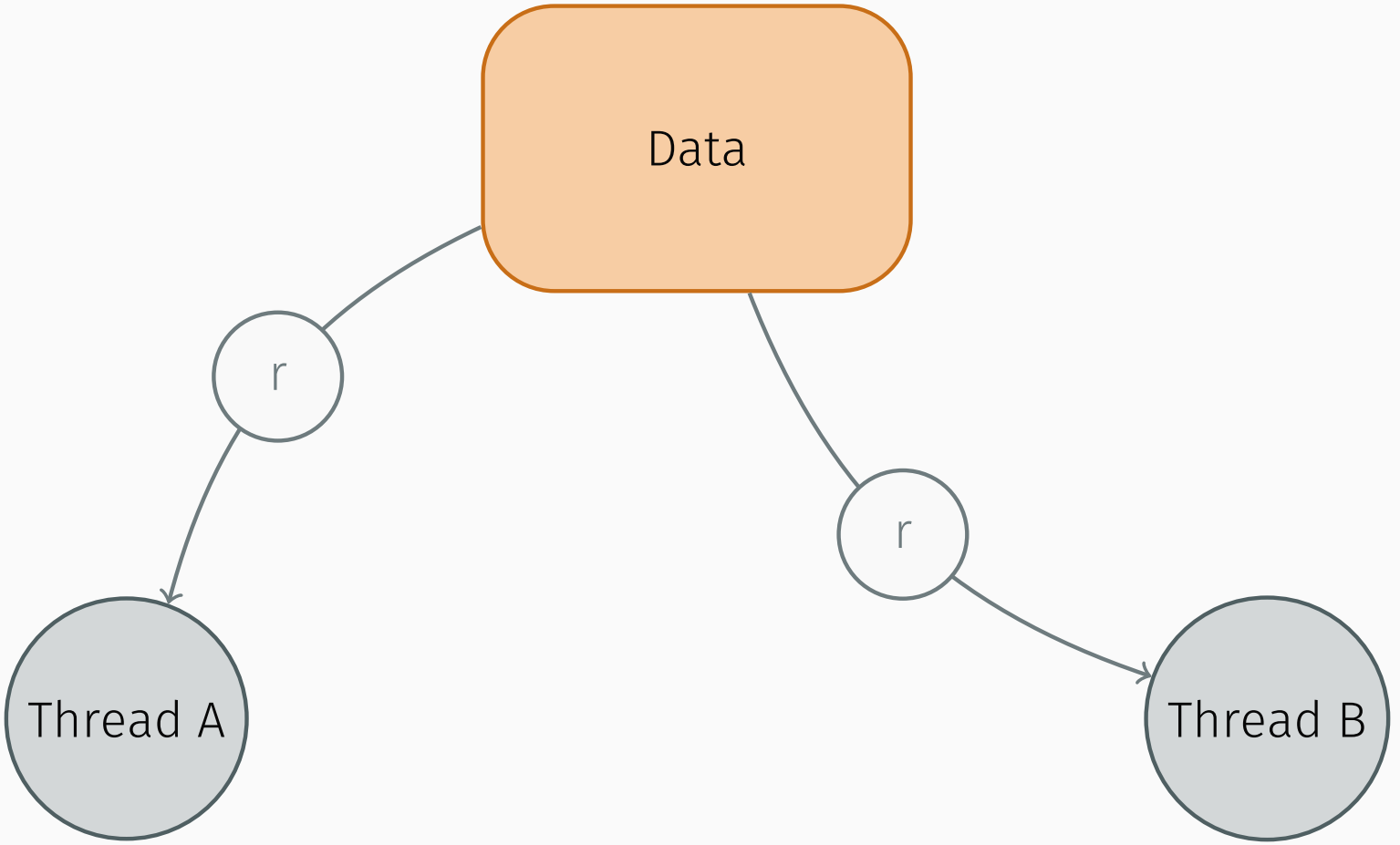

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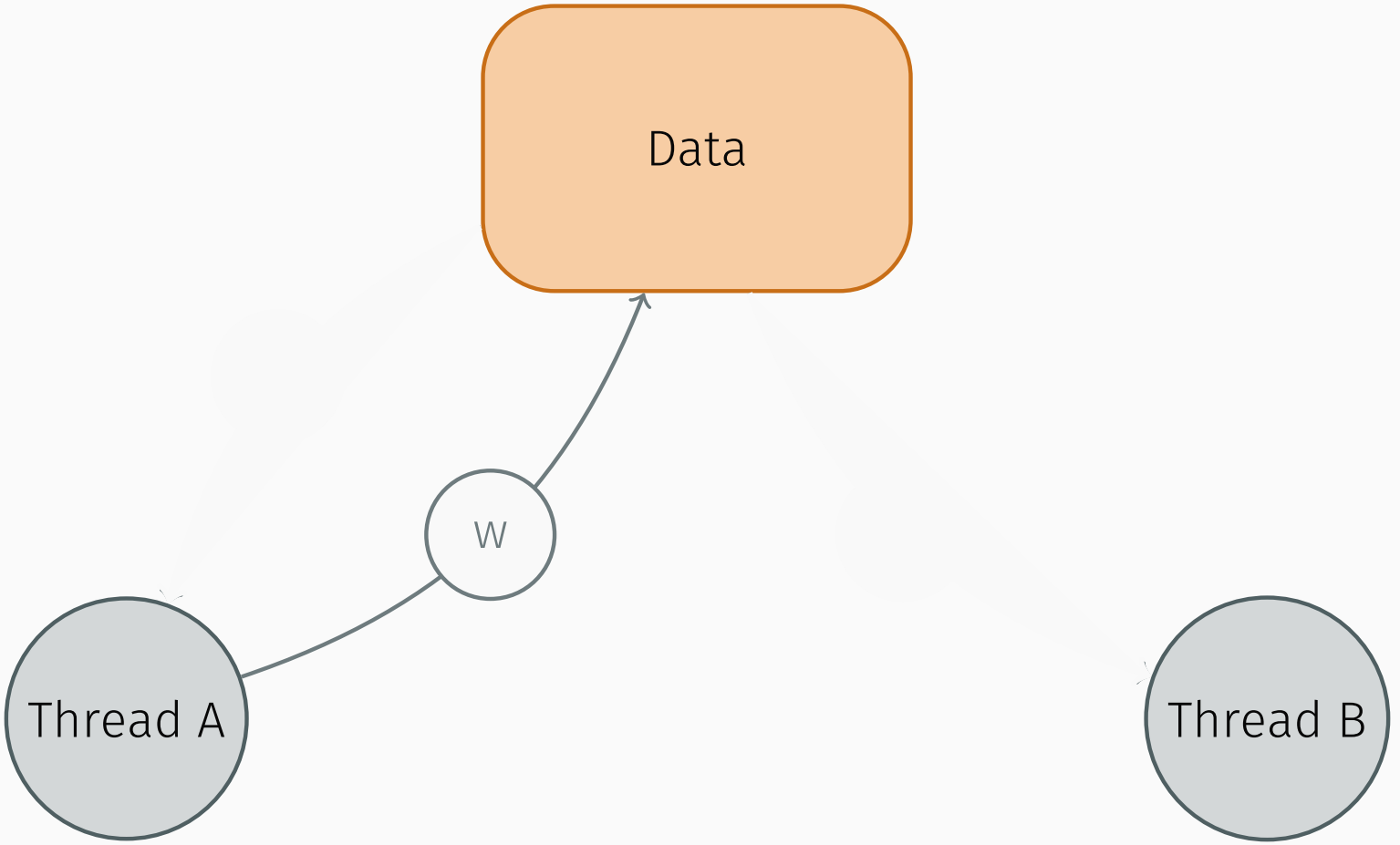

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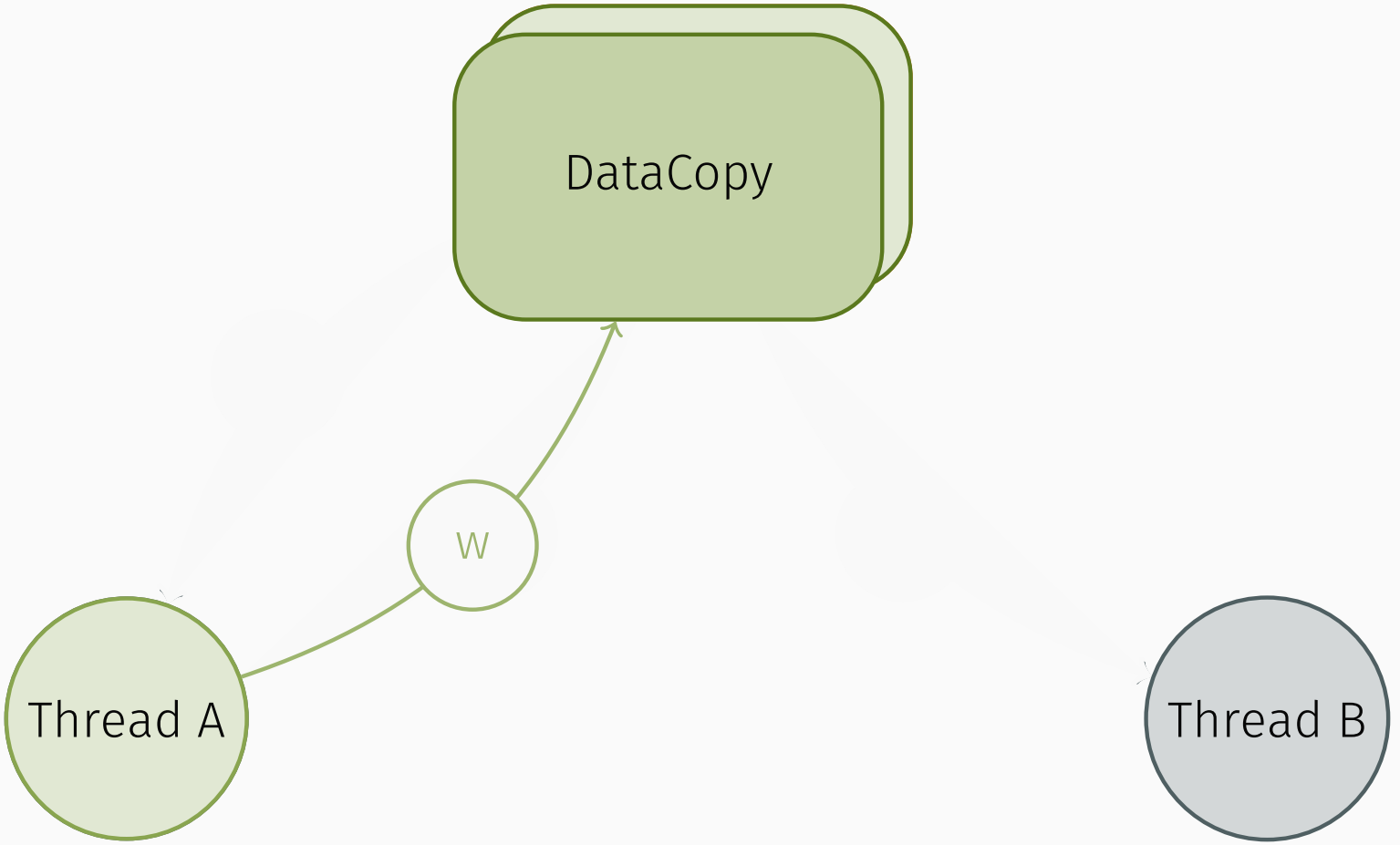

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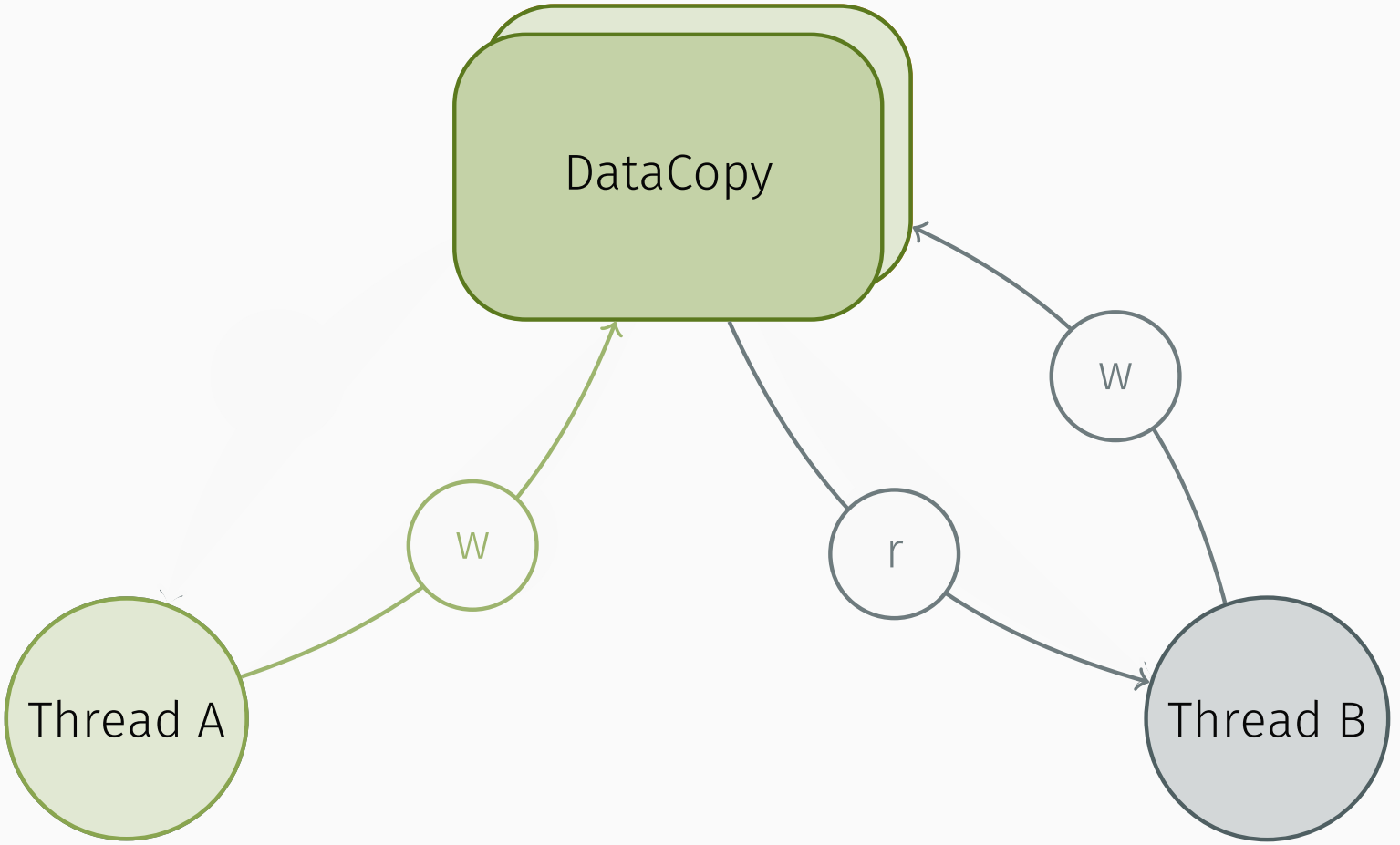

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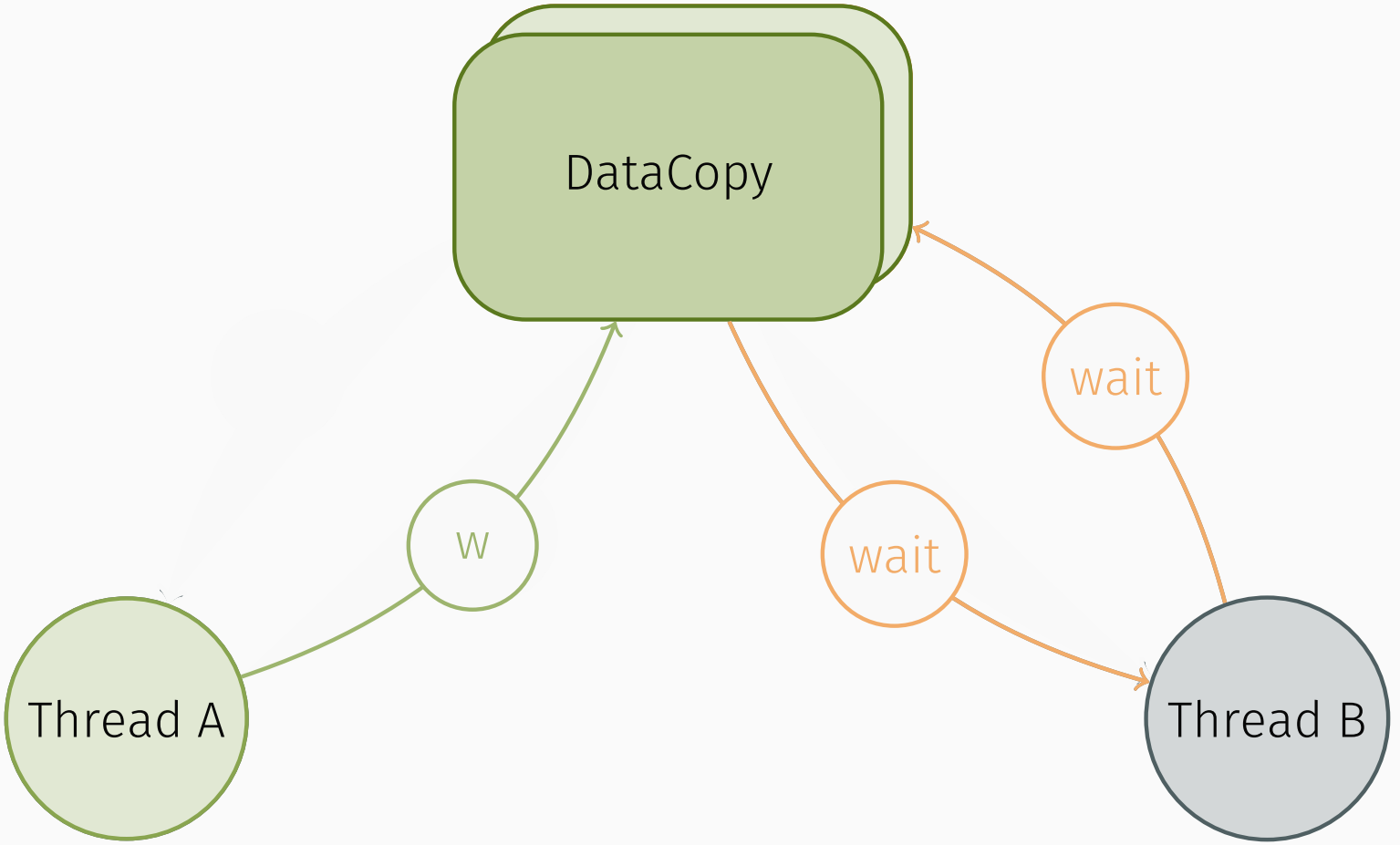

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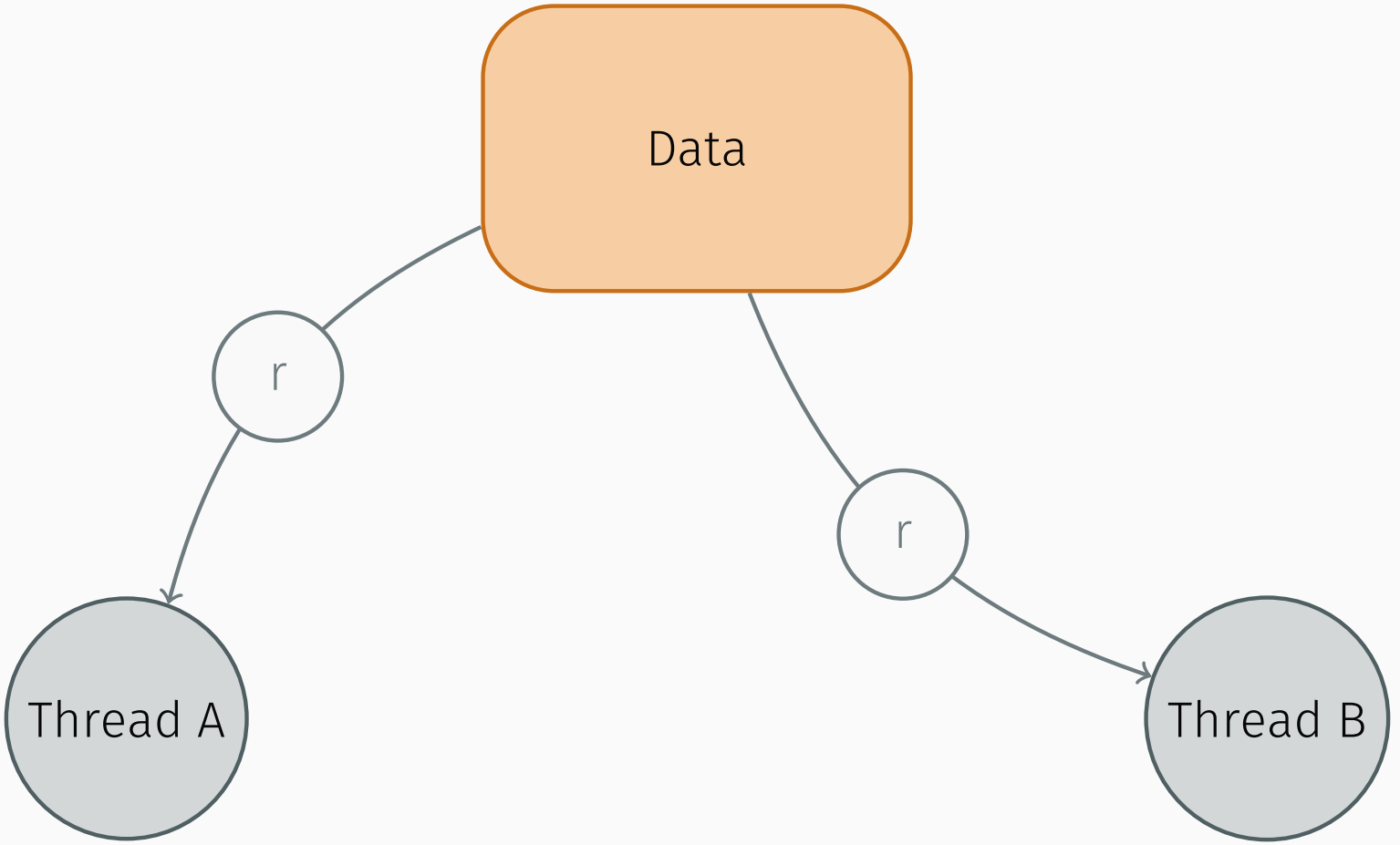

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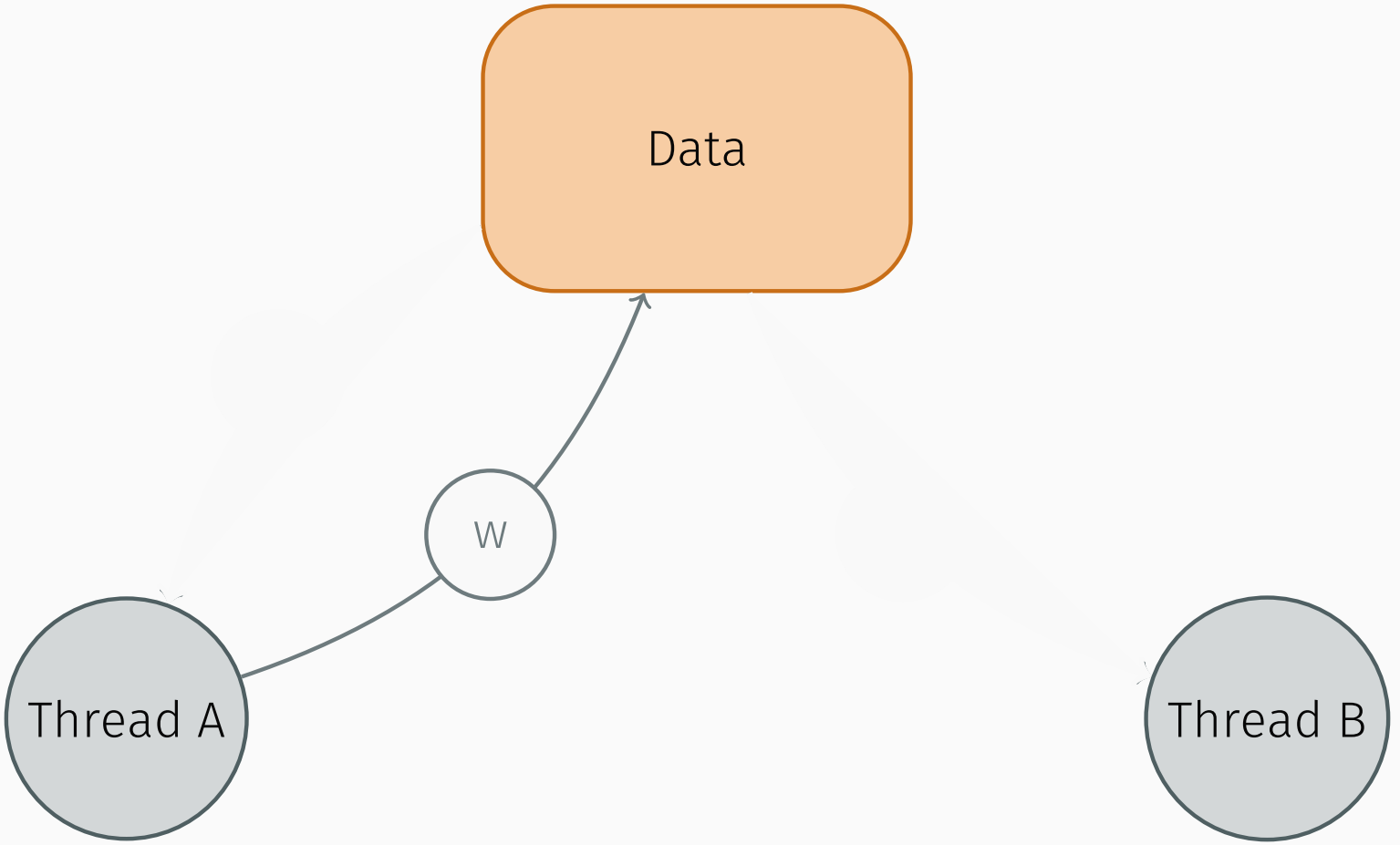

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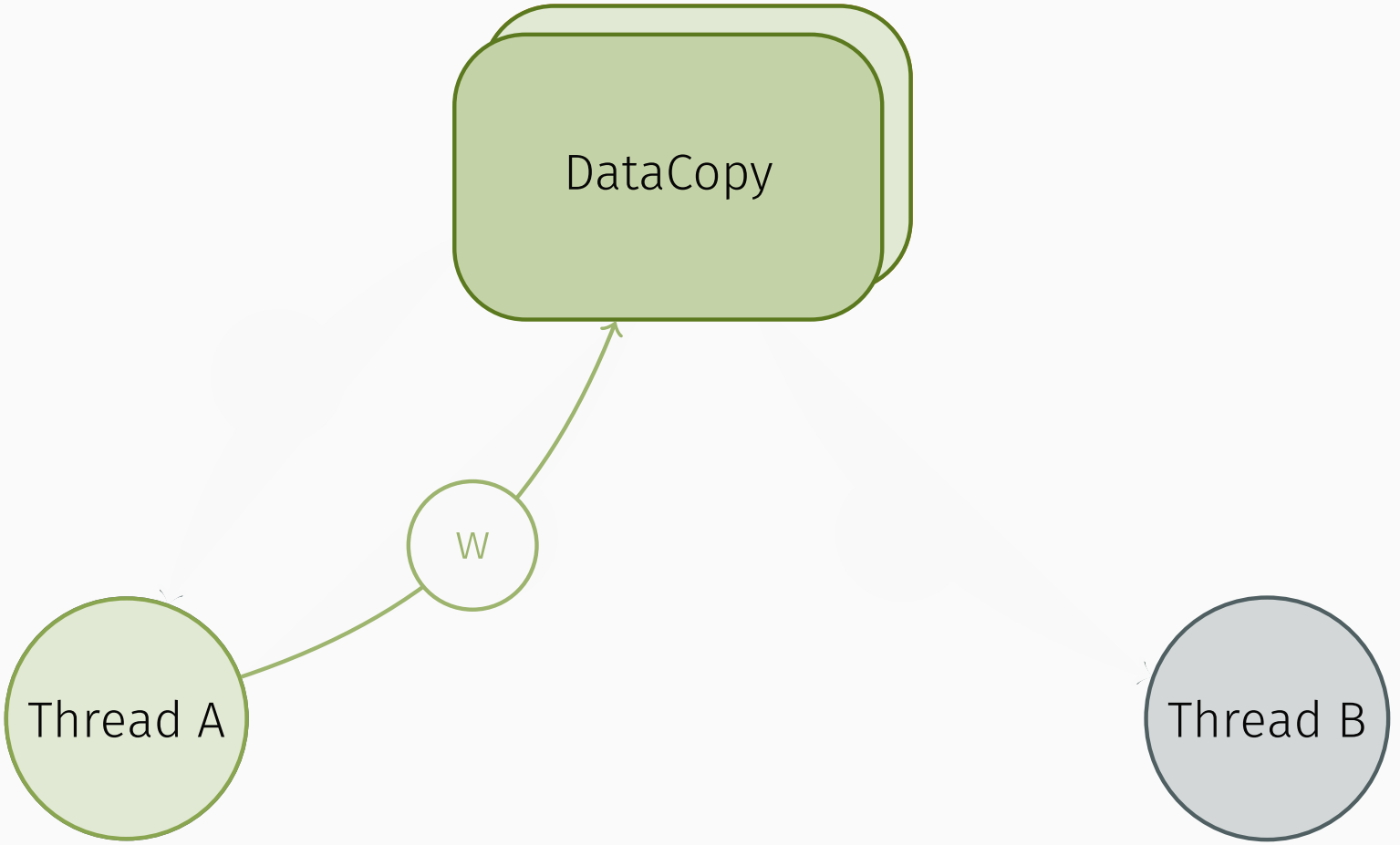

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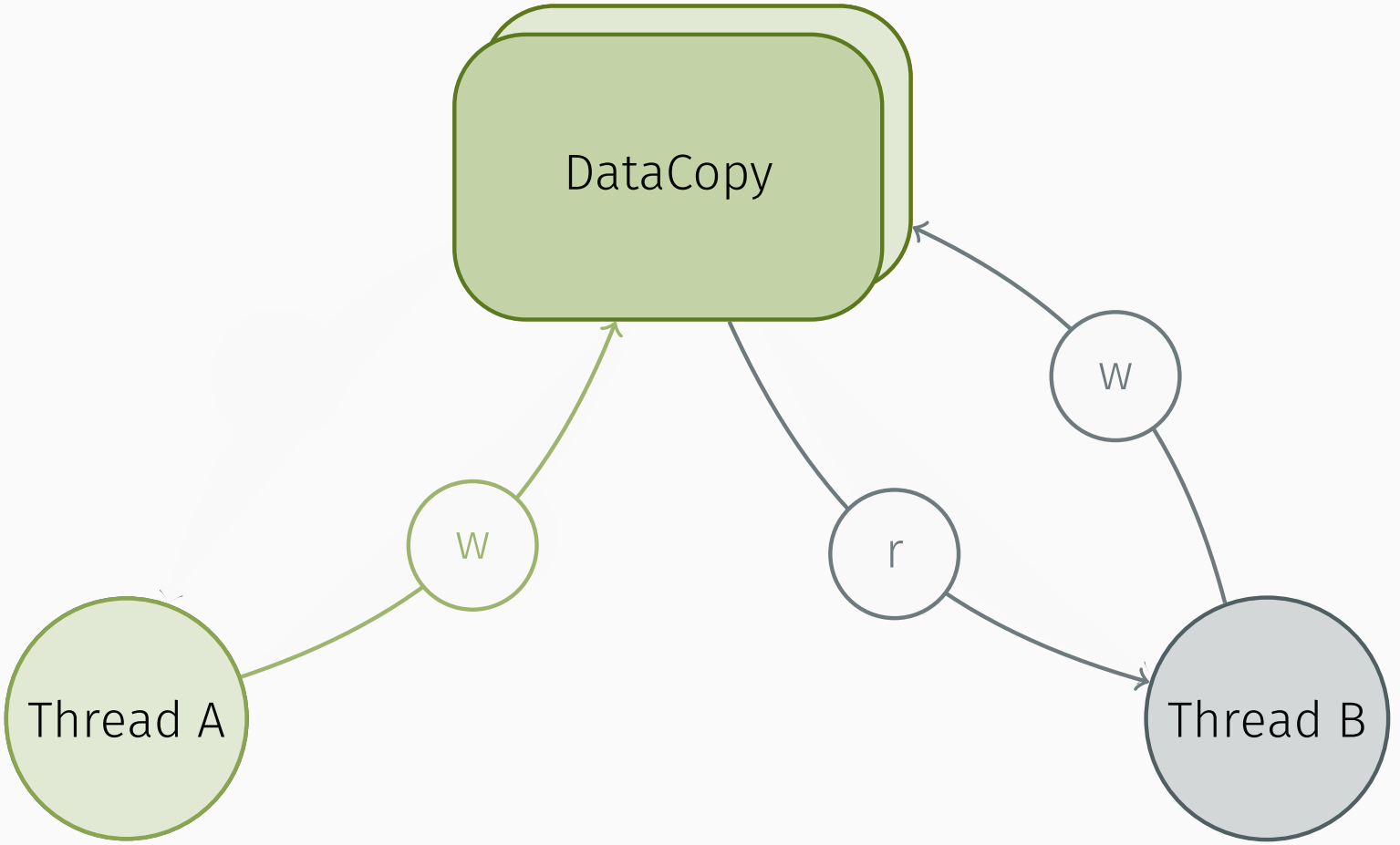

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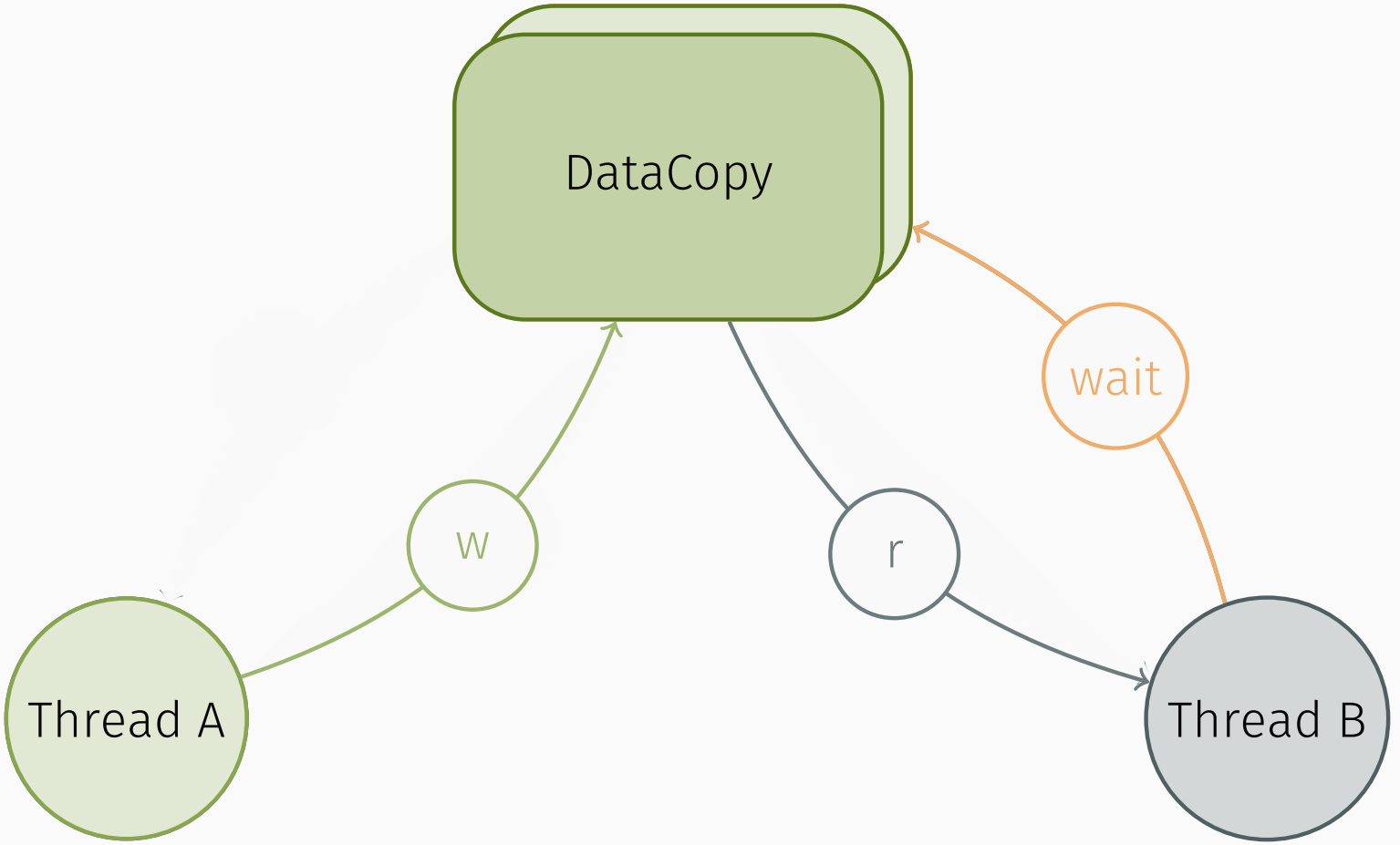

TRANSACTIONAL MEMORY

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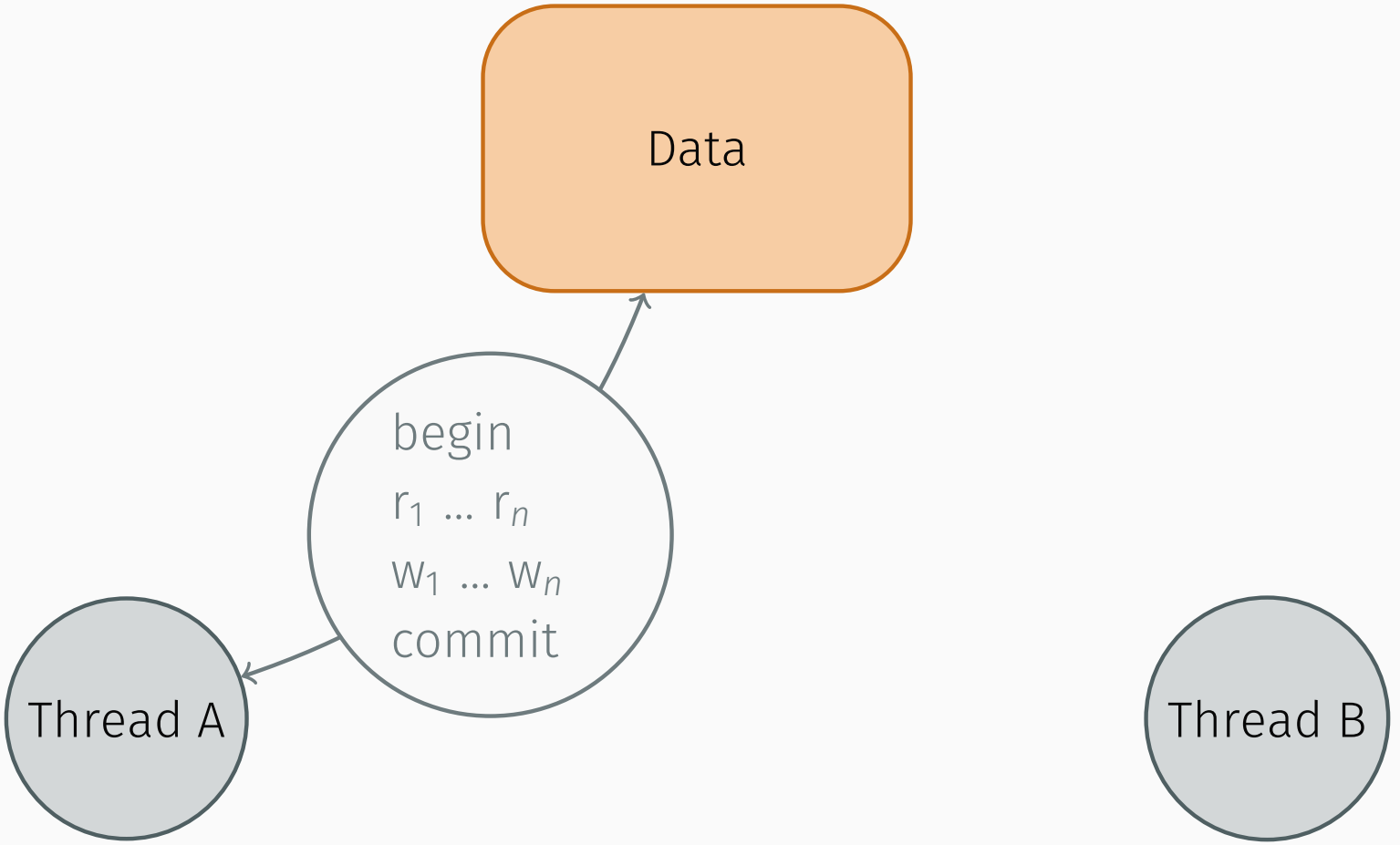

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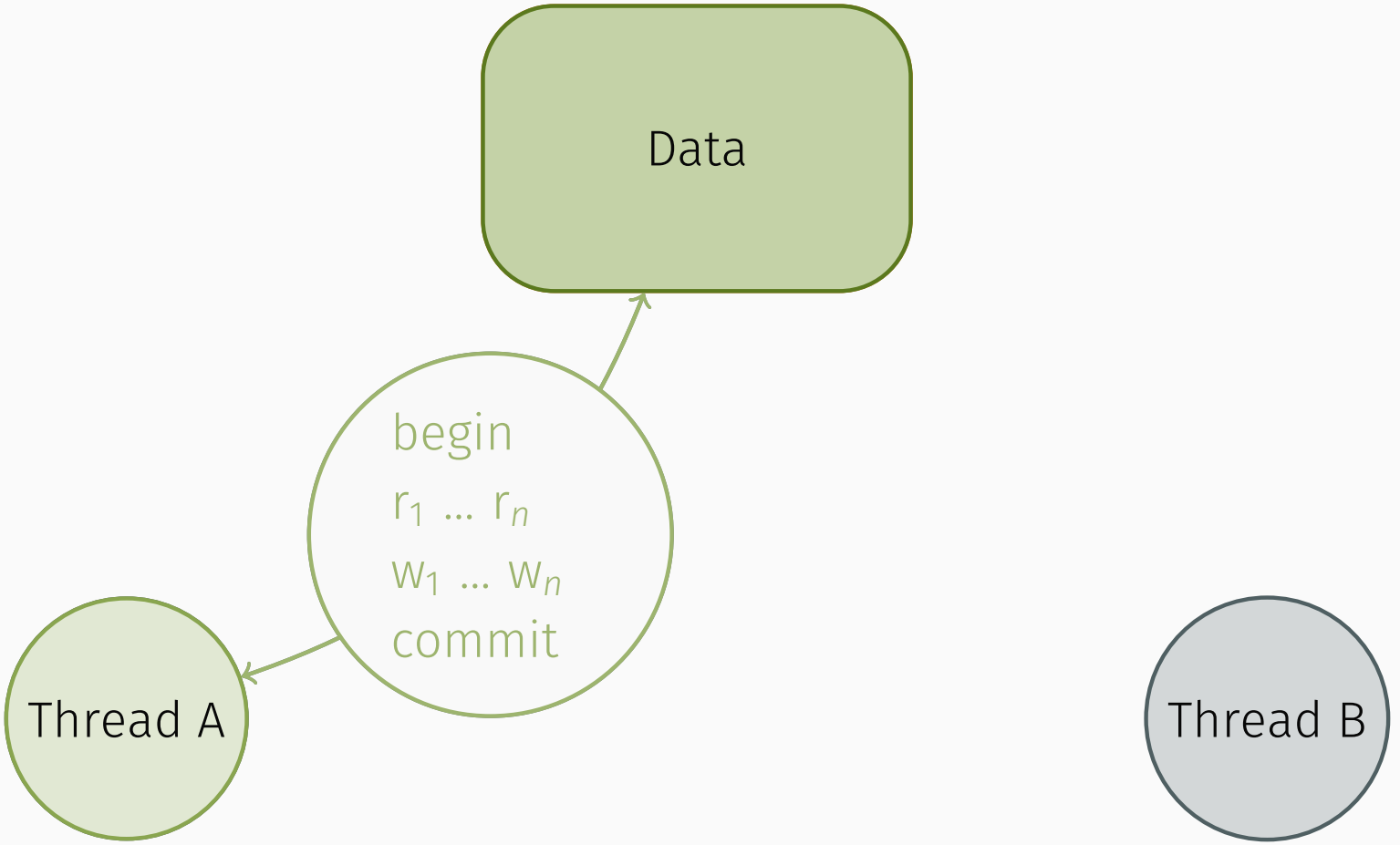

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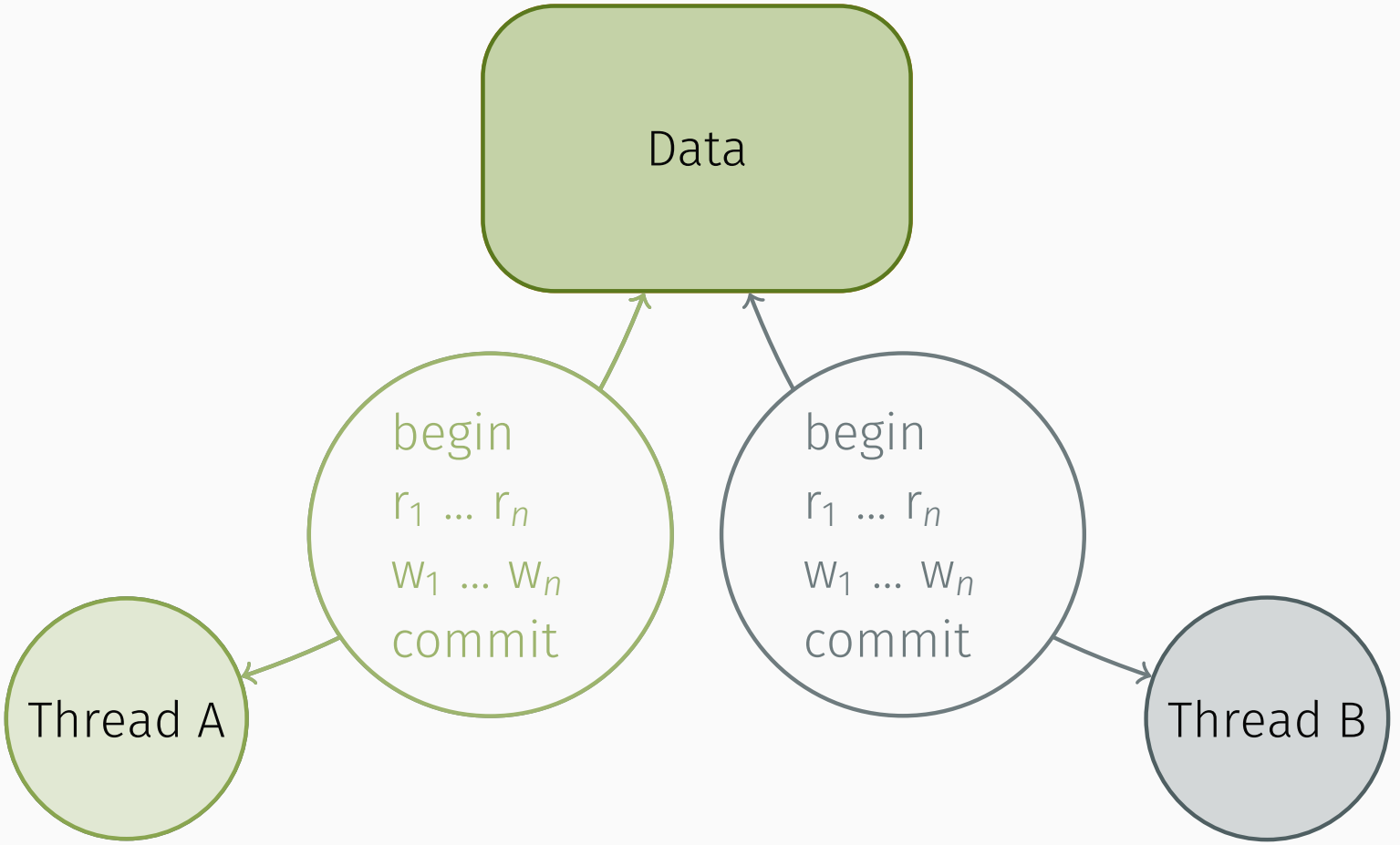

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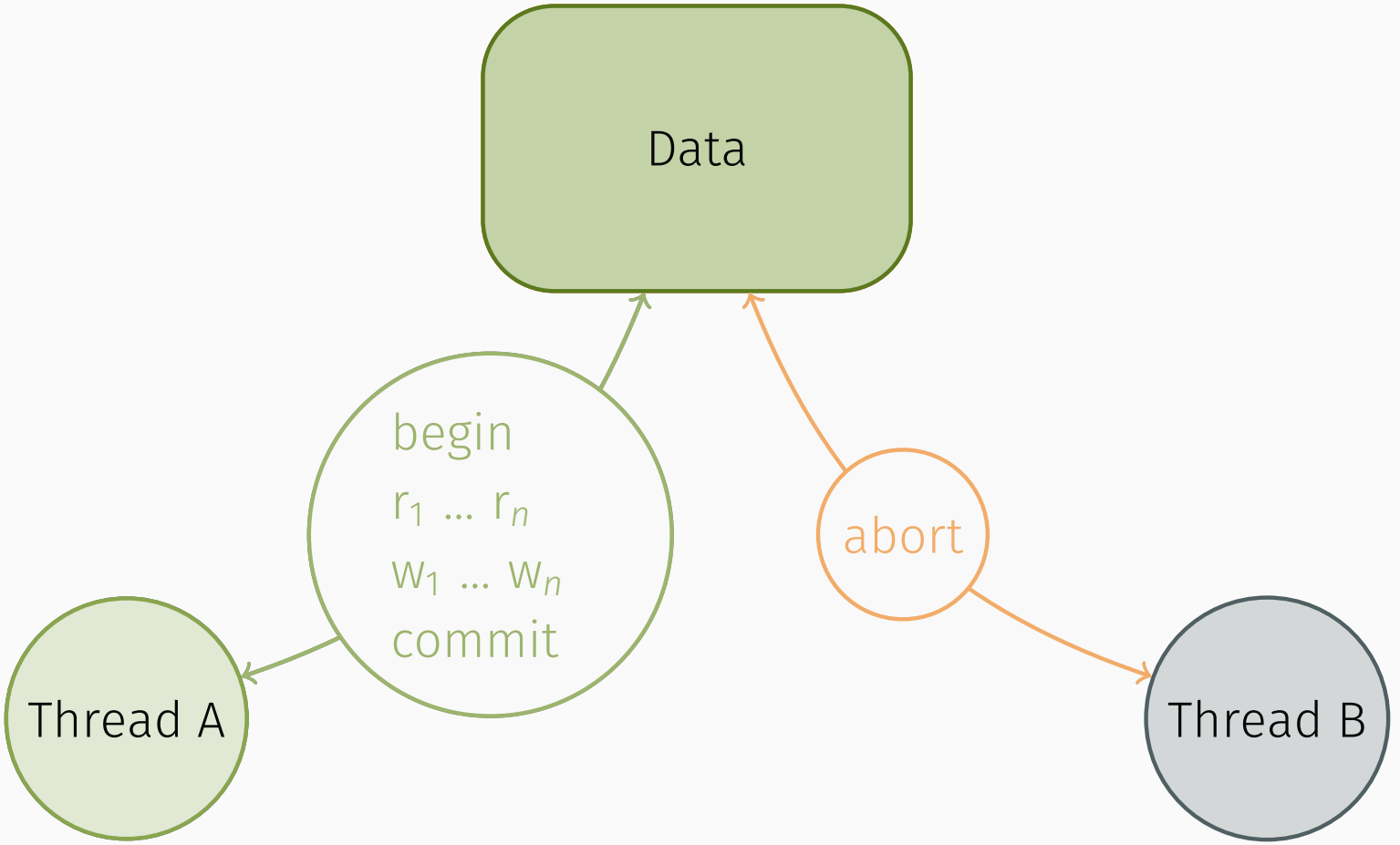

Questions

Which one should be use?

...

Synchrobench

The most extensive comparison of synchronization techniques.

WHAT'S SYNCHROBENCH ?

- Micro-benchmark suite in Java & C/C++
- Open-source [1]
- 31 concurrent data structures
- 5 different synchronization techniques

[1] Available on GitHub https://github.com/gramoli/synchrobench

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8 binary trees
3 dynamic arrays
6 hash tables
6 linked lists
2 queues
6 skip lists

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copy-on-write
mutual exclusion
read-copy-update
read-modify-write
transactional memory

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ε-STM [3], SwissTM [5], LSA [7], NOrec [1], PSTM [6], TinySTM [4], TL2 [2]

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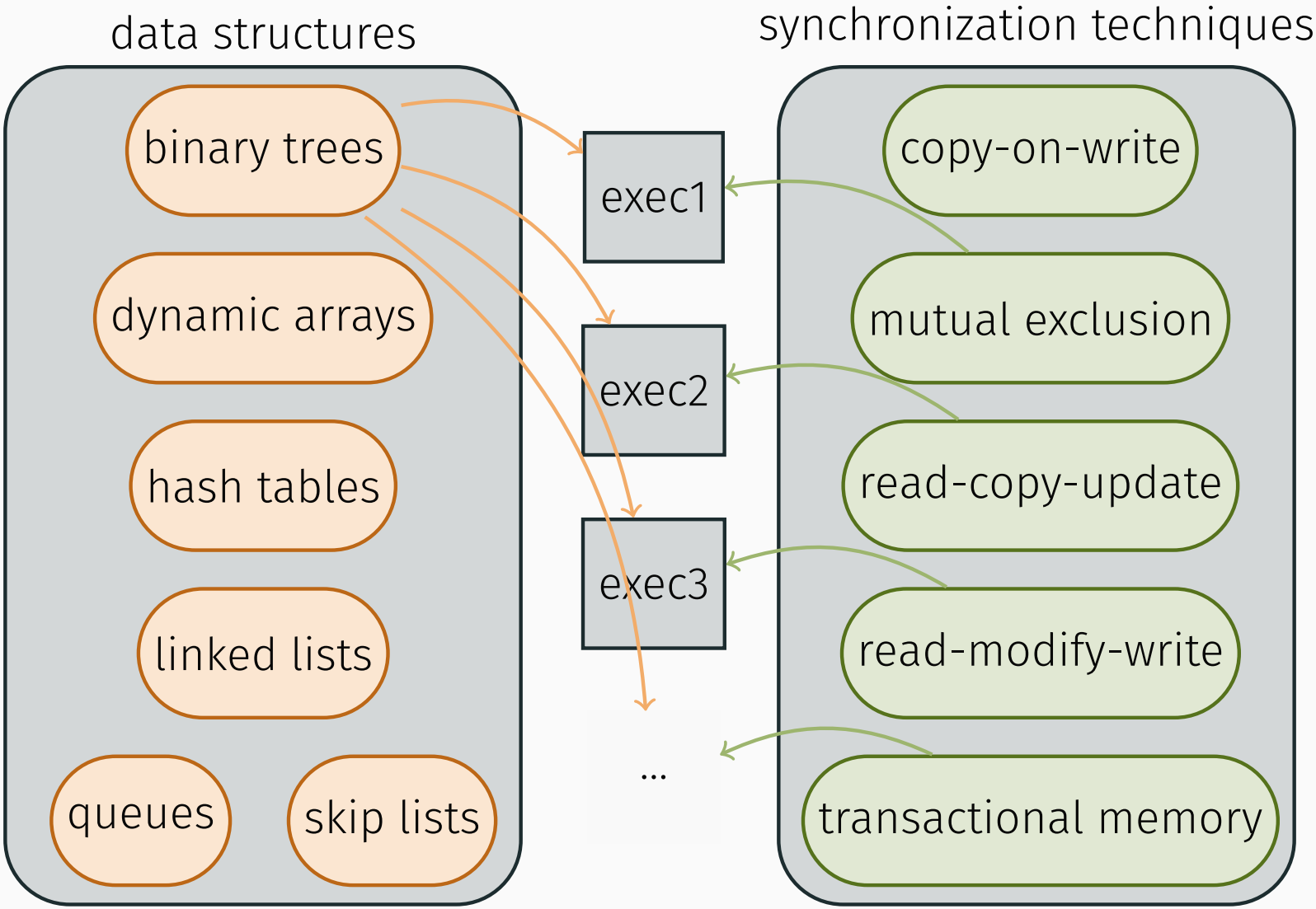
SOME DETAILS



SYNCHROBENCH PARAMETERS

- $t \in \mathbb{N}^*$, no. of threads
- $i \in \mathbb{N}$, initial size
- $r \in \mathbb{N}^*$, value range
- $u \in [0 : 100]$, update ratio
- $f \in \{0, 1\}$, effective update
- $A \in \{0, 1\}$, alternating value
- $d \in \mathbb{N}^*$, duration (milliseconds)
- Java: $W \in \mathbb{N}$, warmup (seconds)
- ...

EXPERIMENTS

Setup

- Average throughput of 5 runs
- Benchmark duration 5 seconds
- Baseline data structure running sequentially (SEQ)

Environment

- AMD Opteron 6378
- **Intel Xeon E5-2450**
- UltraSPARC T2

EXPERIMENTAL RESULTS

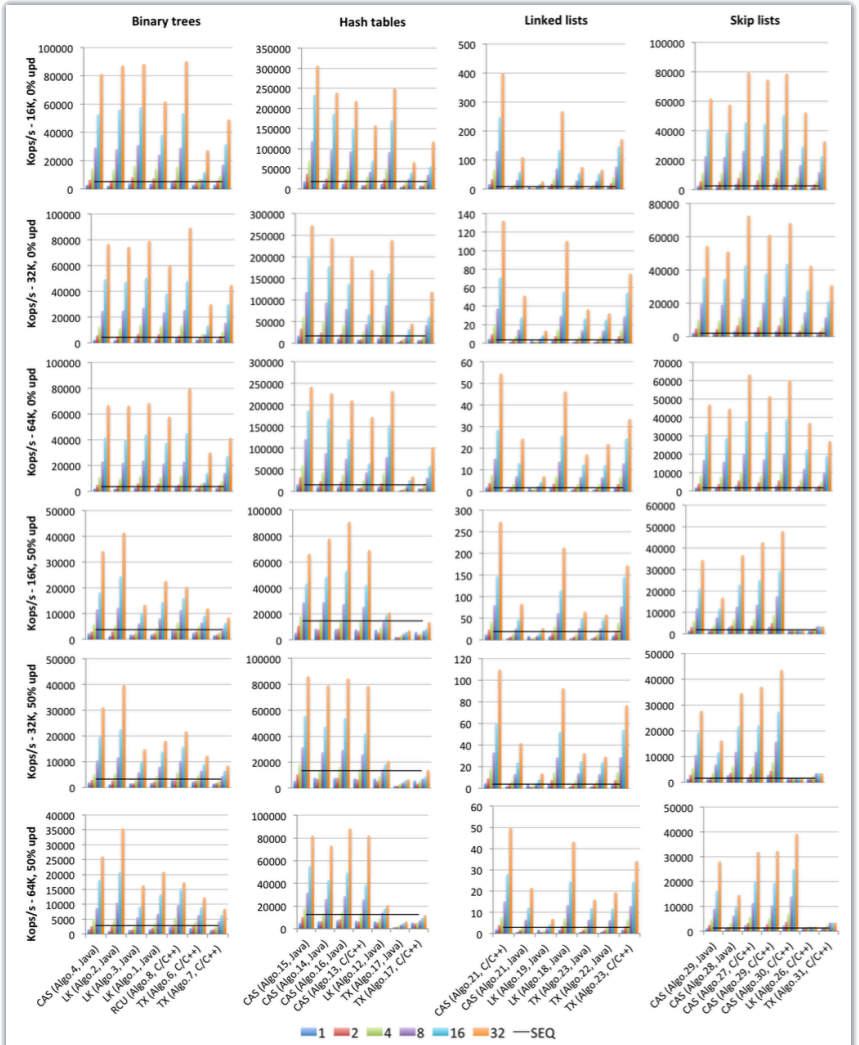
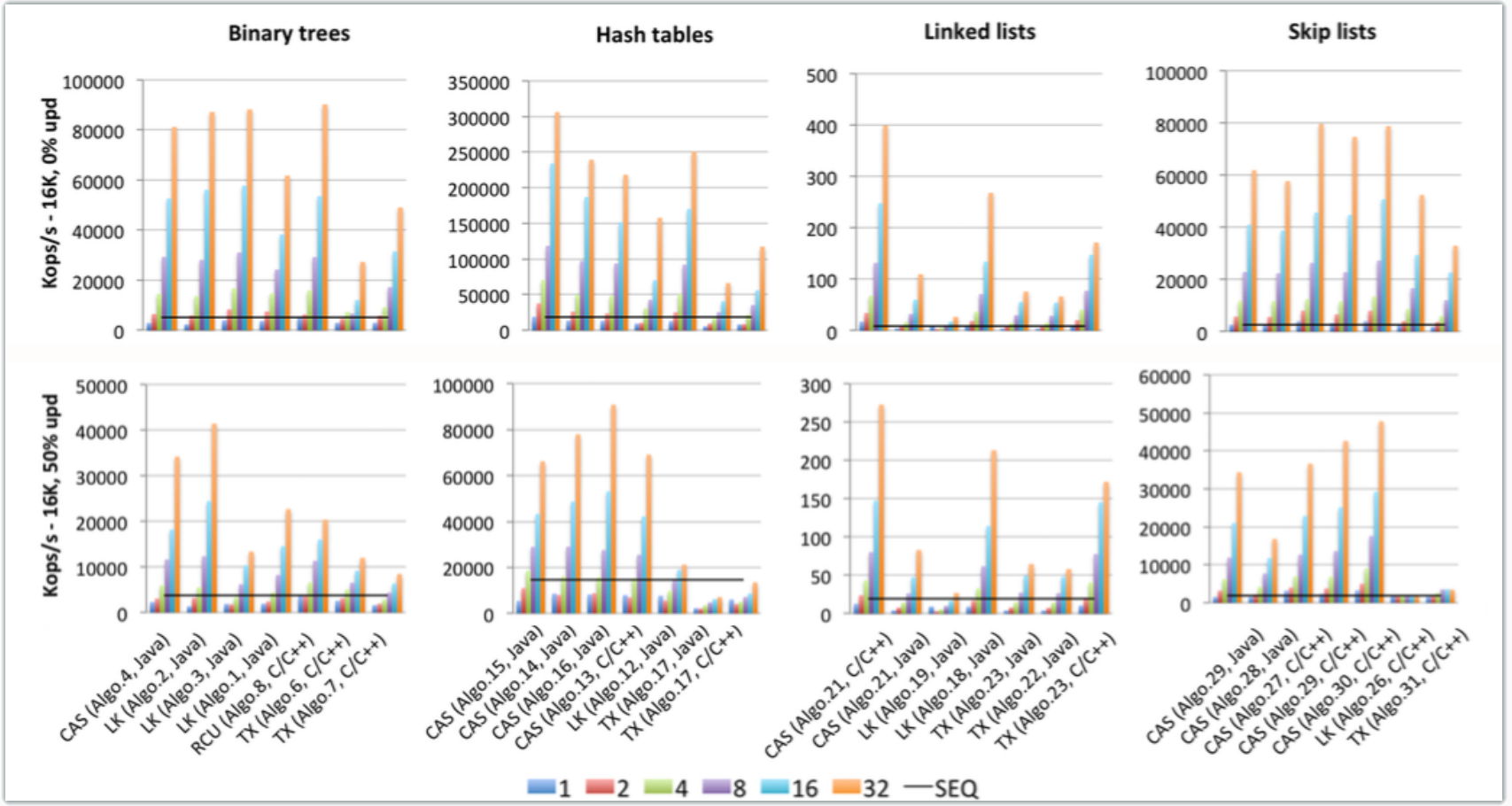


Figure 1. Synchrobench performance results for 1, 2, 4, 8, 16 and 32 threads on the 32-way Intel machine with data structures written in C/C++ and Java, and synchronized with read-modify-write (CAS), locks (LK), read-copy-update (RCU), and transactions (TX), and with sequential performance of non-synchronized data structures as the performance baseline (SEQ)

EXPERIMENTAL RESULTS

CAS ... read-modify-write, LK ... mutual exclusion, RCU ... read-copy-update, TX ... transactional memory



CONCLUSION

Read-modify-write

+ Typically faster than the other techniques
- Design of these data structures difficult

Copy-on-write & Read-copy-update

+ High performance for read intensive workloads
- Low performance for write intensive workloads

Transactional memory (TX) & Mutual exclusion (ME)

· TX offers more consistent performance than ME

REFERENCES

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[3] Aleksandar Dragojević, Pascal Felber, Vincent Gramoli, and Rachid Guerraoui. Why stm can be more than a research toy. *Communications of the ACM*, 54(4):70–77, 2011.

[4] Pascal Felber, Christof Fetzer, and Torvald Riegel. Dynamic performance tuning of word-based software transactional memory. In *Proc. Symposium on Principles and Practice of Parallel Programming (PPoPP)*, pages 237–246. ACM, 2008.

[5] Pascal Felber, Vincent Gramoli, and Rachid Guerraoui. Elastic transactions. In *Distributed Computing*, pages 93–107. Springer, 2009.

[6] Vincent Gramoli and Rachid Guerraoui. Reusable concurrent data types. In *ECOOP 2014–Object-Oriented Programming*, pages 182–206. Springer, 2014.

[7] Torvald Riegel, Pascal Felber, and Christof Fetzer. A lazy snapshot algorithm with eager validation. In *Distributed Computing*, pages 284–298. Springer, 2006.

Thank you for your attention.

Q&A