Concurrency Control 4

R&G Chapter 17

(slides adapted from content by J.Gehrke, J.Shanmugasundaram, and/or C.Koch)

The Concurrency Control Techniques Discussed So Far are **Pessimistic**

Pessimistic CC

- Assume that things will go wrong.
- Work to prevent things from going wrong before they have a chance to (e.g., locking).
- This is expensive!
    - Locking costs are still incurred even if no conflicts ever actually occur!

Optimistic CC

- *Alternative*: Assume nothing will go wrong.
  - … but also check your assumption.
- Execute transactions in isolation
  - Keep transaction effects <u>invisible</u> until the transaction commits.
- Before committing, check to see if a concurrency violation occurred.

Optimistic CC

- **Read Phase**: Transaction executes on a private copy of all accessed objects.
- **Validate Phase**: Check for conflicts.
- **Write Phase**: Make the transaction's changes to updated objects public.

Validation Phase

- We need a set of test conditions that are <u>sufficient</u> to ensure that no conflict has occurred.
- Each transaction gets a numeric Transaction ID.
  - For example, we can use a timestamp.
- After the read phase, we have:
  - **ReadSet(T_i)**: Set of objects read by T_i.
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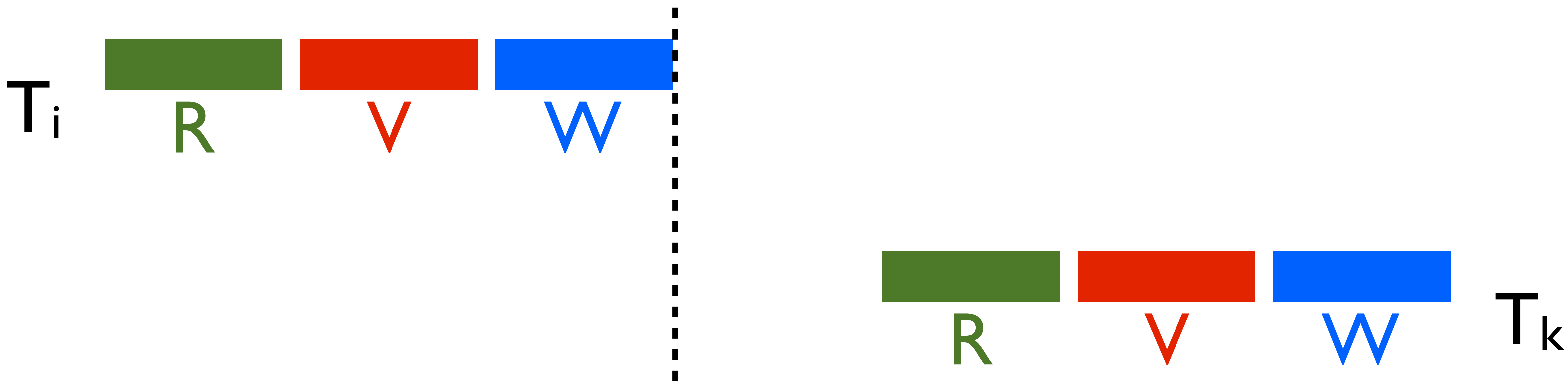
When should we assign Transaction IDs? (Why?)

Simple Test

For all i and k for which i < k,
check that T_i completes before T_k begins.



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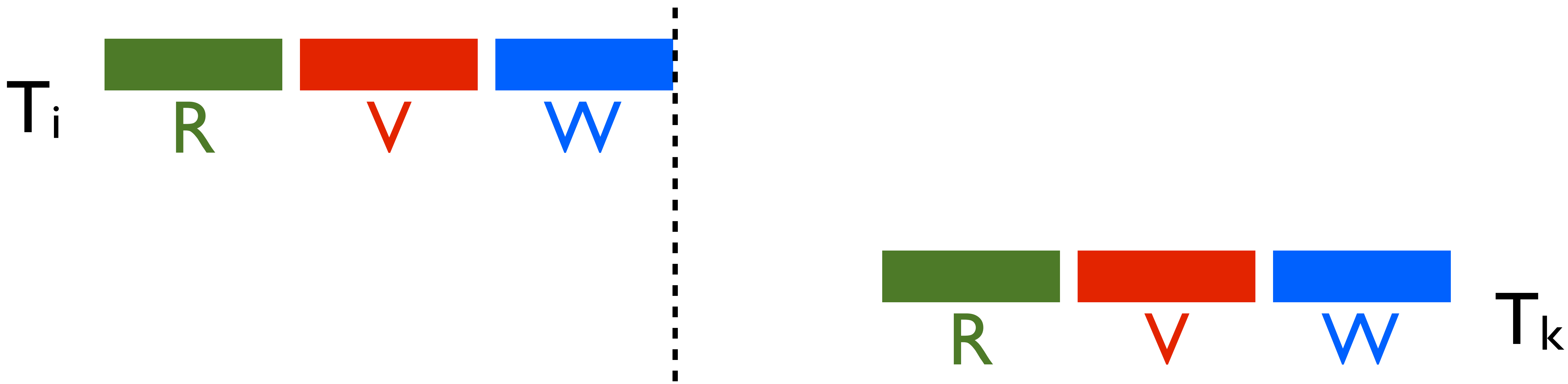

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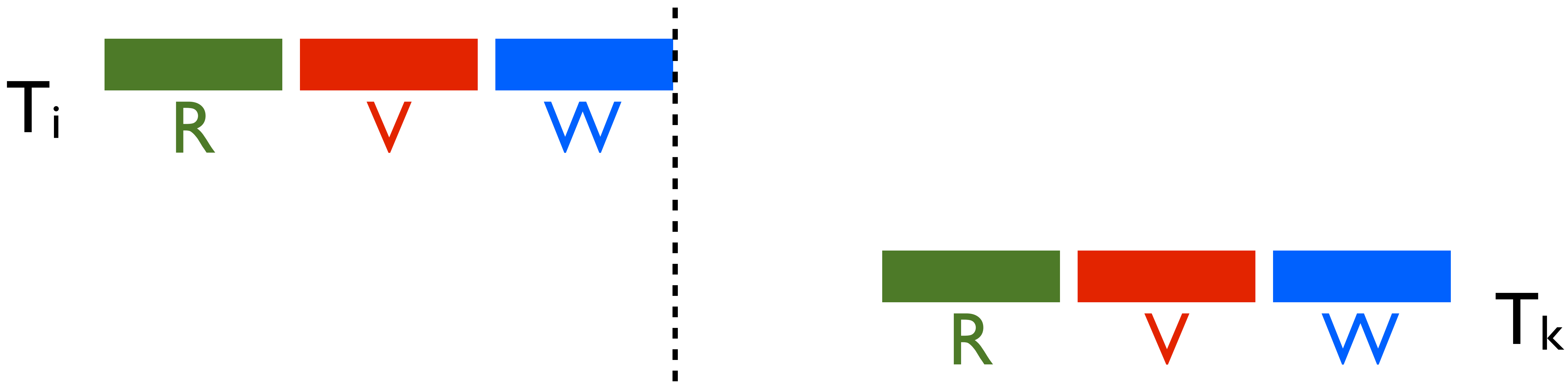


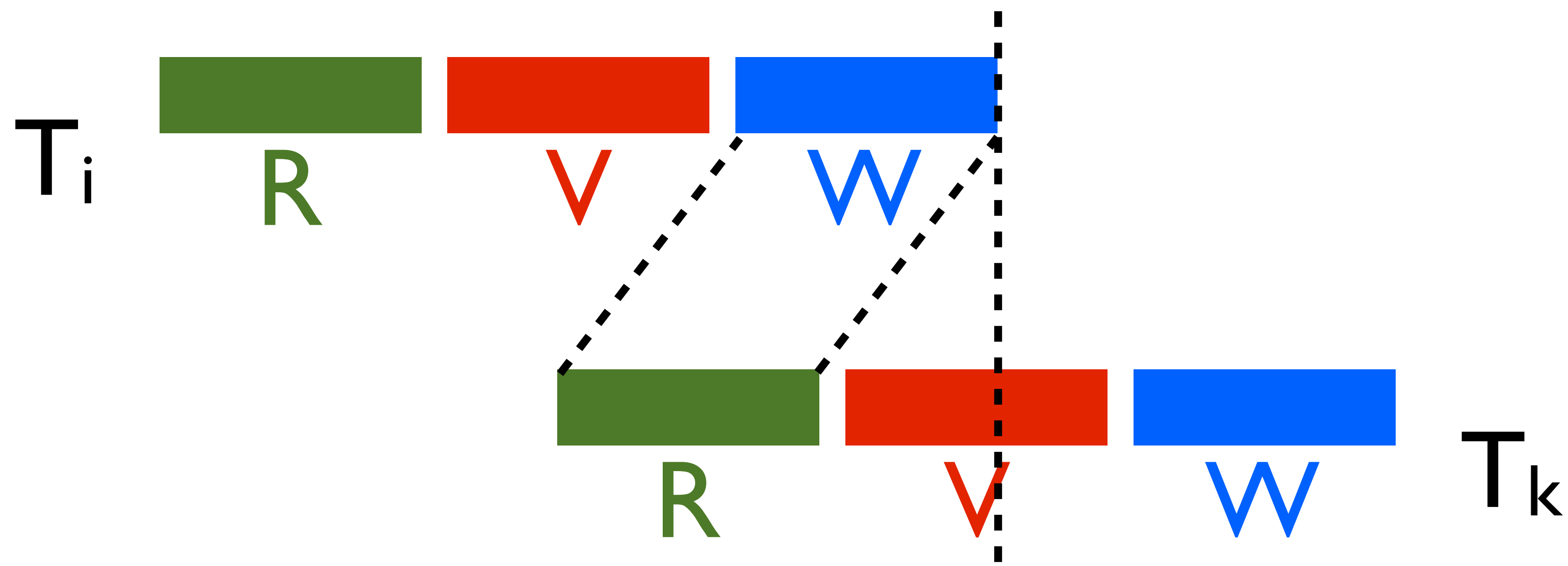
Is this sufficient? Is this efficient?

Test 2

For all i and k for which i < k,

check that T_i completes before T_k begins <u>its write phase</u>

AND $\mathrm{WriteSet}(T_i) \cap \mathrm{ReadSet}(T_k)$ is empty



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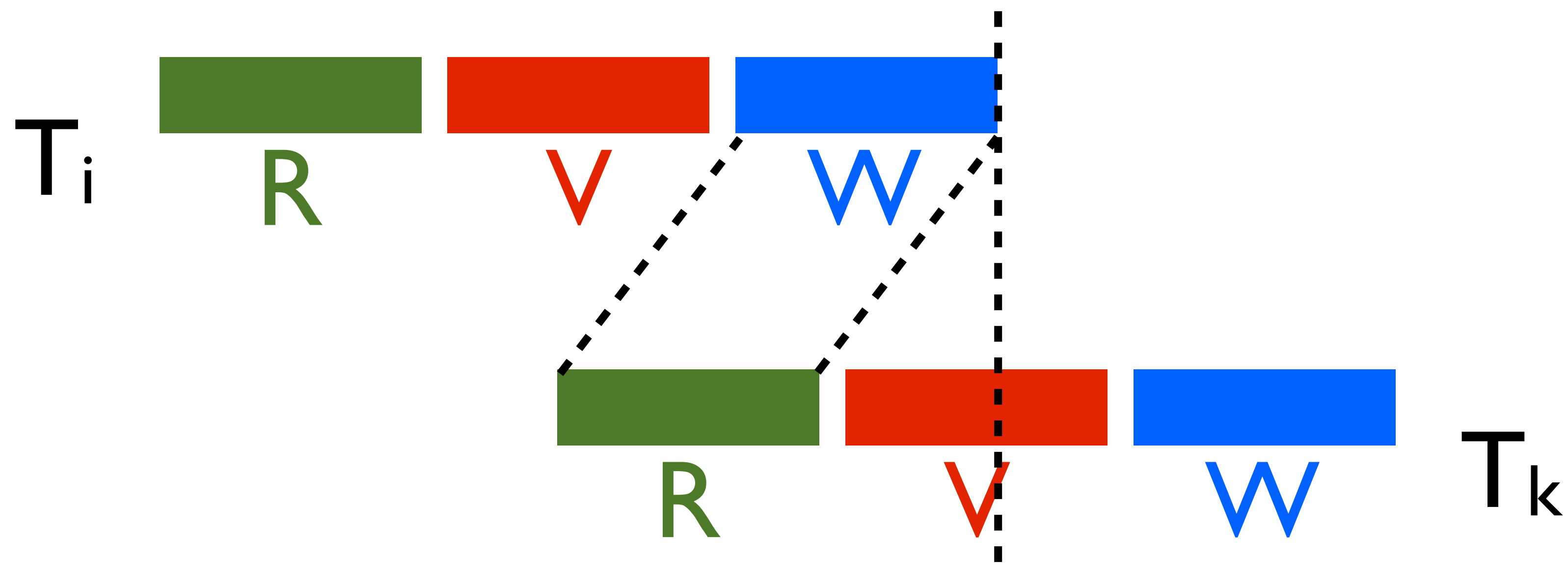

How do these two conditions help?

Test 3

For all i and k for which i < k,
check that T_i completes its read phase first

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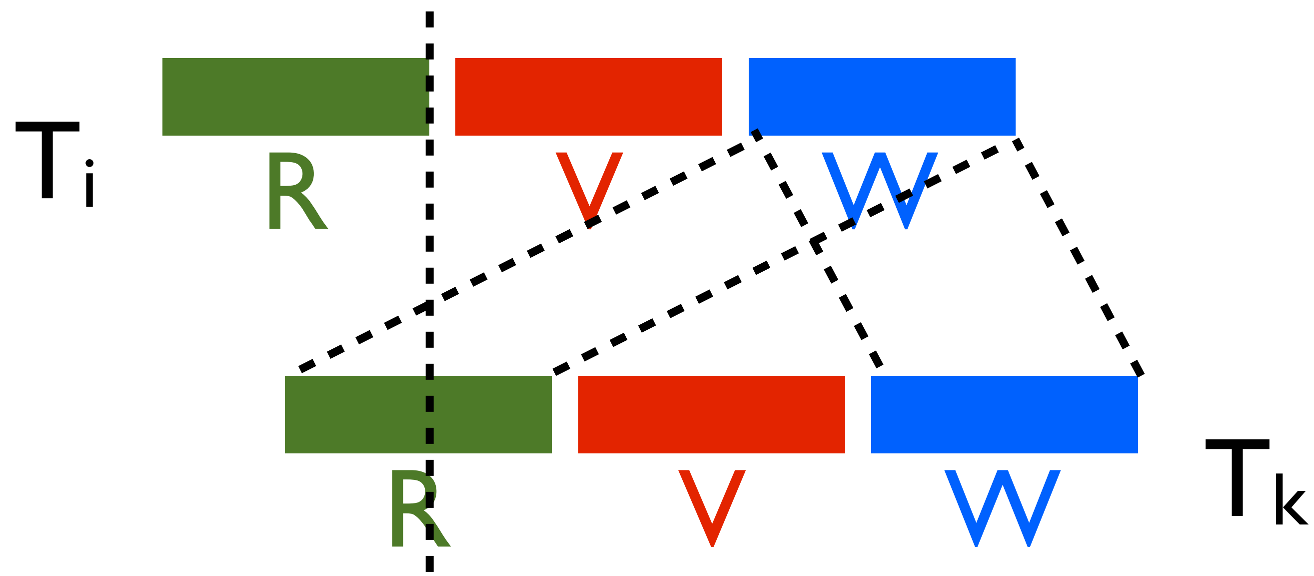

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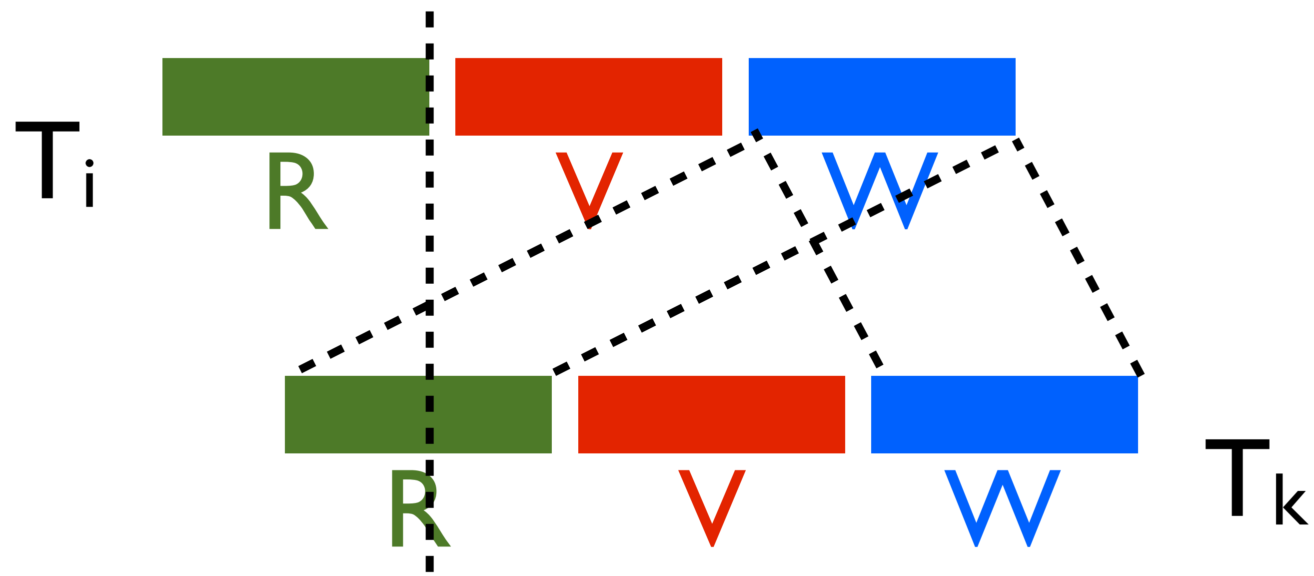

How do these three conditions help?

Which test (or tests) should we use?

Hint: How would you implement each test?

Validation

- Assigning the transaction ID, validation, and the whole write phase are a critical section.
  - Nothing else can go on concurrently.
  - The write phase can be long; This is bad.
- Optimization: Read only transactions don't need a critical section (no write phase).

Optimistic CC Overheads

- Each operation must be recorded in the readset/ writeset (sets are expensive to allocate/destroy)
- Must test for conflicts during validation stage
- Must make validated writes "public".
  - Critical section reduces concurrency.
  - Can lead to reduced object clustering.
- Optimistic CC must **restart** failed transactions.

“Optimistic” 2PL

- Optimistic approach to 2PL
  - Set S locks as usual to read data
  - Make changes to private copies of objects.
  - Obtain X locks at end of transaction, make writes public, and then release all locks
- Unlike Optimistic CC, conflicting transactions are blocked, but not killed (modulo deadlock).

Timestamp CC

- Give each object a read timestamp (RTS) and a write timestamp (WTS)
- Give each transaction a timestamp (TS) at the start.
- Use RTS/WTS to track previous operations on the object.
    - Compare with TS to ensure ordering is preserved.

Timestamp CC

- When T_i reads from object O:
  - If WTS(O) > TS(T_i), T_i is reading from a 'later' version.
    - Abort Ti and restart with a new timestamp.
  - If WTS(O) < TS(T_i), T_i's read is safe.
    - Set RTS(O) to MAX(RTS(O), TS(T_i))

Timestamp CC

- When T_i writes to object O:
  - If $RTS(O) > TS(T_i)$, T_i would cause a dirty read.
    - Abort T_i and restart it.
  - If $WTS(O) > TS(T_i)$, T_i would overwrite a 'later' value.
    - Don't need to restart, just ignore the write.
  - Otherwise, allow the write and update WTS(O).

Problem: Recoverability

Time	T1	T2
	`W(A)`	
		`R(A)`
		`W(B)`
		`COMMIT`

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		`W(B)`
		`COMMIT`

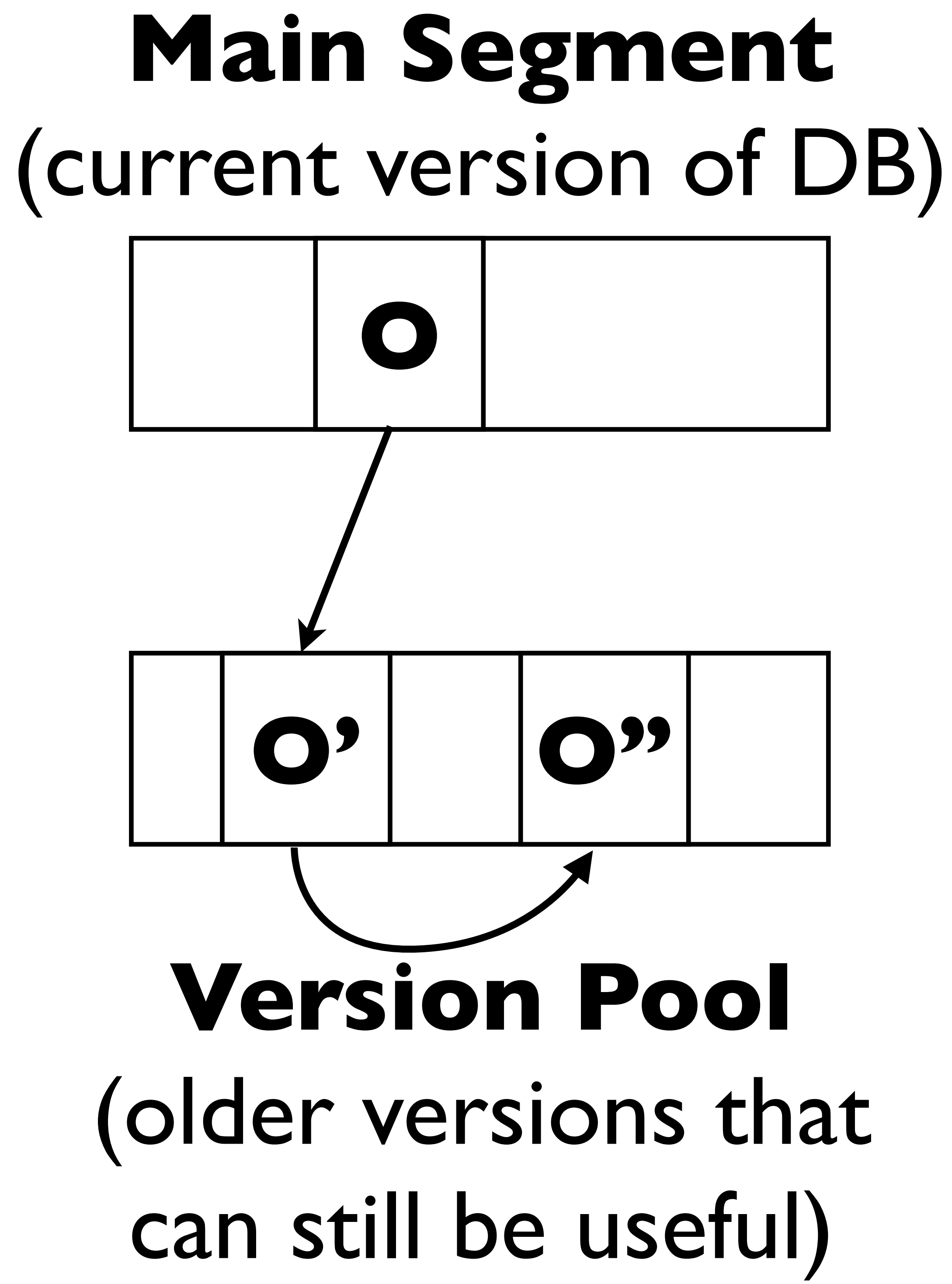
What happens if T1 aborts (or the system crashes)?

Timestamp CC and Recoverability

- Buffer all writes until a writer commits.
  - But update WTS(O) when the write to O is **allowed**.
- Block readers of O until the last writer of O commits.
- Similar to writers holding X locks until commit, but not quite 2PL.

Multiversion TS CC

- Let writers make a "new" copy, while readers use an appropriate "old" copy.
- Readers are **always** allowed to proceed.
- … but may need to be blocked until a writer commits.

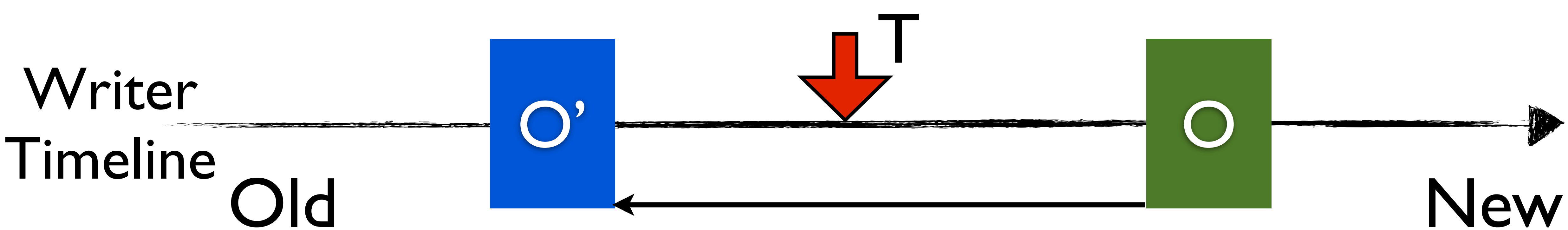


Multiversion TS CC

- Each version of an object has:
  - The writing transaction's TS as its WTS.
  - The highest transaction TS that read it as its RTS.
- Versions are chained backwards in a linked list.
  - We can discard versions that are too old to be "of interest".
- Each transaction classifies itself as a reader or writer for each object that it interacts with.

Reader Transactions

- Find the newest version with WTS < TS(T)
  - Start with the latest, and chain backward.
- Assuming that some version exists for all TS, reader xacts are never restarted!
  - … but may block until the writer commits.



Writer Transactions

- Find the newest version V s.t. WTS < TS(T)
- If RTS(V) < TS(T) make a copy of V with a pointer to V with WTS = RTS = TS(T).
  - The write is buffered until commit, but other transactions can see TS values.
- Otherwise reject the write (and restart)