Incremental Garbage Collection

Part II

Roland Schatz

Baker – Disadvantages

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- not even threadsafe

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- expensive read trap

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- expensive read trap
- requires hardware support

Appel-Ellis-Li Collector

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  - mutator only sees black objects

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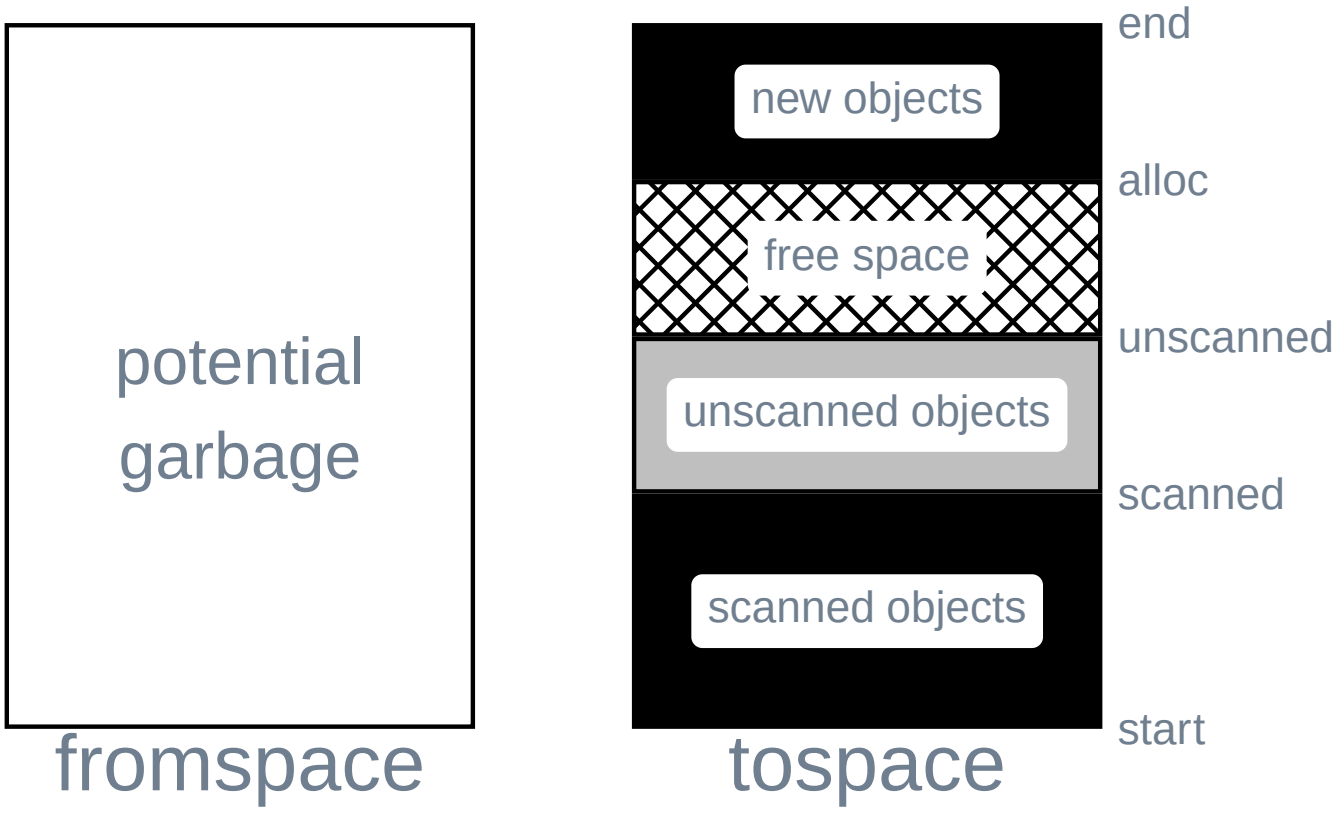
  - mutator never sees white pointers
  - intercept all pointer reads
- slightly stricter constraint
  - mutator only sees black objects
  - use page protection hardware

Memory Layout



Page Protection

- black pages

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- black pages
  - contain only tospace pointers

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  - no problem

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Page Protection

- black pages
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  - no problem
- white pages
  - mutator never sees white pointers

Page Protection

- black pages
  - contain only tospace pointers
  - no problem
- white pages
  - mutator never sees white pointers
  - so we don’t care

Page Protection

- gray pages

Page Protection

- gray pages
  - mutator may see gray pointers

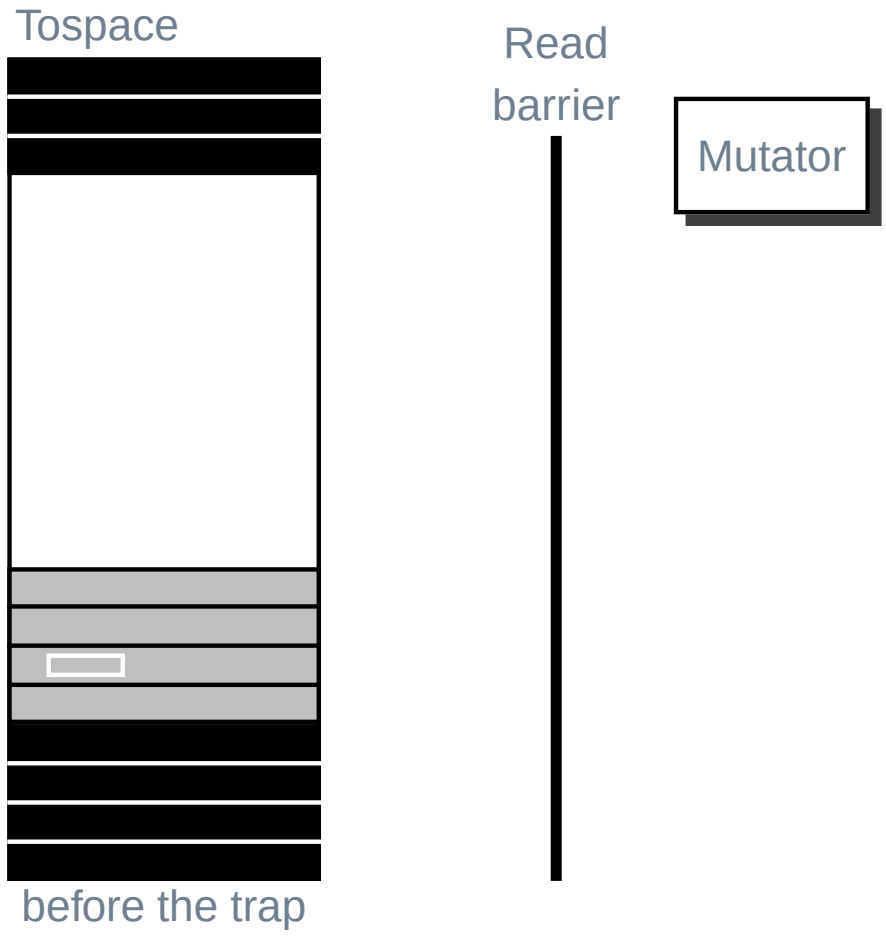
Page Protection

- gray pages
  - mutator may see gray pointers
  - mutator must not see gray objects

Page Protection

- gray pages
  - mutator may see gray pointers
  - mutator must not see gray objects
  - set to no access

Handling Page Faults



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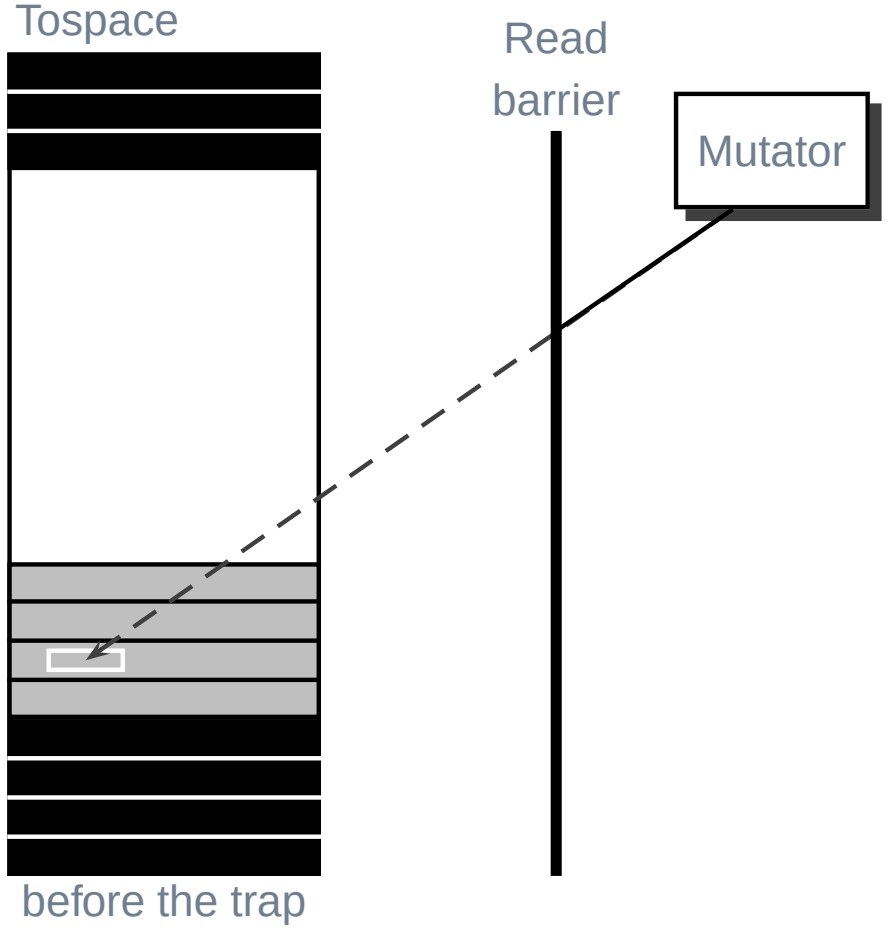

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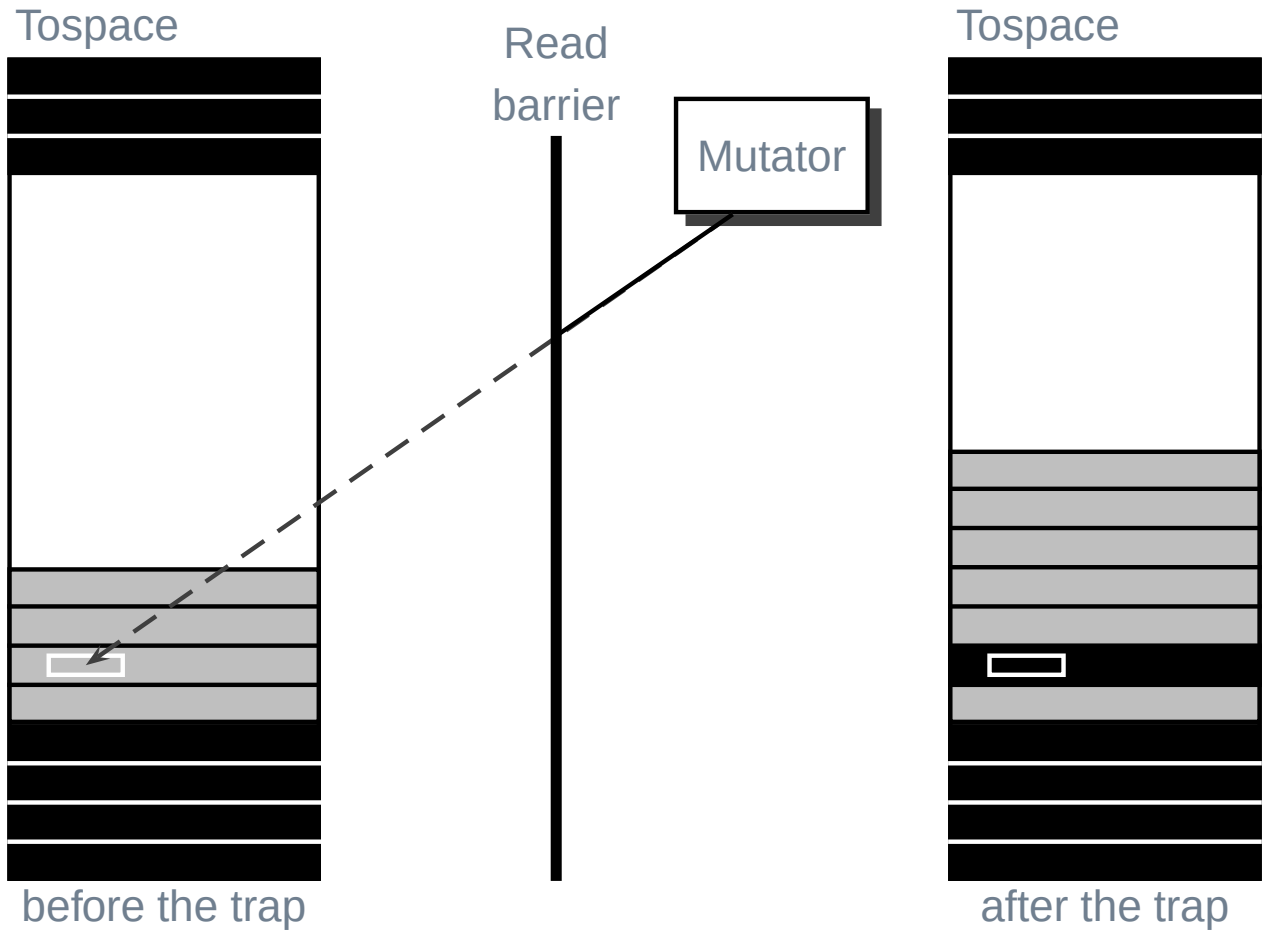

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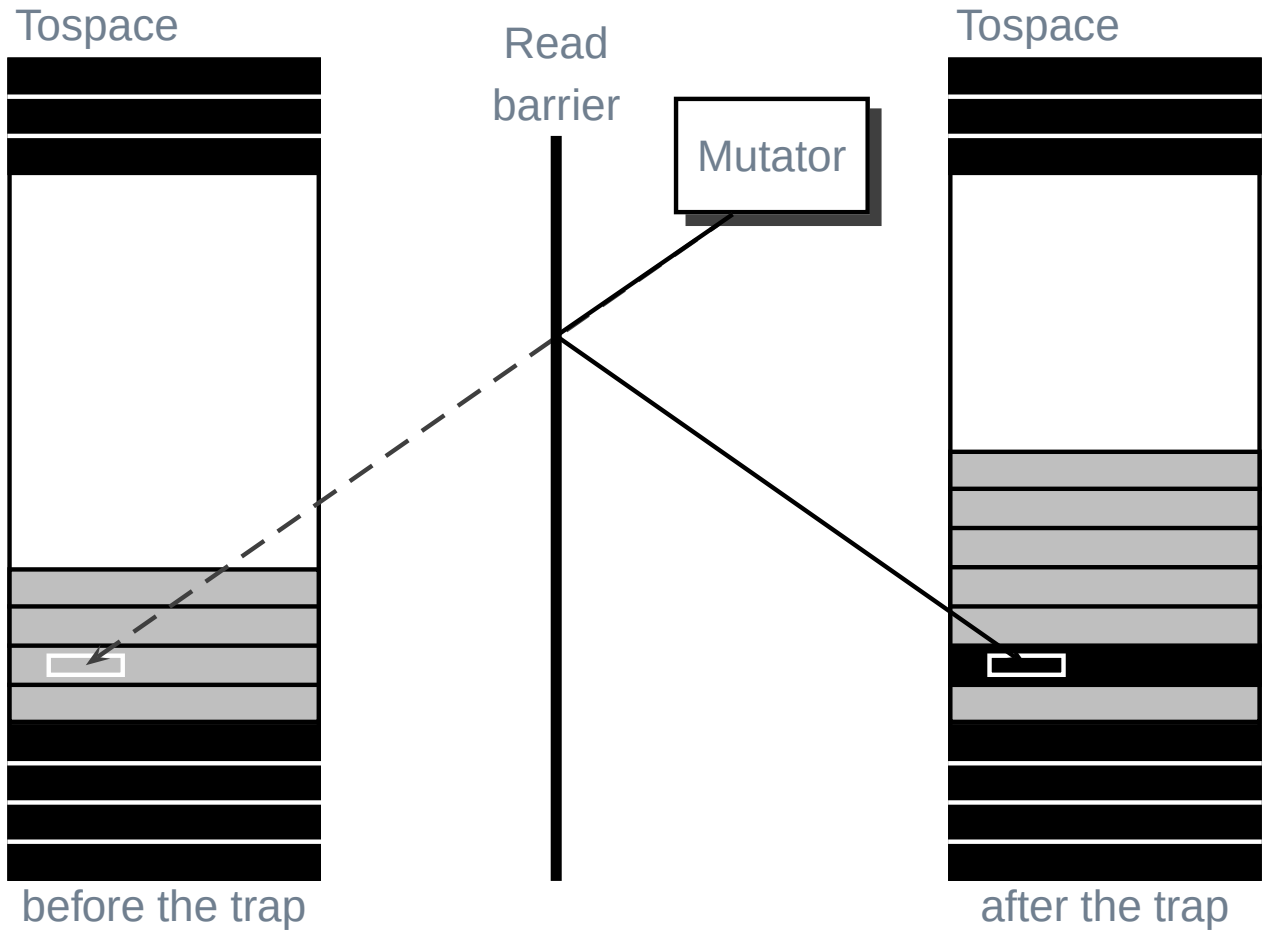

Summary

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- problems
  - relies on virtual memory
  - global lock is bottleneck
  - flip is still stop-the-world

Nettle's Replicating Collector

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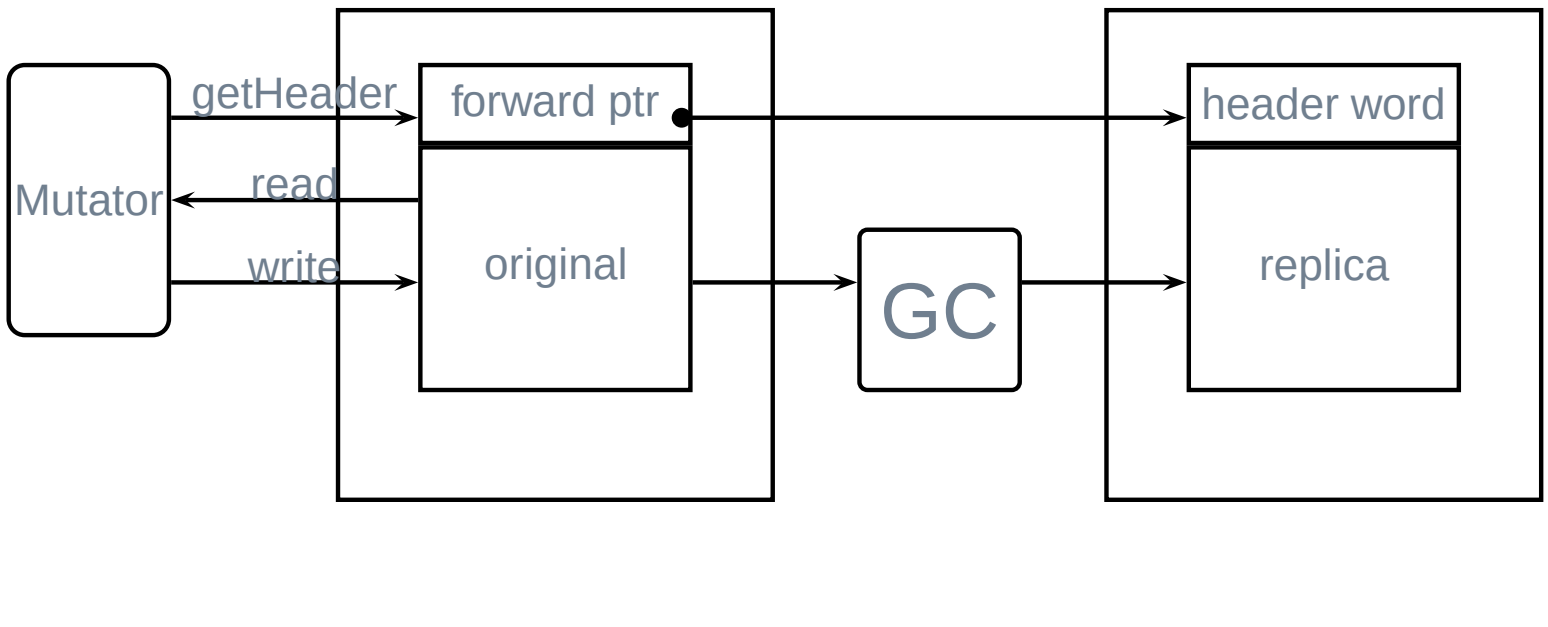
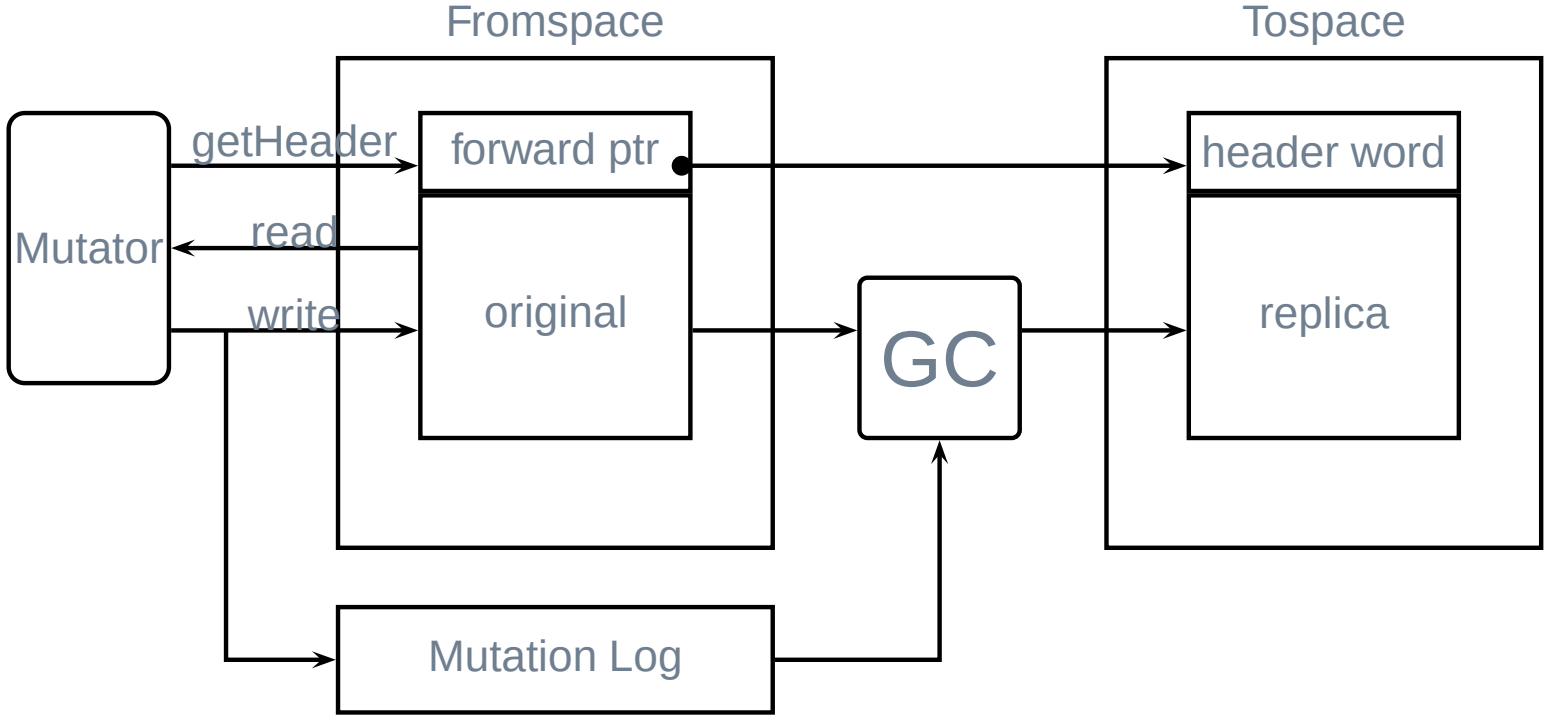
- read barrier is still expensive
- use write barrier instead

Nettle's Replicating Collector



Nettle's Replicating Collector



Huelsbergen-Laurus Collector

- distinguish mutable/immutable objects

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  - e.g. ML

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Huelsbergen-Laurus Collector

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  - e.g. ML
- immutable objects
  - replicating collection
- mutable objects
  - classic copying collection

Doligez-Leroy Collector

- Problem: heavy synchronization

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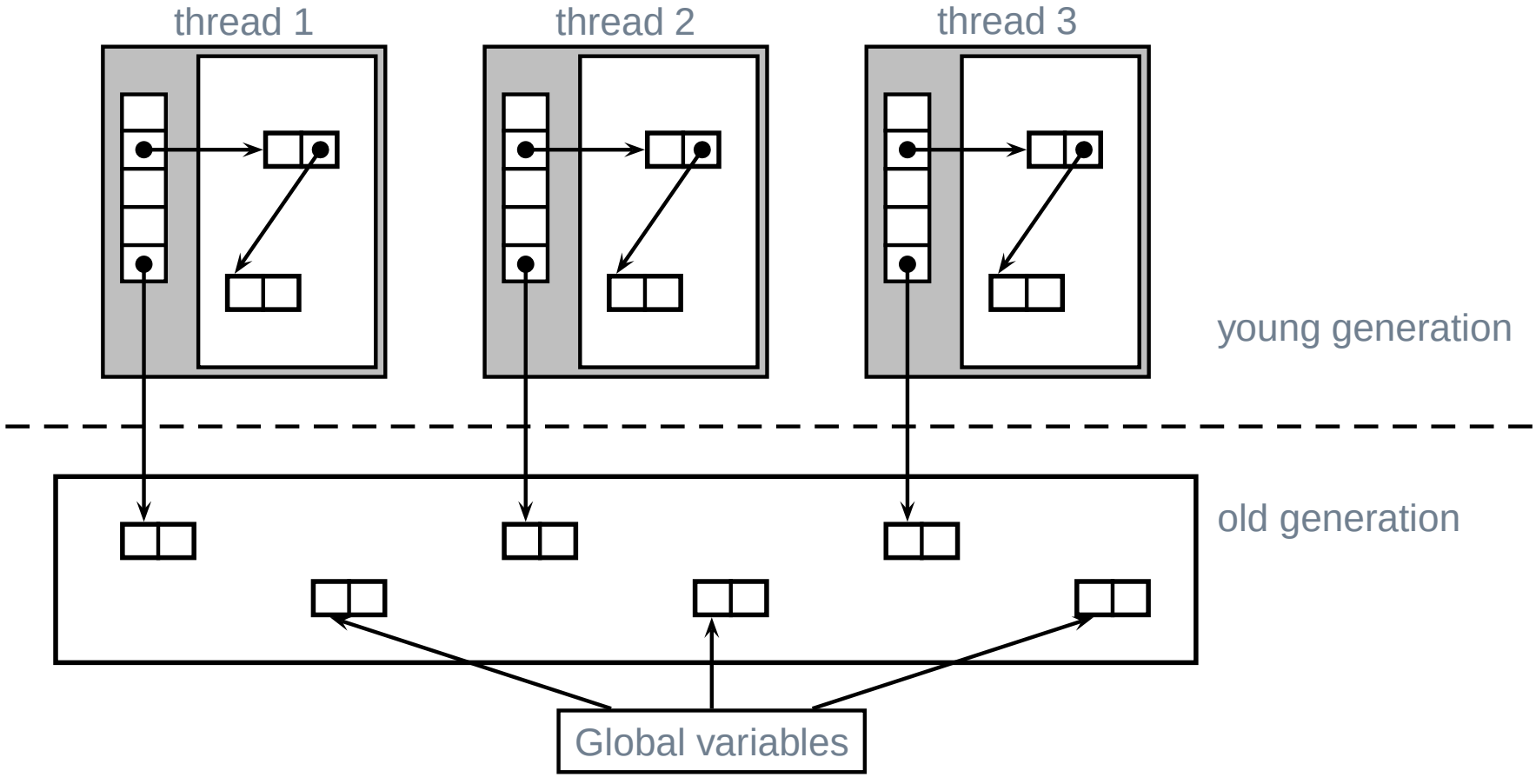
- young generation
  - thread-local
  - immutable
- old generation
  - the rest

Thread Local Heaps



In-Place Garbage Collection

- uncooperative environment

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- relaxed consistency requirements

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- Fragmentation!

Four-Color Abstraction

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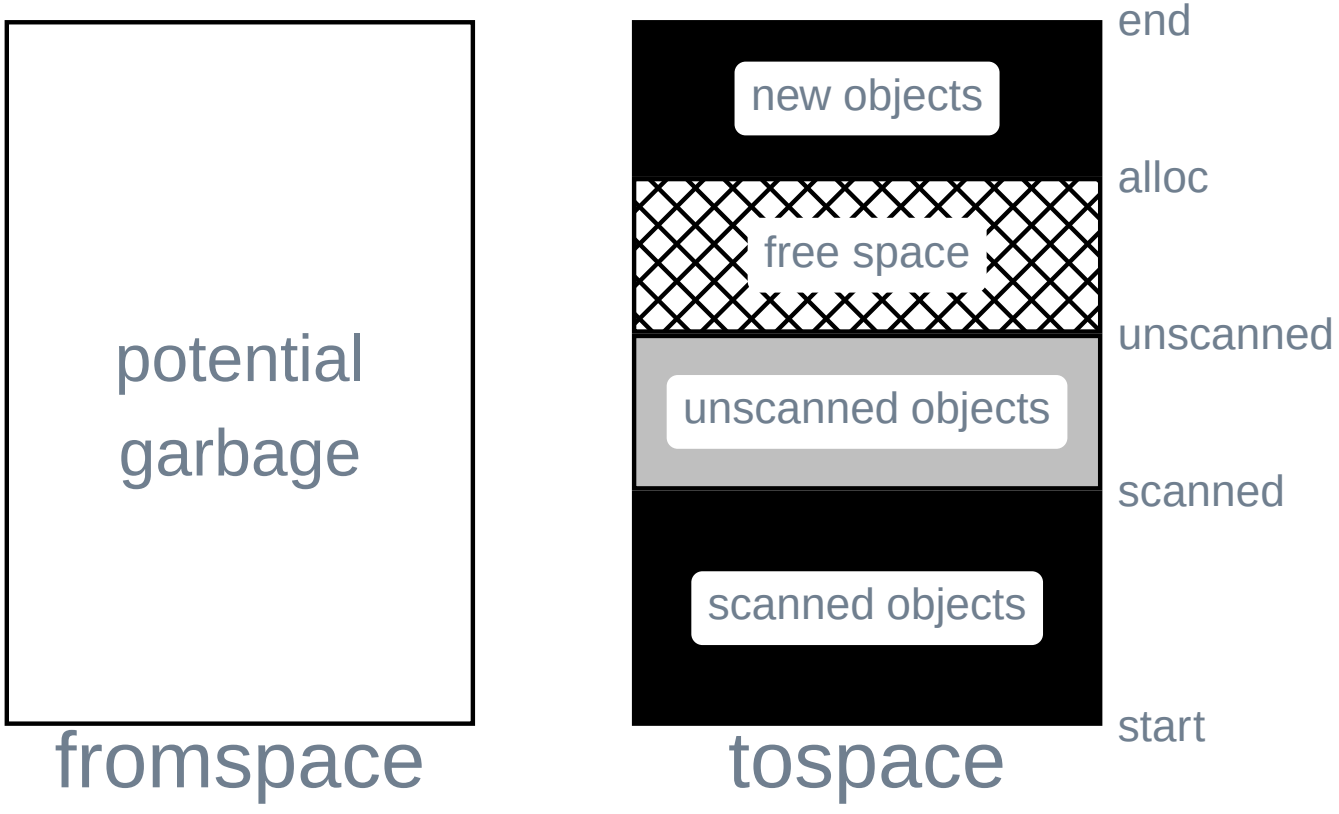
Four-Color Abstraction

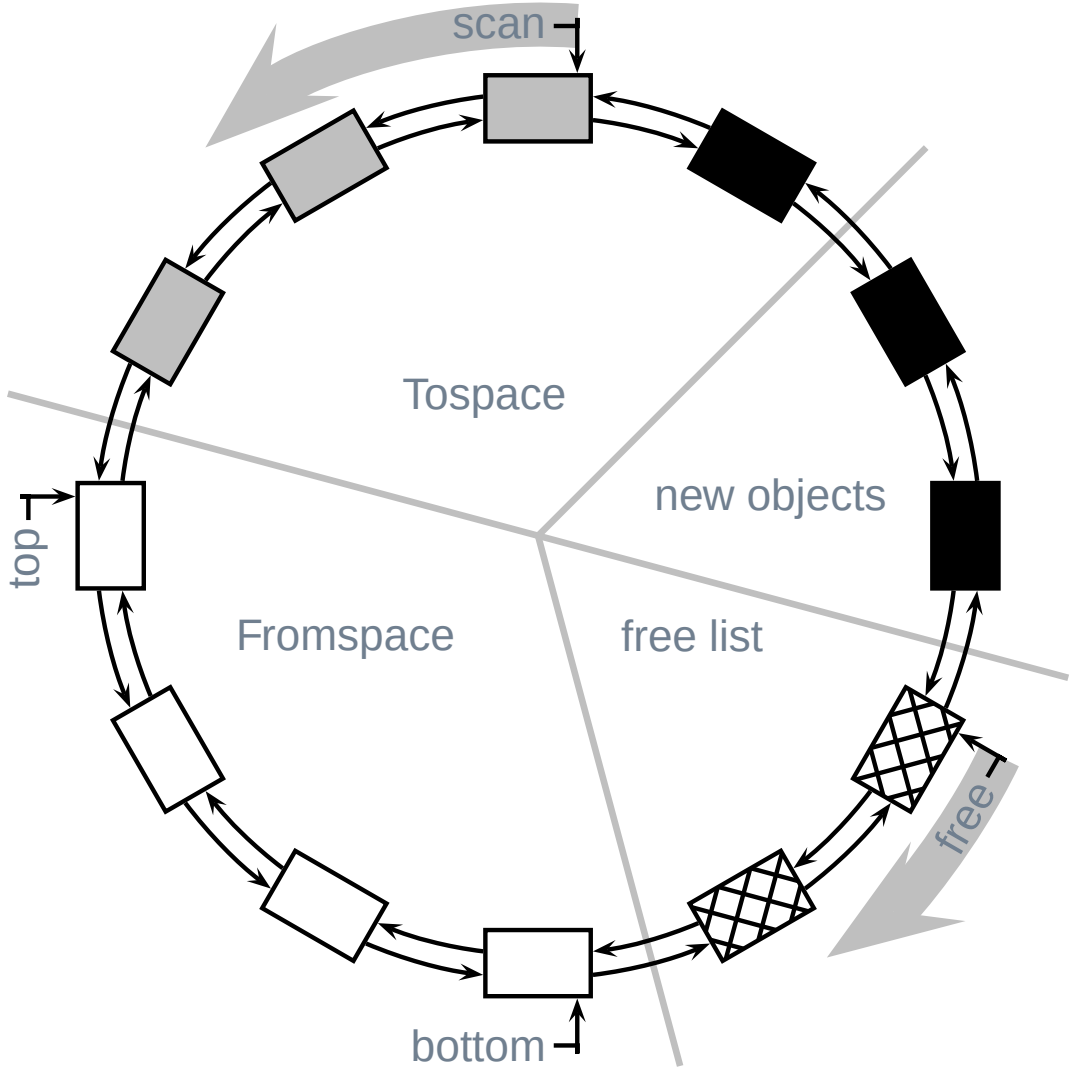
- black: scanned
- gray: marked, not scanned
- white: not marked

- dead-white: free objects

Four-Color Implementation



Baker's Treadmill



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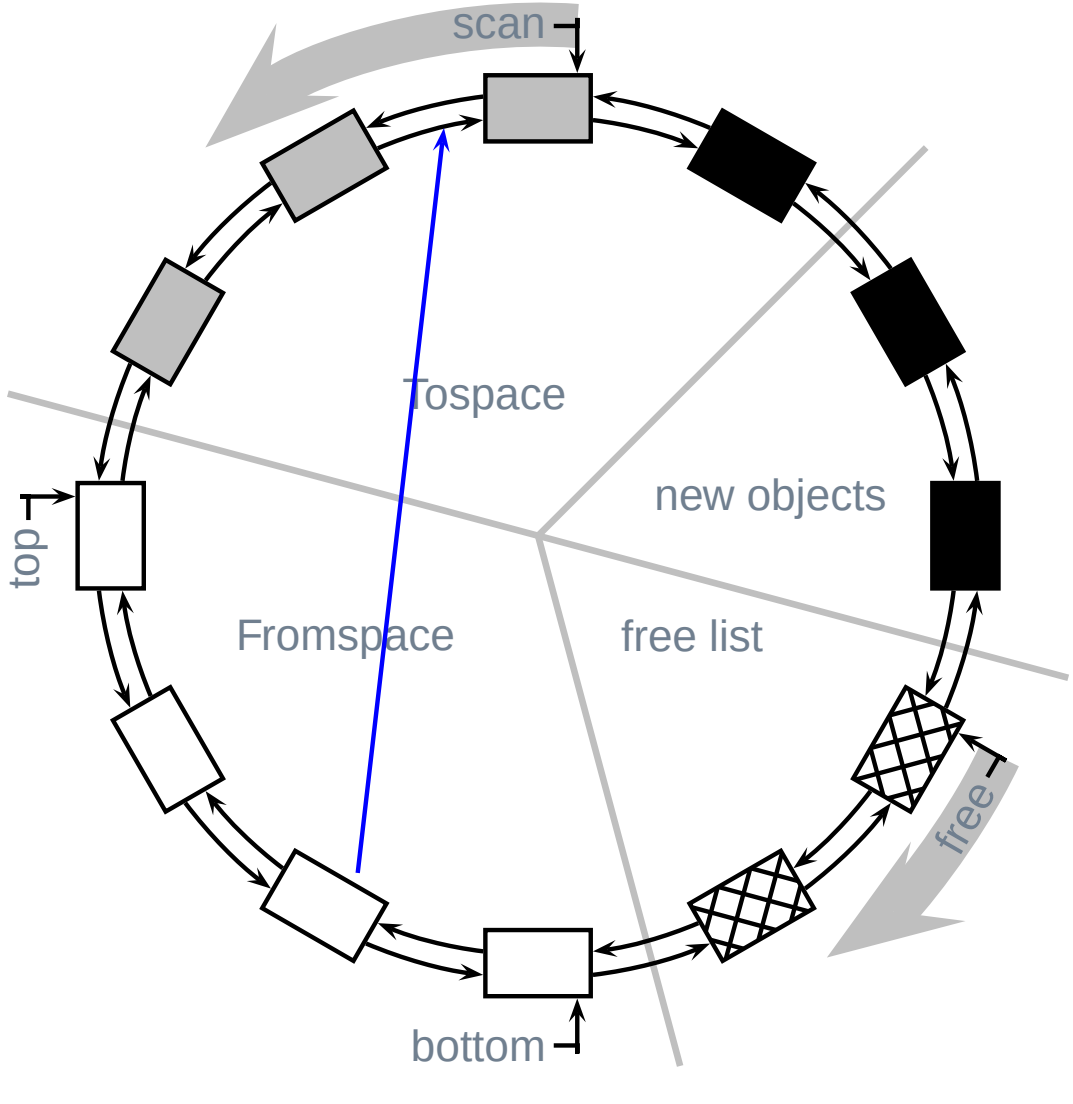

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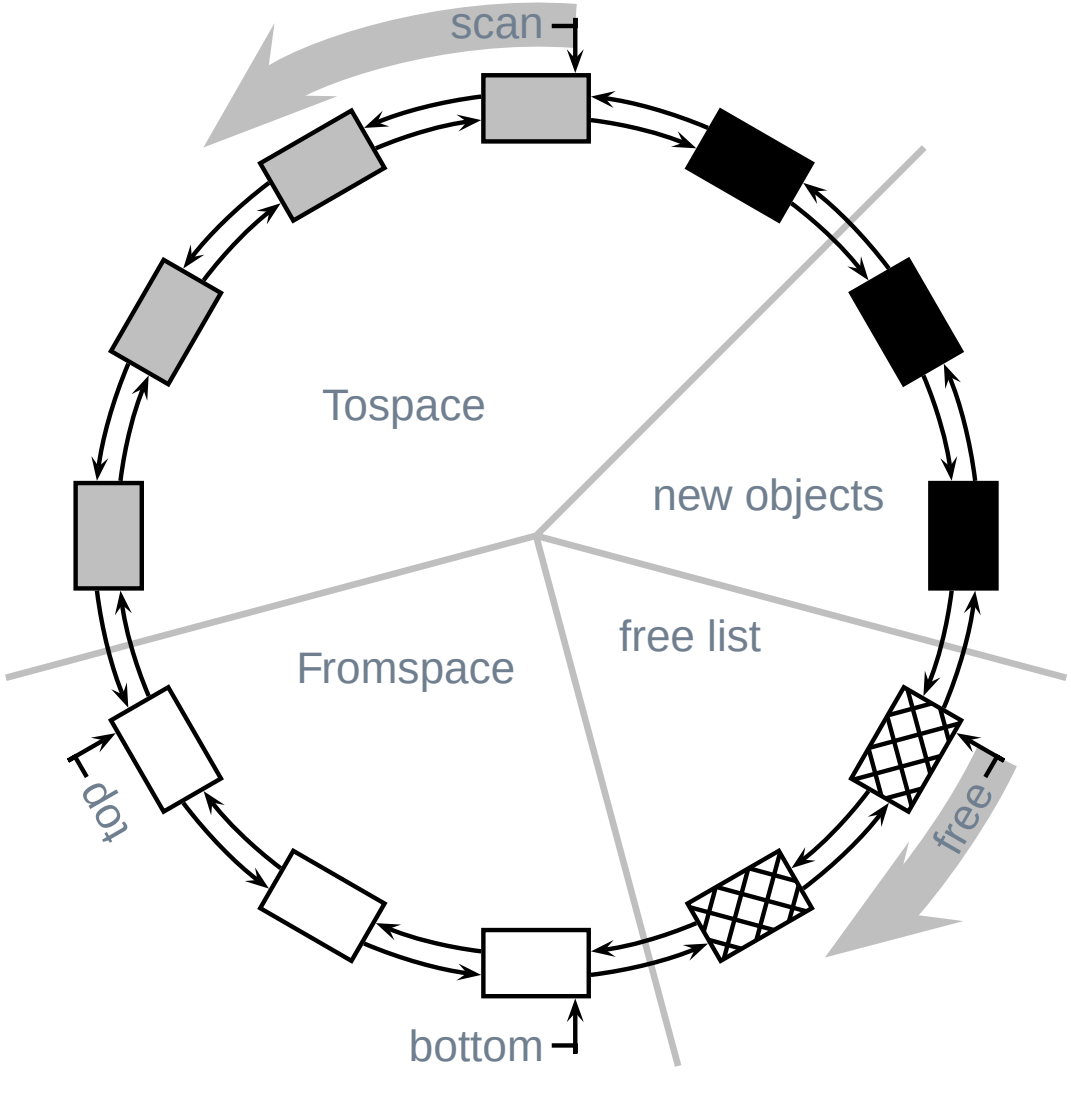

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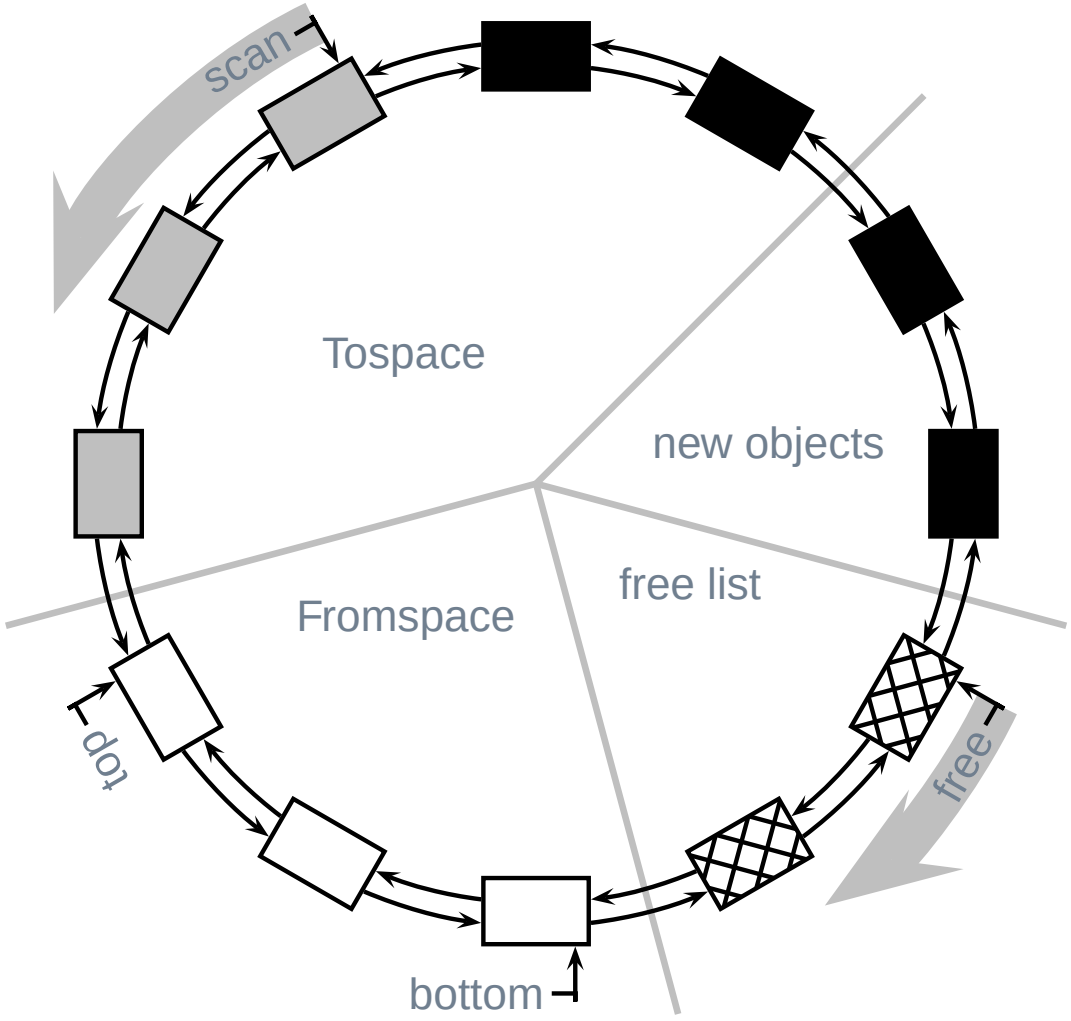

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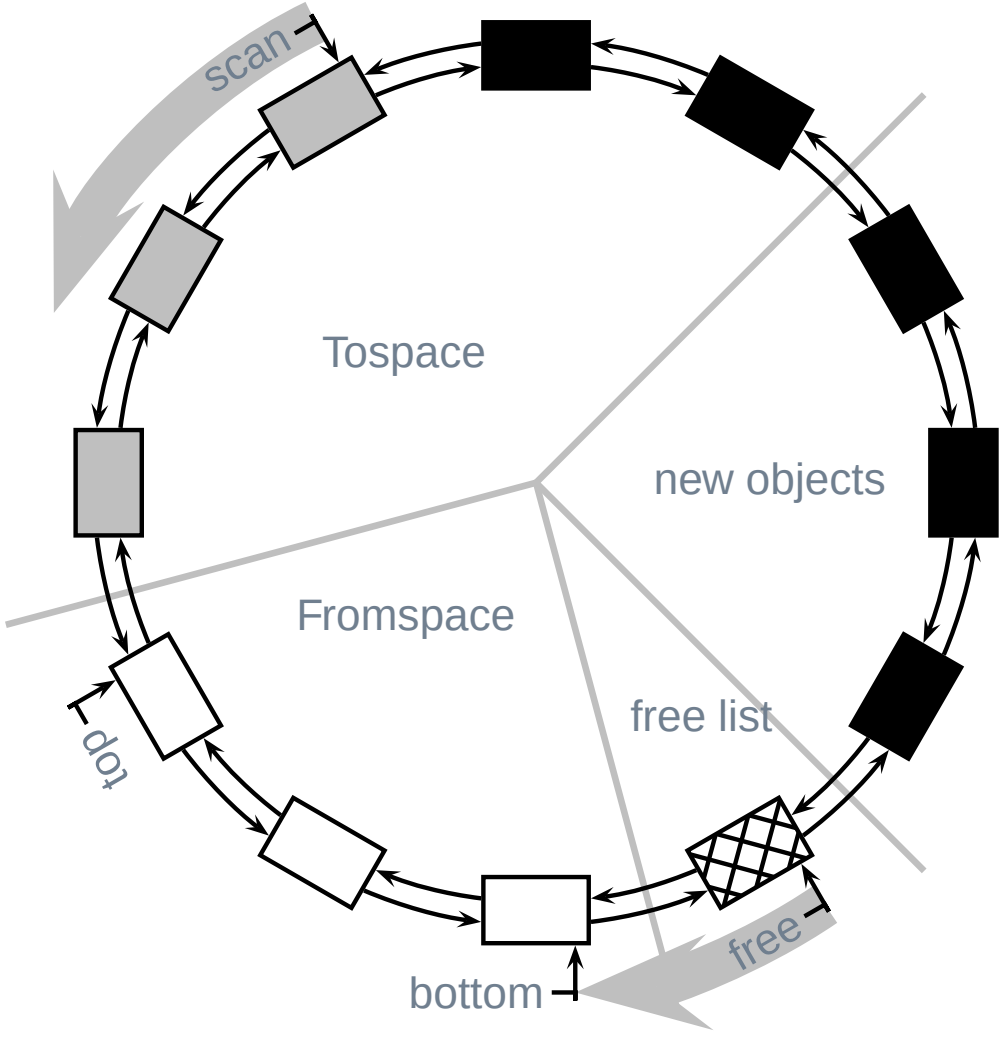

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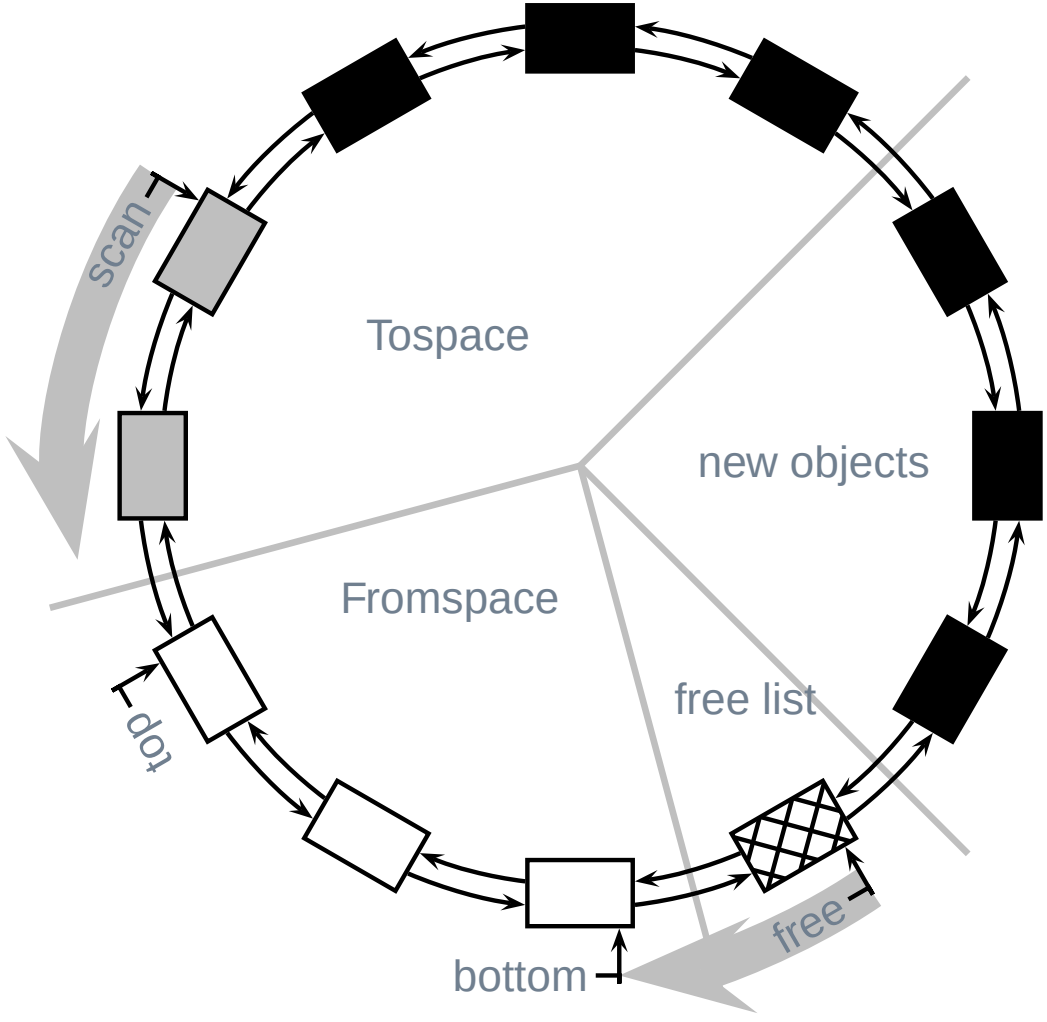

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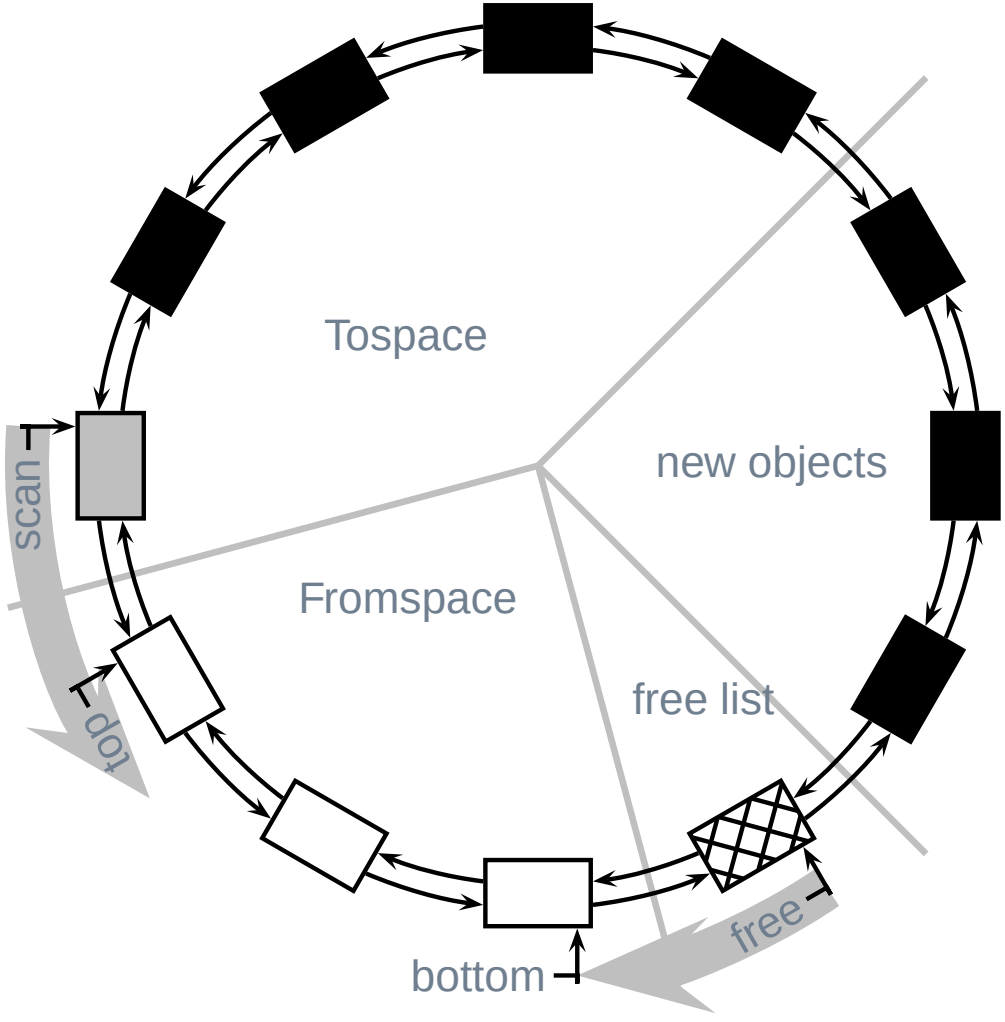

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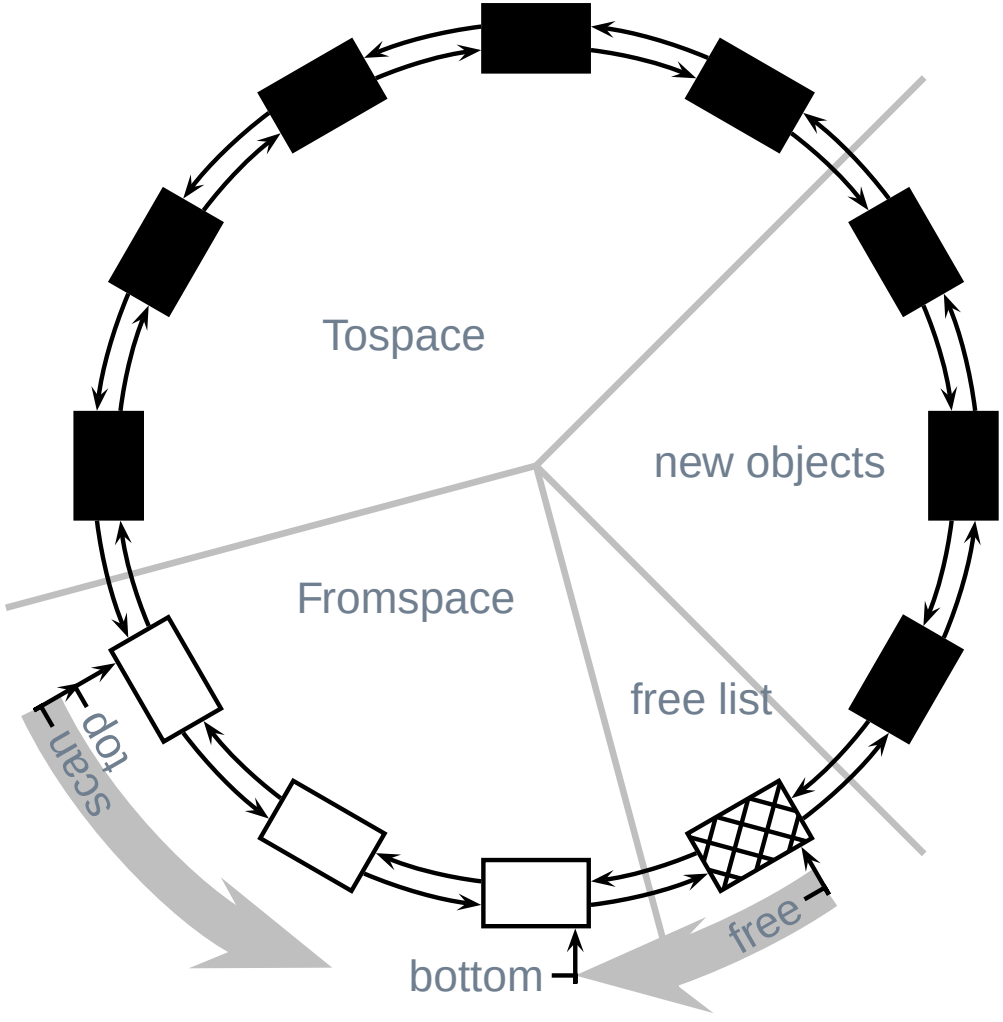

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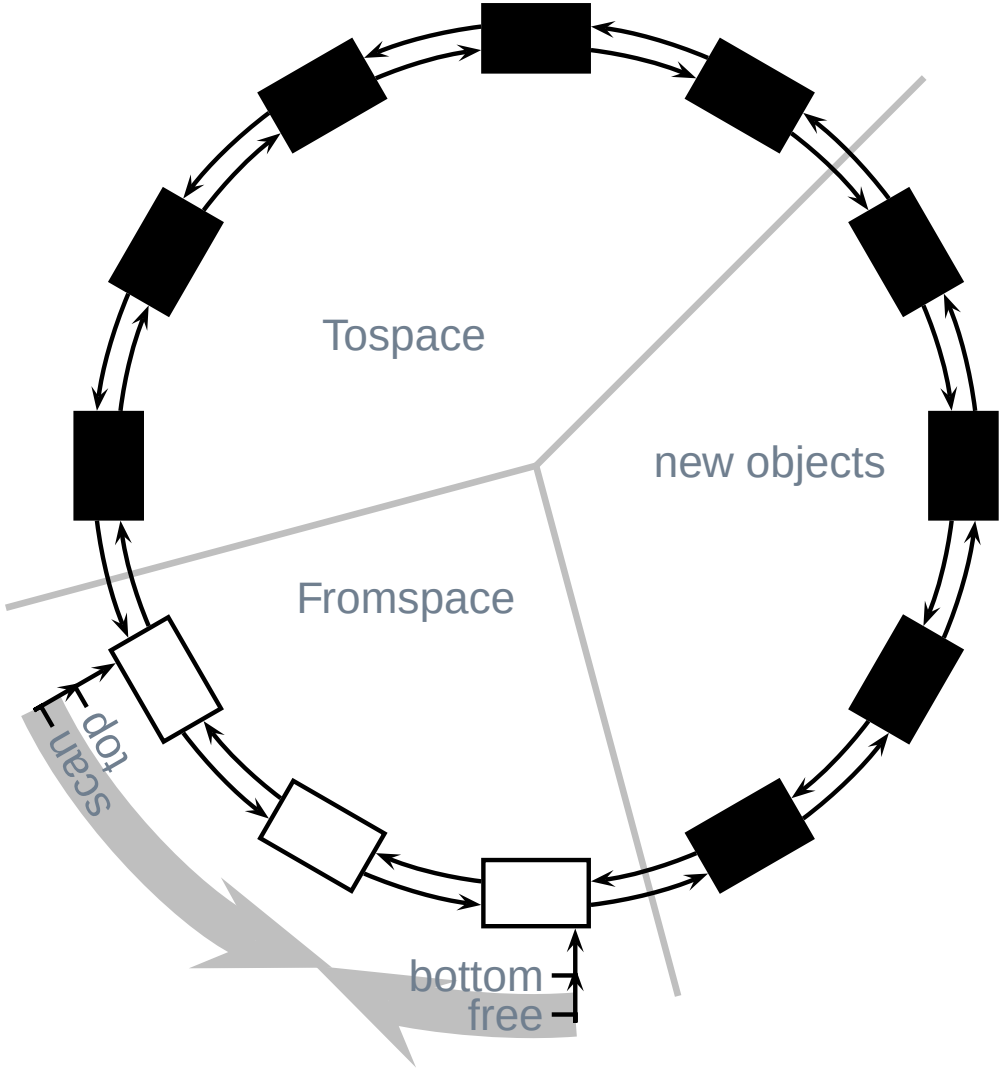

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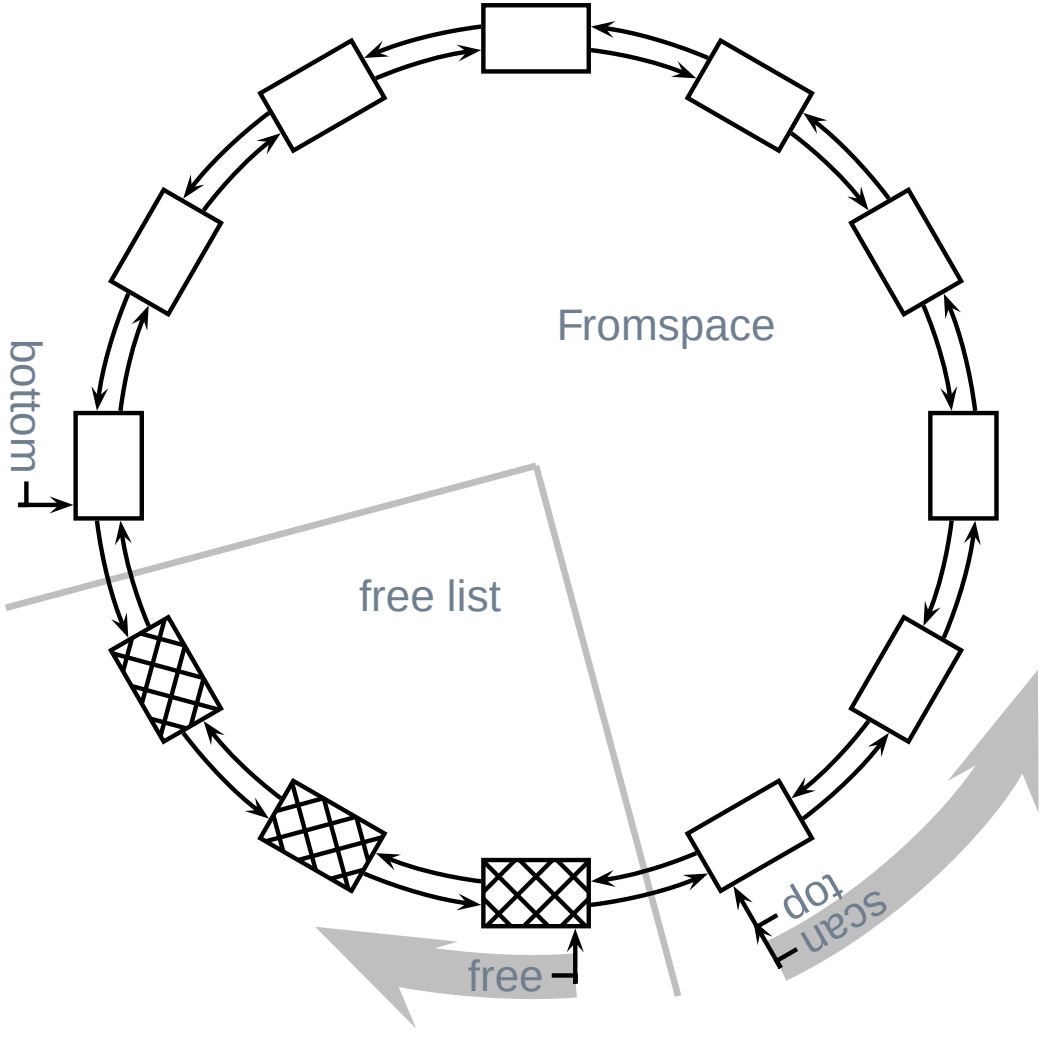

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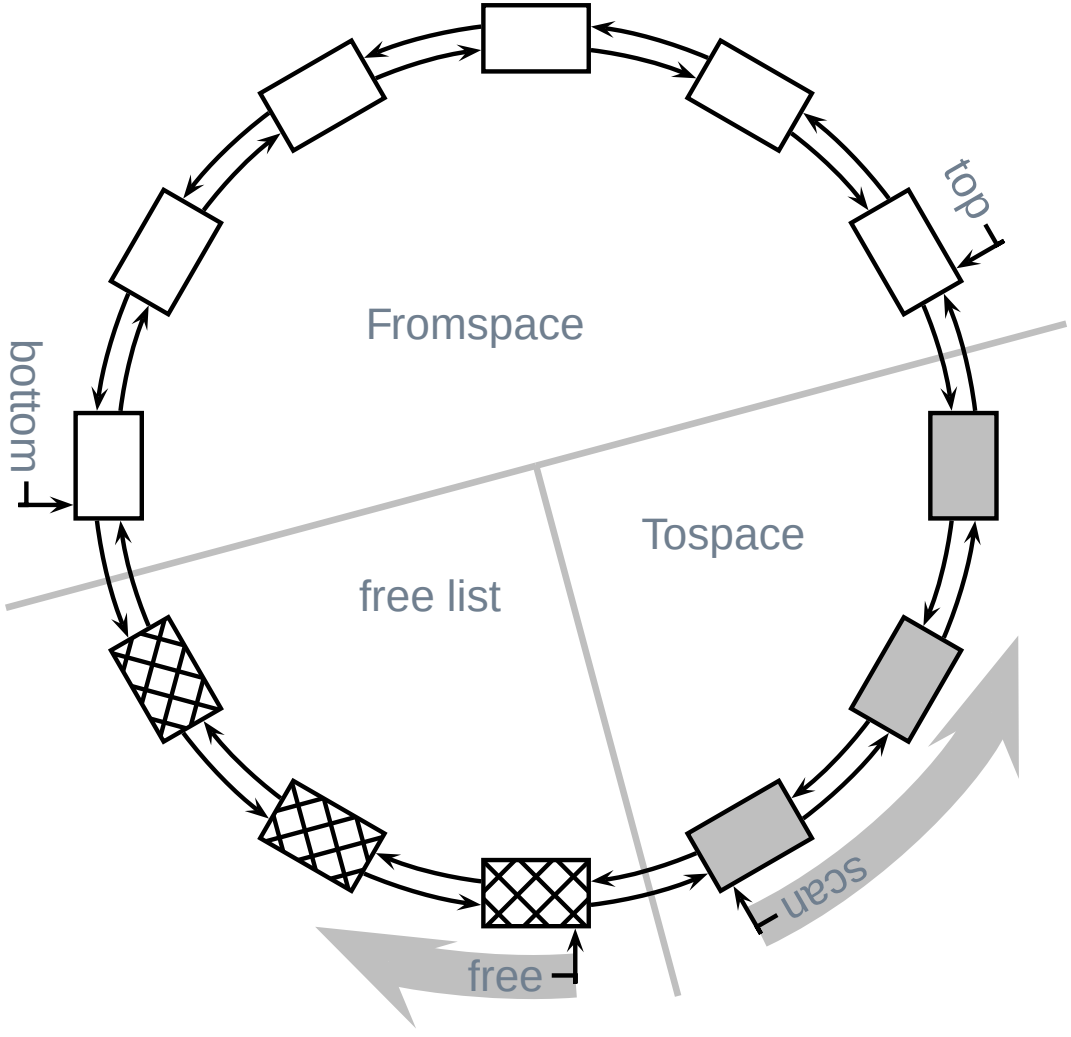

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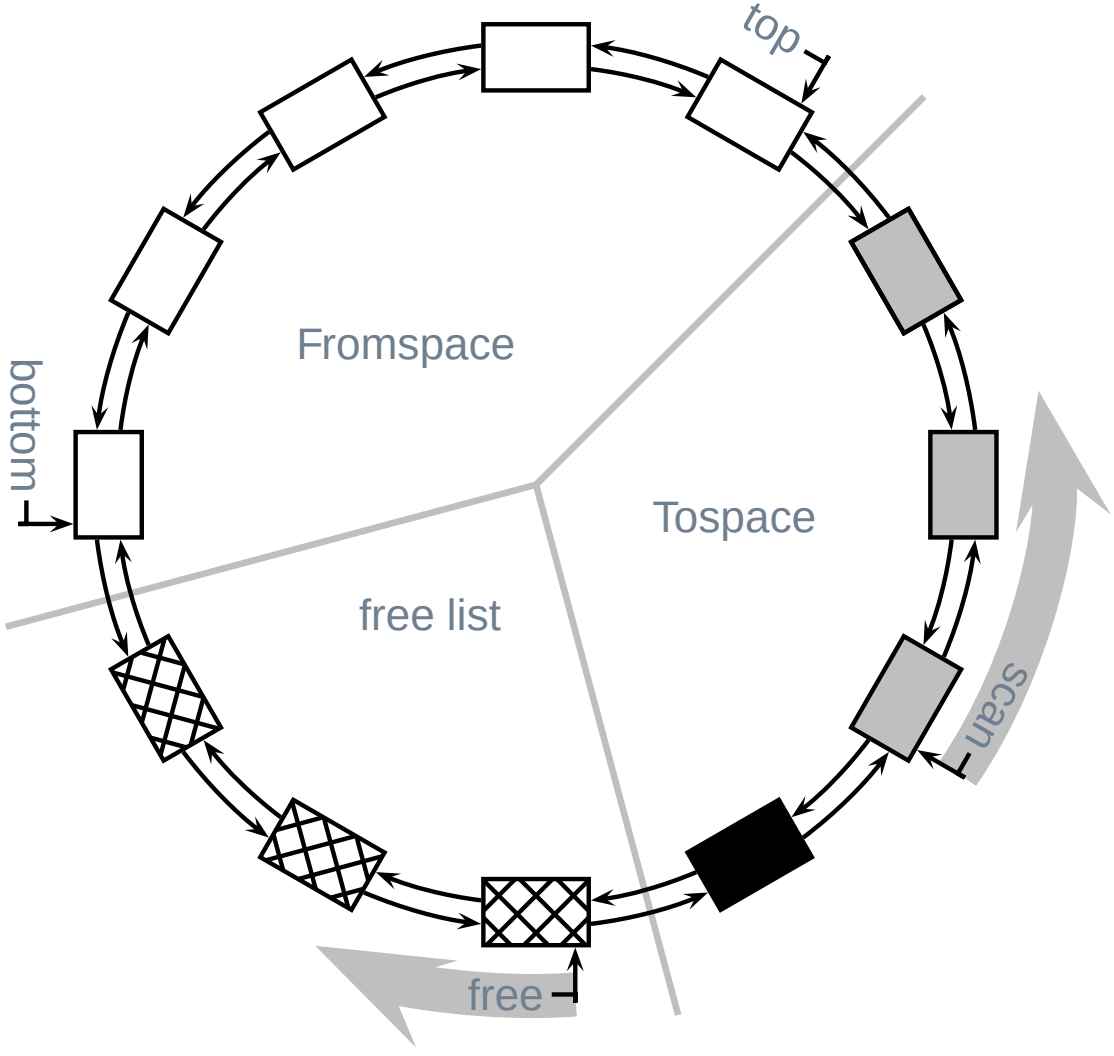

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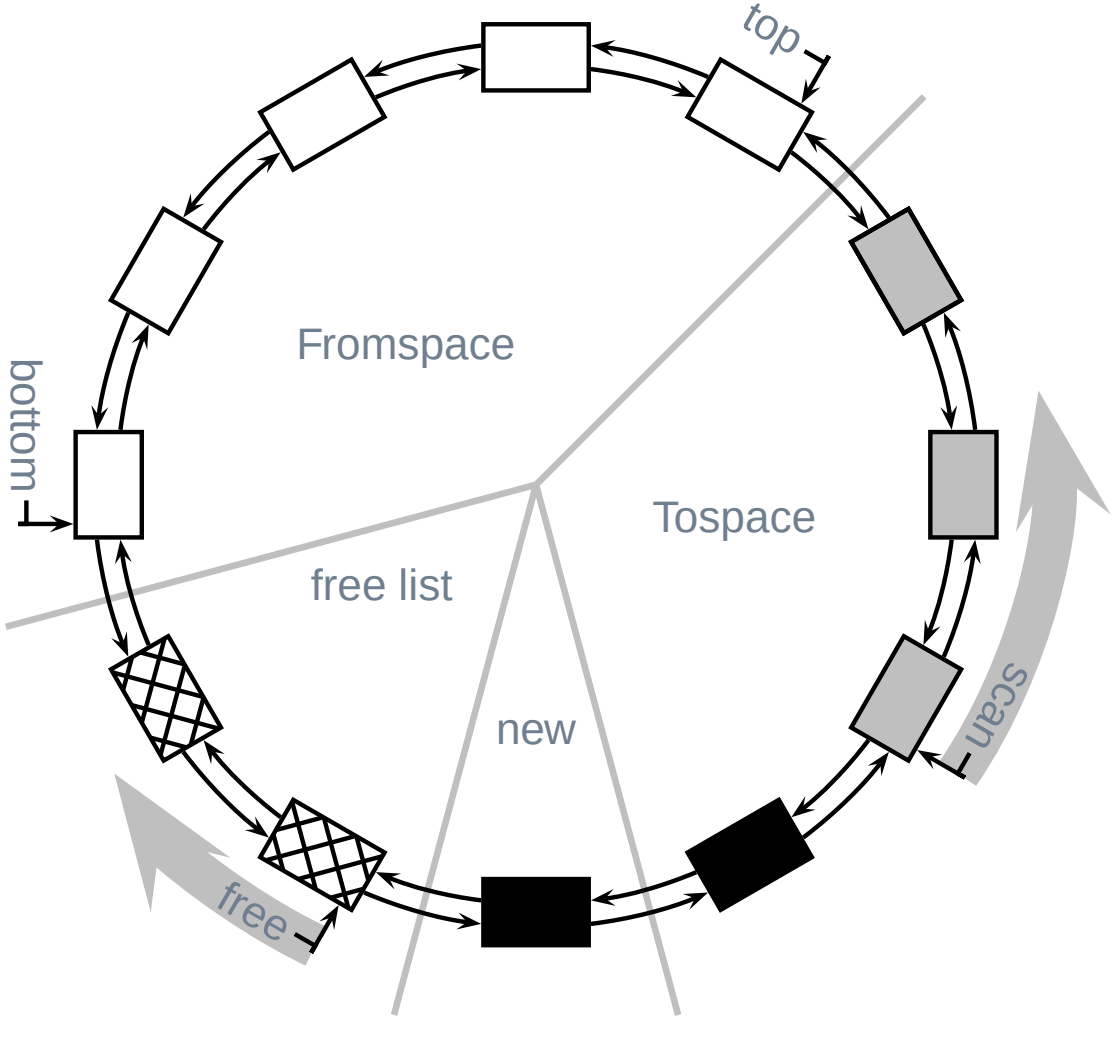

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  - depth first traversal for free

Problems

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- memory fragmentation

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Questions?

Thanks for your attention!