Before-image log, checkpoints, crashes

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PROGRESS
software

abstract

In this talk we examine the "before-image file", what it's for, how it works, and how you can configure it properly. You might get answers to questions that have been troubling people for over $25 * 10^{-2}$ centuries:
Why doesn't the before-image file have before-images ?
Why aren't the data on disk ever current ?
What are checkpoints ?
Why do we have them ?
When your system crashes (and they all do eventually) how can the RDBMS recreate all the data that were lost in the crash and restore your database to a consistent state?

The OpenEdge RDBMS is brought to you by

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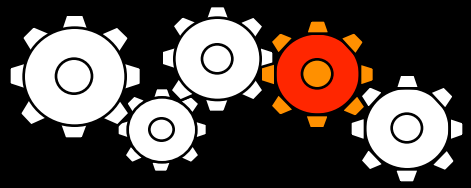
SOFTWARE



Engine Crew

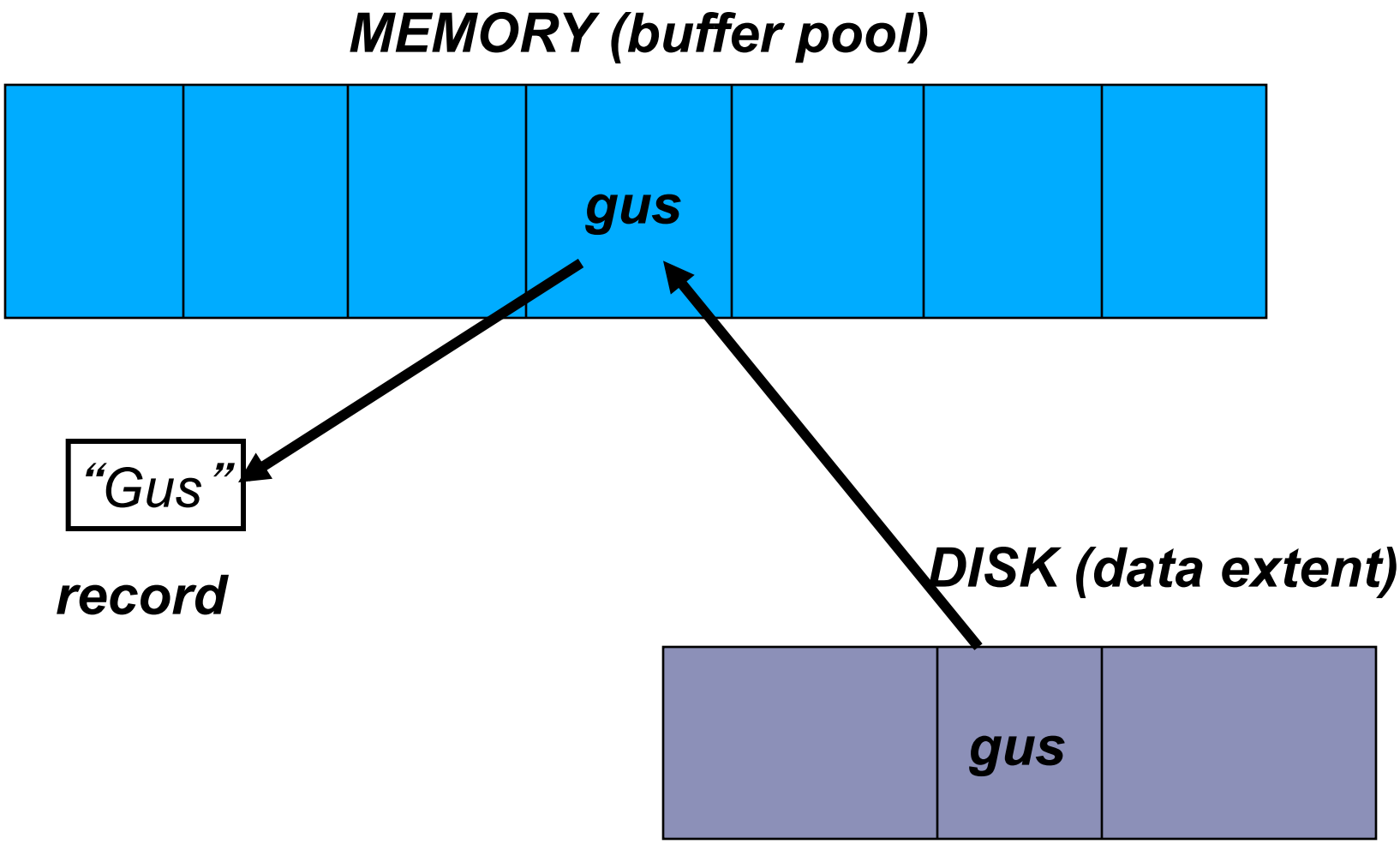
Builders of The Best RDBMS

on the Third Planet From The Sun

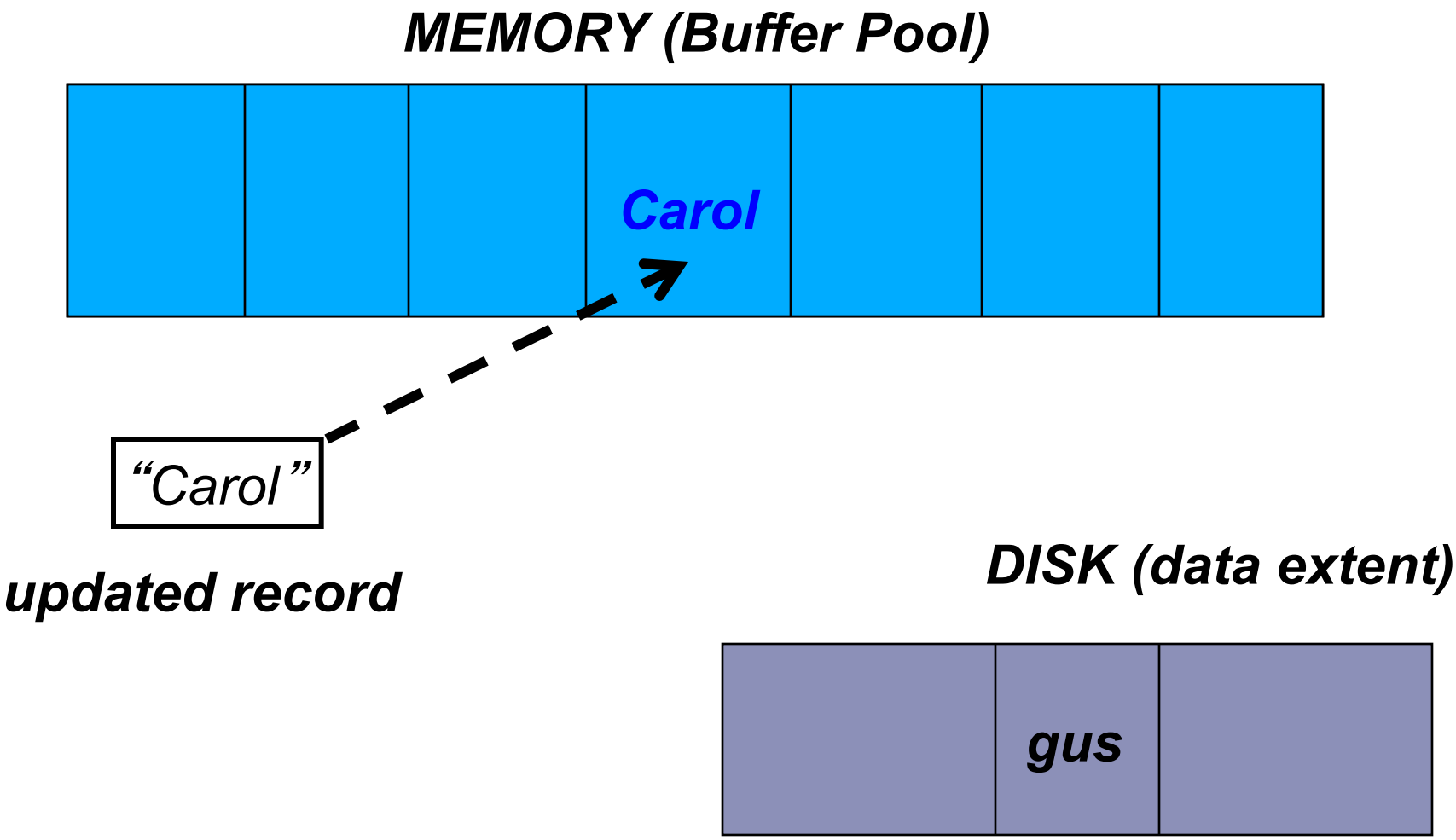
a typical data block – for records

an update

data block - before



data block - after



but….we changed memory only – not disk

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- What if someone unplugs server to plug in vacuum cleaner?
- What if we want to undo (rollback) ?
- What if we make several more changes and only one block of a fragmented record chain is written to disk to make room in the buffer pool ?
- What if an asteroid wipes out all the data centers?

but….we changed memory only – no disk write

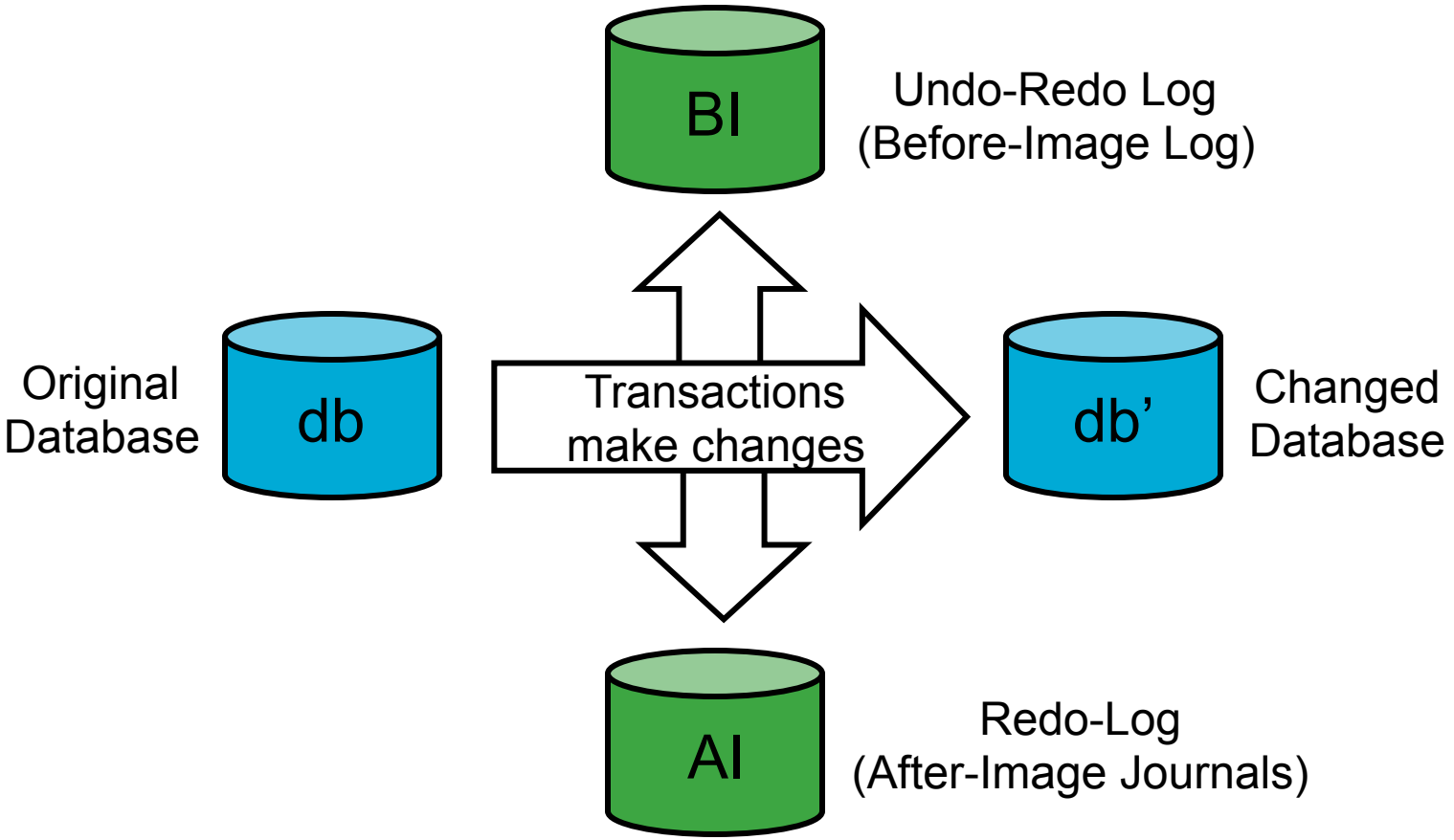
PROGRESS software

- What if someone unplugs server to plug in vacuum cleaner?
  - the change will be lost
- What if we want to undo (rollback) ?
  - we don't know the old value or how to undo
- What if we make several more changes and only one block of a fragmented record chain is written to disk to make room in the buffer pool ?
  - the database will be corrupted
- What if an asteroid wipes out all the data centers?
  - the database will disappear completely

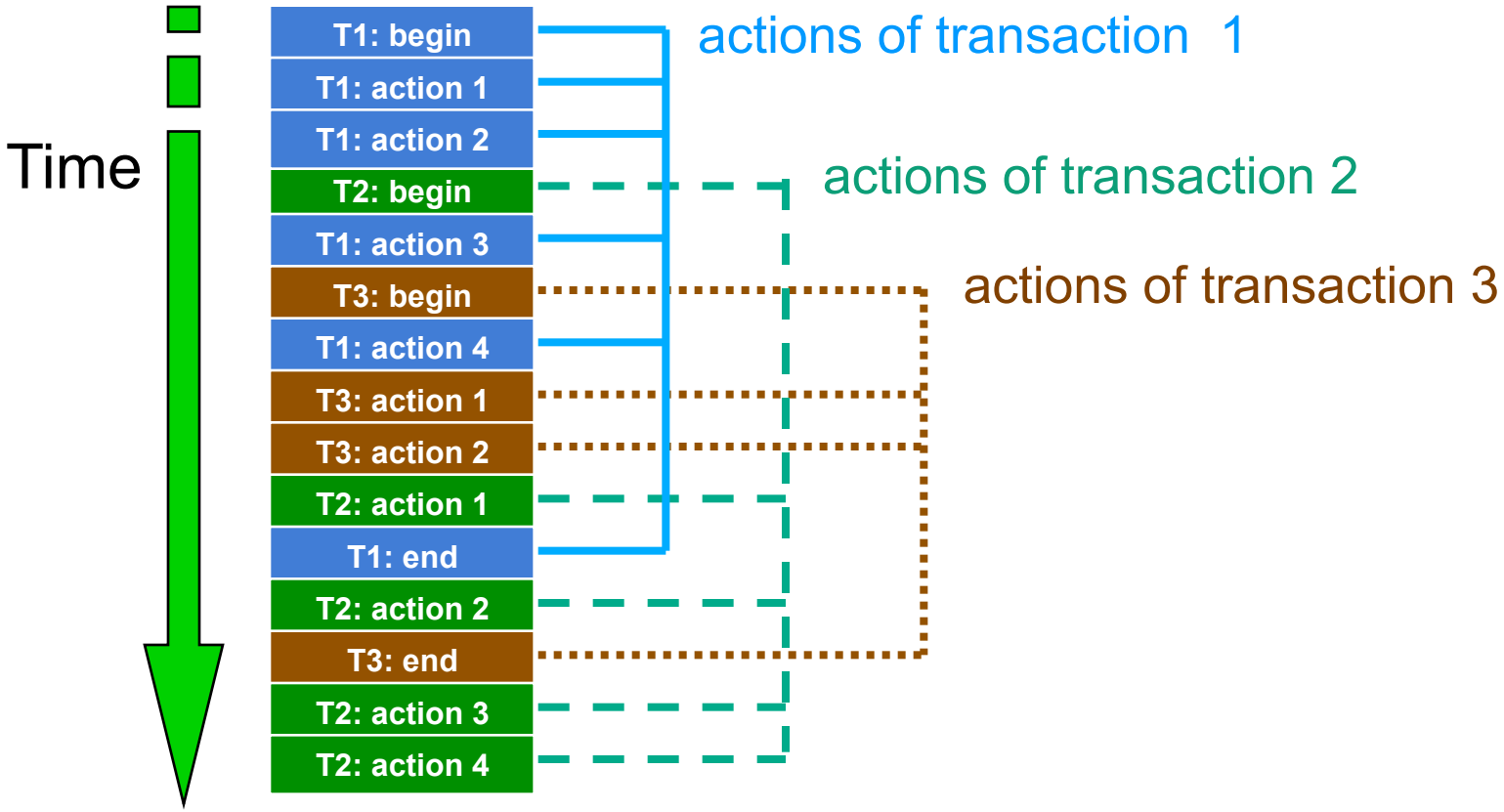
these are all bad things (tm)

transaction logging to the rescue!

Two transaction logs



transaction log records (aka “notes”)



notes form a complete history of everything

log records (notes)

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- generated for every change to database.
- each describes exactly one change to one database block.
  - almost - there are log records that describe changes to purely memory-resident data structures like the transaction table
- apply only to specific version number of block
- some operations require more than one change
  - index splits, multi-block records
- written in same order changes are executed.
- notes from concurrent transactions are mixed together.

Undo-Redo (BI) Log Records

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- each log record (or “note”) contains:
  - area number
  - database block number (its dbkey)
  - database block *version number*
  - note type - identifies operation to do
  - any information needed to undo the operation
    - in case we have to roll back
  - any information needed to redo the operation
    - in case we lose what is in memory

an update, with notes

a typical data block – for us to update

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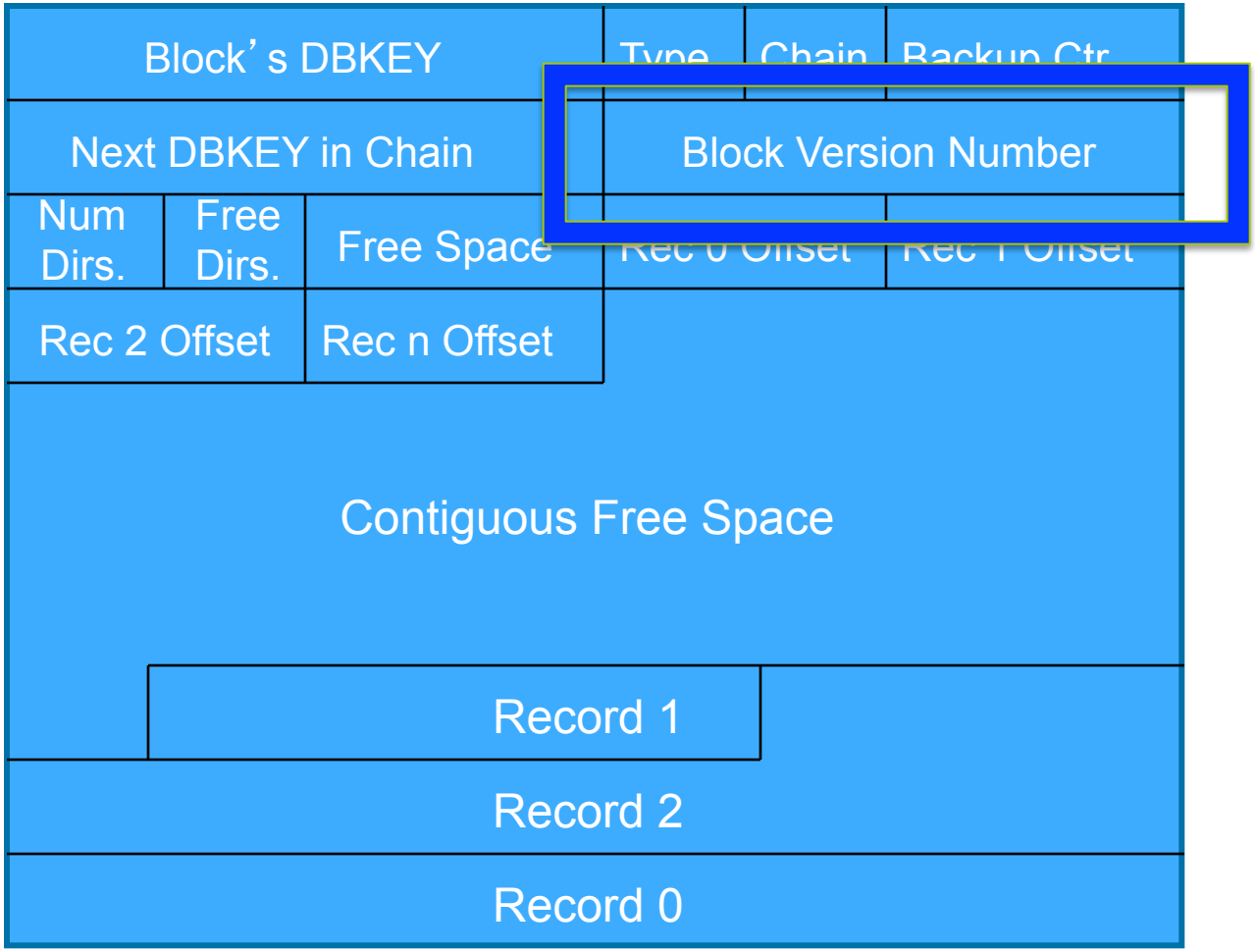

updating a block - revisited

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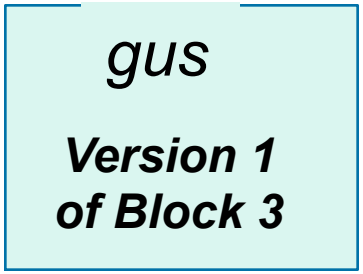

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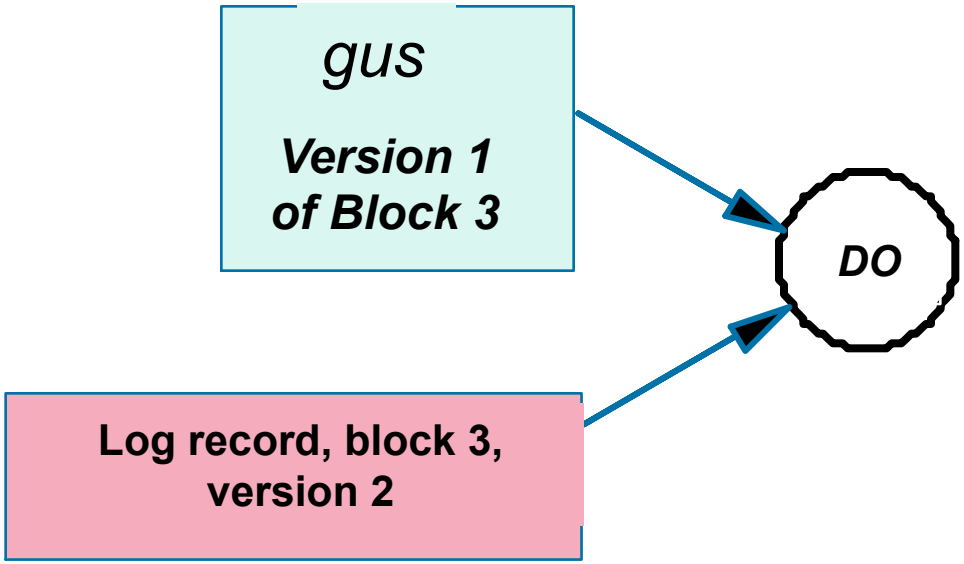
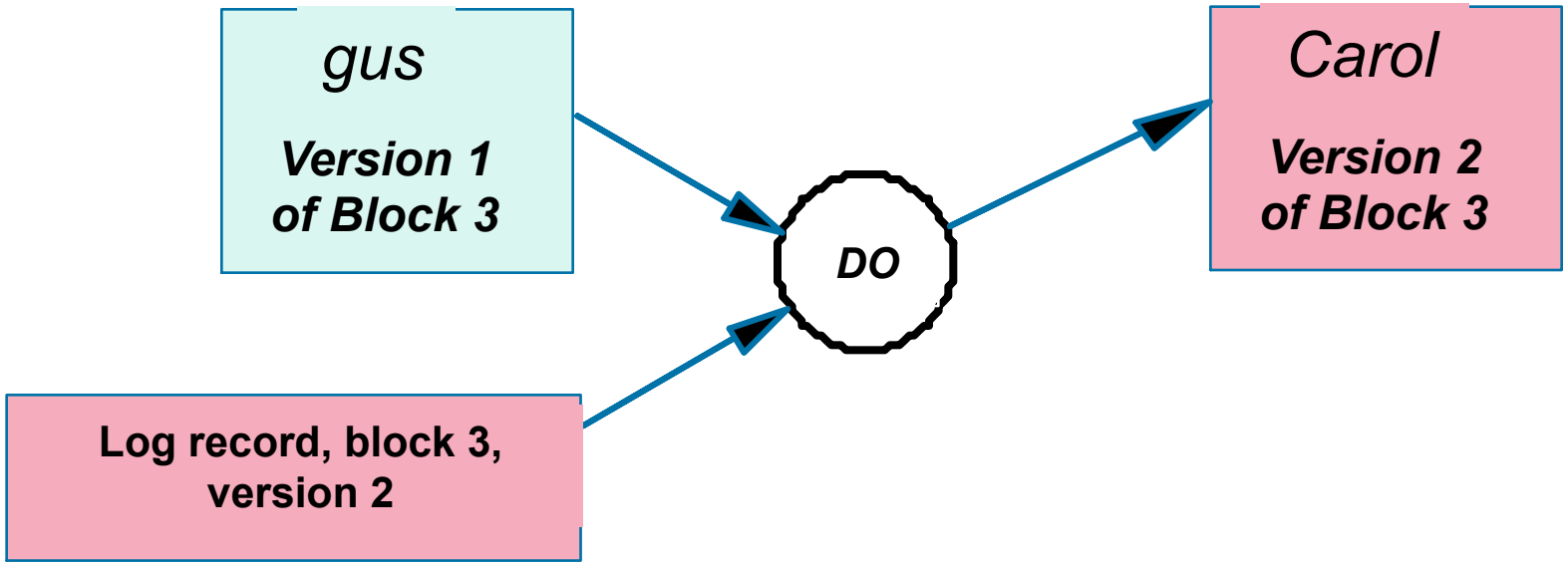


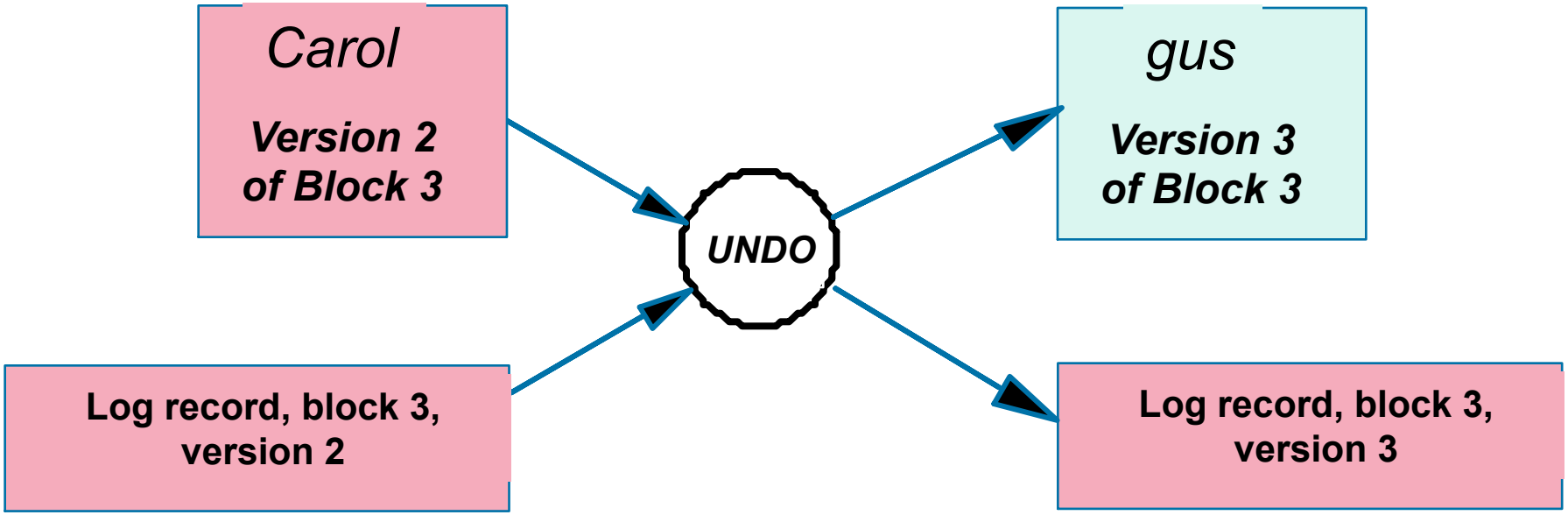
updating a block - revisited

new data values
new version



updating a block - undoing

original data values
new version



putting things back the way they were before you touched them

houston, we have a problem!

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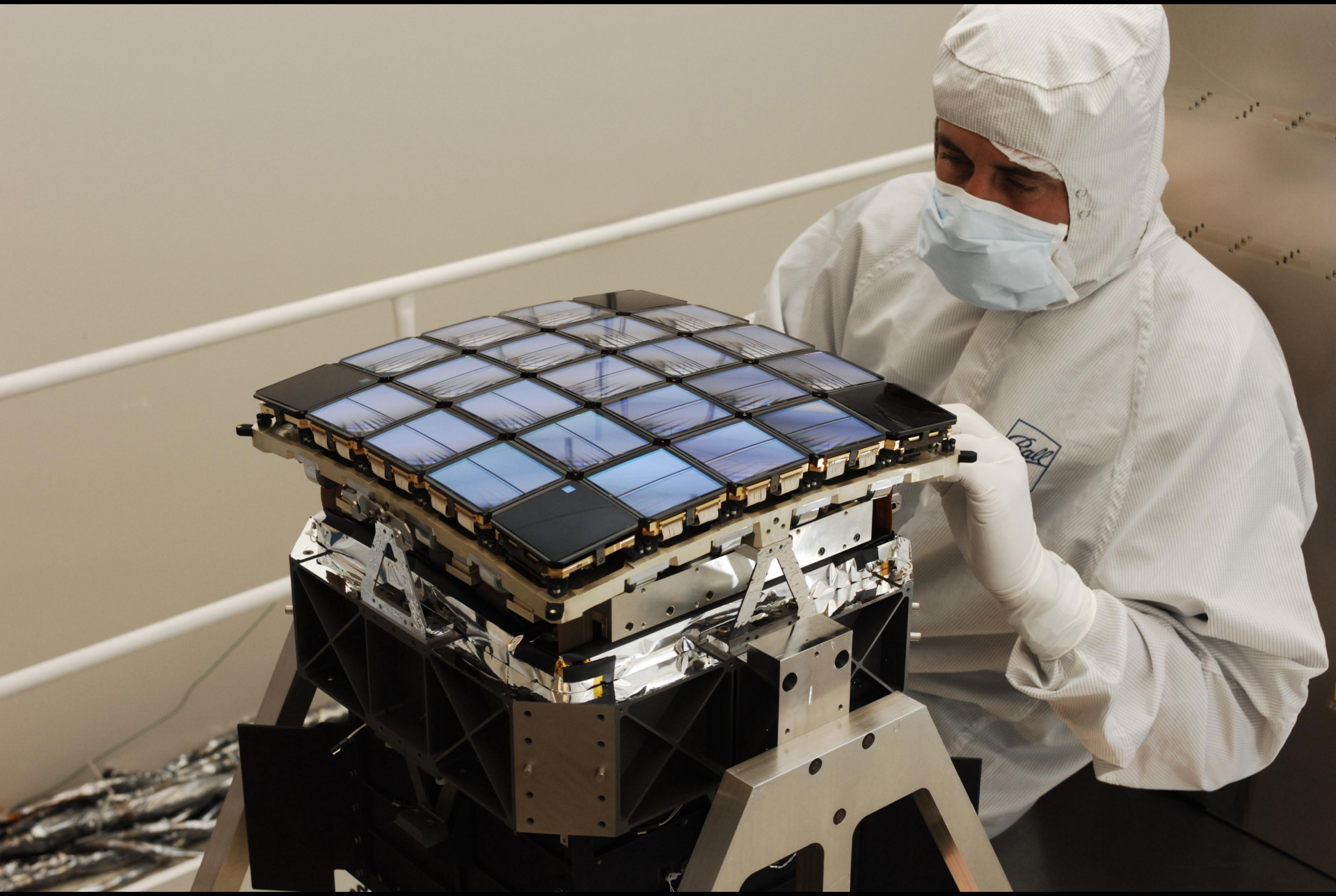
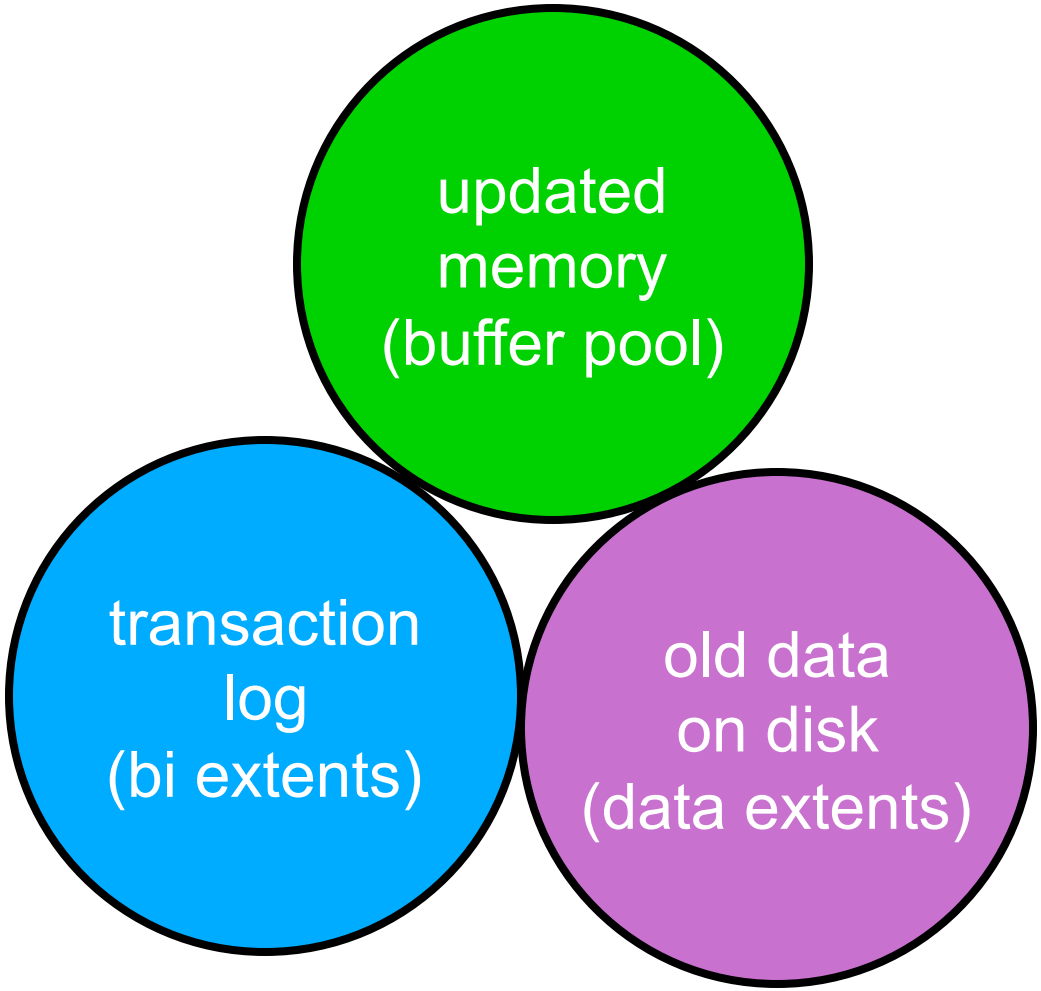
- notice that we did the change just in memory
- we are logging the changes, and we can undo if necessary, but
  - how about writing changes to disk ?
  - when ?
  - what if server unplugged ?



The checkpoint process

complete database state – in 3 part harmony



Database Checkpoints

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- We have memory resident database state (updates are done in memory)
- Must update disk resident data once in a while
- Definition:
  A checkpoint is a process for making what is on disk consistent with the changed or updated database parts that are present only in memory.

  It is a process, not an event.

Benefits of Checkpointing (1)

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- Smaller undo-redo (BI) transaction logs
  - Space can be re-used when the recovery information is no longer needed
- Example:
  - 1,000,000 transactions
  - 350 bytes logged per transaction

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  - so:
    - about 350 megabytes of log data
    - can execute thousand times more transactions a day
    - How much space will that take?
    - Most transactions are larger

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Benefits of Checkpointing (2)

PROGRESS software

- Shorter Recovery time
  - fewer changes must be repeated when a crash occurs
- Example:
  - 1,000,000 transactions
  - 3.2 disk io's per transaction
  - assume disks do about 100 io's per second
  - Arrival rate of seconds is fixed at 86,400 per day
  - So:

Benefits of Checkpointing (2)

PROGRESS software

- Shorter Recovery time
  - few changes must be repeated when a crash occurs
- Example:
  - 1,000,000 transactions
  - 3.2 disk i/o's per transaction
  - modern disks do 100 io's per second
  - Arrival rate of seconds is fixed at 86,400 per day
  - So:
    - 320,000 seconds (3.7 days) to recover
    - What if you had to recover a thousand times more?

Drawbacks of Checkpointing

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- Not free !
  - Requires (some) extra processing
  - Requires (some) extra io
  - Takes (some) time
  - Can freeze all database updates for a (short) time

well worth the costs !

Checkpoint Process

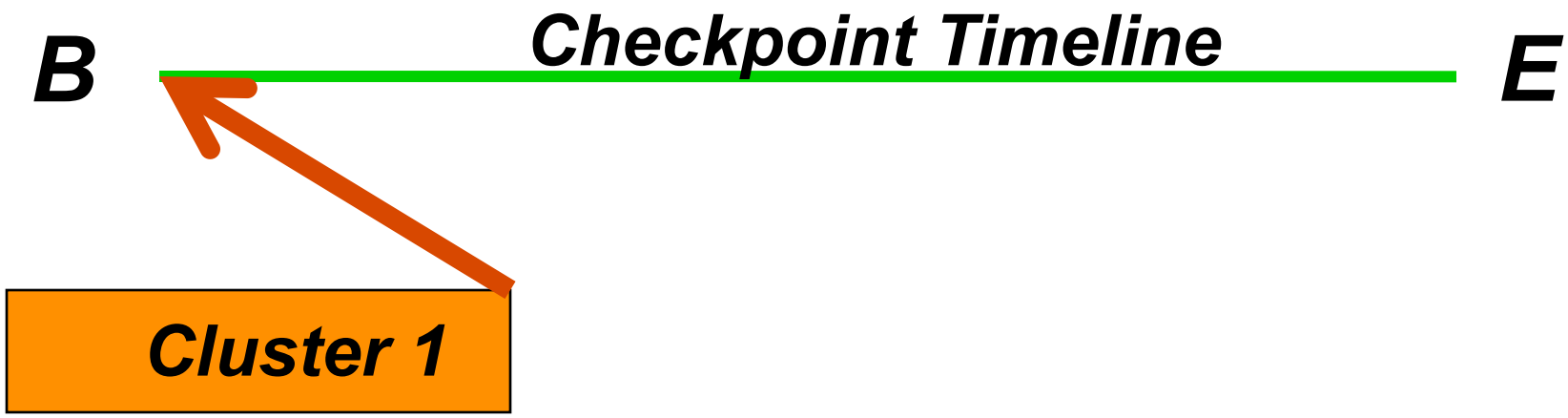
- There are 3 phases to a checkpoint

Checkpoint Process

- There are 3 phases to a checkpoint
  - Beginning
  - Middle
  - and End

Checkpoint Phase 1 (Begin)

- Unwritten BI and AI buffers forced to disk
- All dirty blocks placed on checkpoint queue
- Next BI cluster opened
  - (may require formatting if new)



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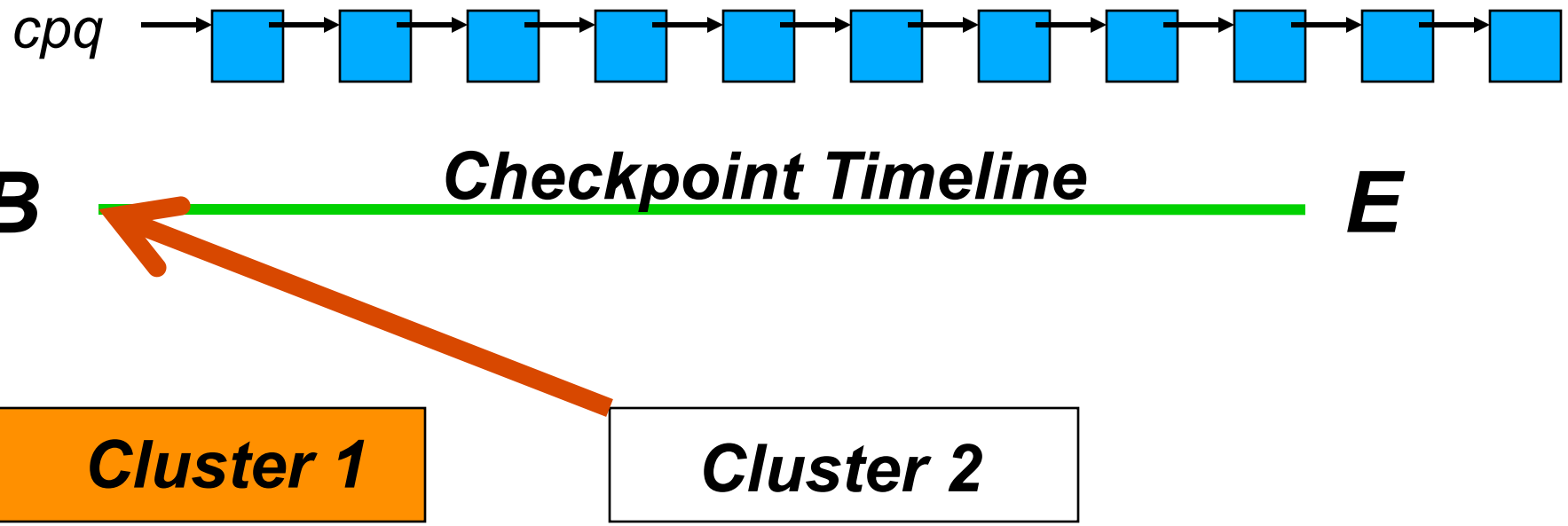
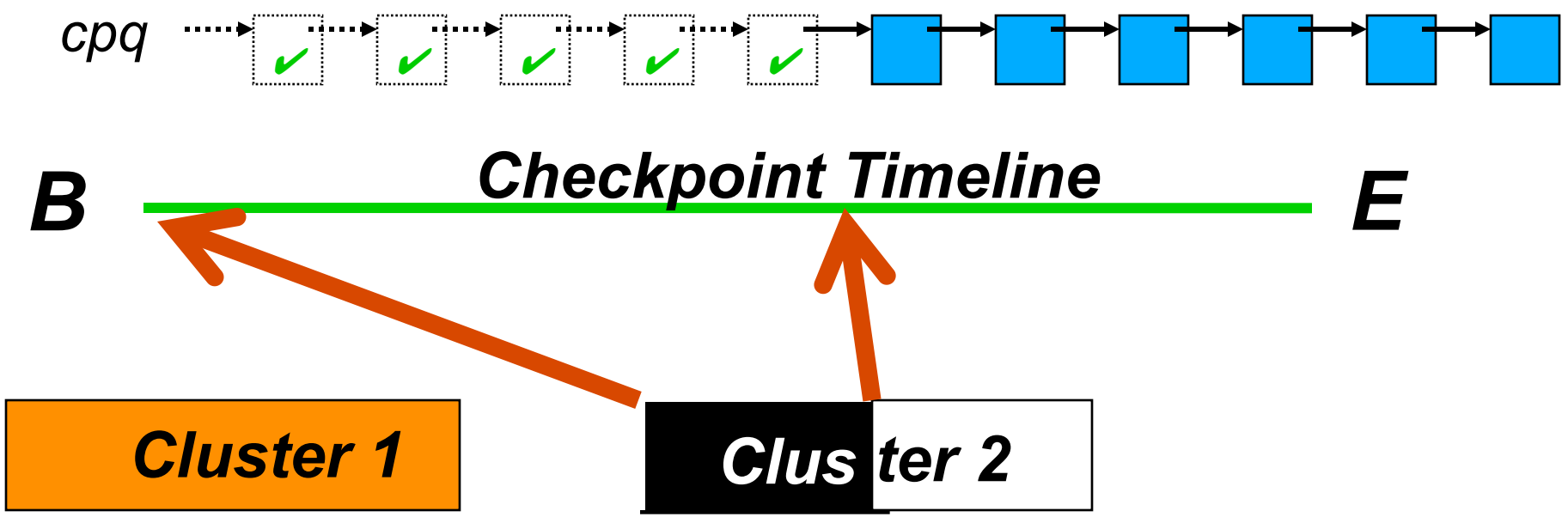


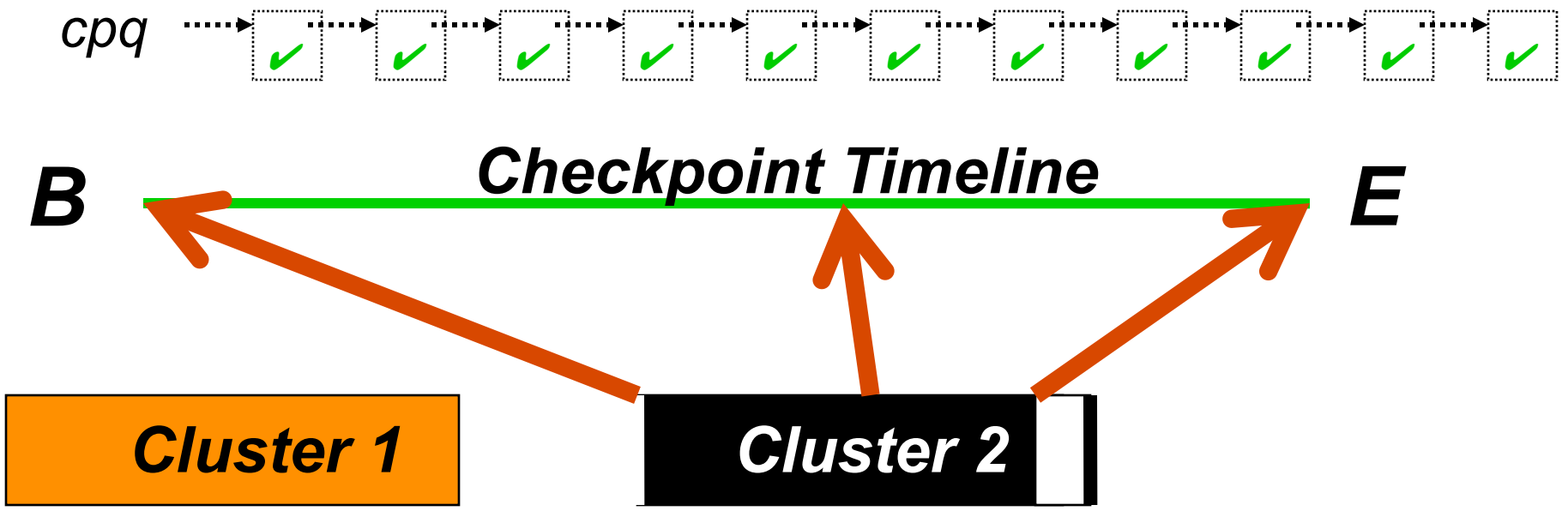
Checkpoint Phase 2 (Middle)

- Asynchronous Page Writers take blocks off the Checkpoint Queue and write them to disk.
- APW's pace themselves



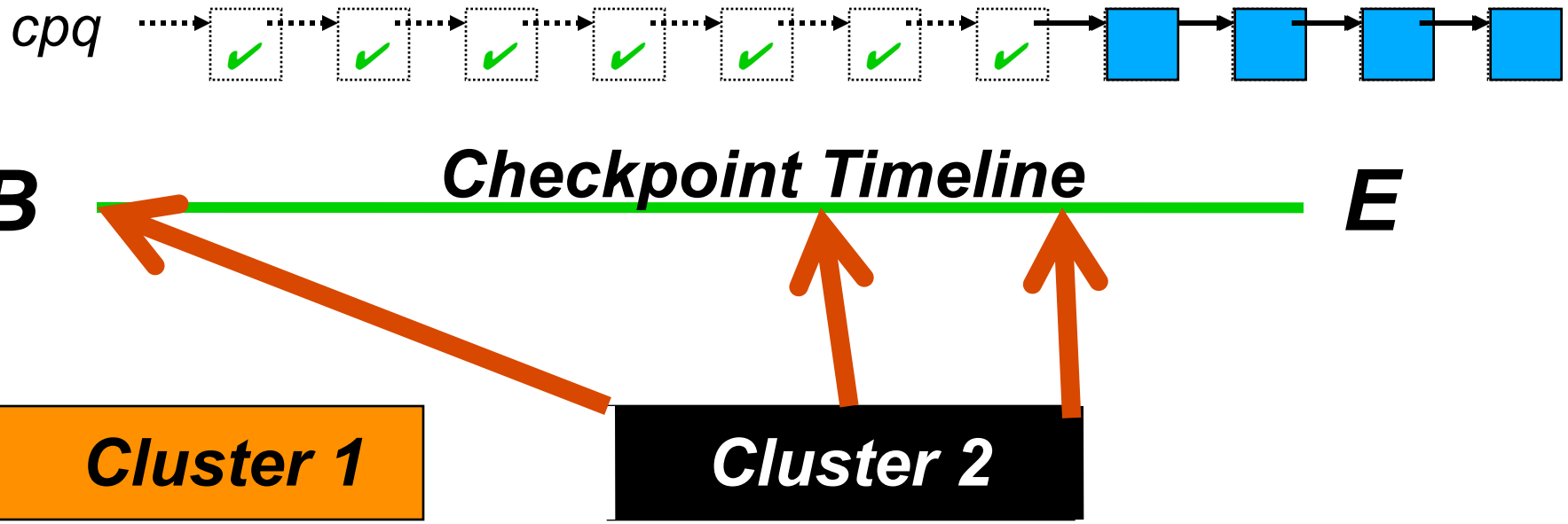
Checkpoint Phase 3 (End)

- As cluster approaches full, all blocks from checkpoint queue have been written to disk
- Checkpoint queue now empty



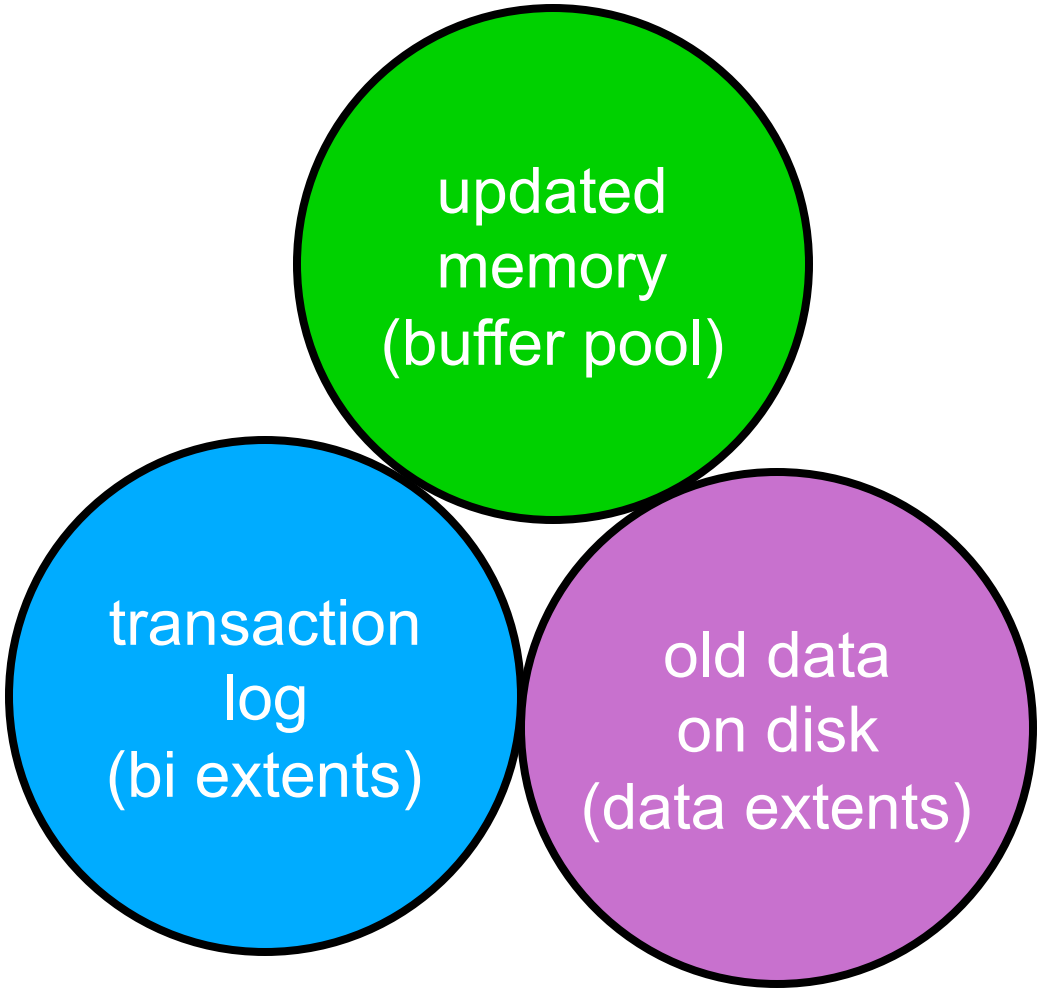
Checkpoint Phase 3 (alternate ending)

- Cluster might fill *before* queue emptied
- Now we have to flush remaining blocks
- Delay ! AND: fdatasync() calls take more time than normal – more delay

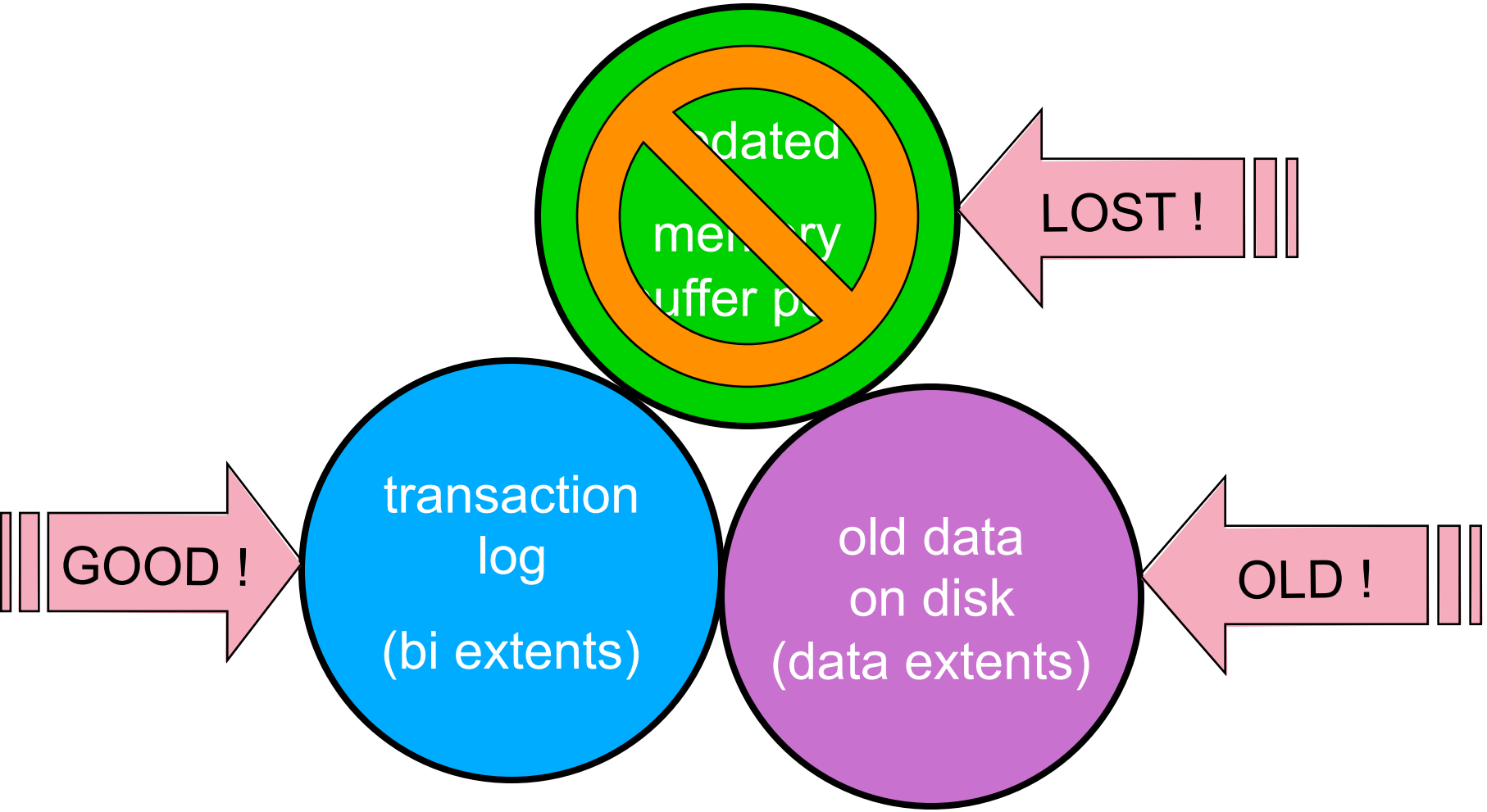


Crash recovery

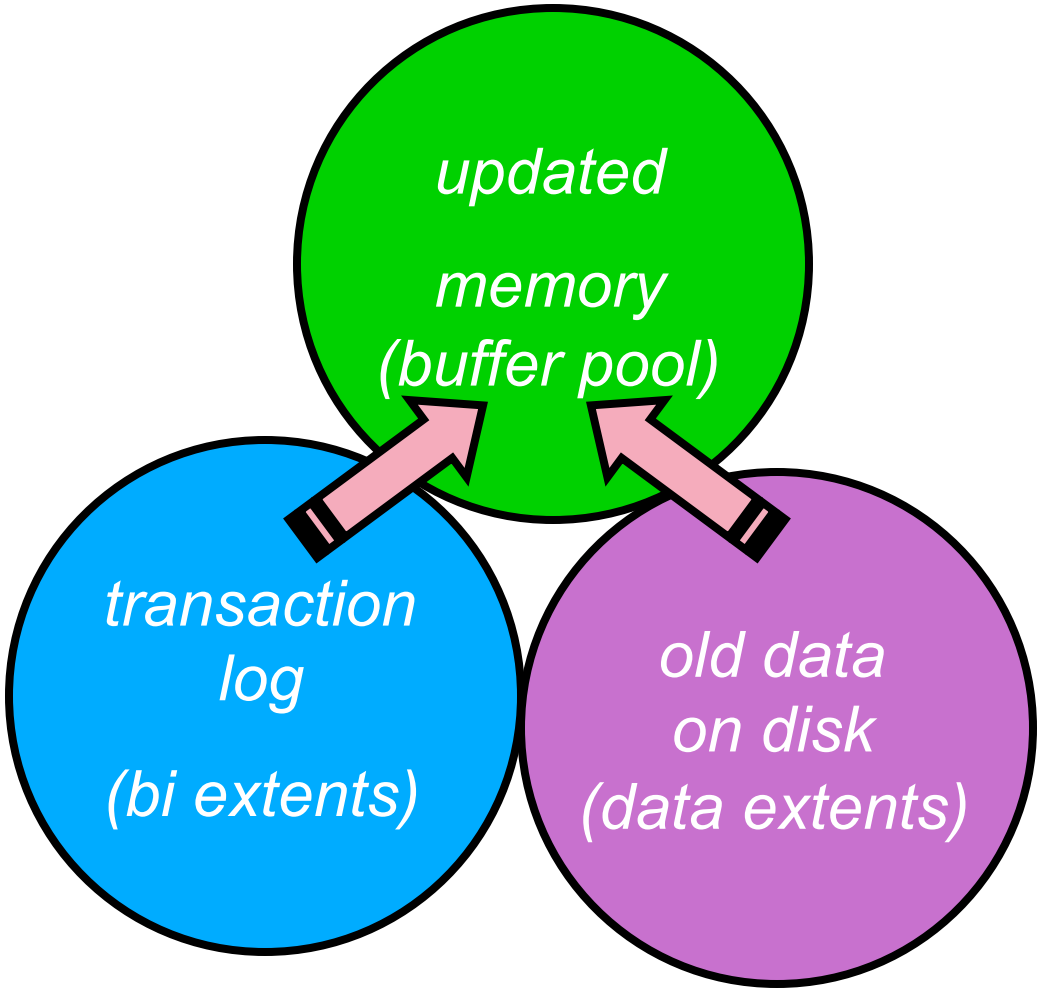
complete database state – in 3 part harmony



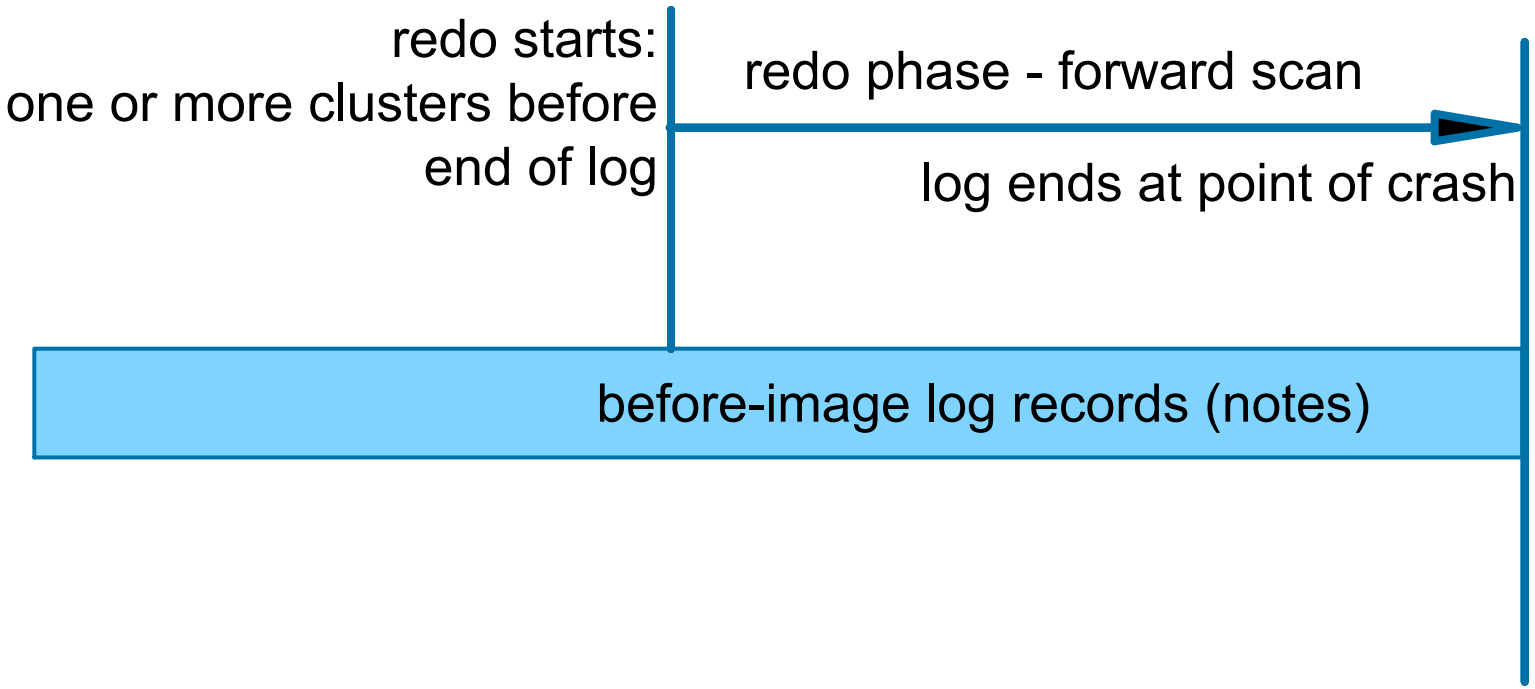
disaster strikes



reconstructive surgery

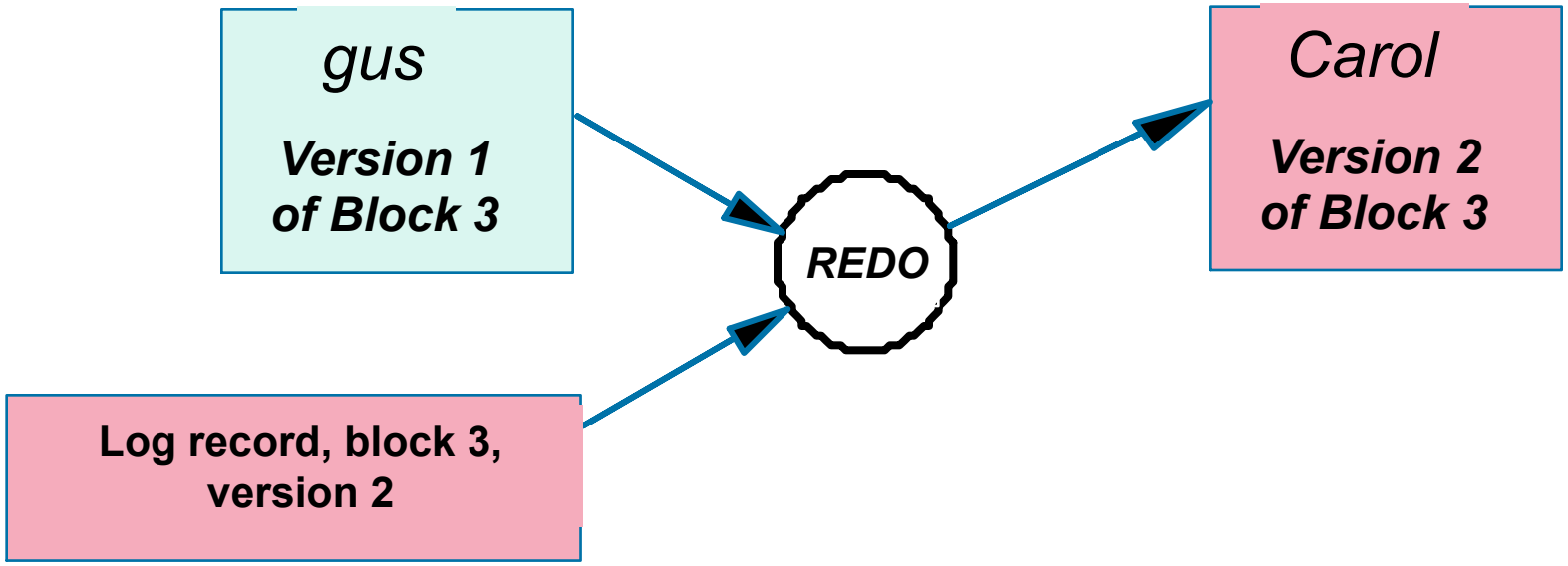


crash recovery processing

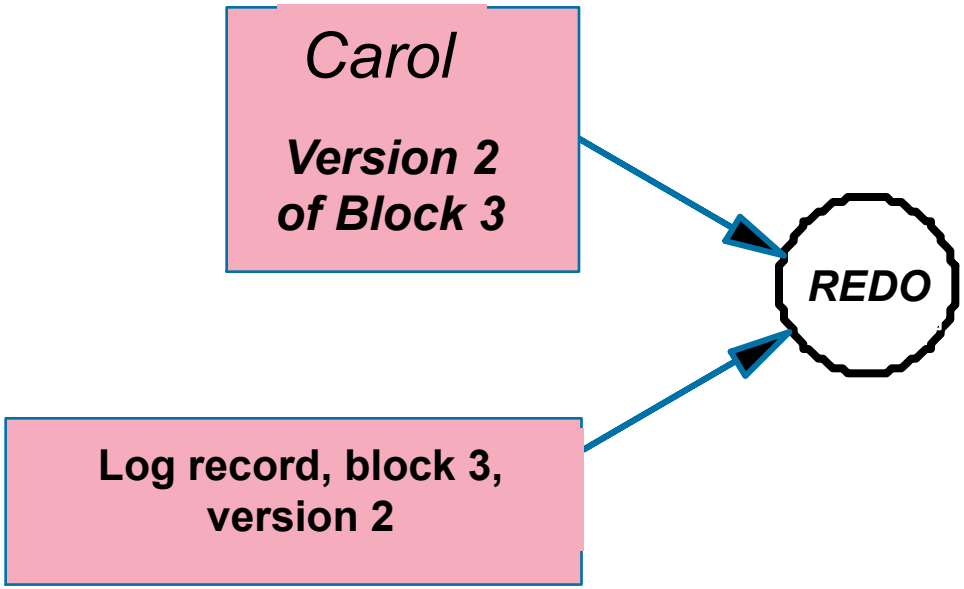


redo a change

new data values
new version



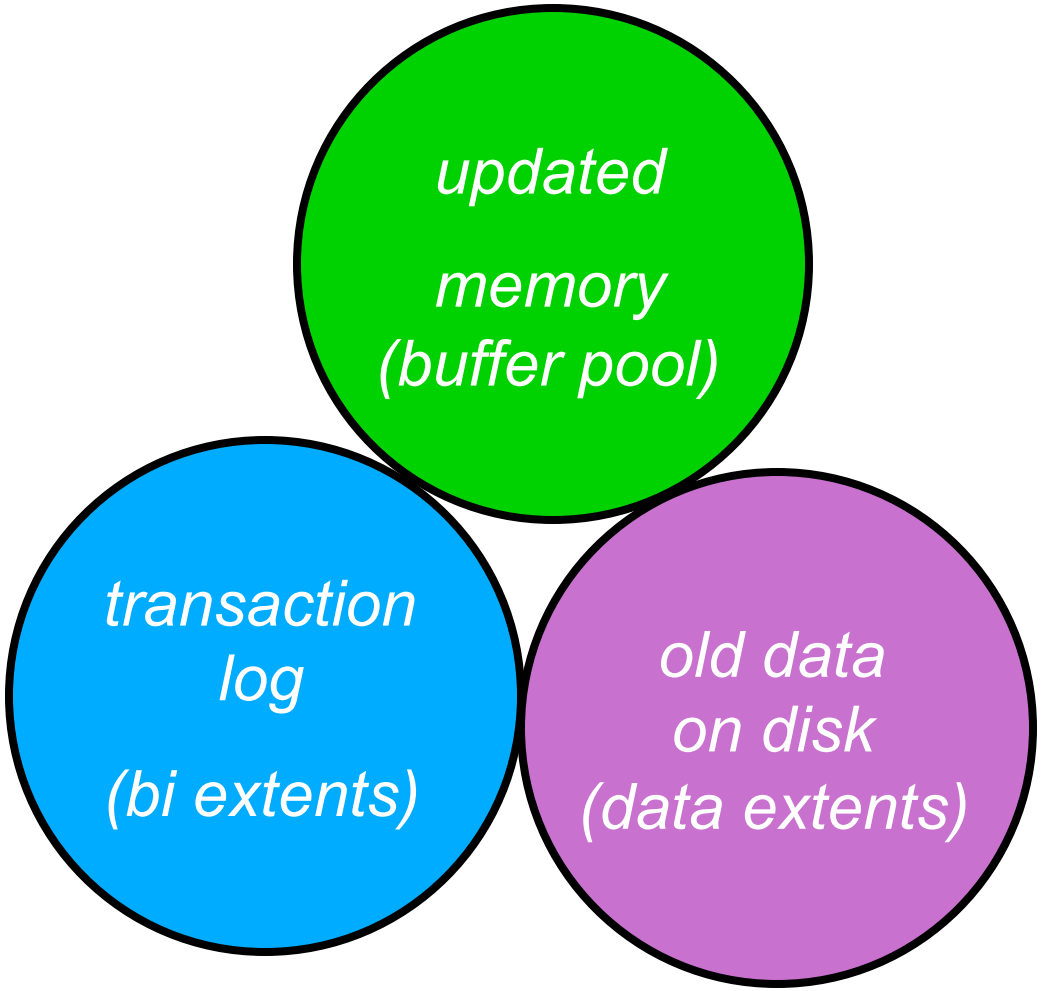
not redoing a change



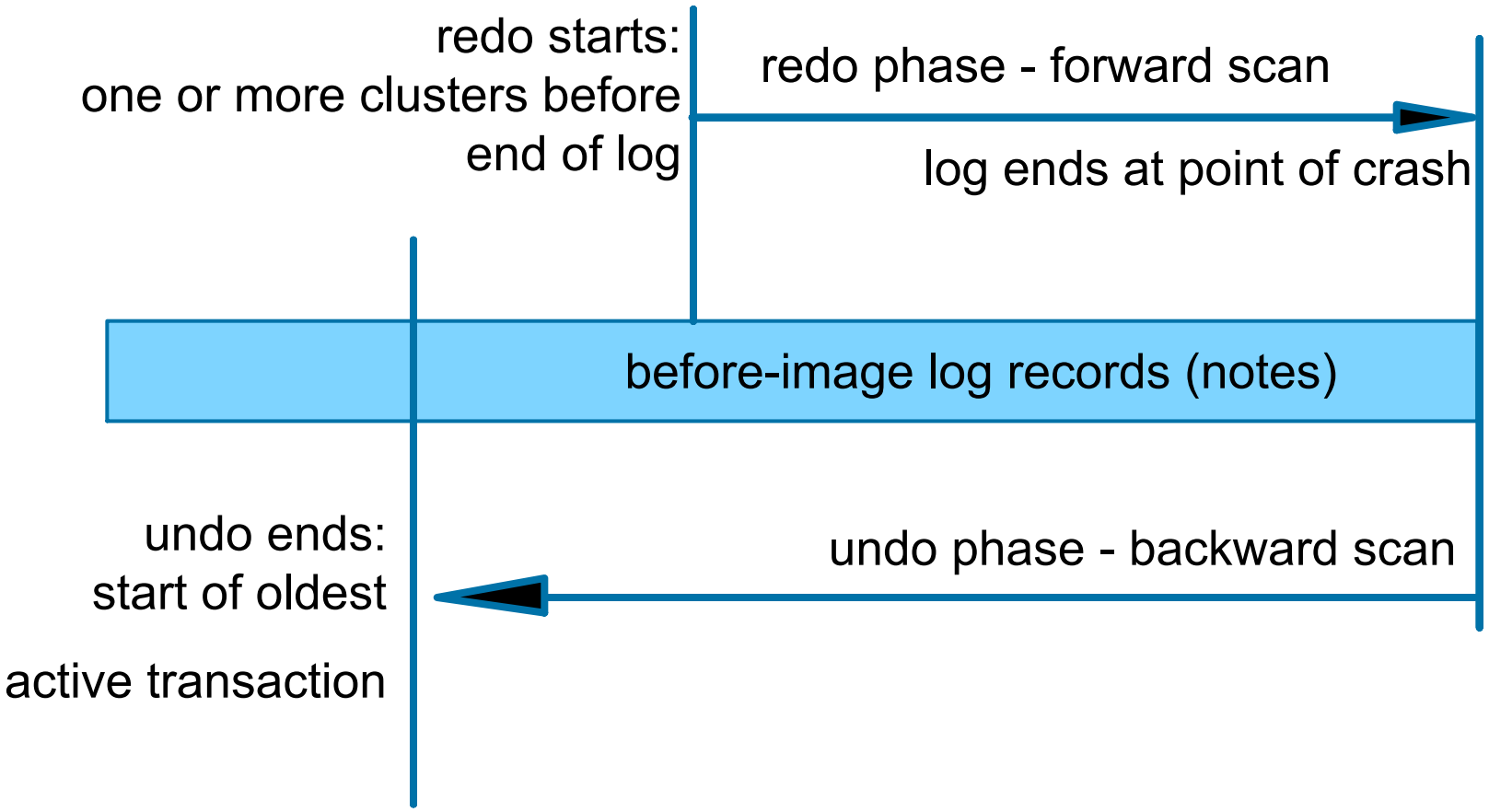
nothing to do
we already have
version 2 of the block

note is skipped

complete database state - 3 parts



crash recovery processing



now we are good.

everything is back the way it was before

you touched it

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software

That's all we have time for today, except

Answers

email:

gus@progress.com