datto

New Scrub Prefetcher

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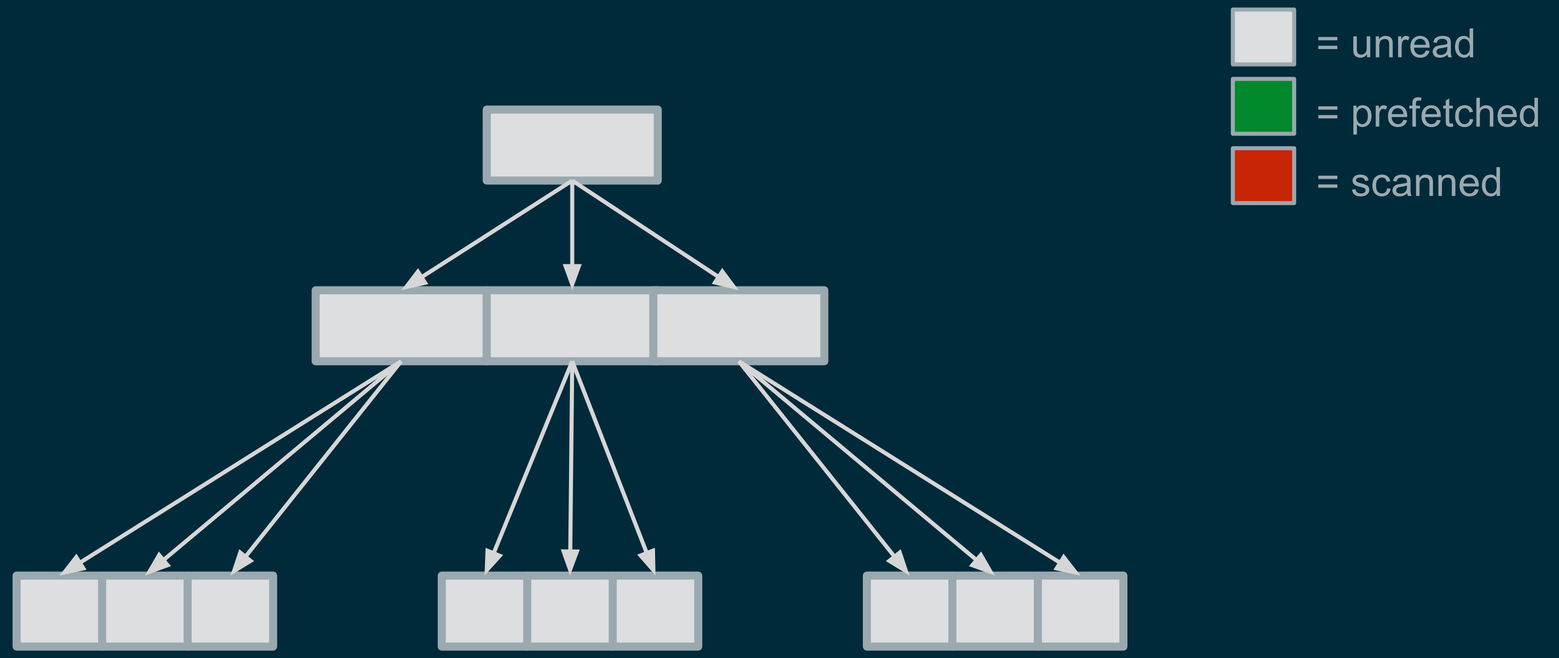
Scrub and Resilver Background

- Scrubs and resilver use exactly the same code
- Scrubs happen completely in syncing context
  - After spending some time scrubbing we suspend
  - Resume next txg, reconciling any state that changed
- Scrub iteration
  - Iterate through all object sets in the pool (discovering as we go)
  - Traverse through all blocks of each object set in logical order
- Read all copies / parity of each block
  - Self healing code automatically handles fixing / reporting

Current Design



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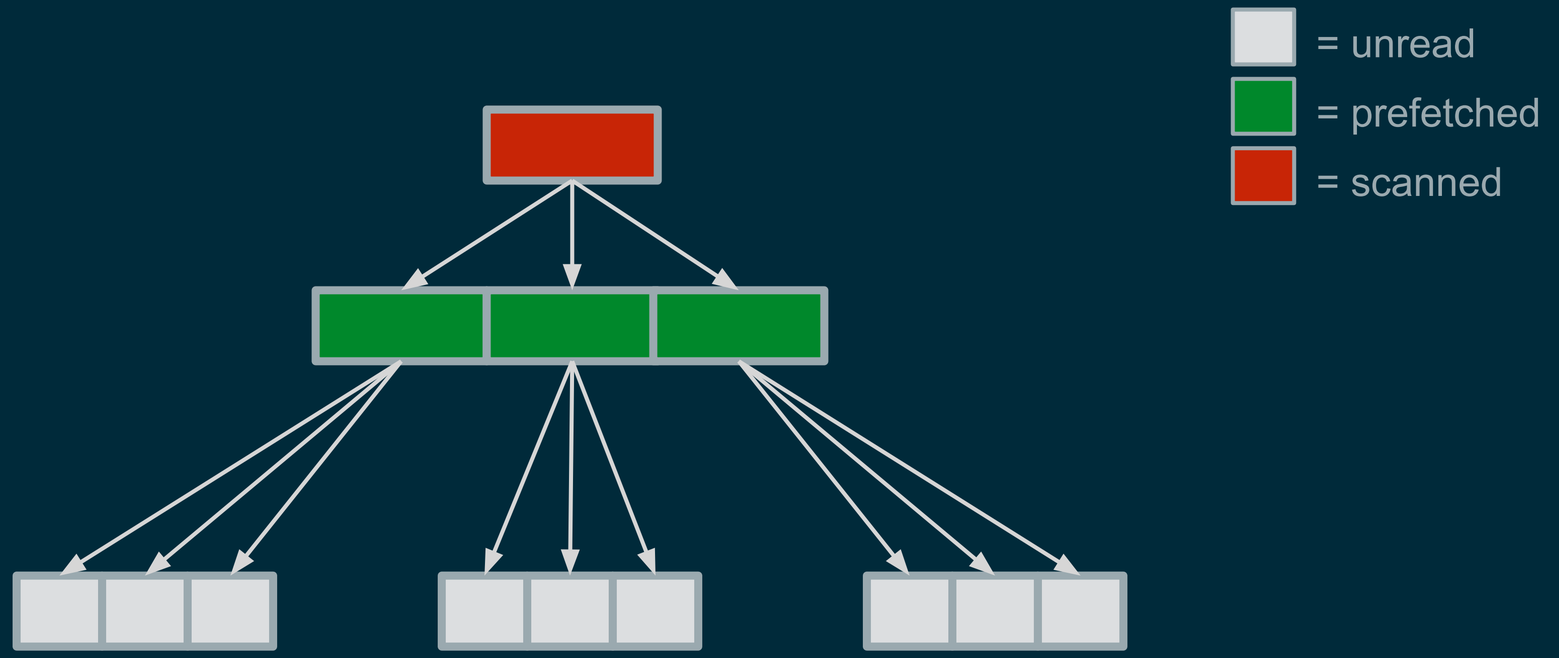

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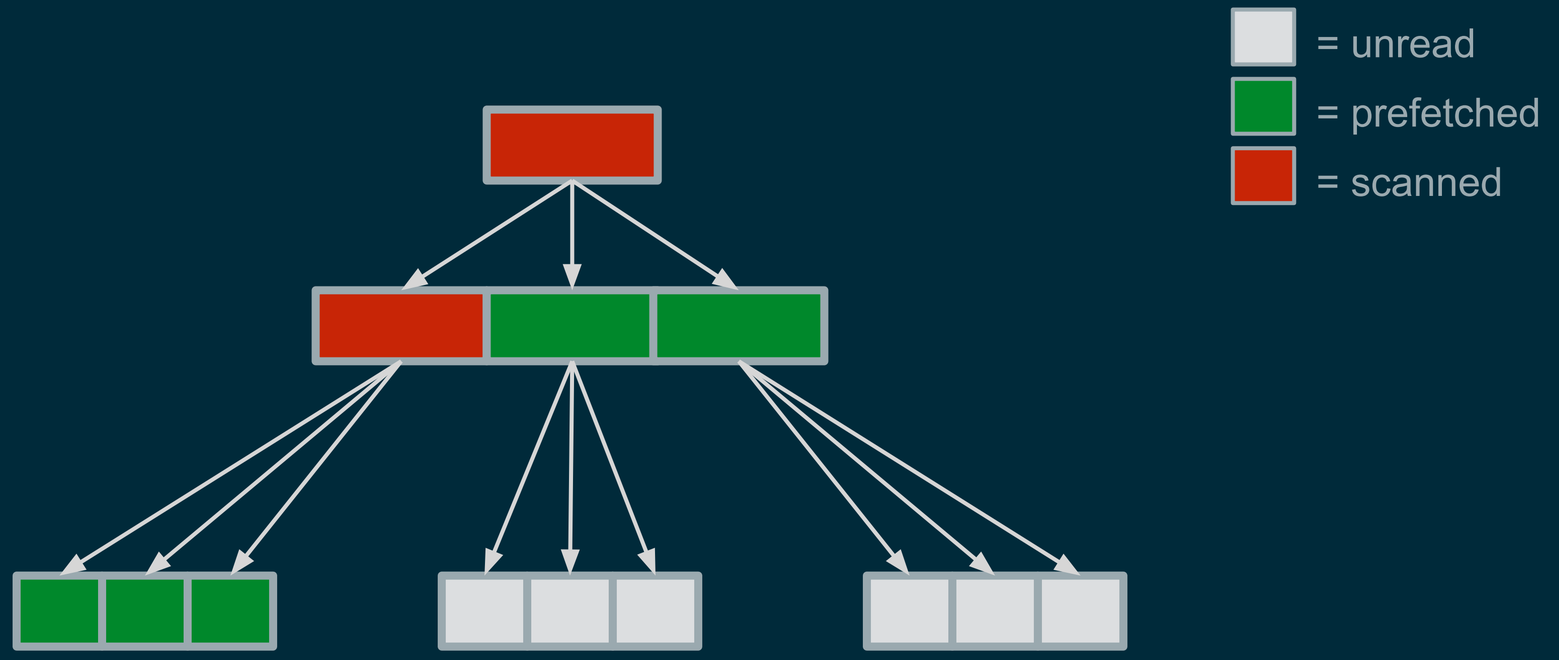

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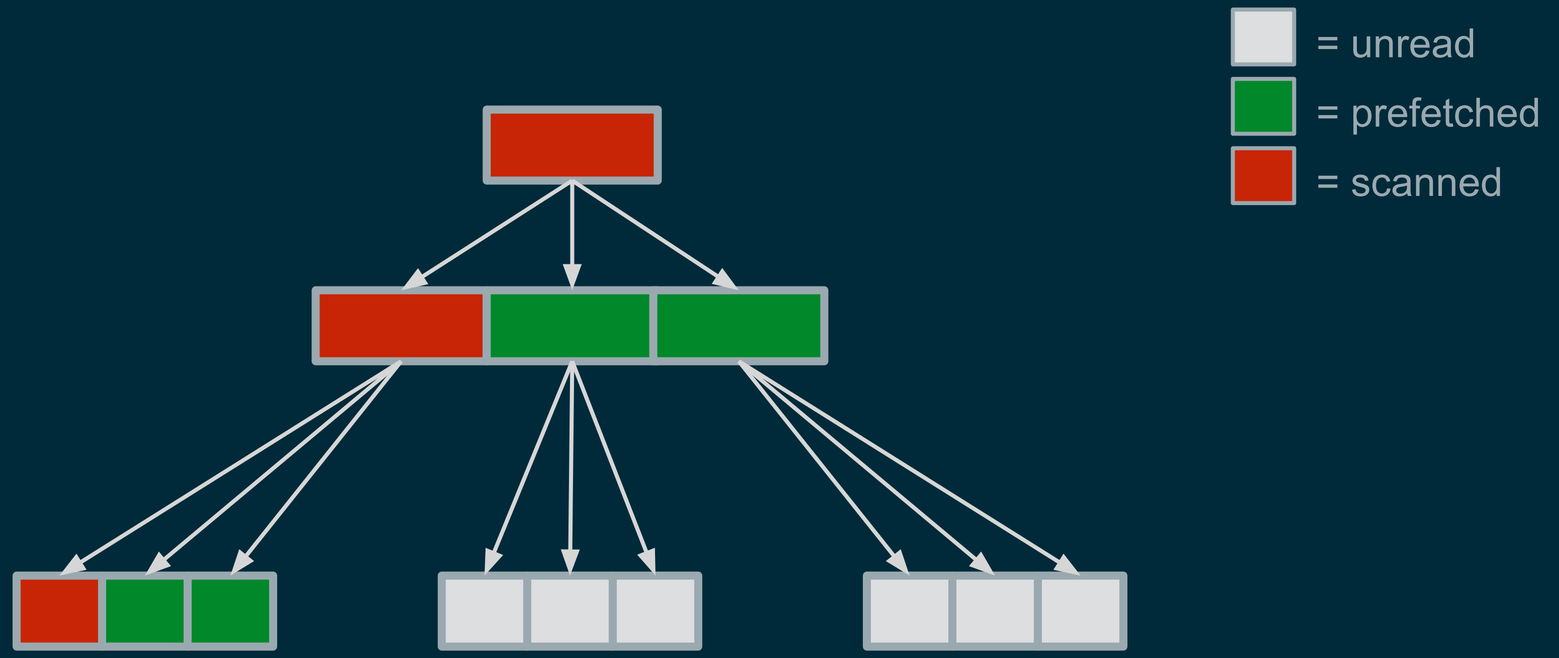

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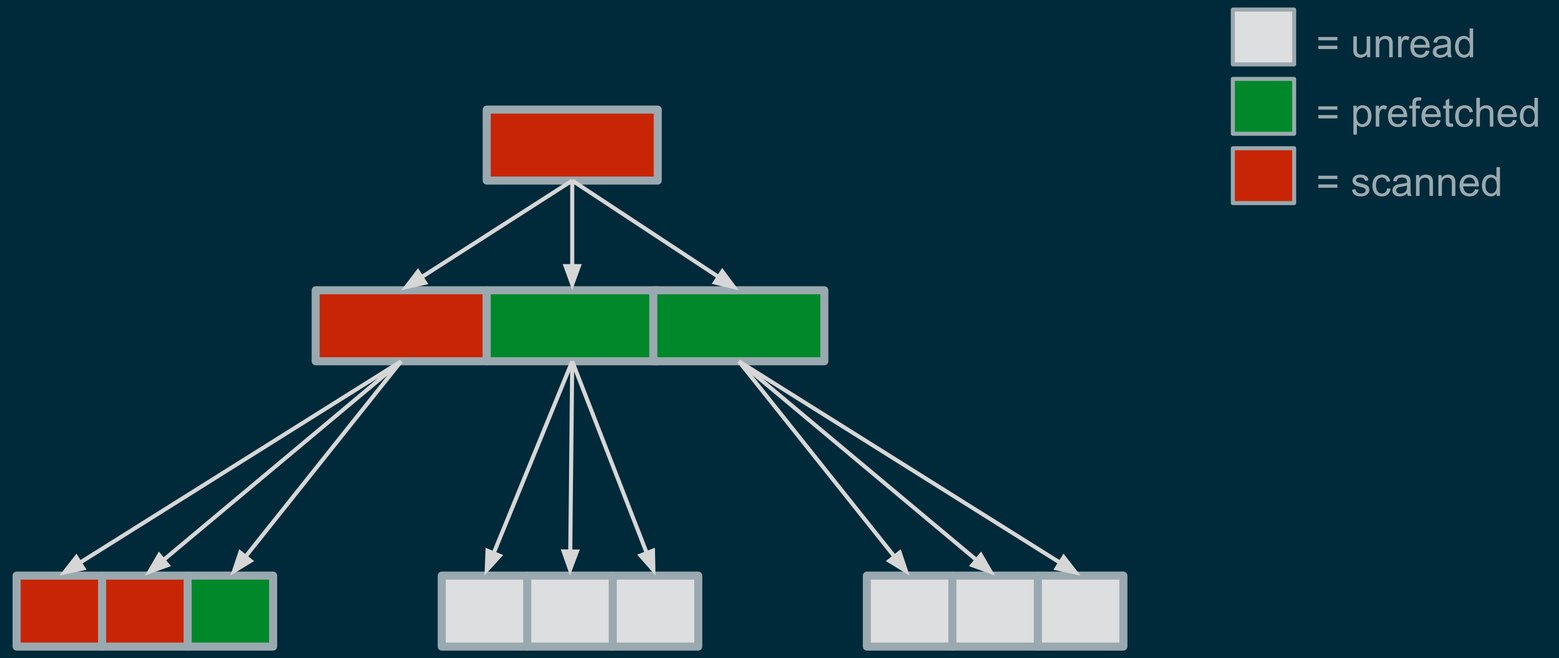

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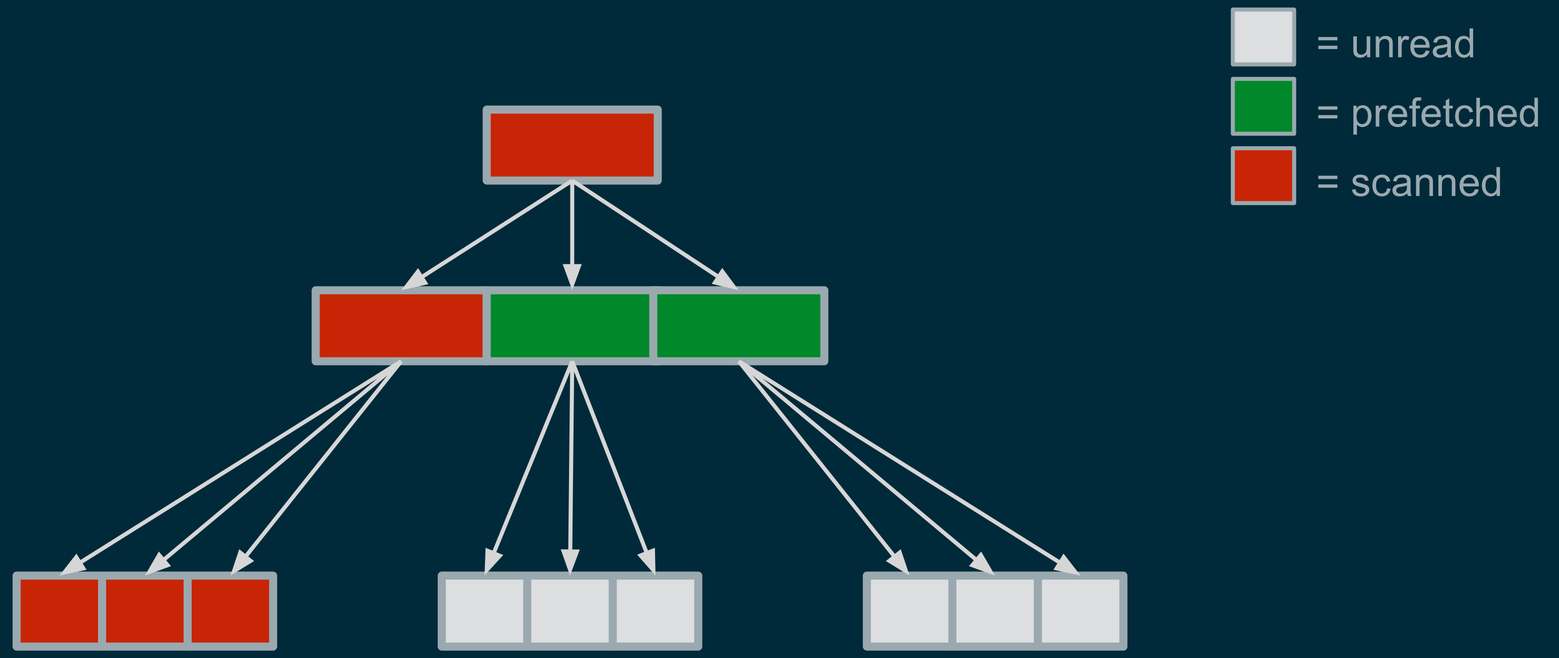

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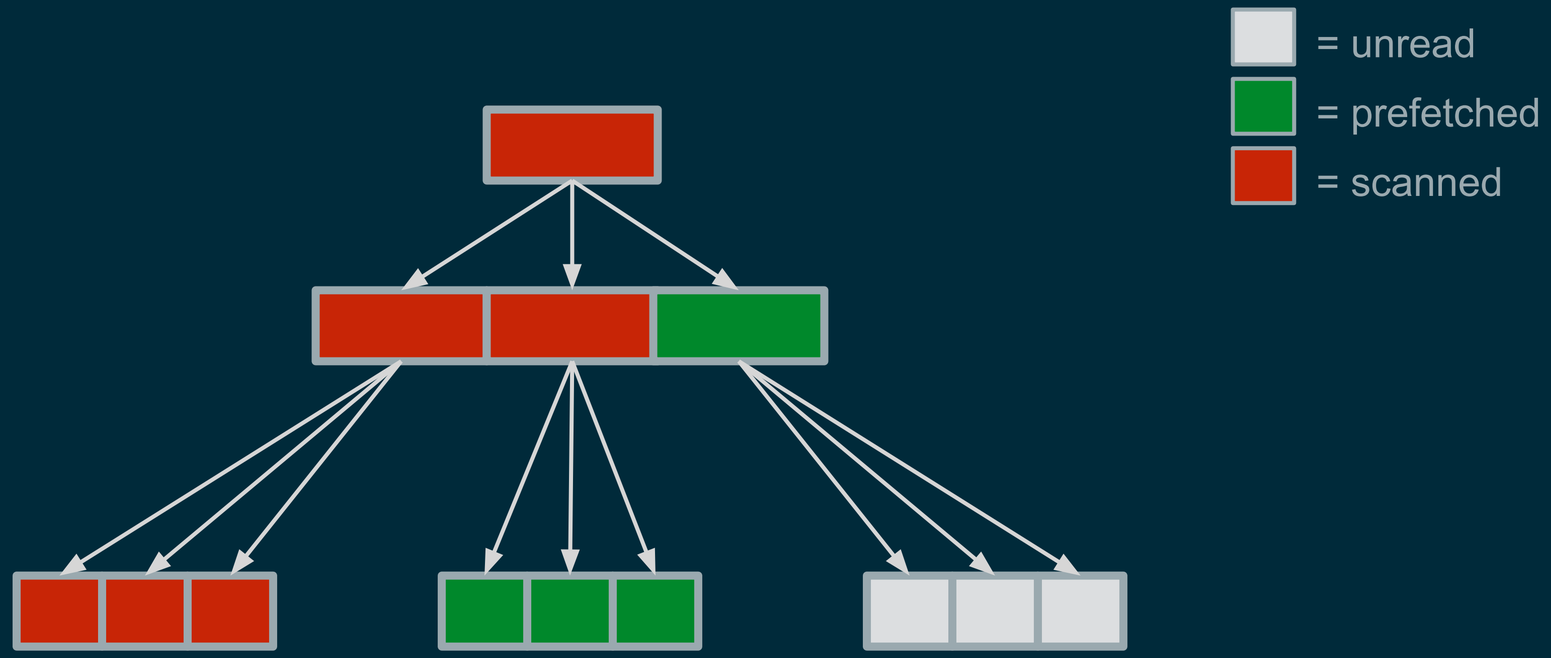

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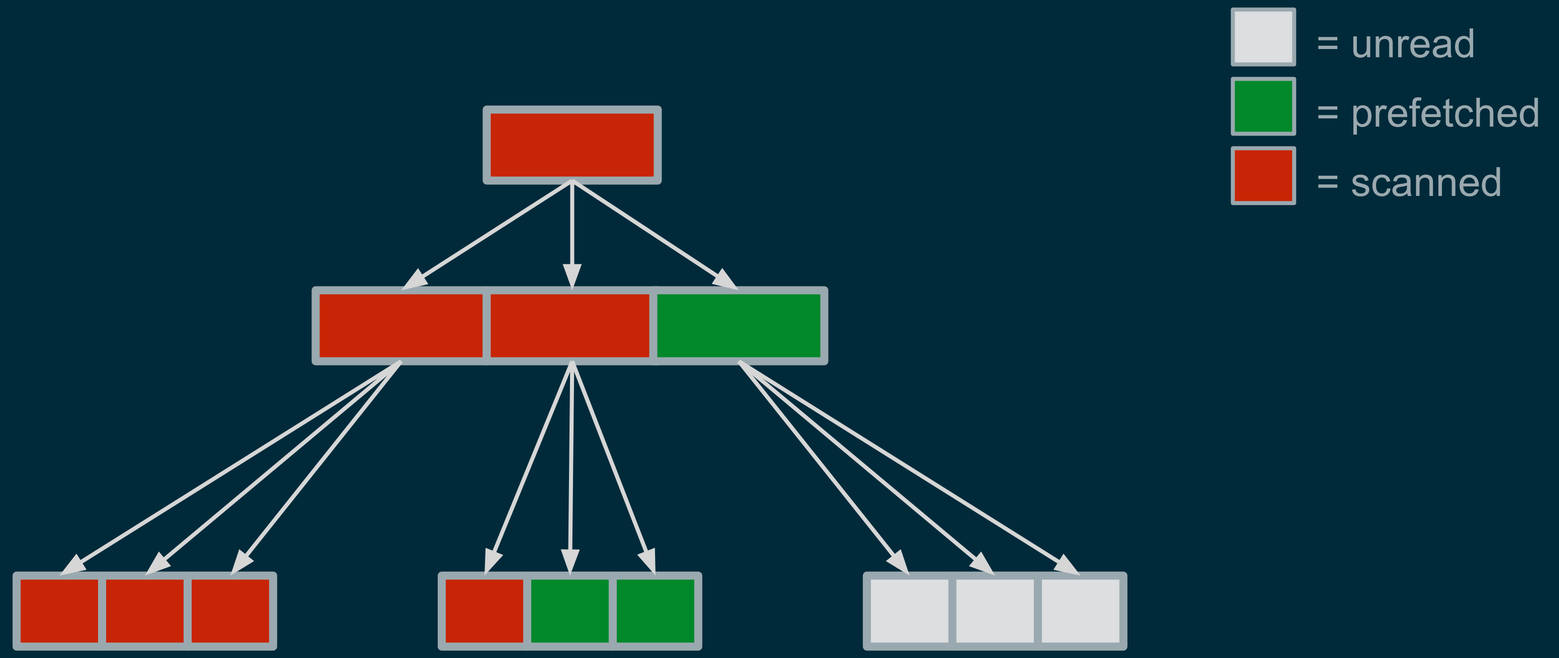

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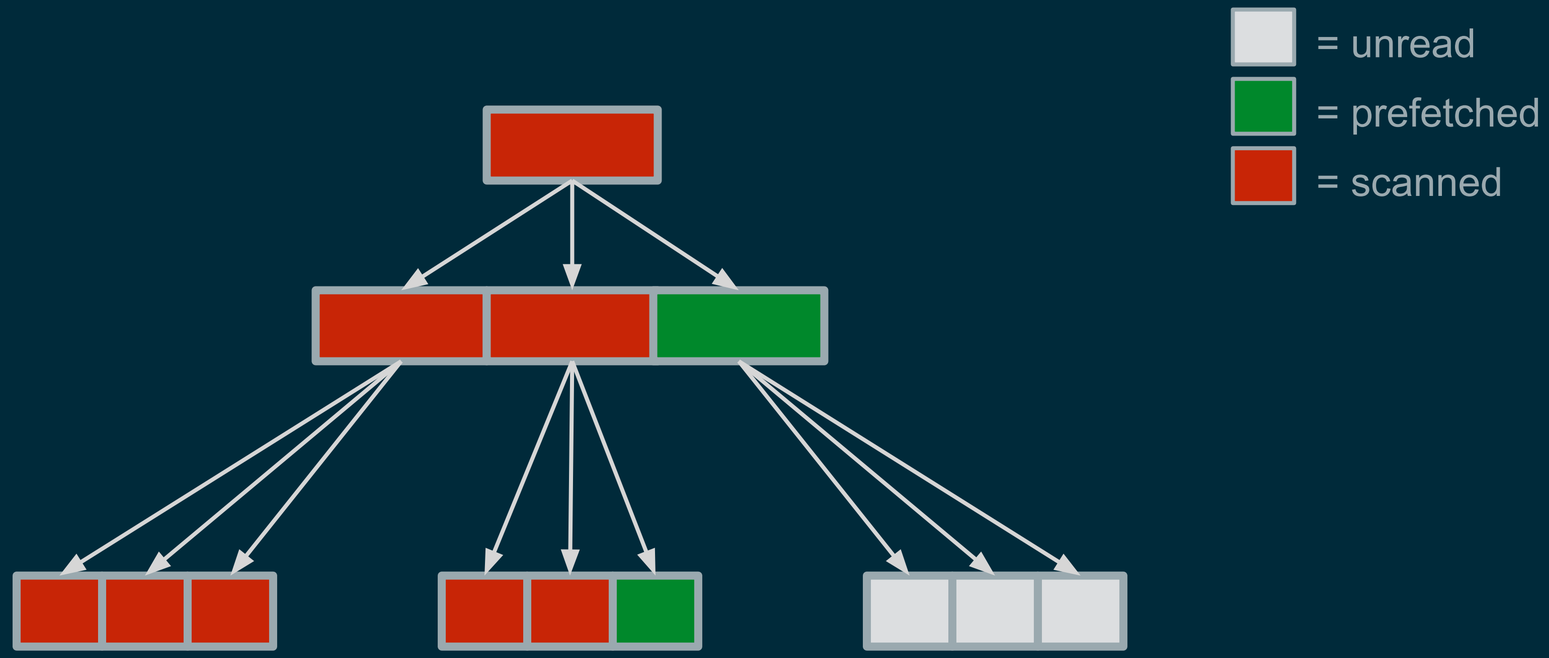

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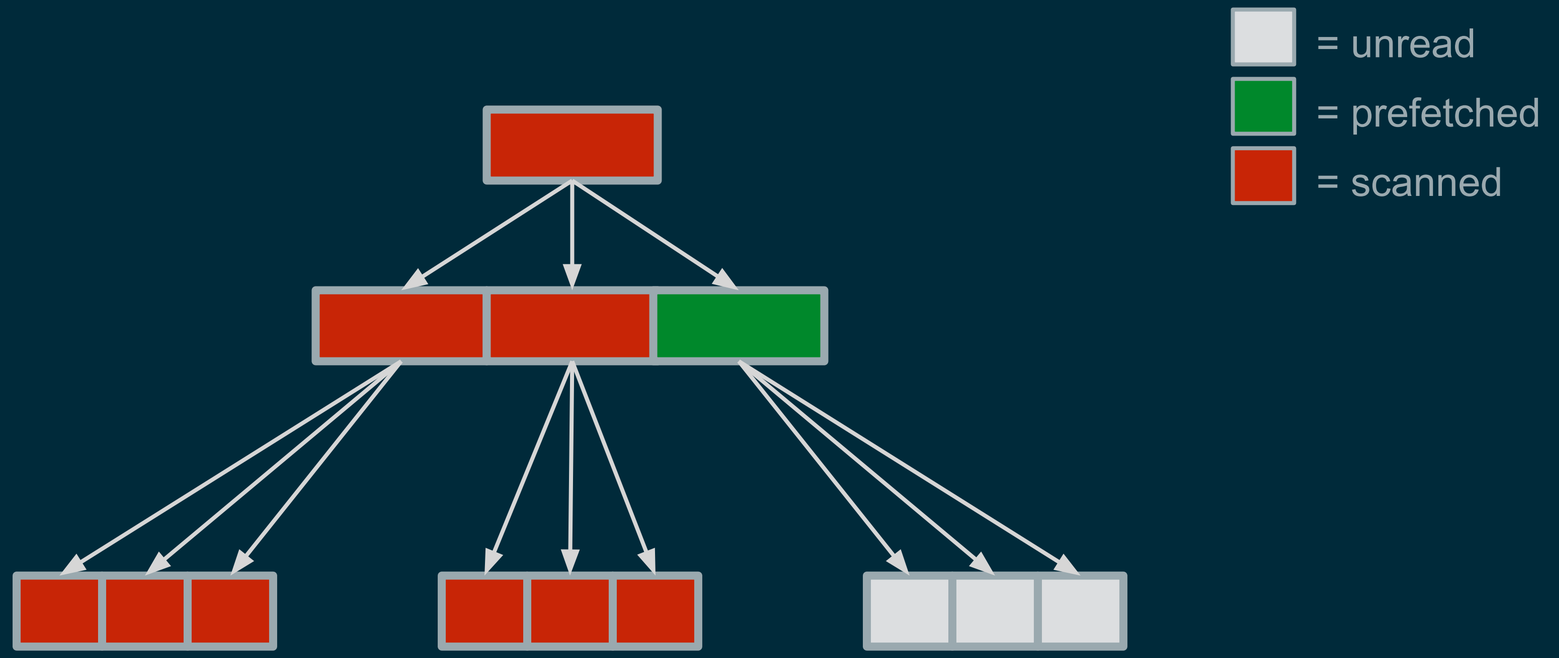

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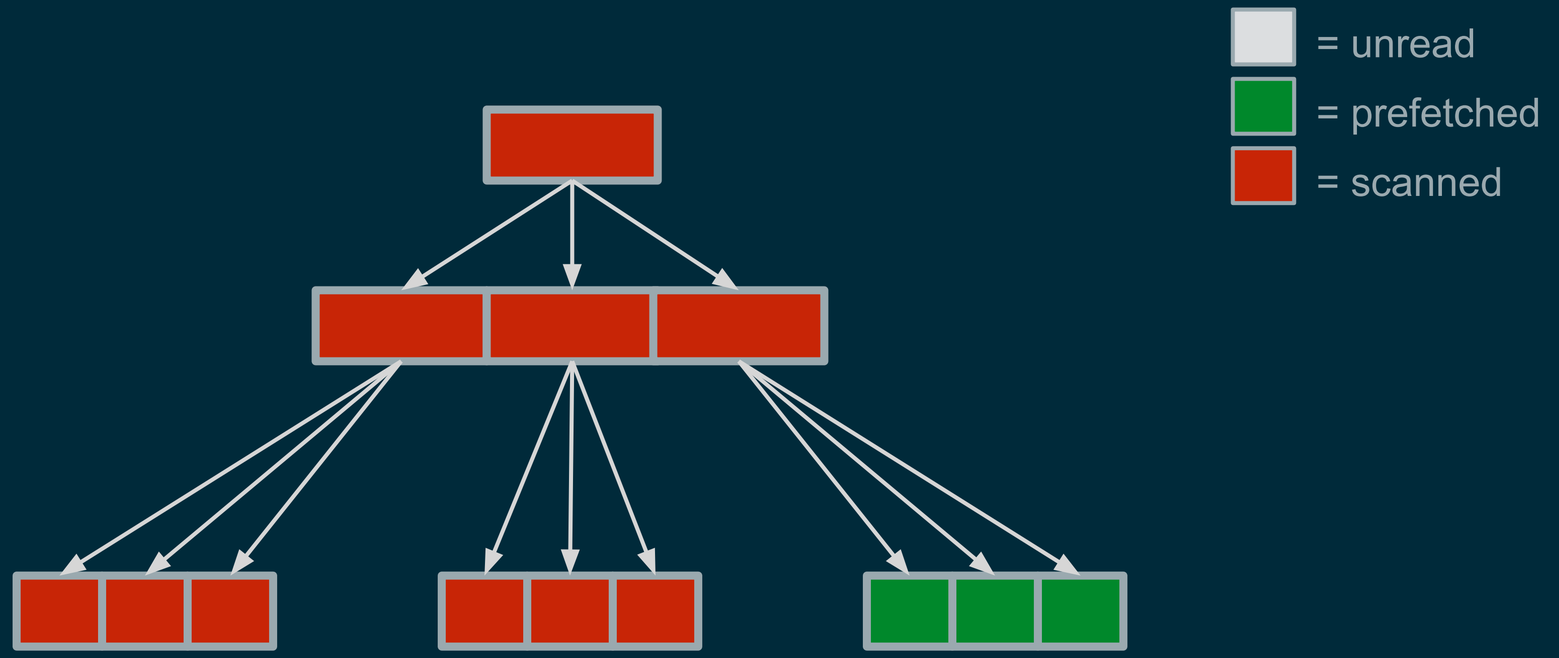

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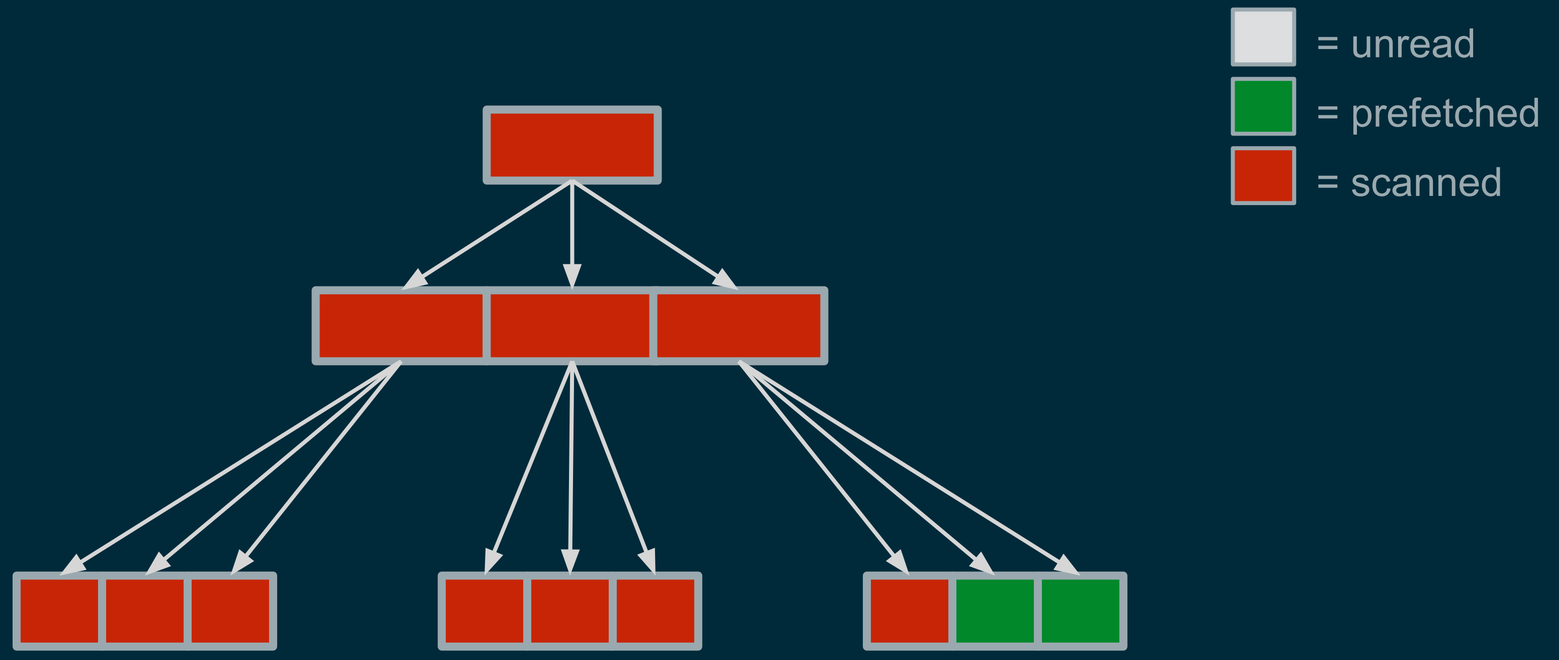

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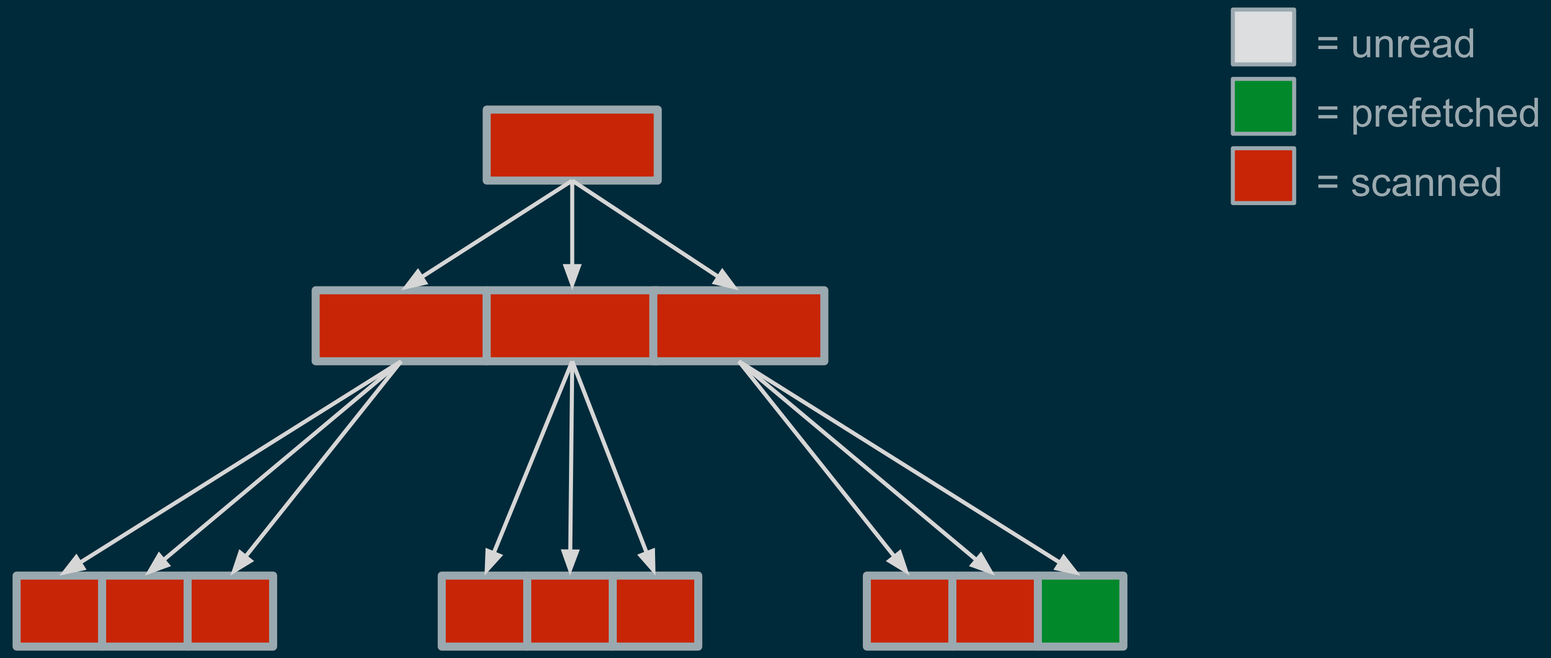

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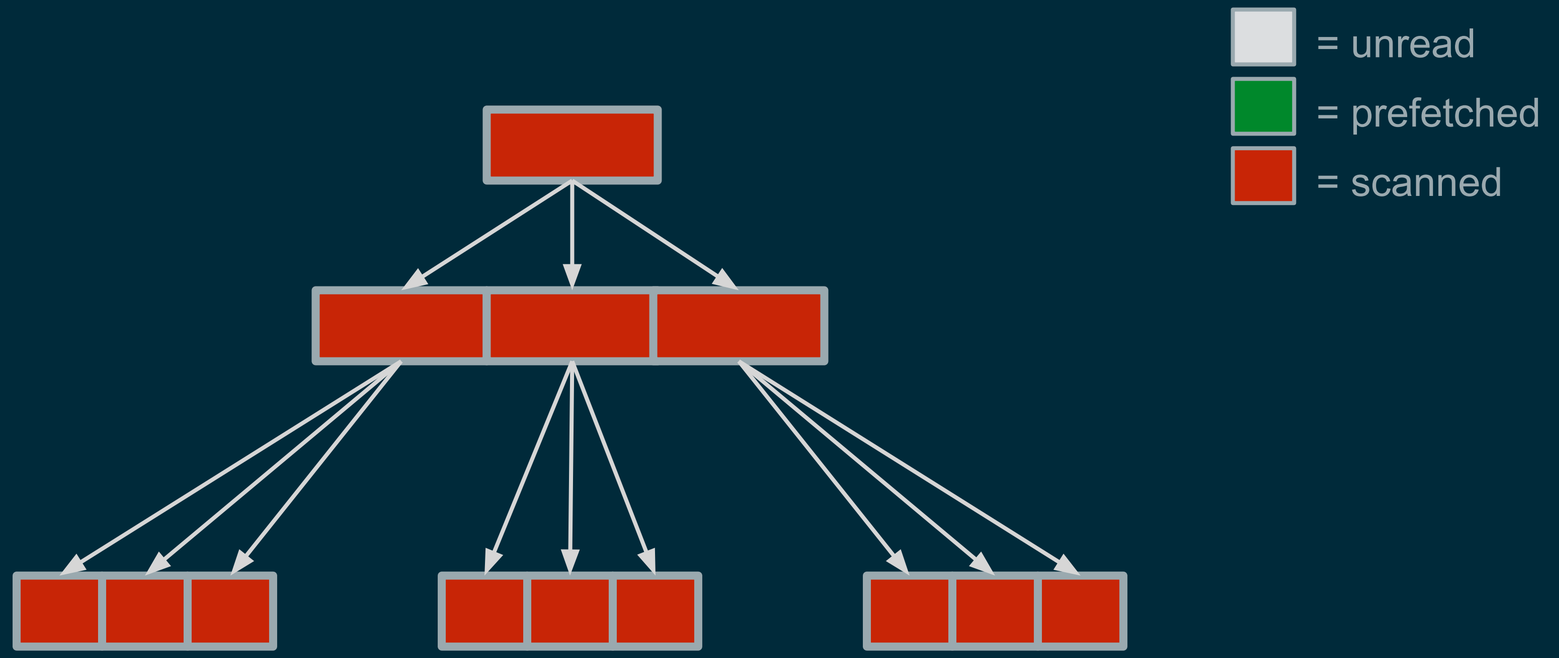
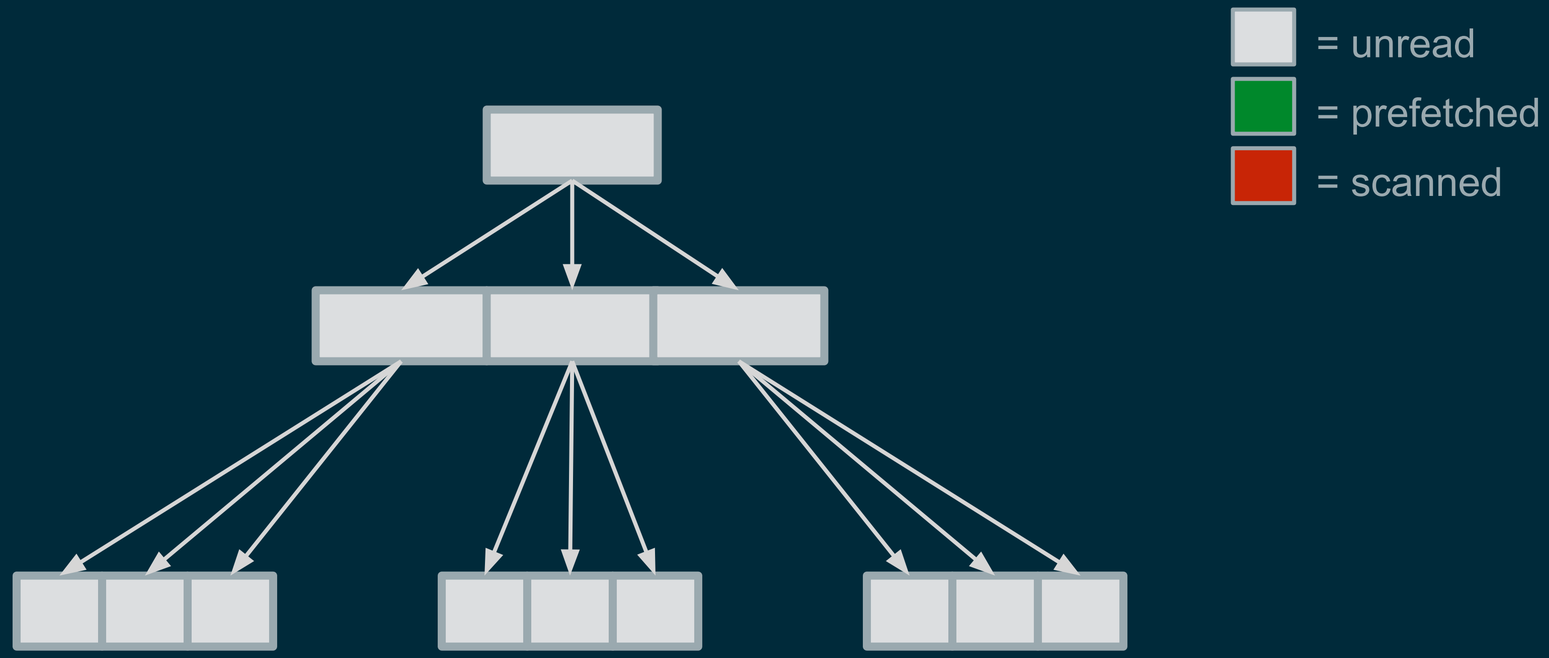


Current Design: Problems

- Prefetches are held up by synchronous `arc_read()`
  - Issuing code is completely single-threaded
  - Prefetches are not issued while leaf blocks are being issued
- First prefetch below a given block is effectively useless
  - arc_read() called immediately after its prefetch (depth first traversal)
- Bursty IO requests
  - Scrubbing leaf -> no prefetches (most blocks in a dataset are leaves)
  - Scrubbing metadnode -> tons of prefetches

New Design (Ideal)



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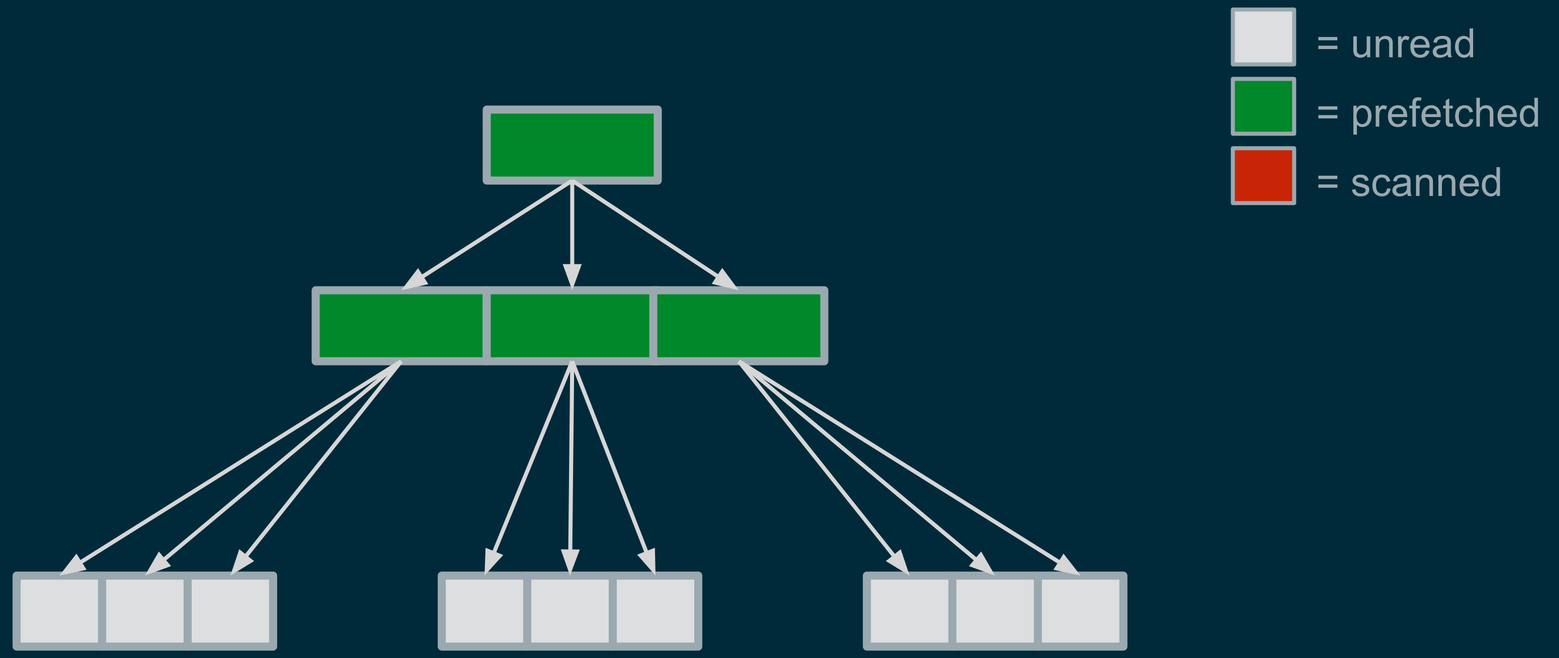

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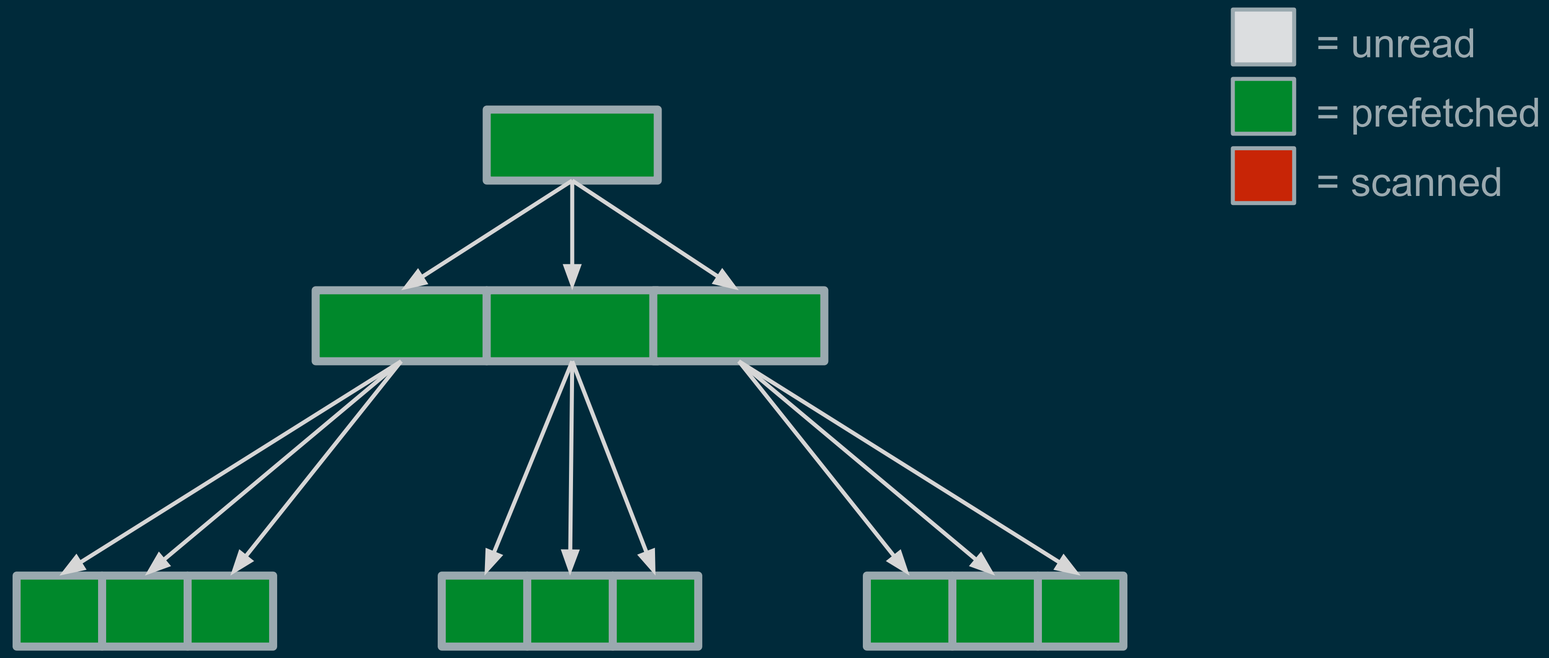
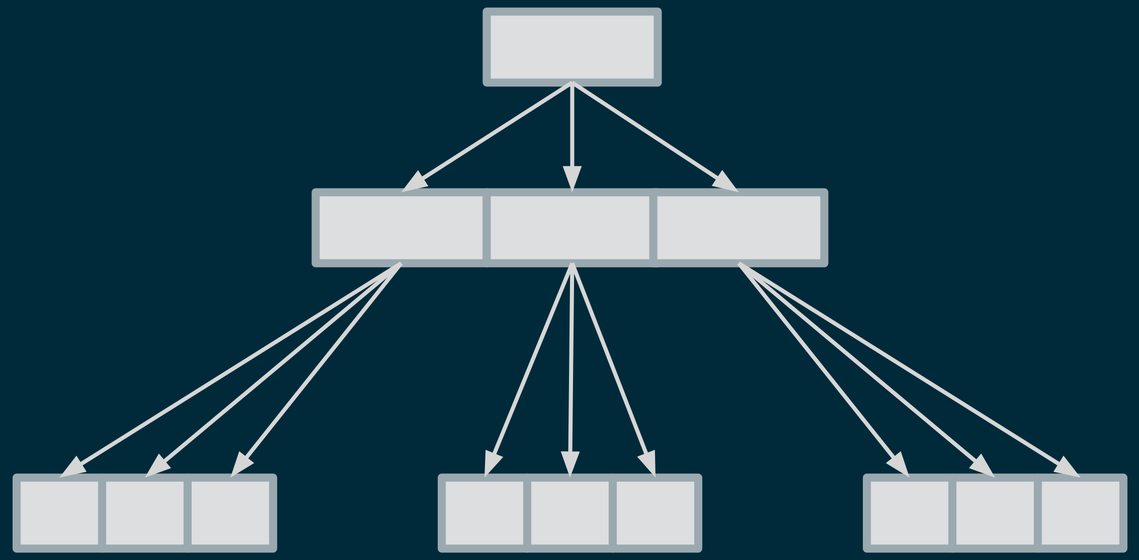


New Design: Additional Considerations

- Ideal prefetcher makes 2 bad assumptions
  - ARC memory available >= size of all blocks in the dataset
  - All IO can be issued in parallel (infinite disk bandwidth)

- Solution
  - Prefetch function just places IO into a priority queue
  - Prioritize blocks we will actually need first based on ZIO bookmark
  - Spin up a thread to issue prefetches from the queue and rate-limit IO

New Design



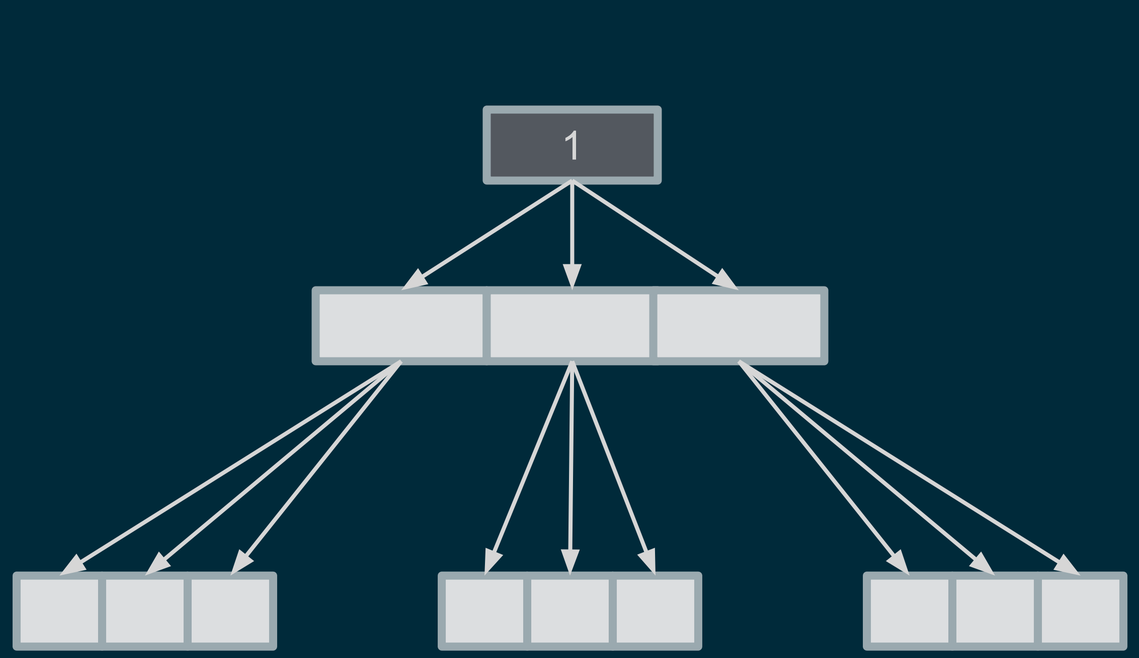
= unread

= prefetched

= queued

Max IOs at once = 2

New Design



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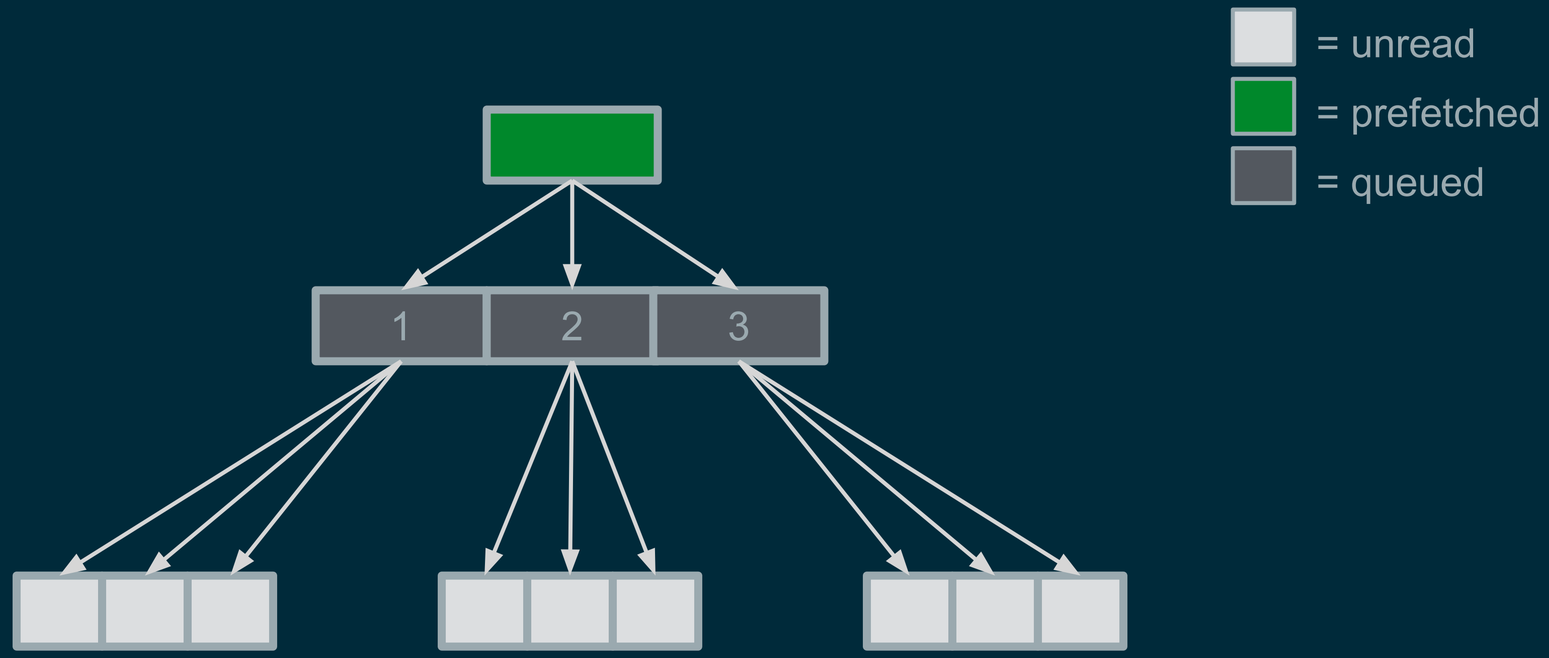

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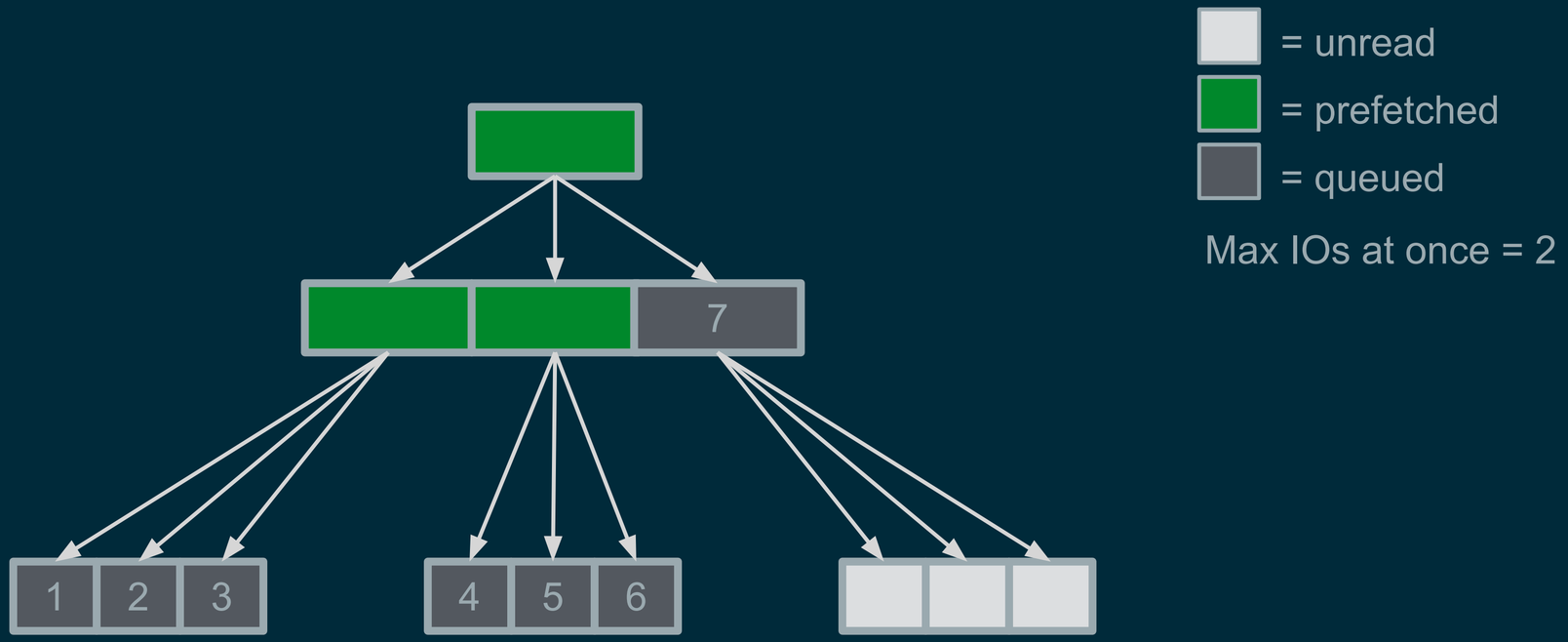

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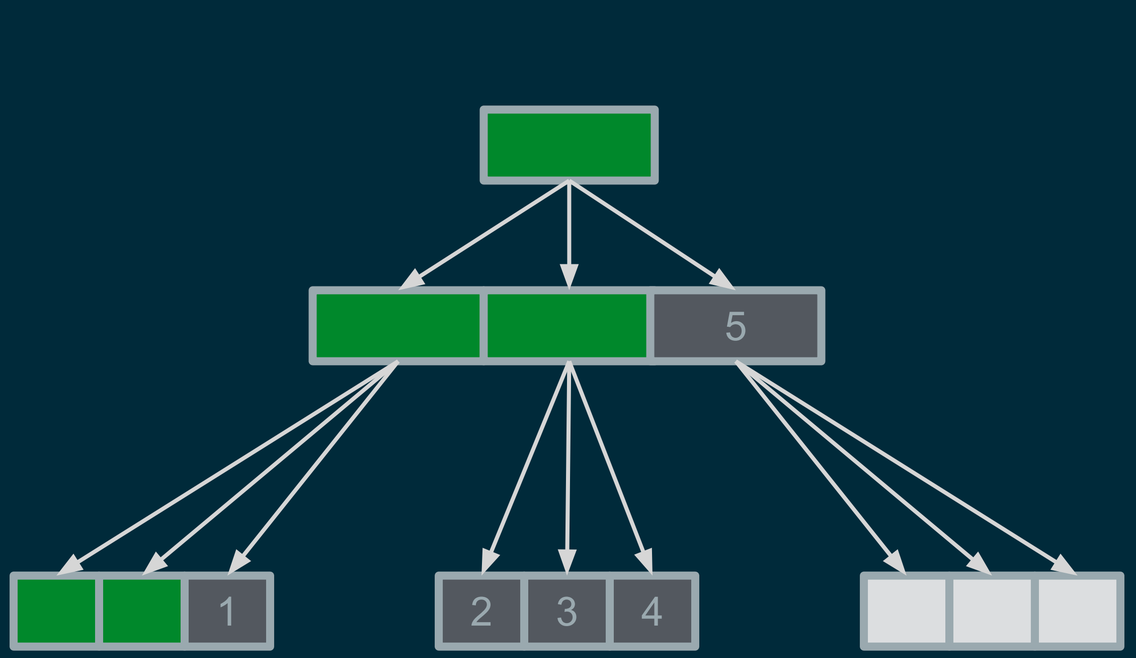

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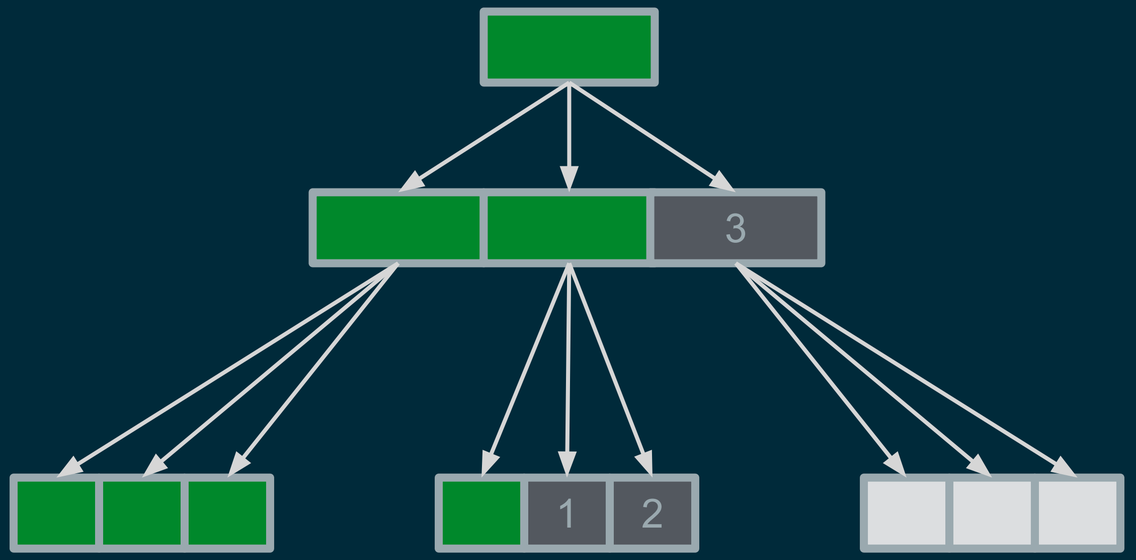

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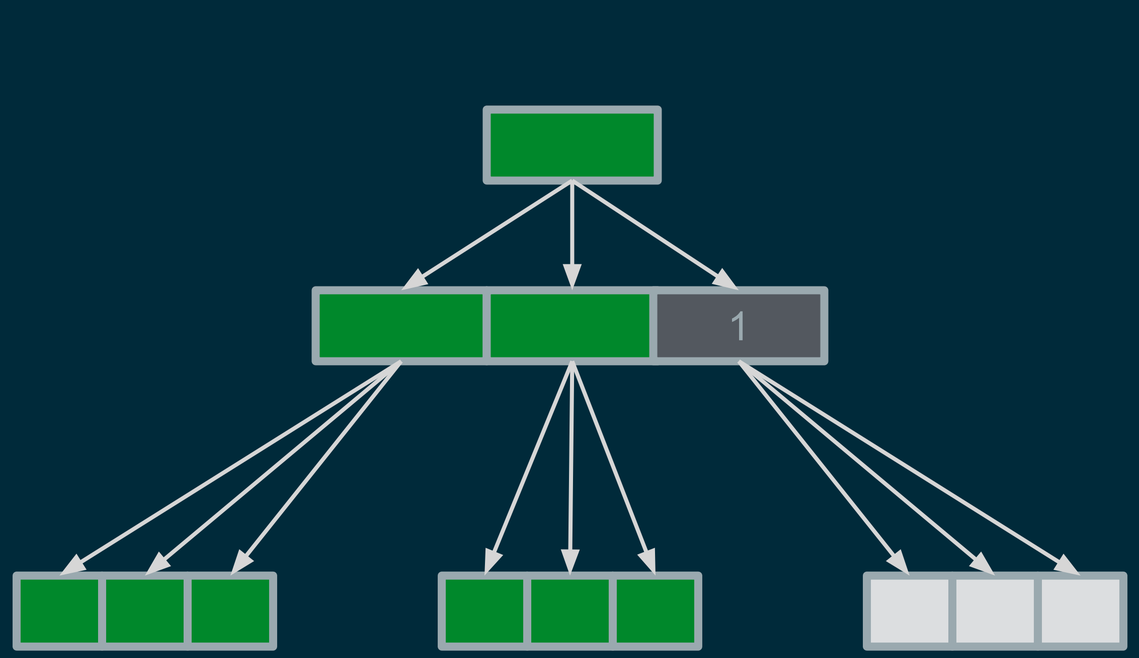

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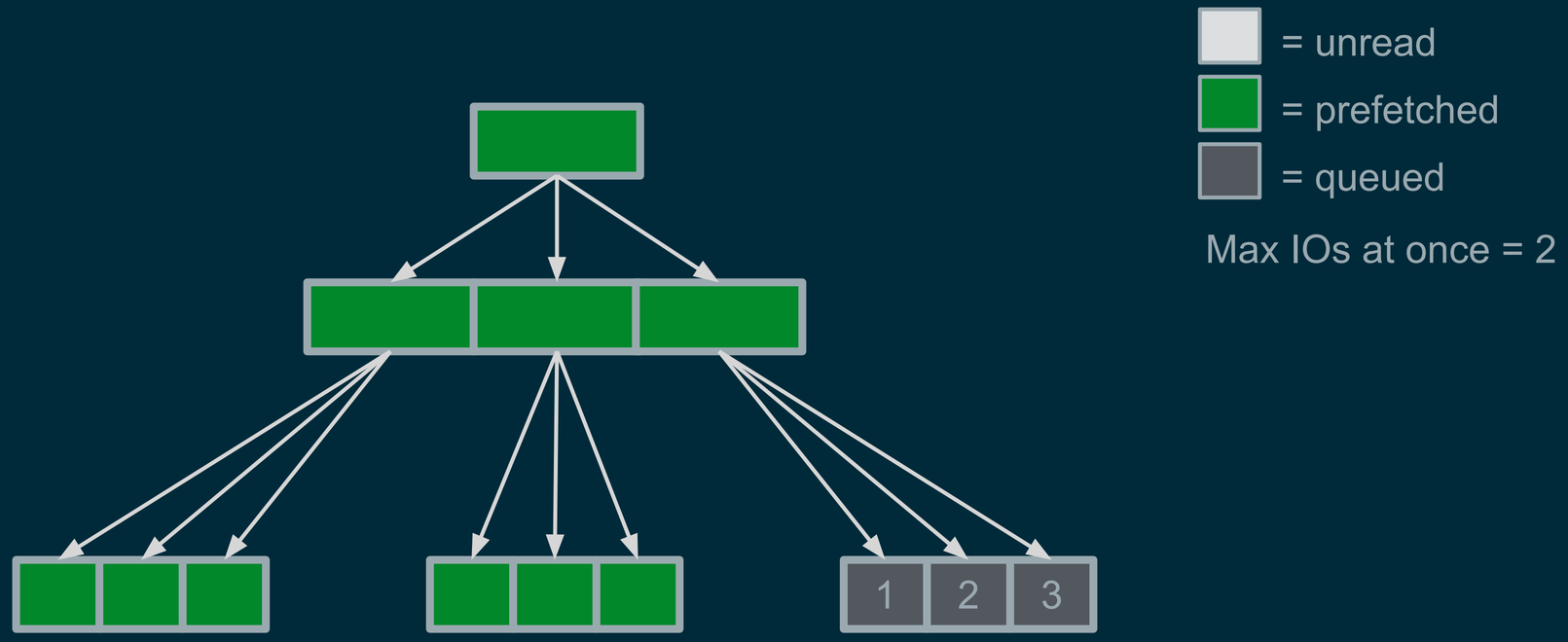

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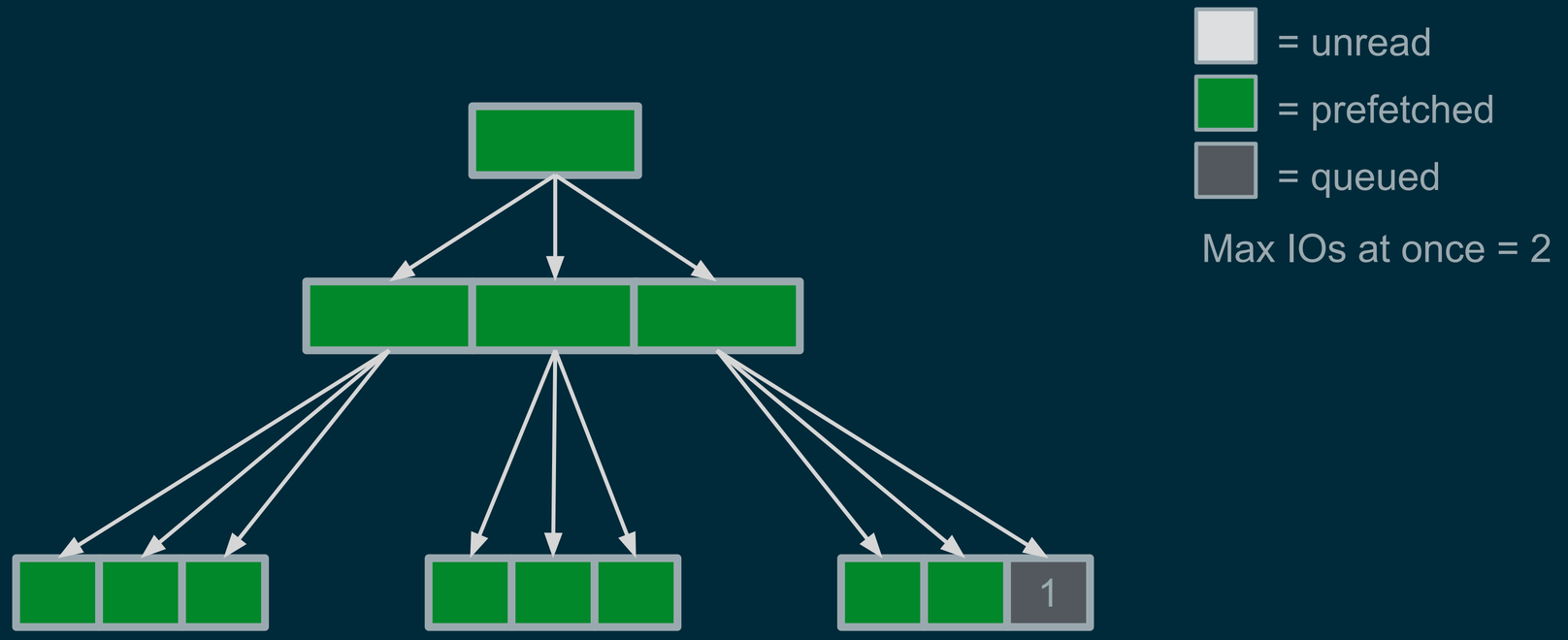

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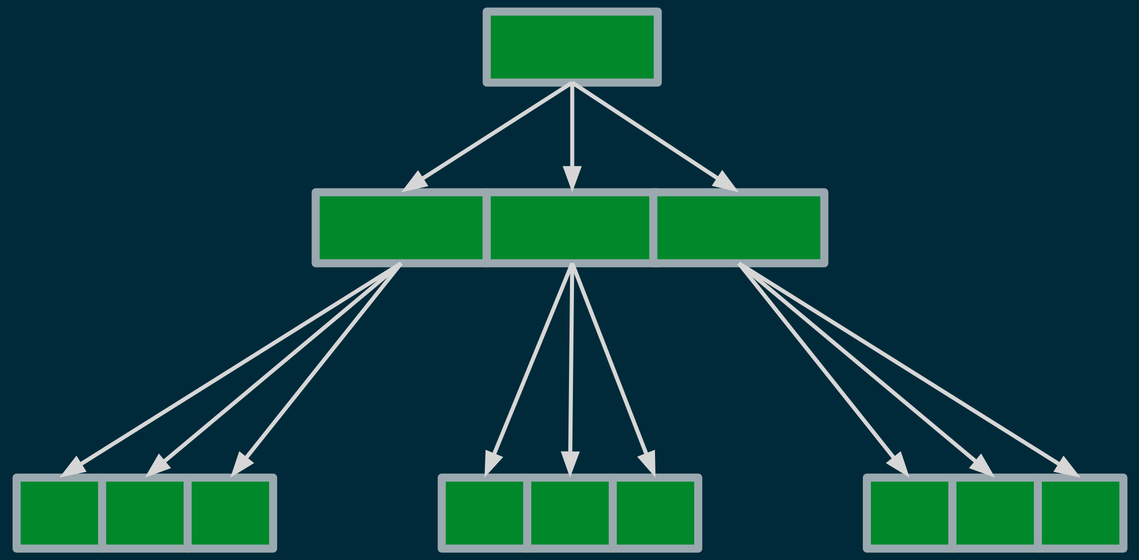

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New Design: Code Changes and Applications

- ARC code adjusted so that prefetch IOs can have a read callback
- `arc_read_done()` adjusted to provide bookmark and bp for context
  - Allows IO read callbacks to issue next prefetch easily and inexpensively

- ZFS Currently has 3 prefetching implementations (not counting zfetch)
  - dbuf.c (`arc_read_done()` changes help here)
  - dmu_traverse.c
  - dsl_scan.c

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Questions?

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https://github.com/zfsonlinux/zfs/pull/6256