Squawk – Status Update

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What's new

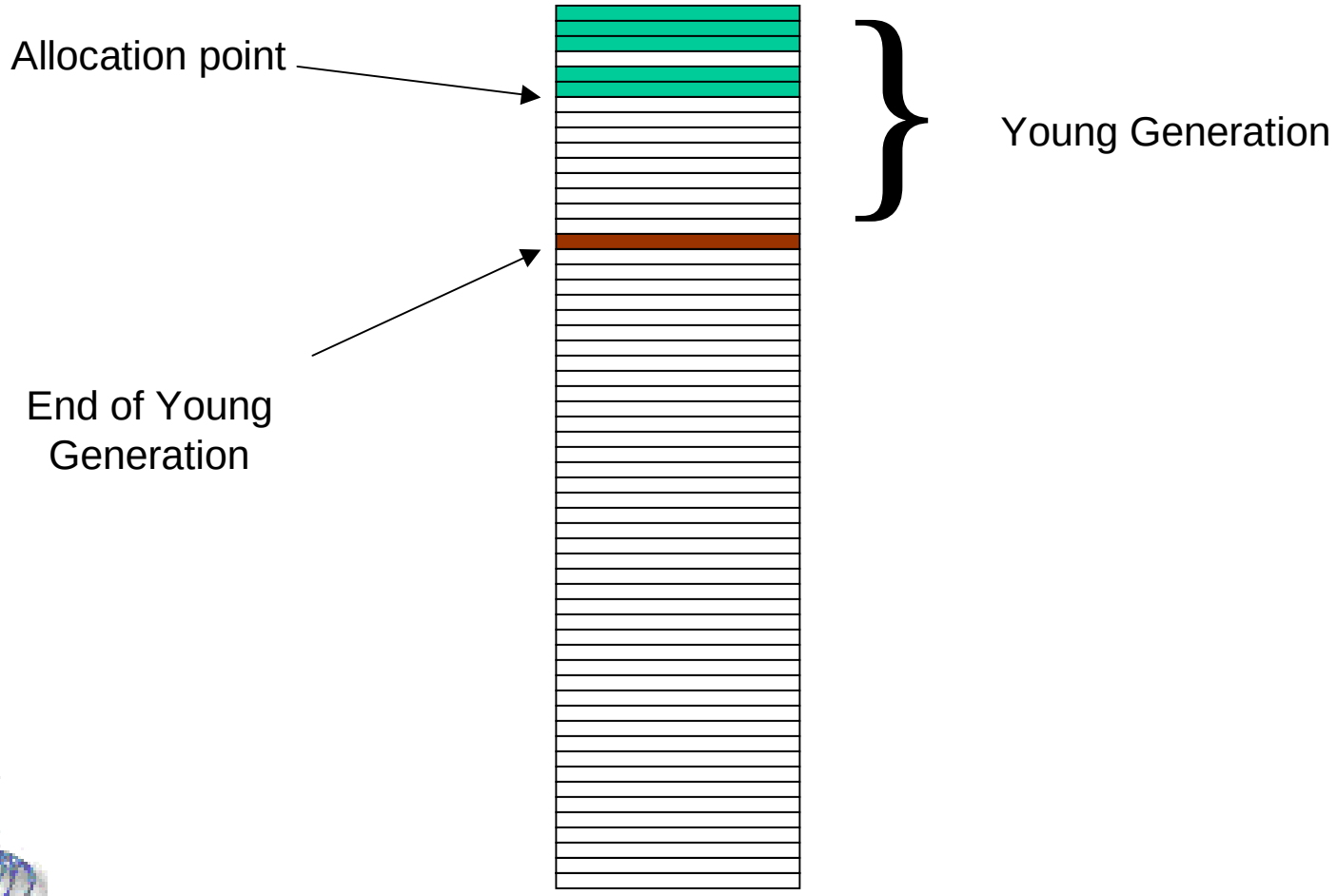
- Prototype RAM usage numbers
- Compacting, generational garbage collector for working storage (RAM)
- Mark-sweep, non-compacting collector for persistent memory (EEPROM)
- Migration/copying objects from RAM → EEPROM
- Loader runs inside Squawk
- Support for finalizers and auto-migration

Loader & RAM numbers

- The suite loader now runs in Squawk
  - Uses RAM → EEPROM migration functionality
- RAM usage by Squawk VM when running 'nop' program:
  - Java Heap: ~844 bytes
  - Native stack & data: ~532 bytes
- ROM required for Java Purse: 4516 bytes

RAM architecture

RAM architecture



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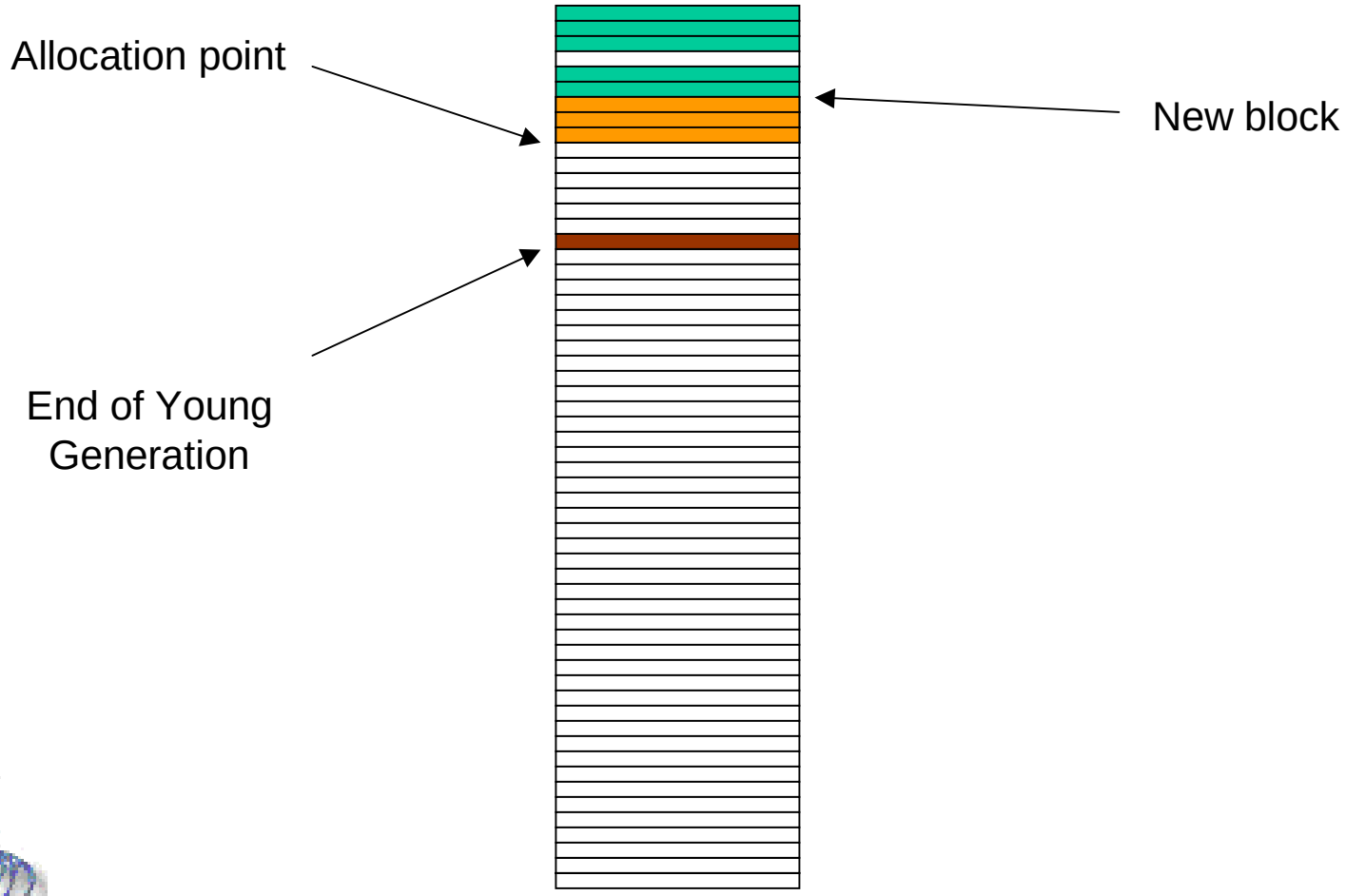

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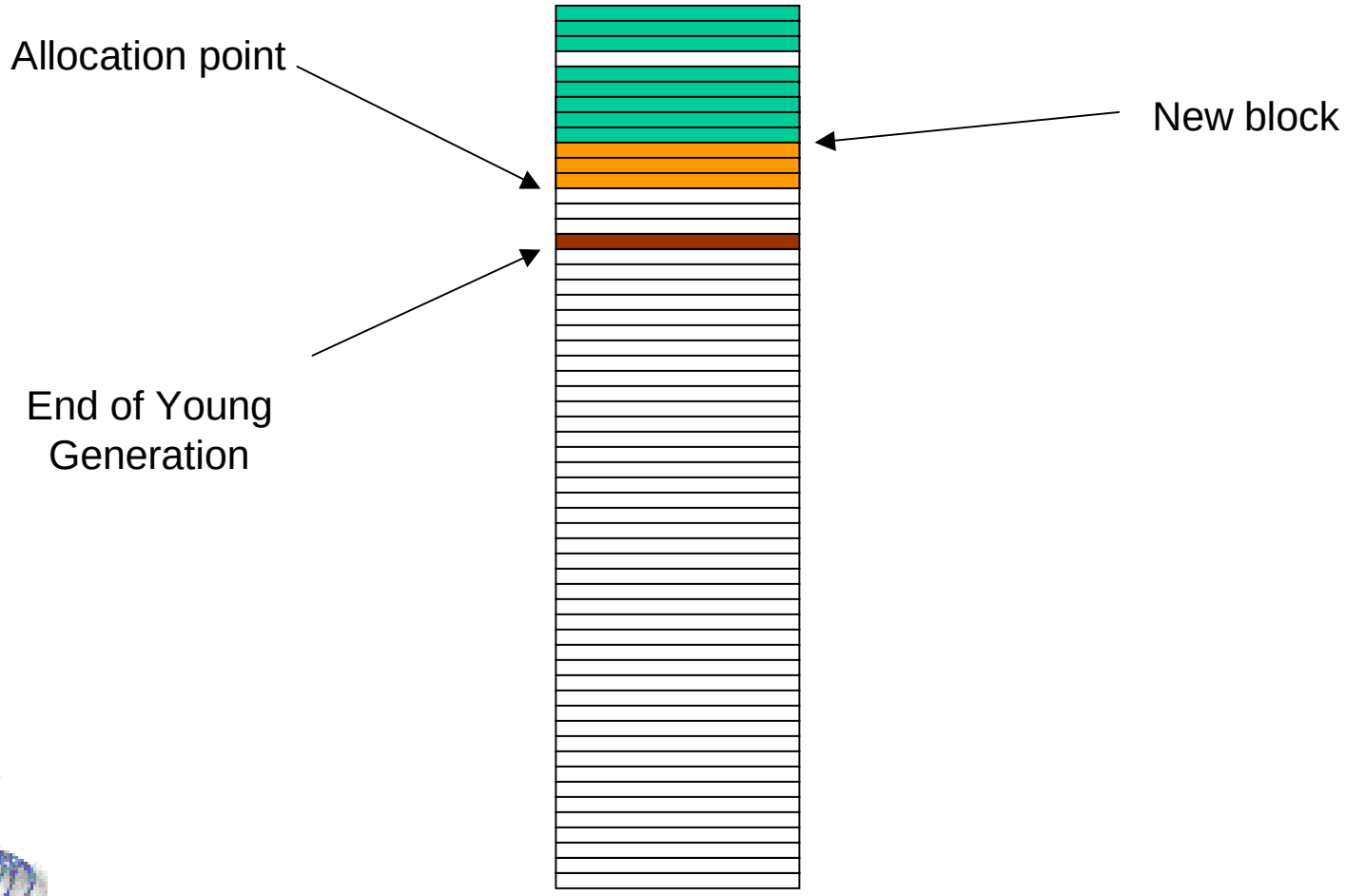

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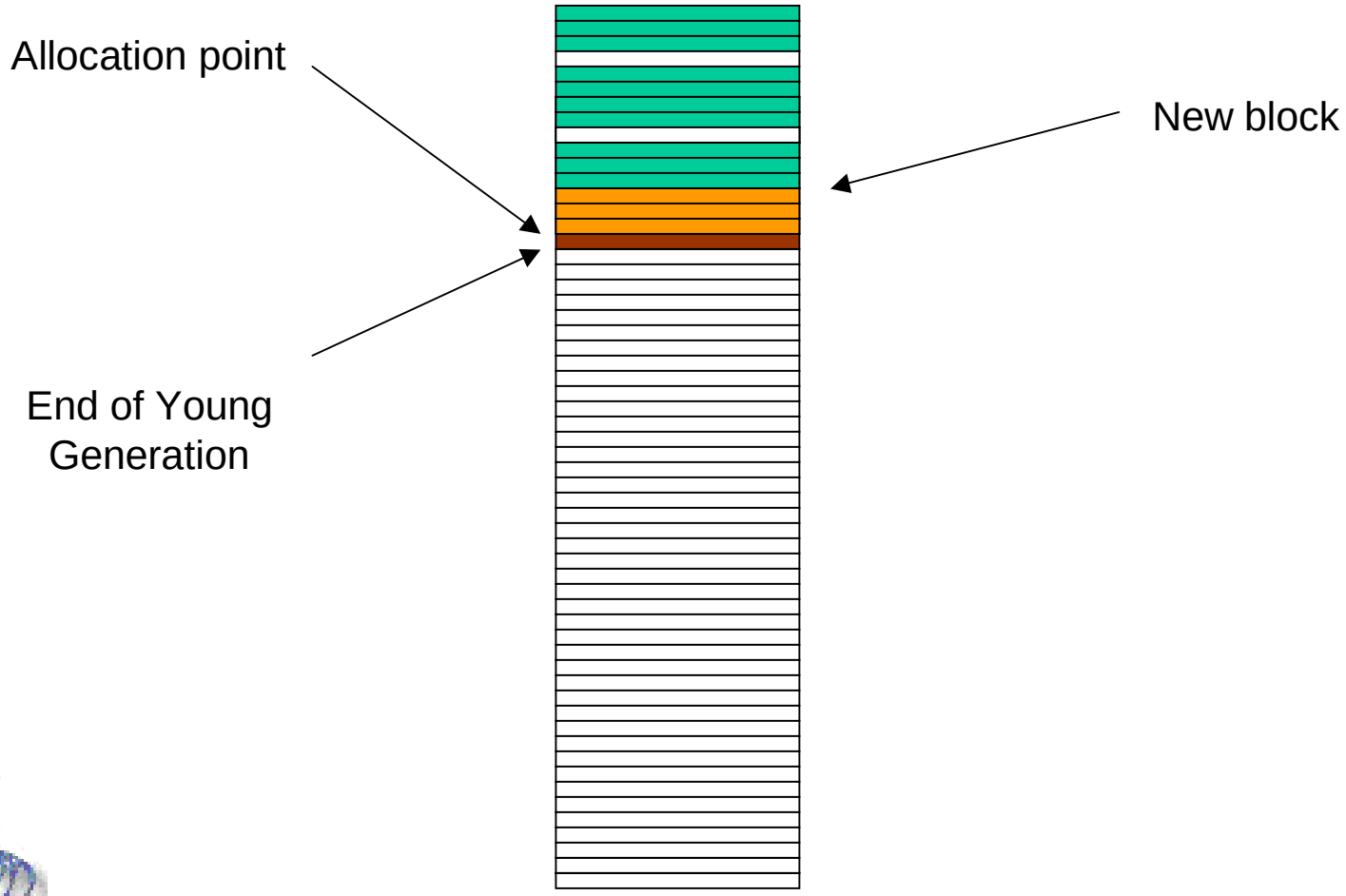

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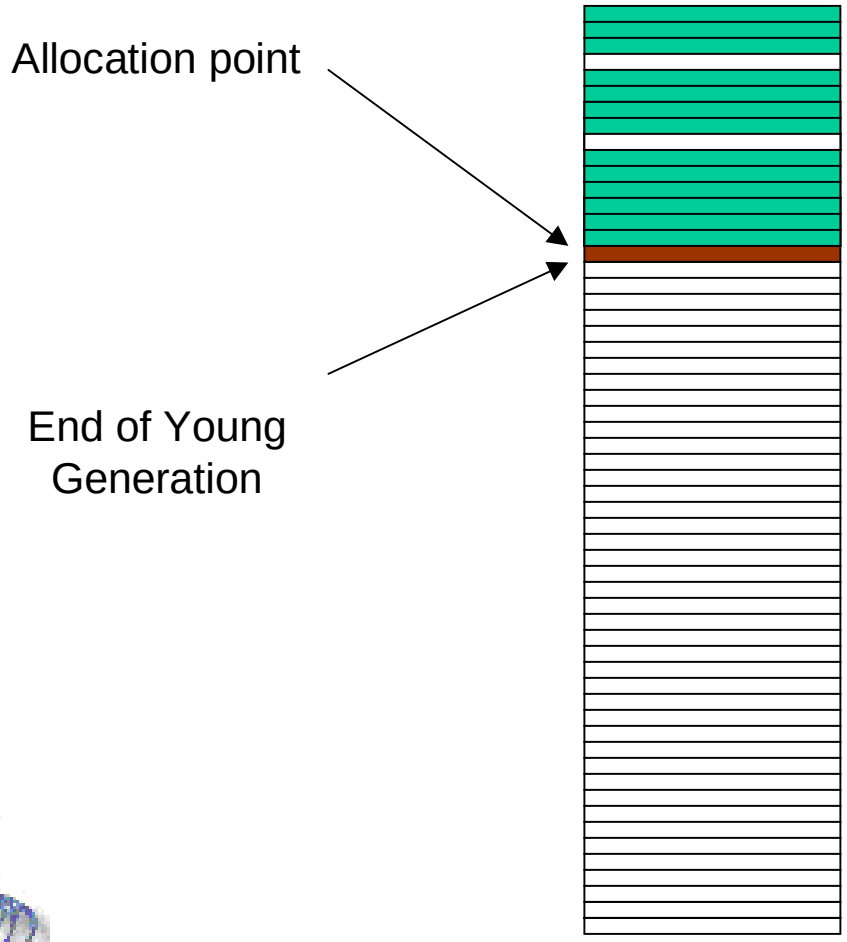
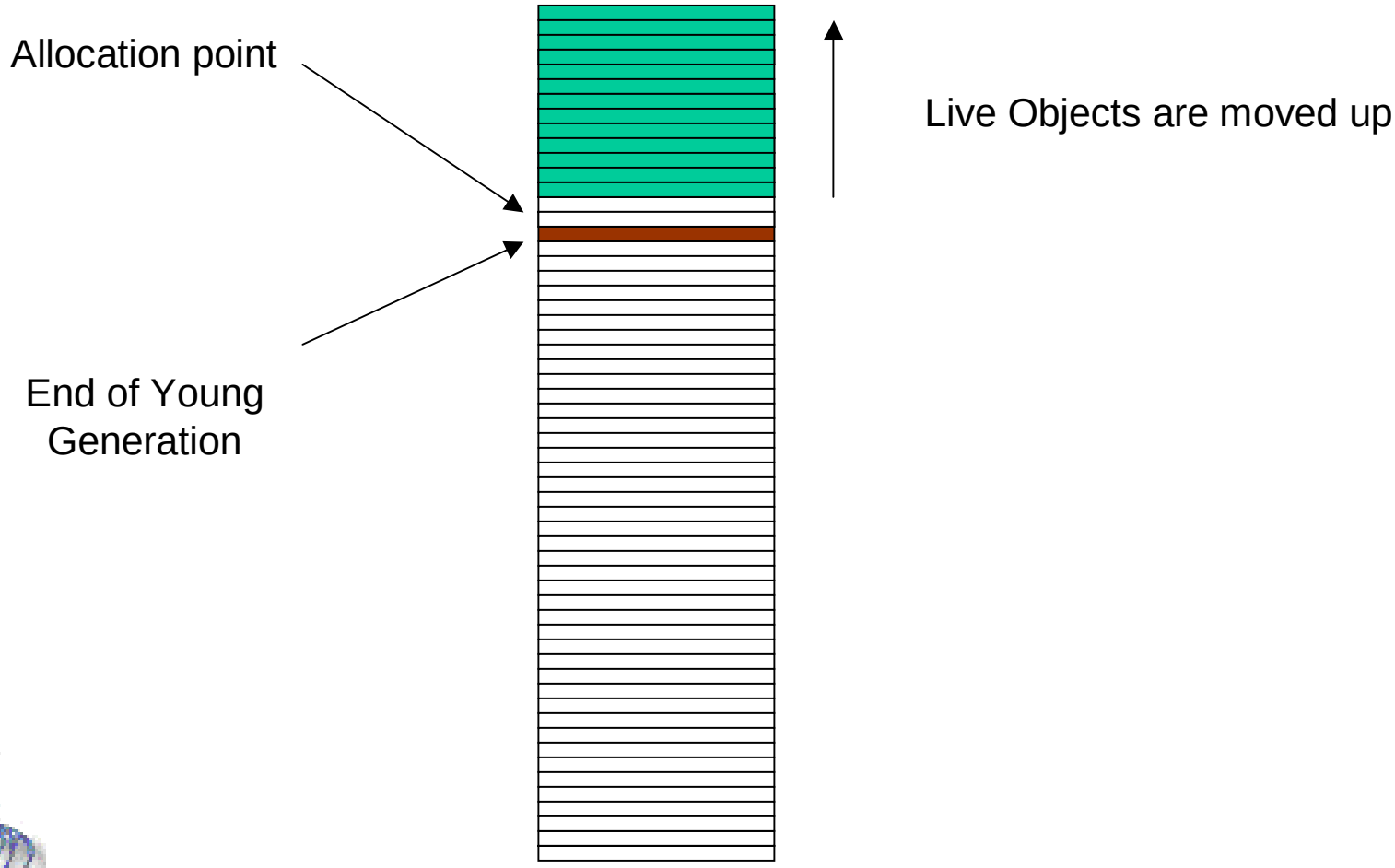


GC Required

RAM architecture



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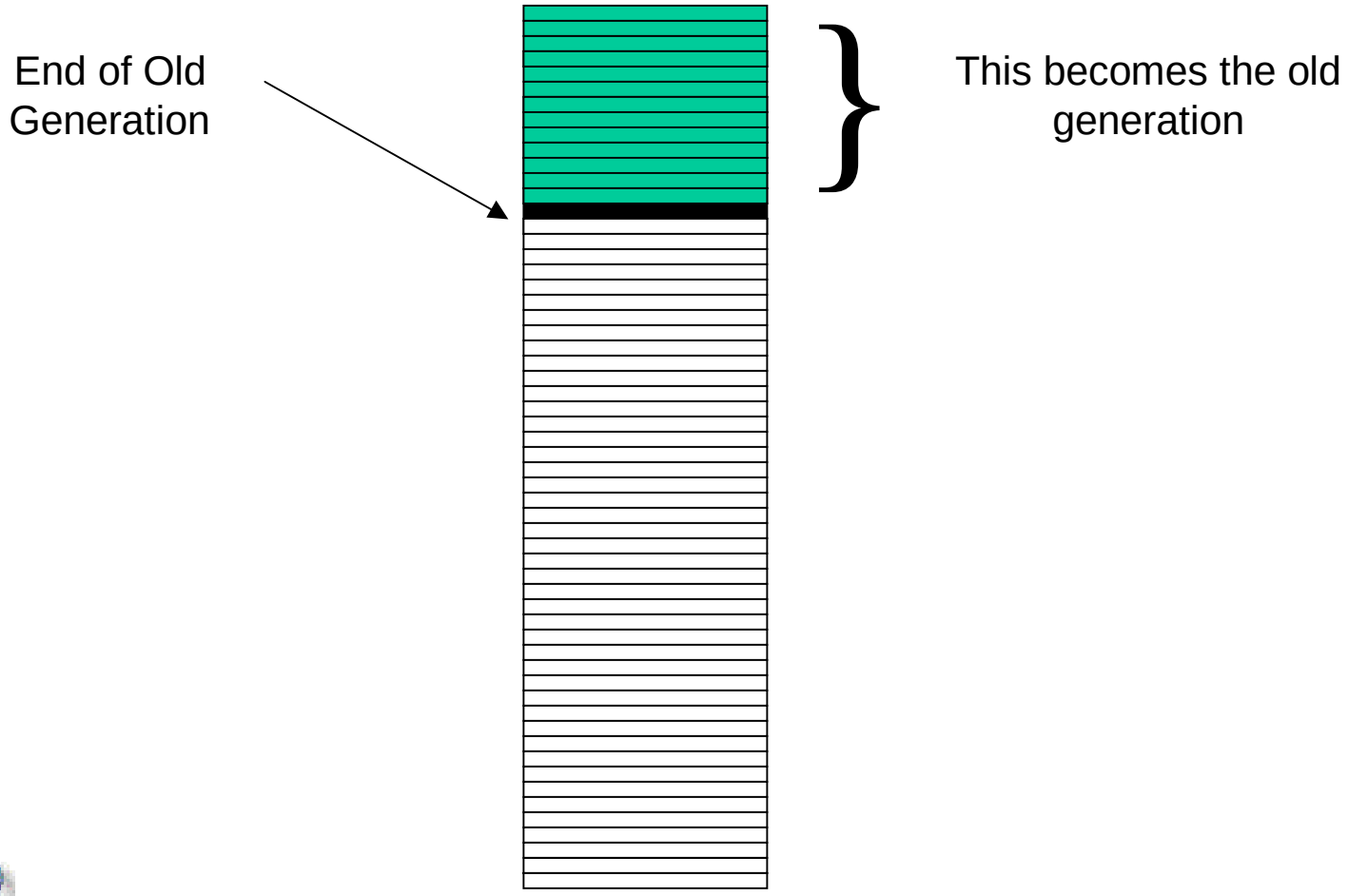

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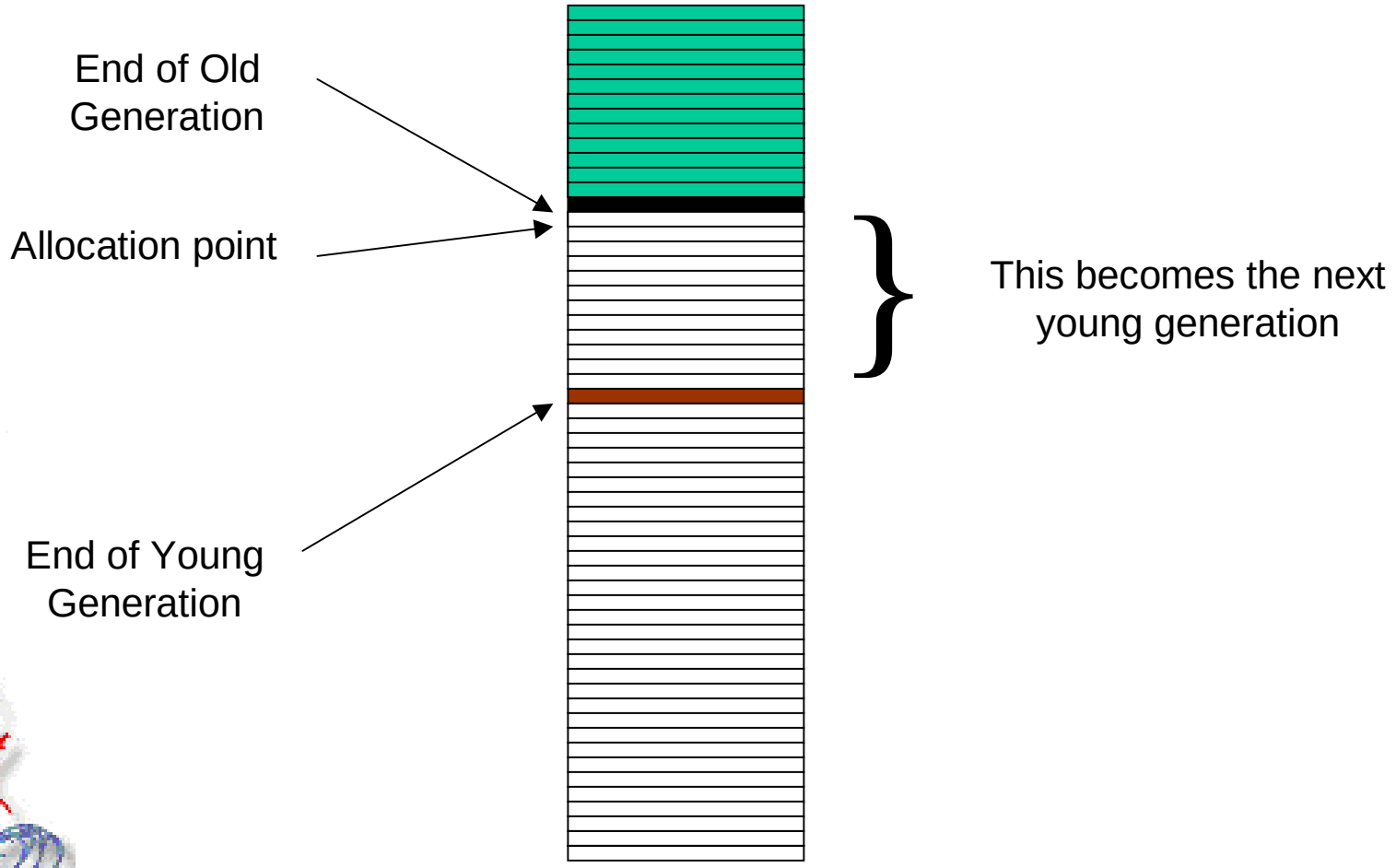

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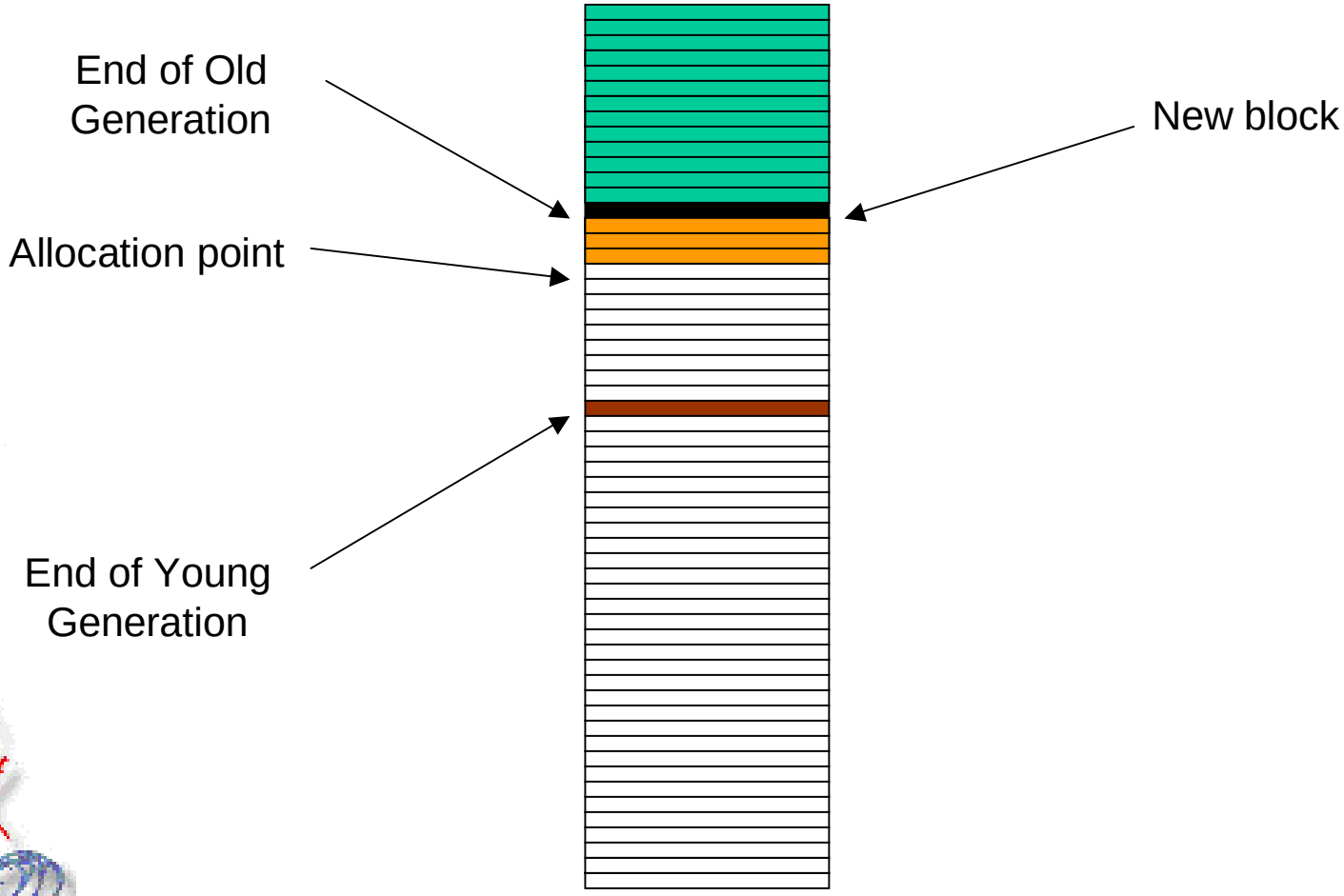

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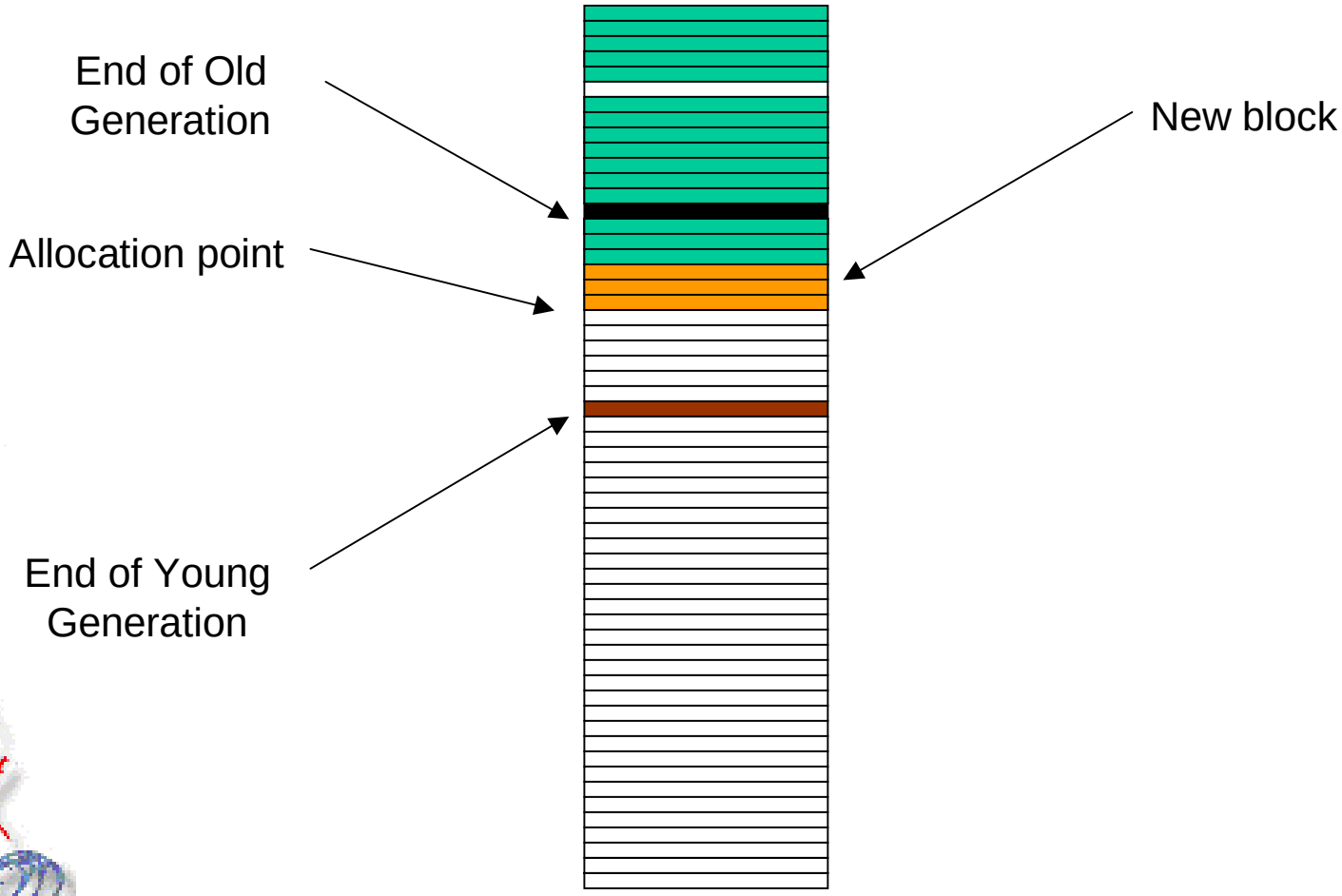

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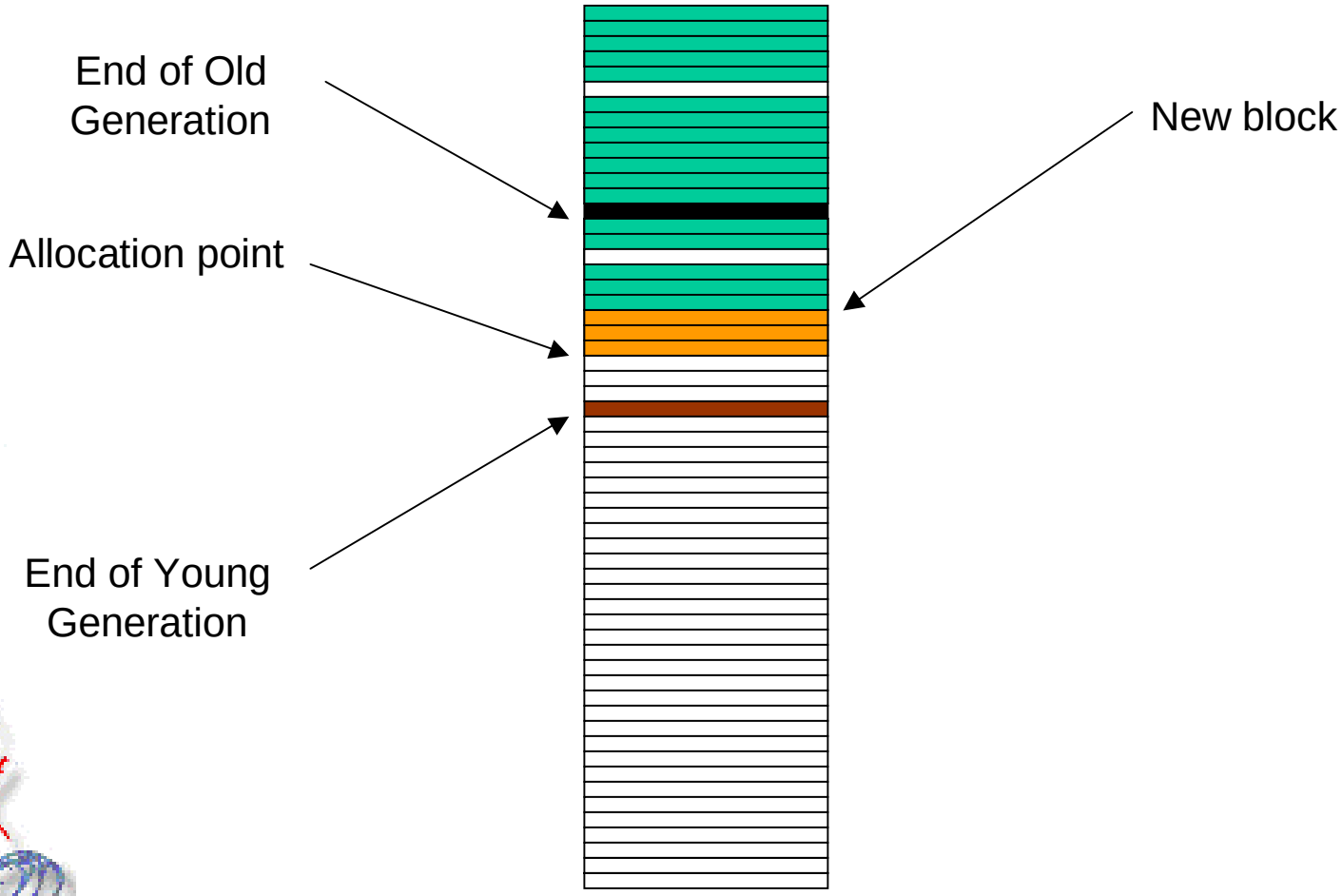

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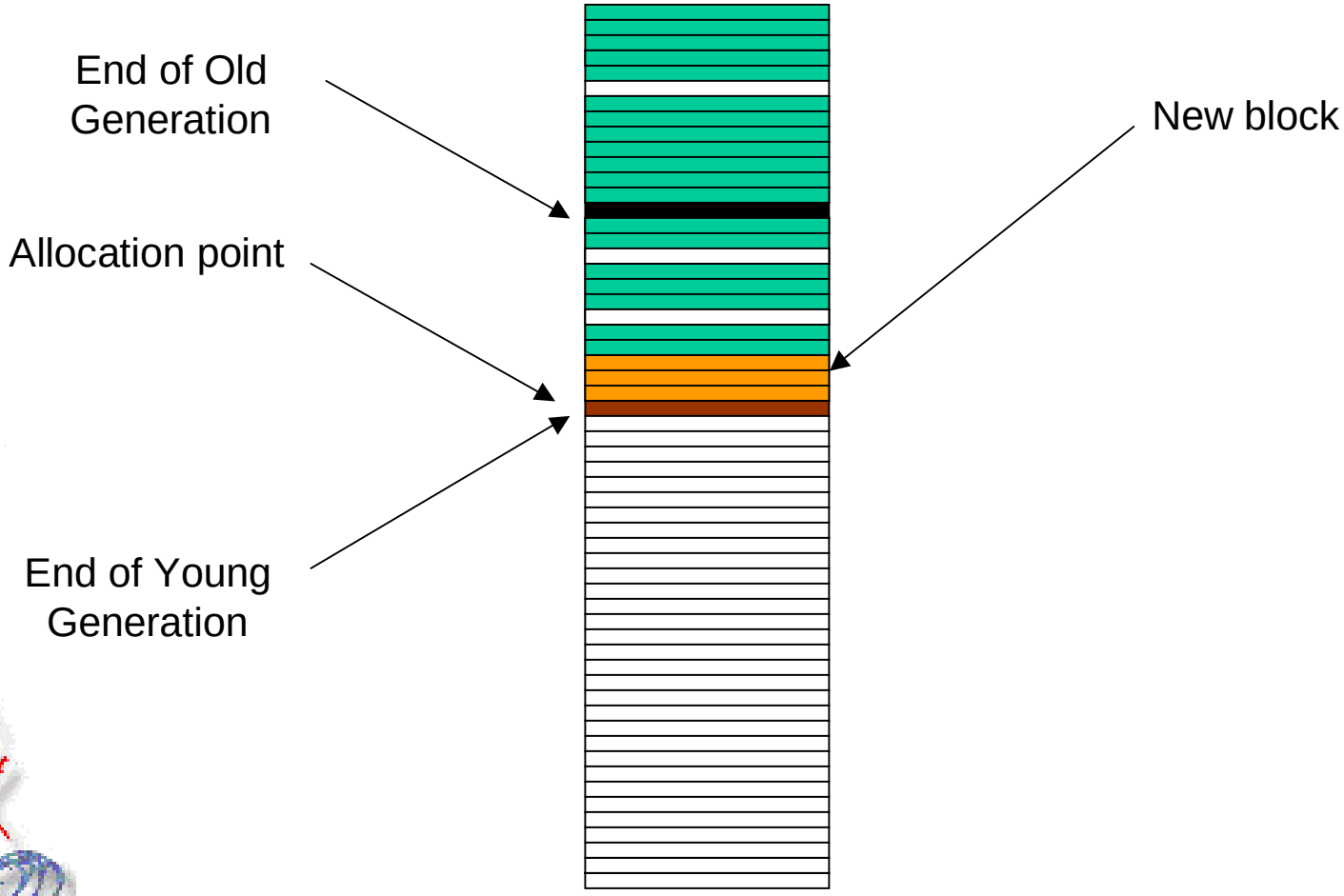

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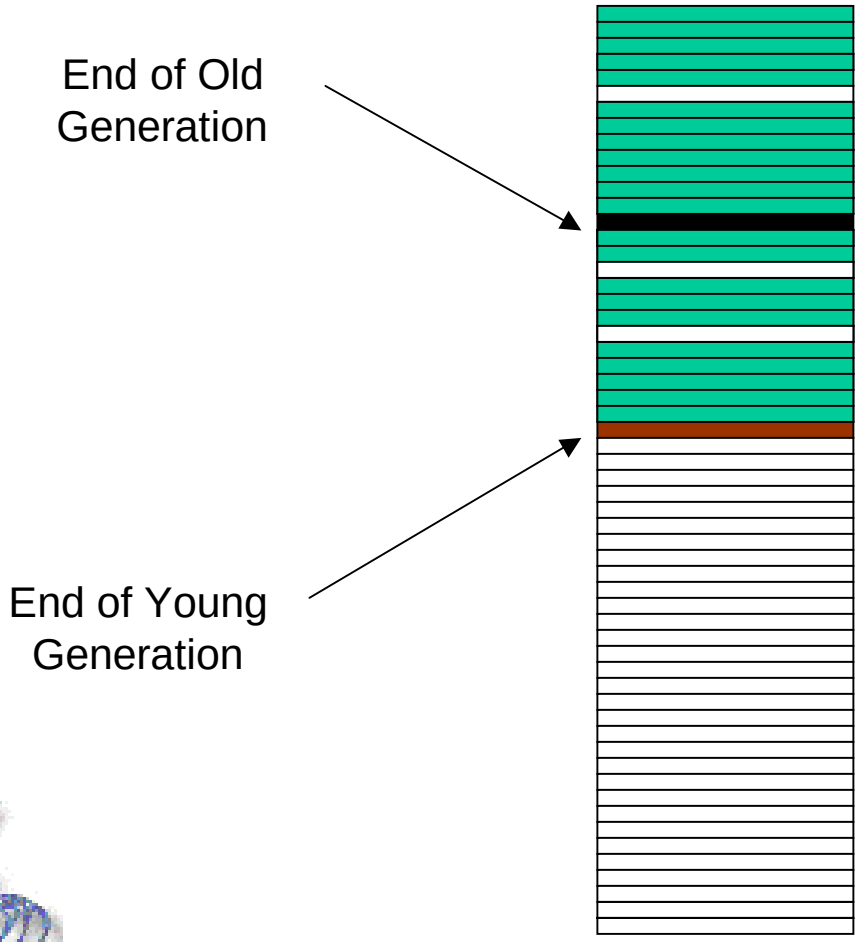
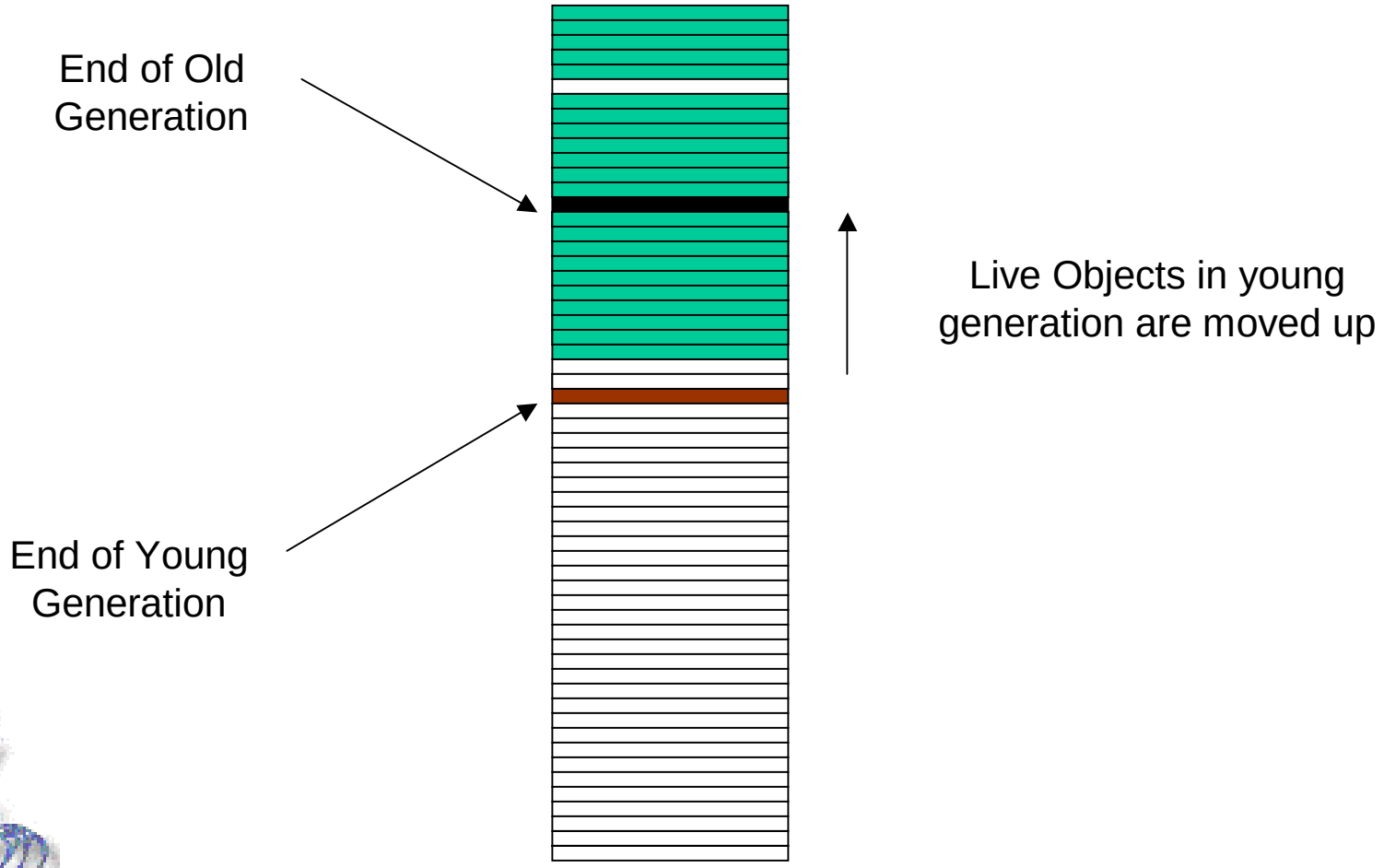


GC required

RAM architecture



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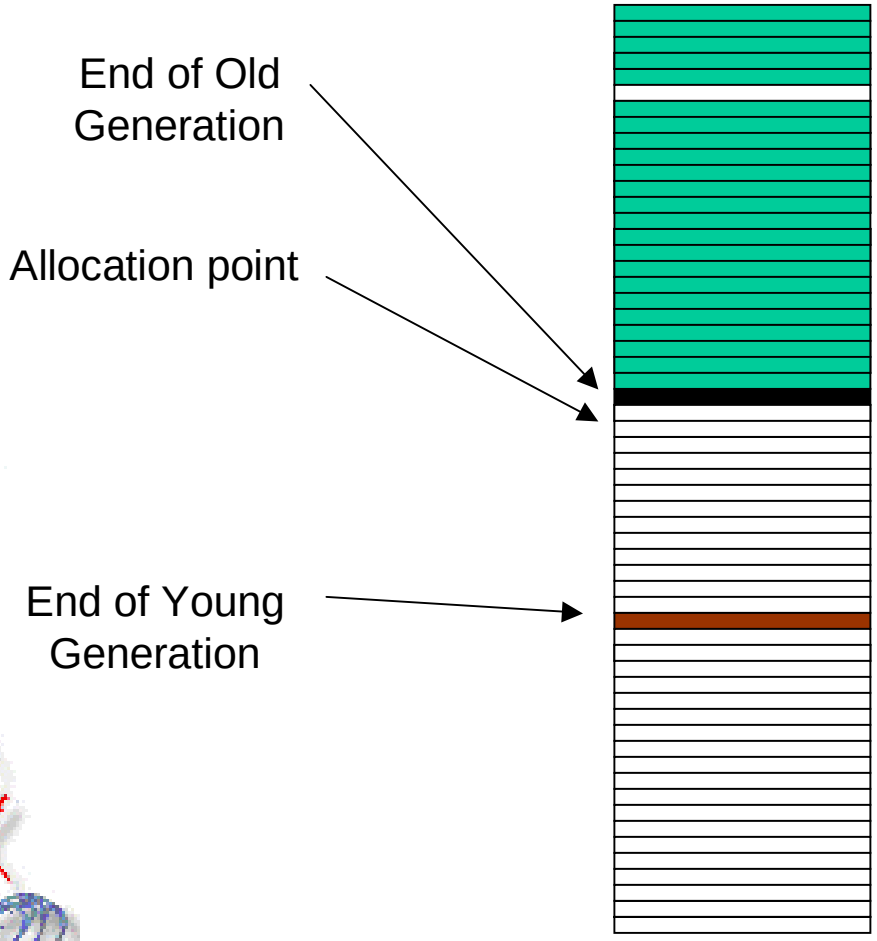

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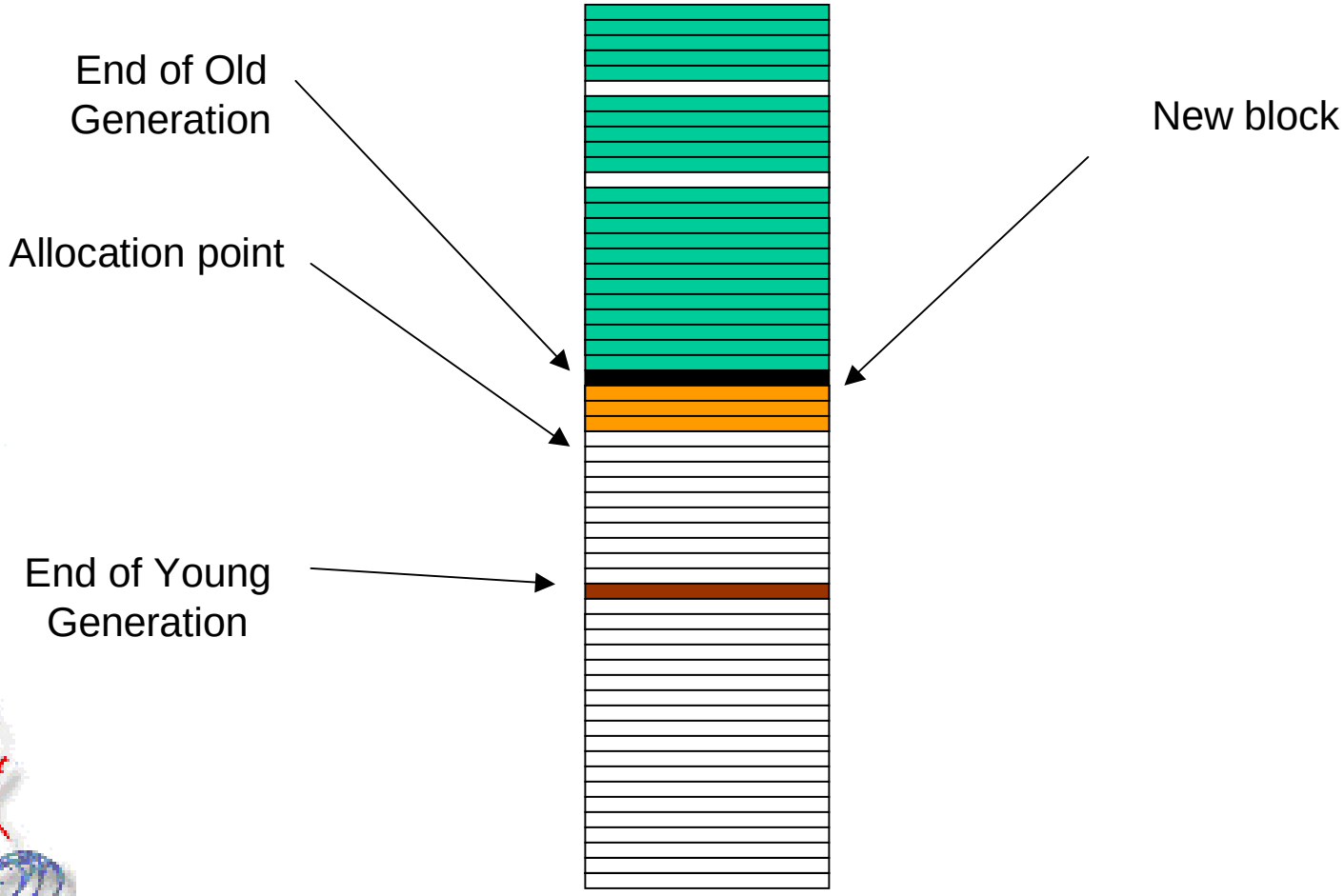

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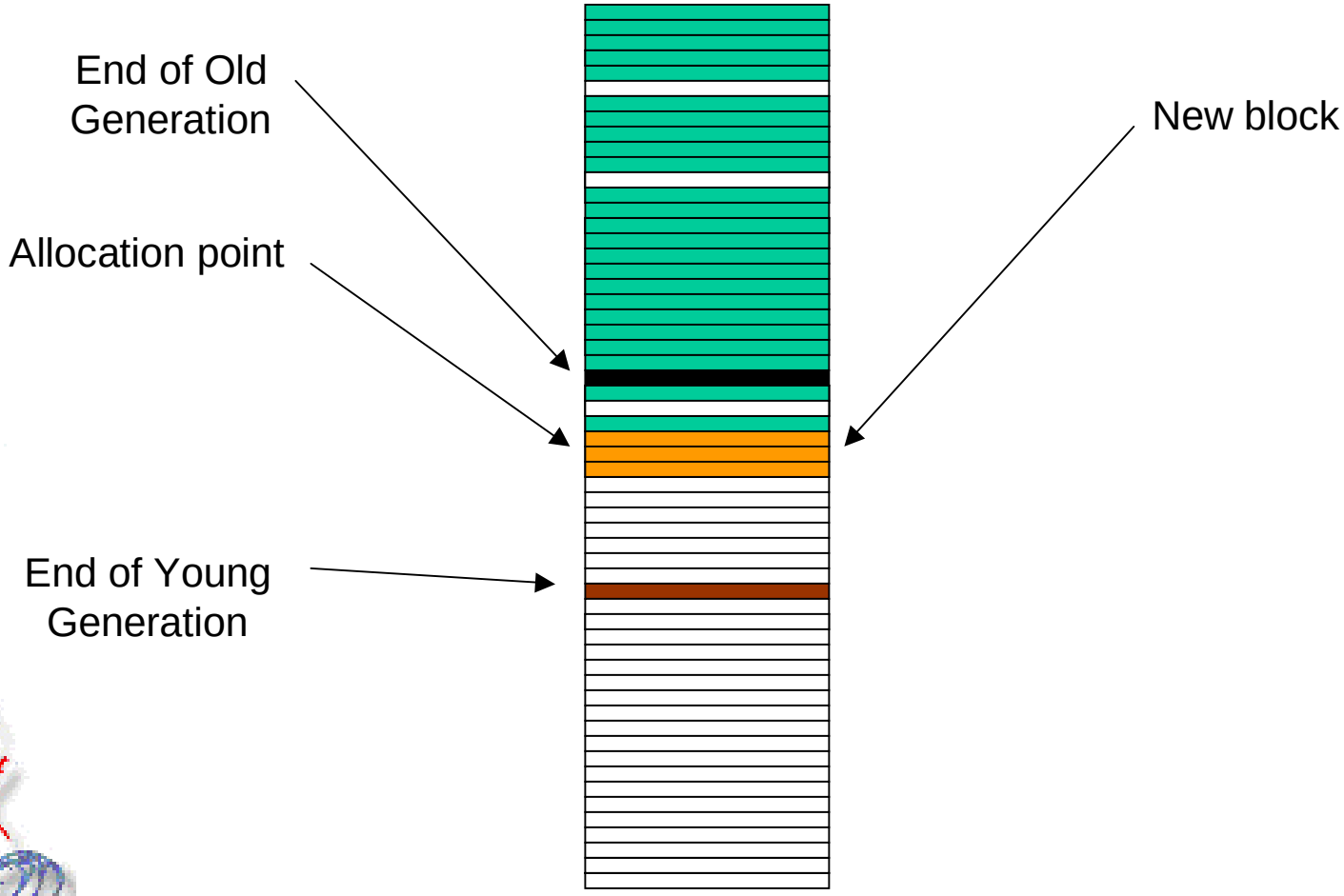

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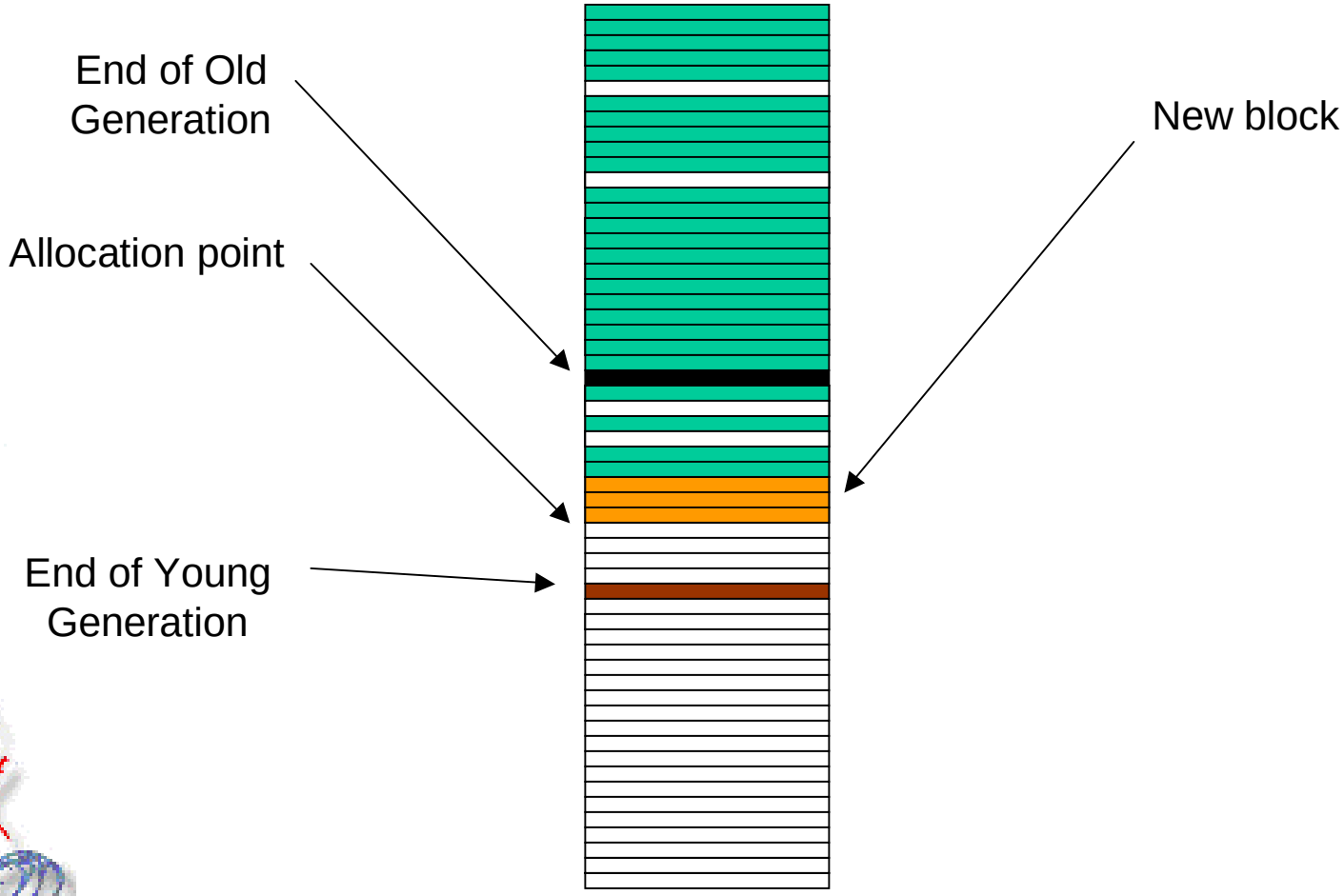

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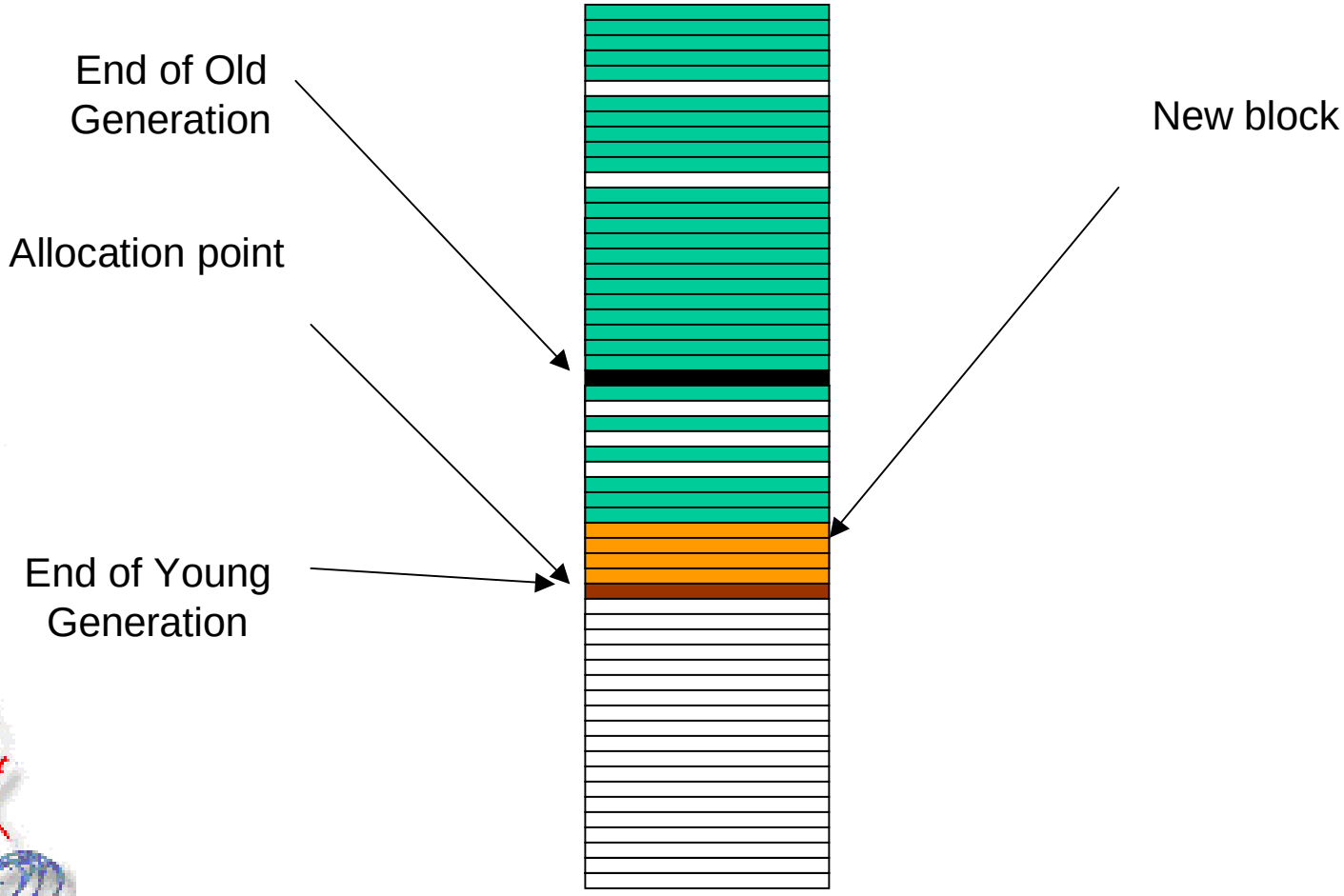

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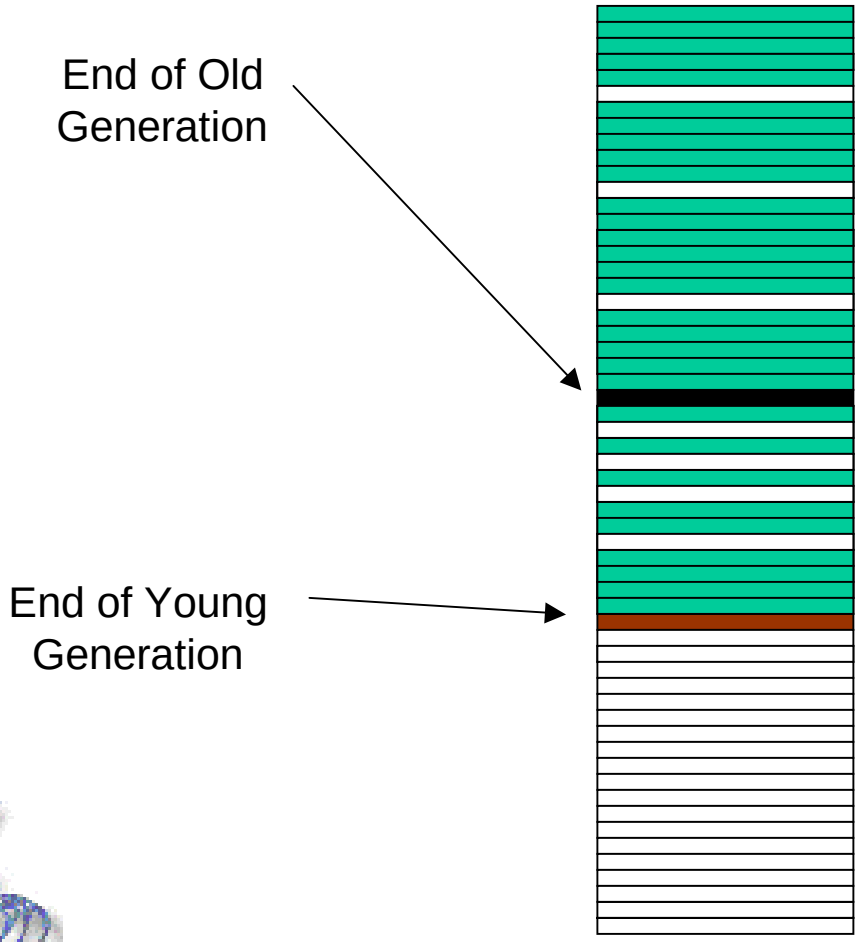

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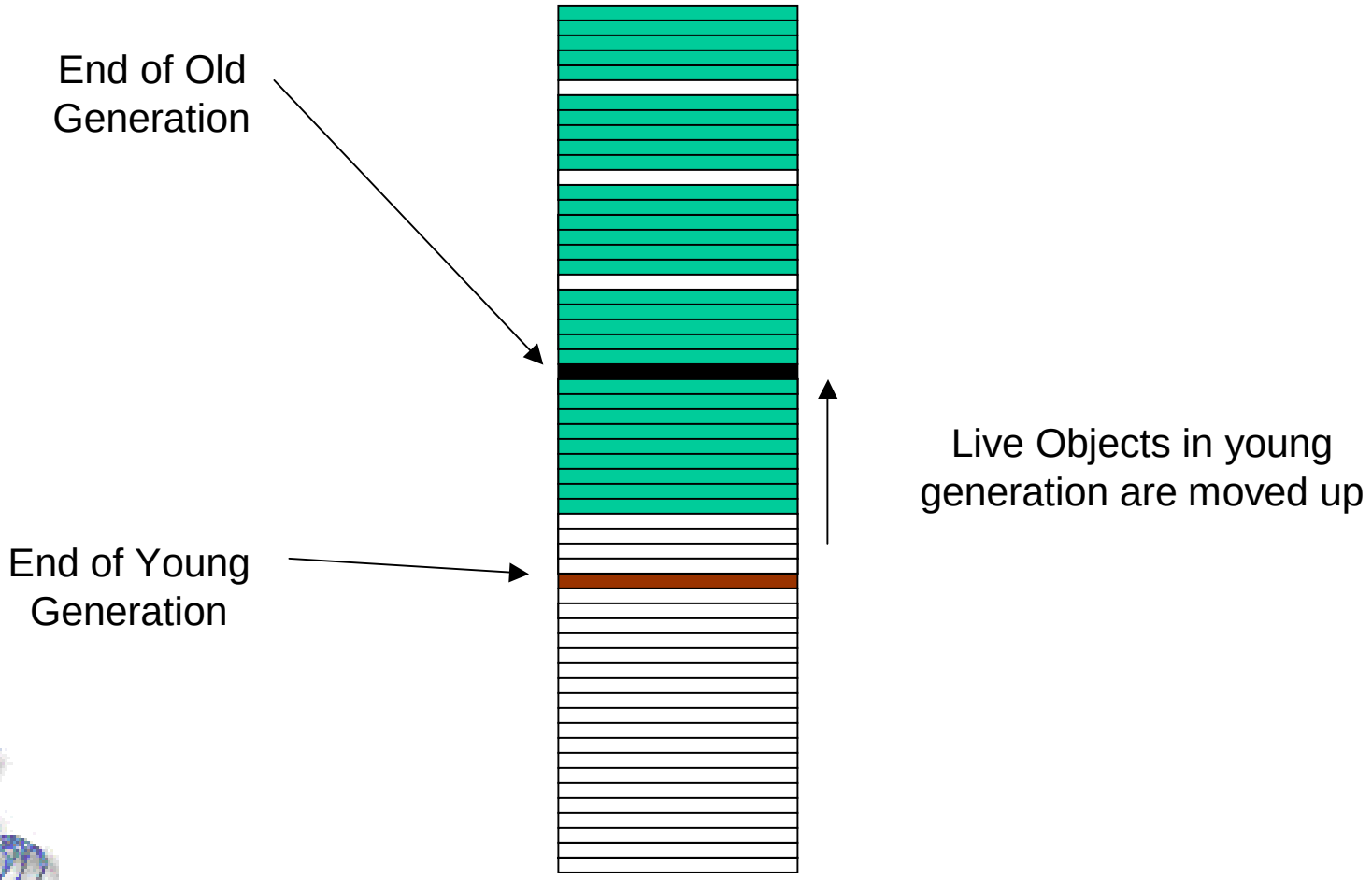

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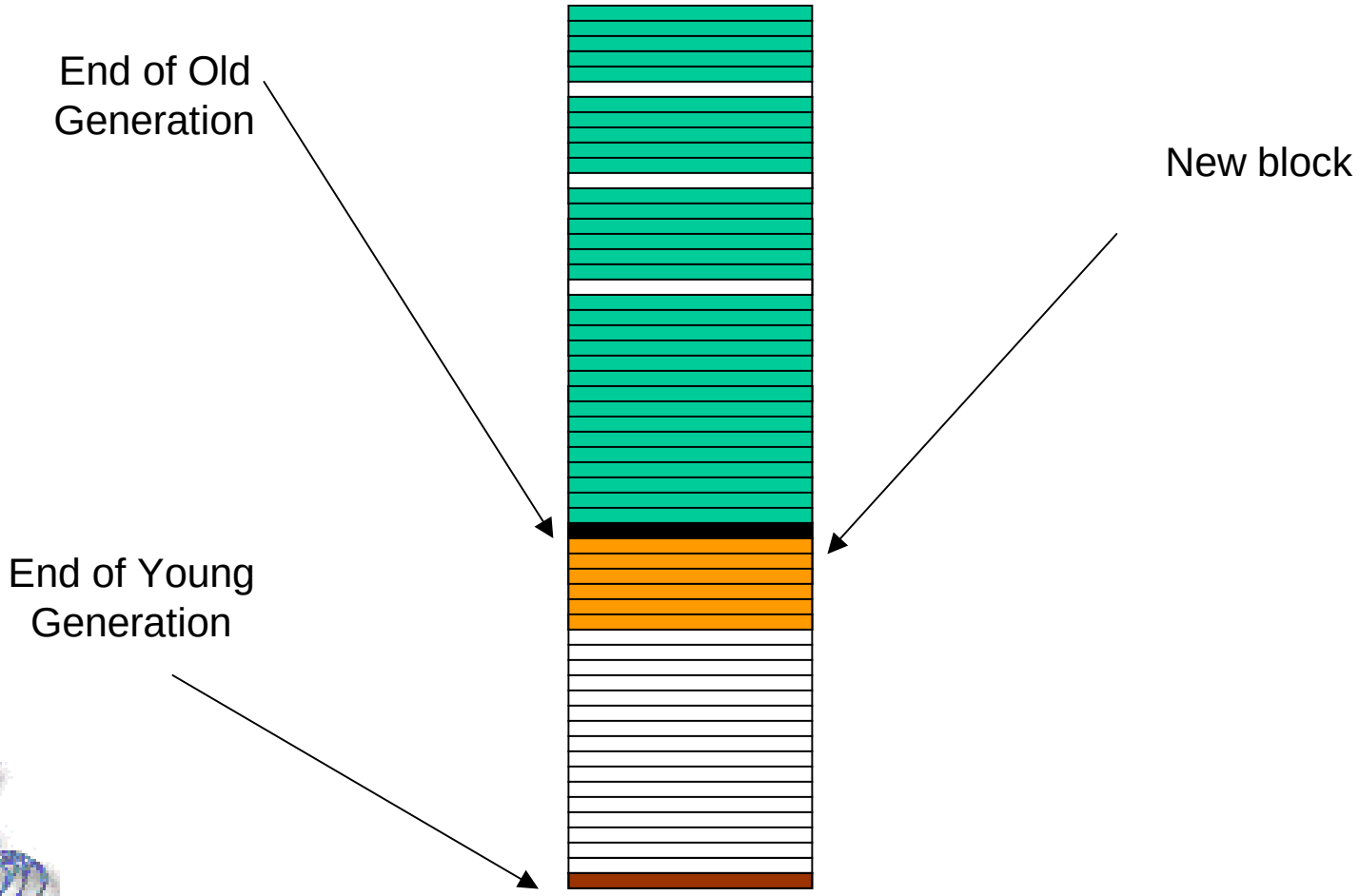

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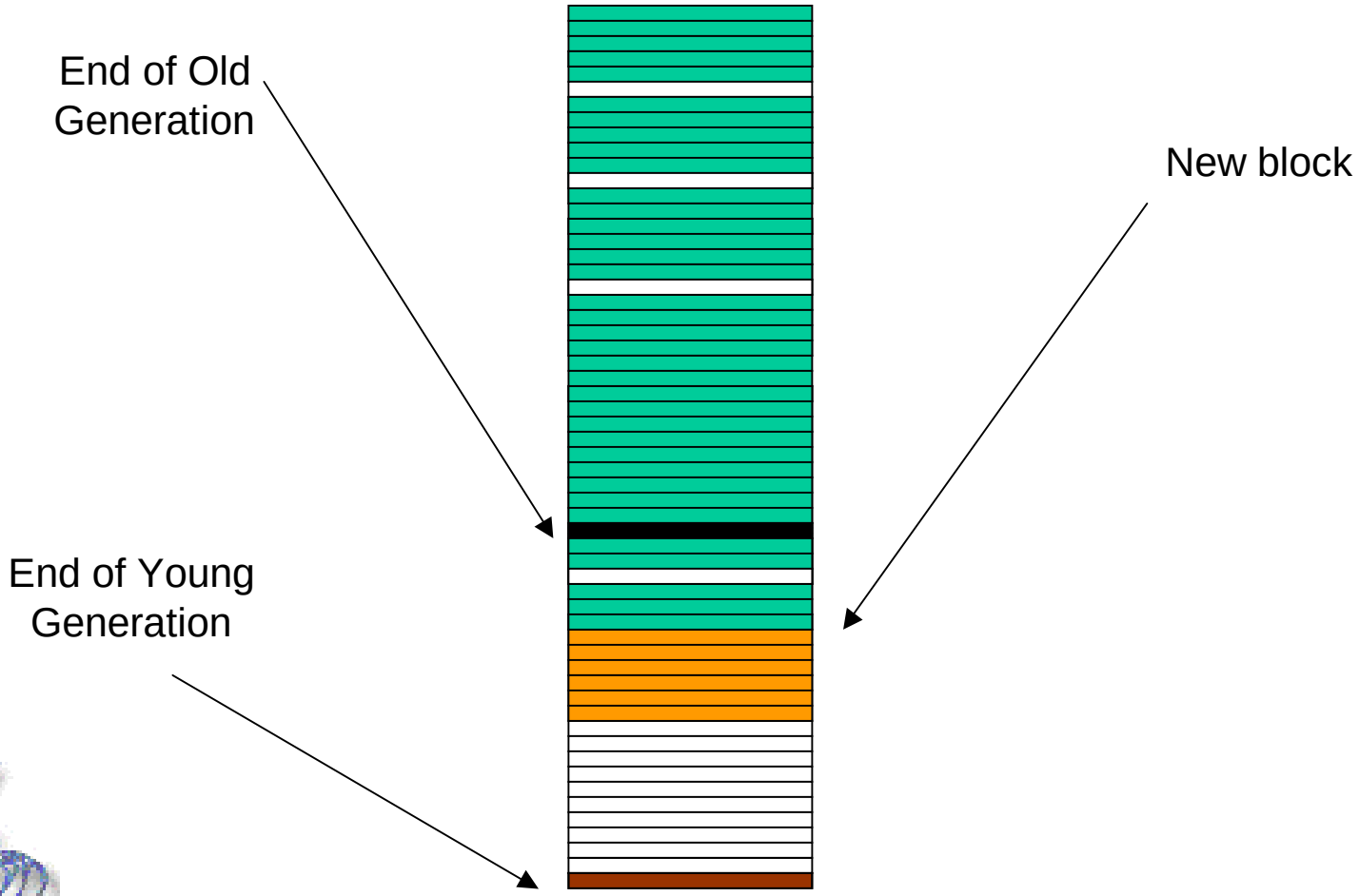

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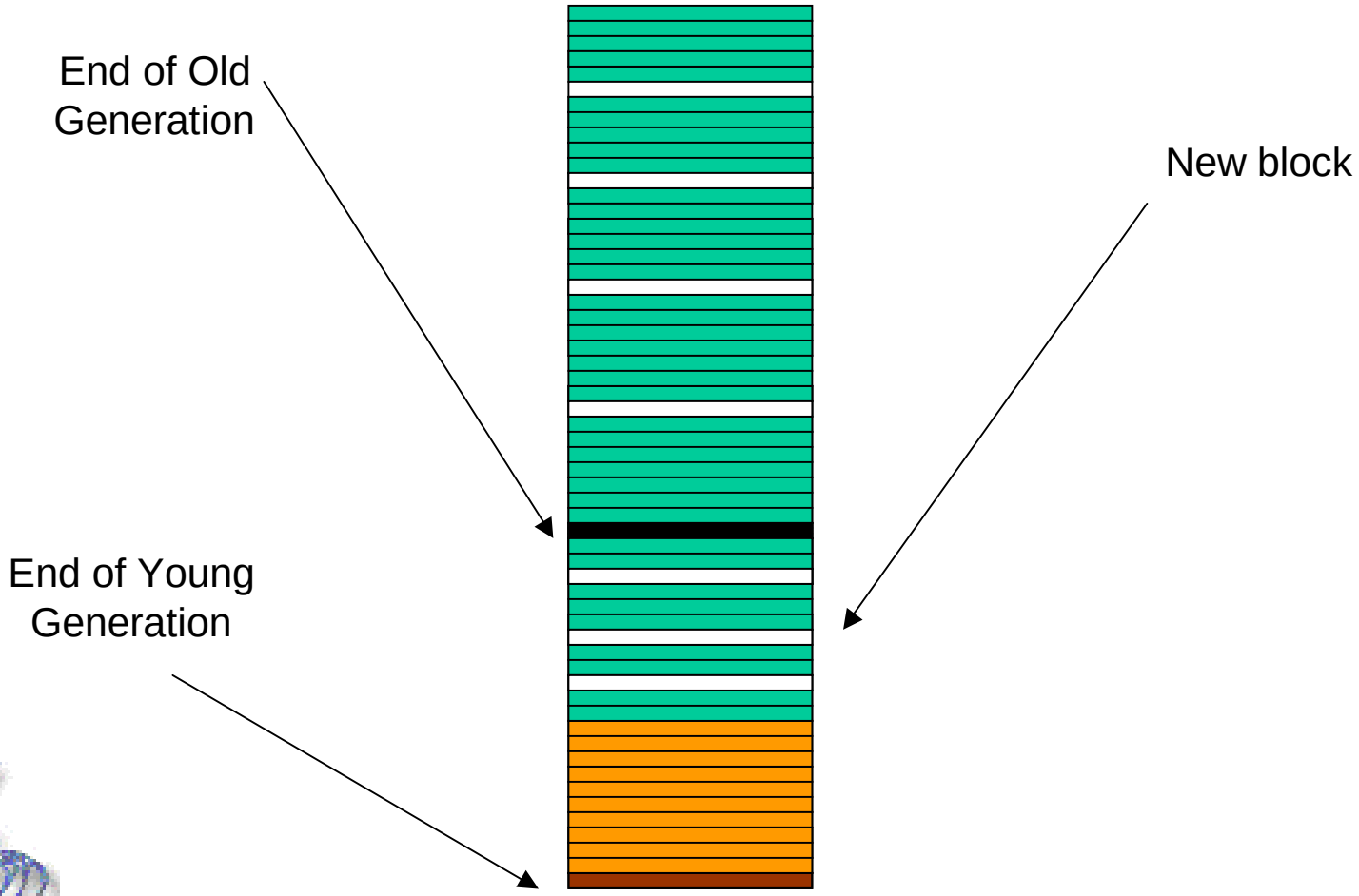

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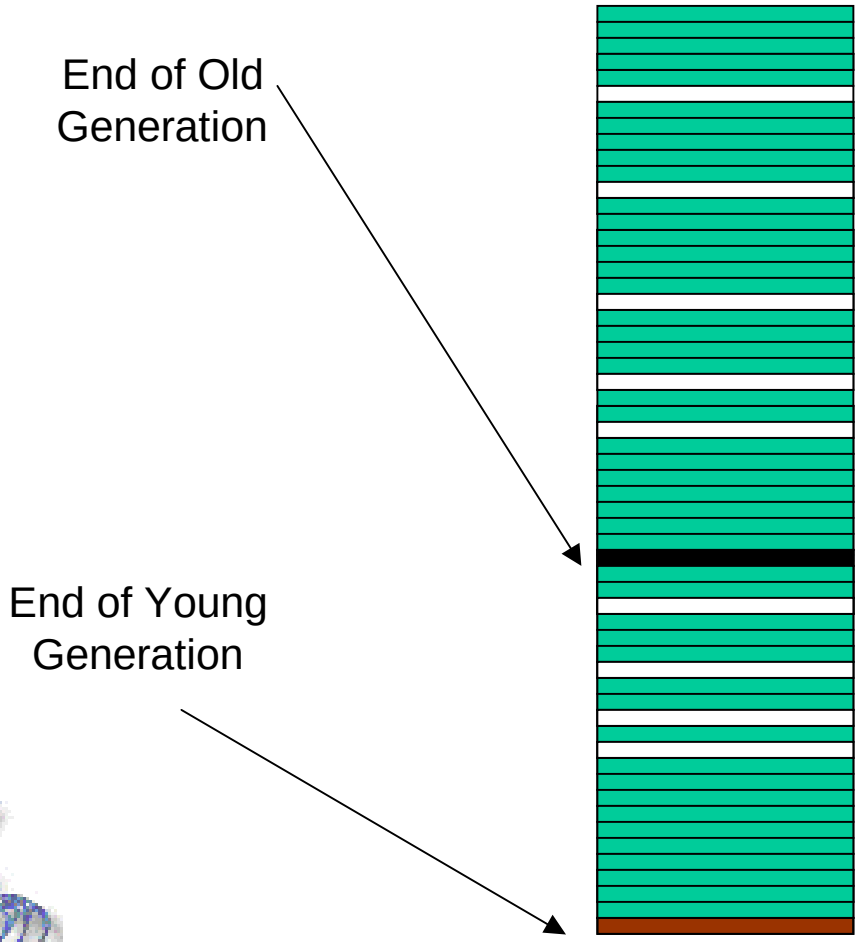
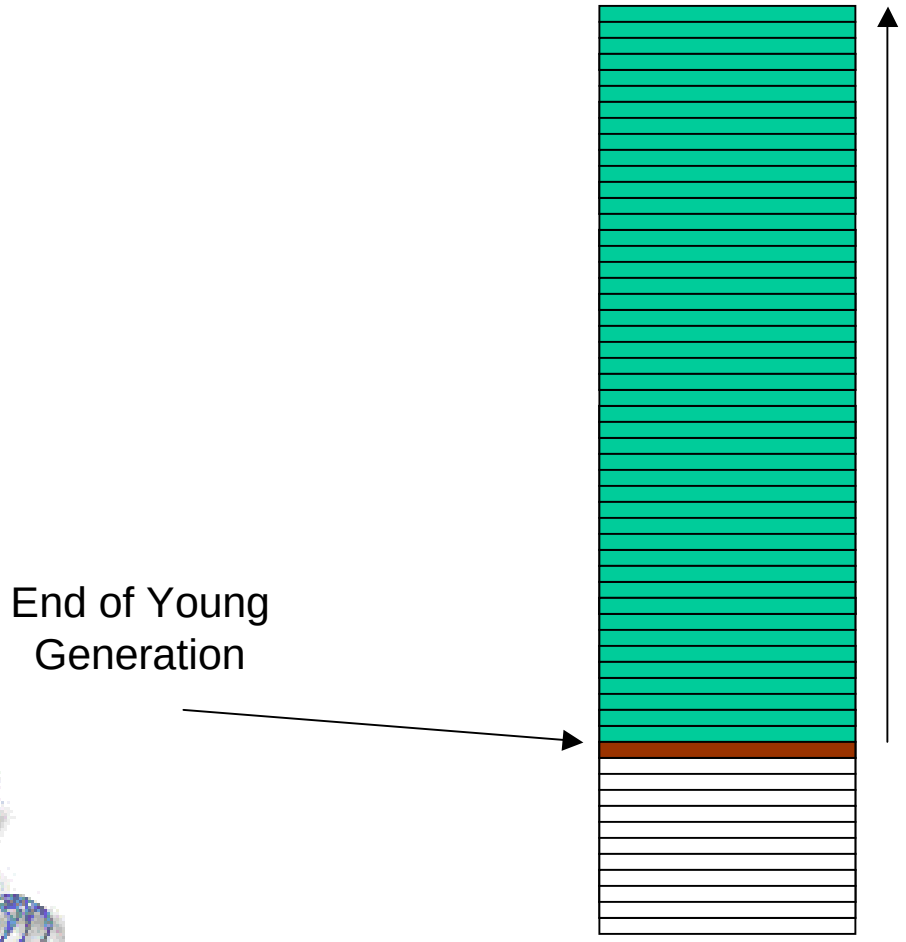


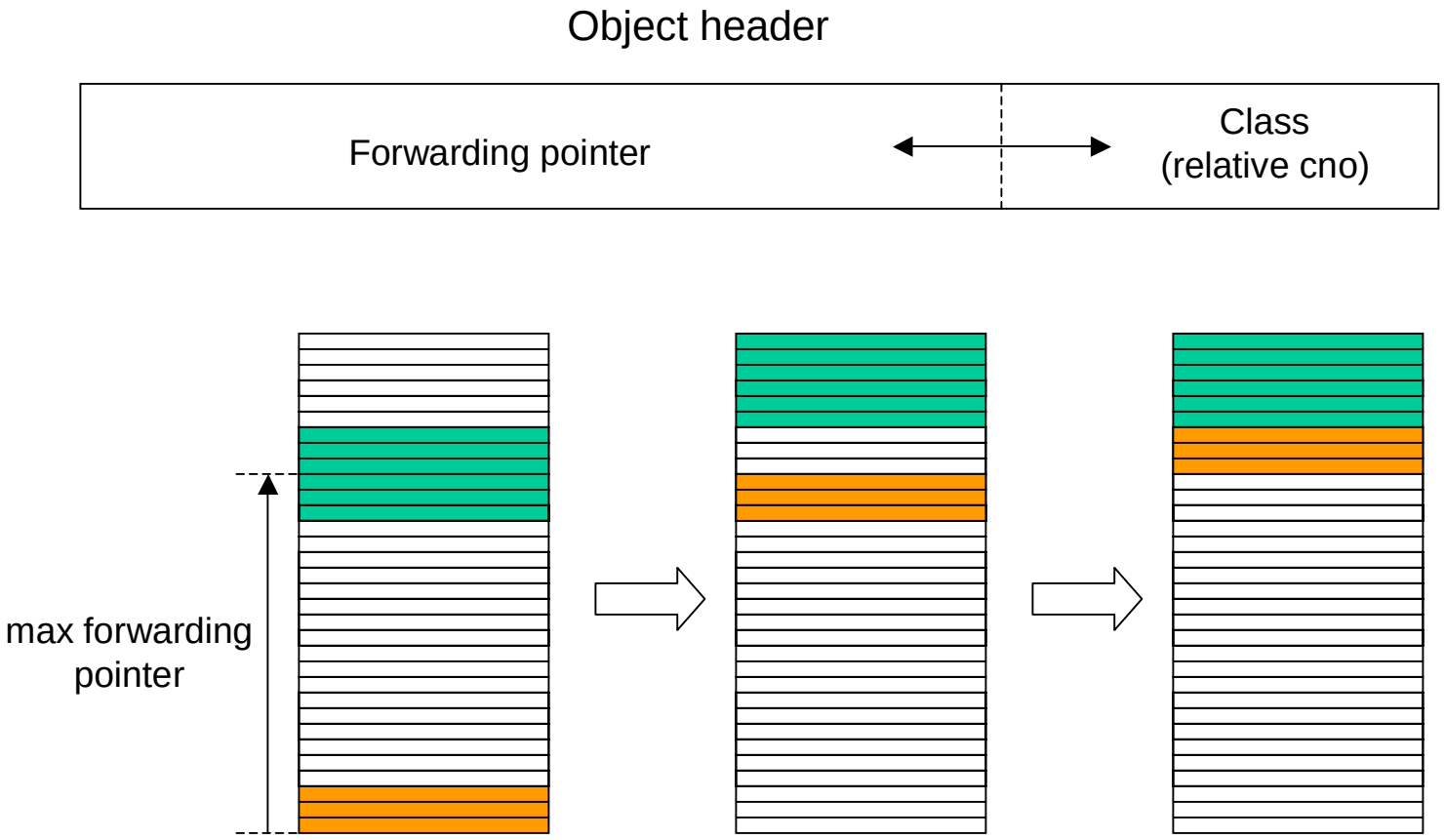
Full GC Required

RAM architecture



Live Objects in heap
generation are moved up

Collecting large heaps

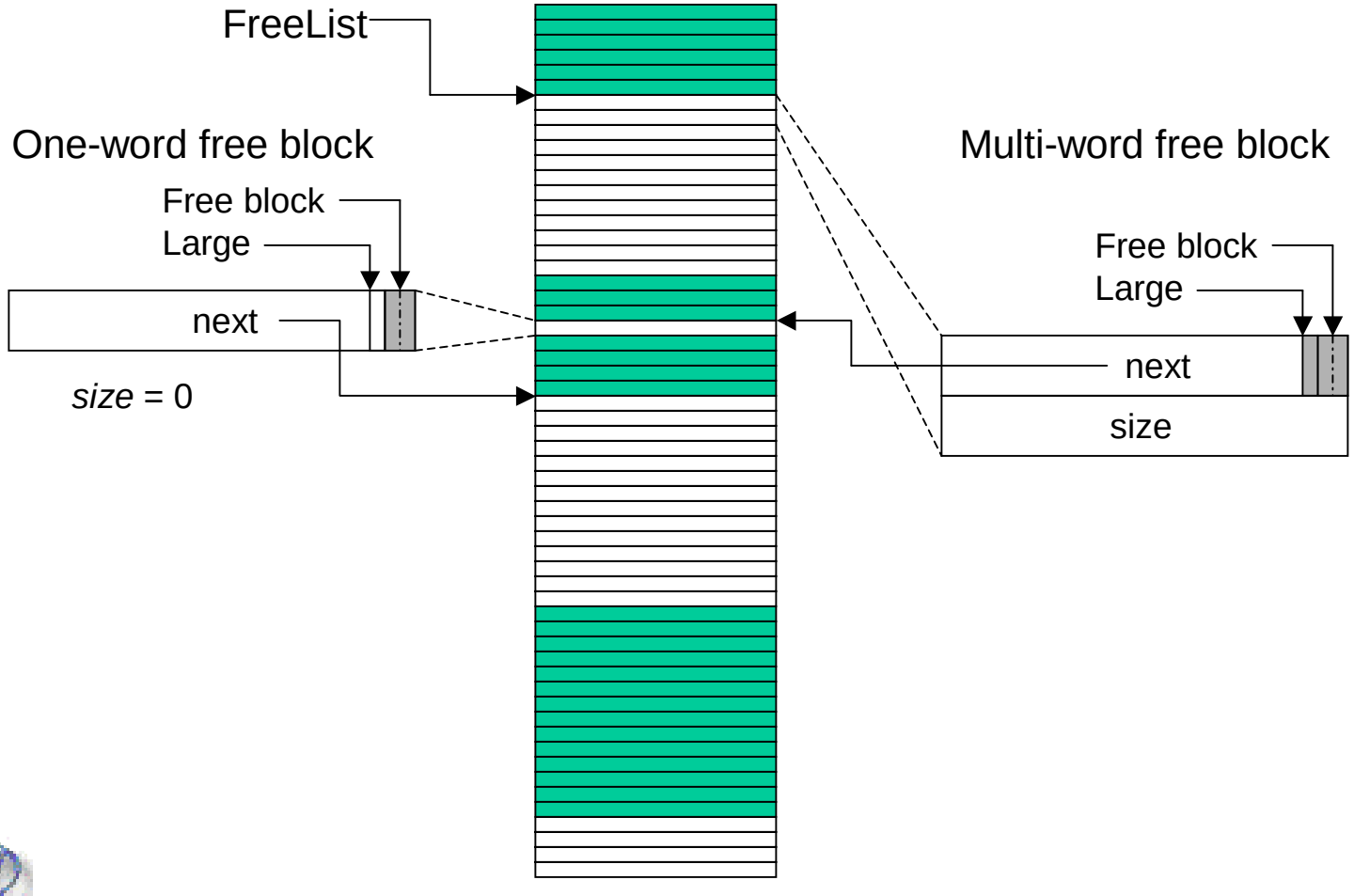


EEPROM

Design goals

- Object memory (i.e. not a file-system)
- Minimize EEPROM writes:
  - Use mark-sweep, *non-compacting* collector
  - Use free list for allocation
  - Doesn't automatically zero allocated blocks

EEPROM allocation



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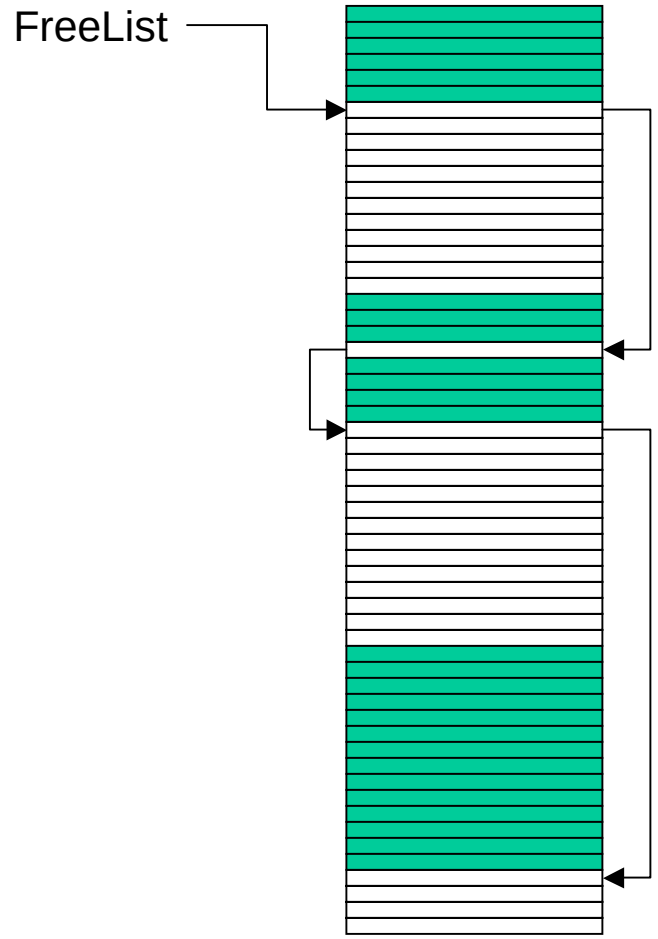
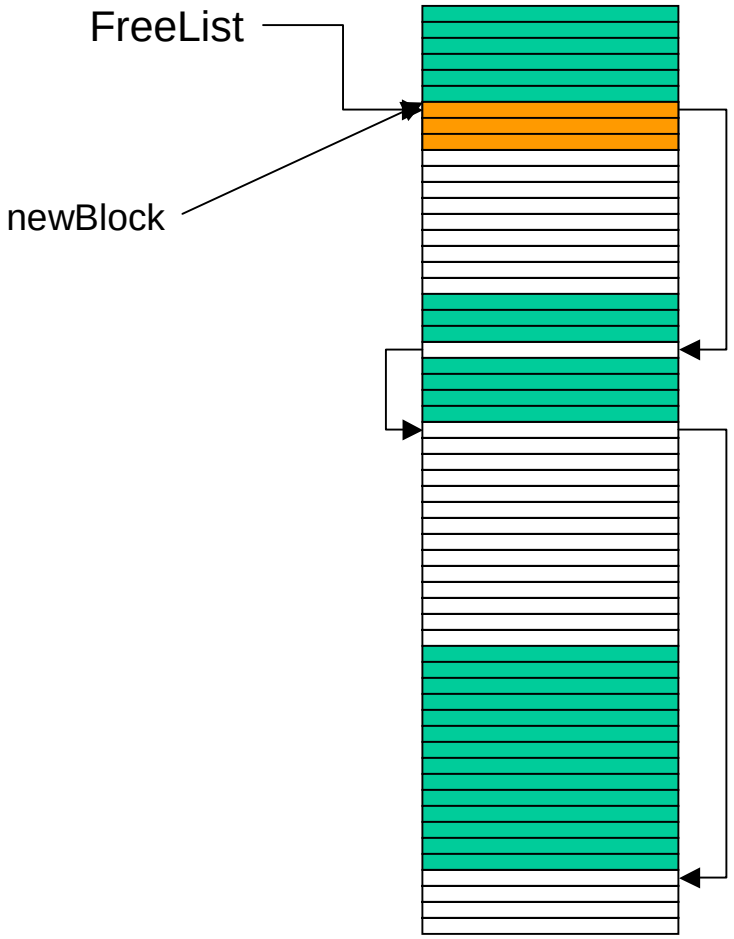


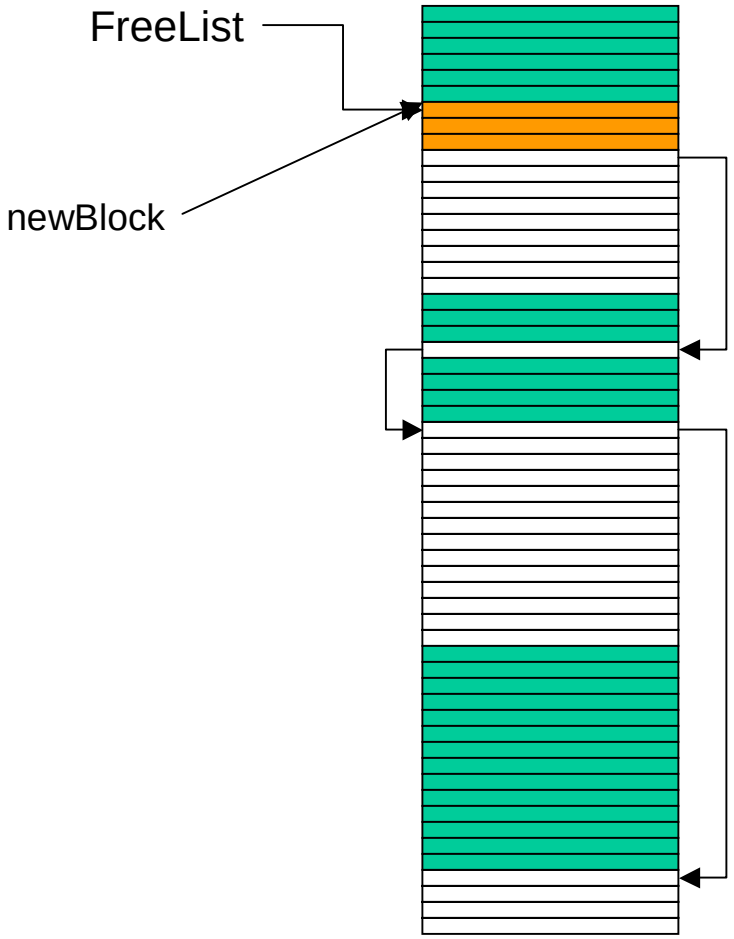
1. Allocate 12 bytes

EEPROM allocation



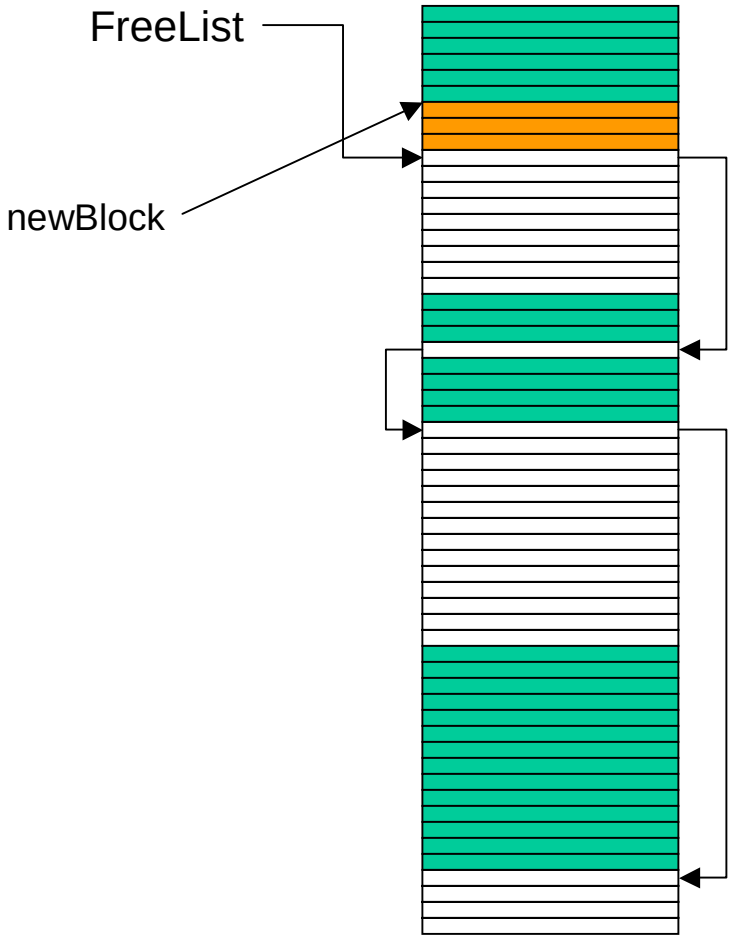
1. Allocate 12 bytes
2. Find chunk >= 12 bytes

EEPROM allocation



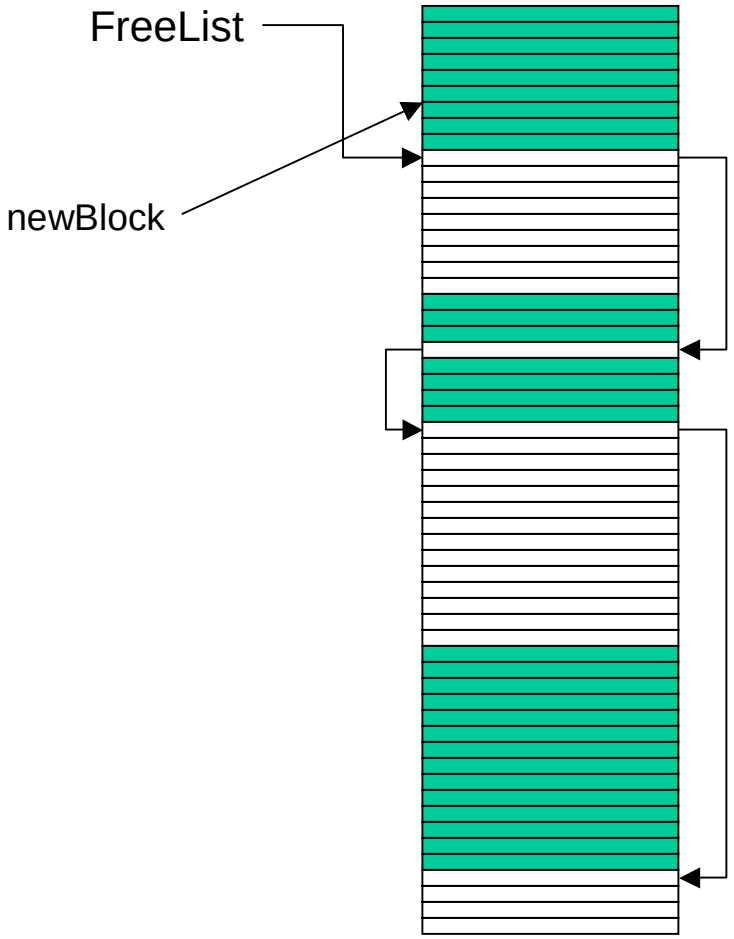
1. Allocate 12 bytes
2. Find chunk >= 12 bytes
3. Split chunk

EEPROM allocation



1. Allocate 12 bytes
2. Find chunk >= 12 bytes
3. Split chunk
4. Fix up free list

EEPROM allocation



1. Allocate 12 bytes
2. Find block >= 12 bytes
3. Split block
4. Fix up free list
5. Return new block

EEPROM collector

- Primary goal is to minimize EEPROM writes.
- Uses 2 RAM data structures:
  1. Bit vector for marking → requires 3% EEPROM length
  2. Small stack to limit recursion (~ 20 bytes)

- Persistent GC is only run at well known points when RAM is always available
- Collector auto restarts if interrupted by power tear (via invalidating free list pointer)

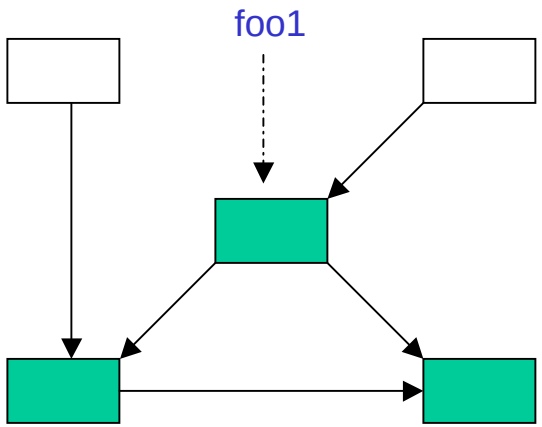
Copying to EEPROM

Copying to EEPROM

```
Foo foo2 = (Foo)PersistentMemory.makePersistentCopy(foo1);
```

RAM

EEPROM



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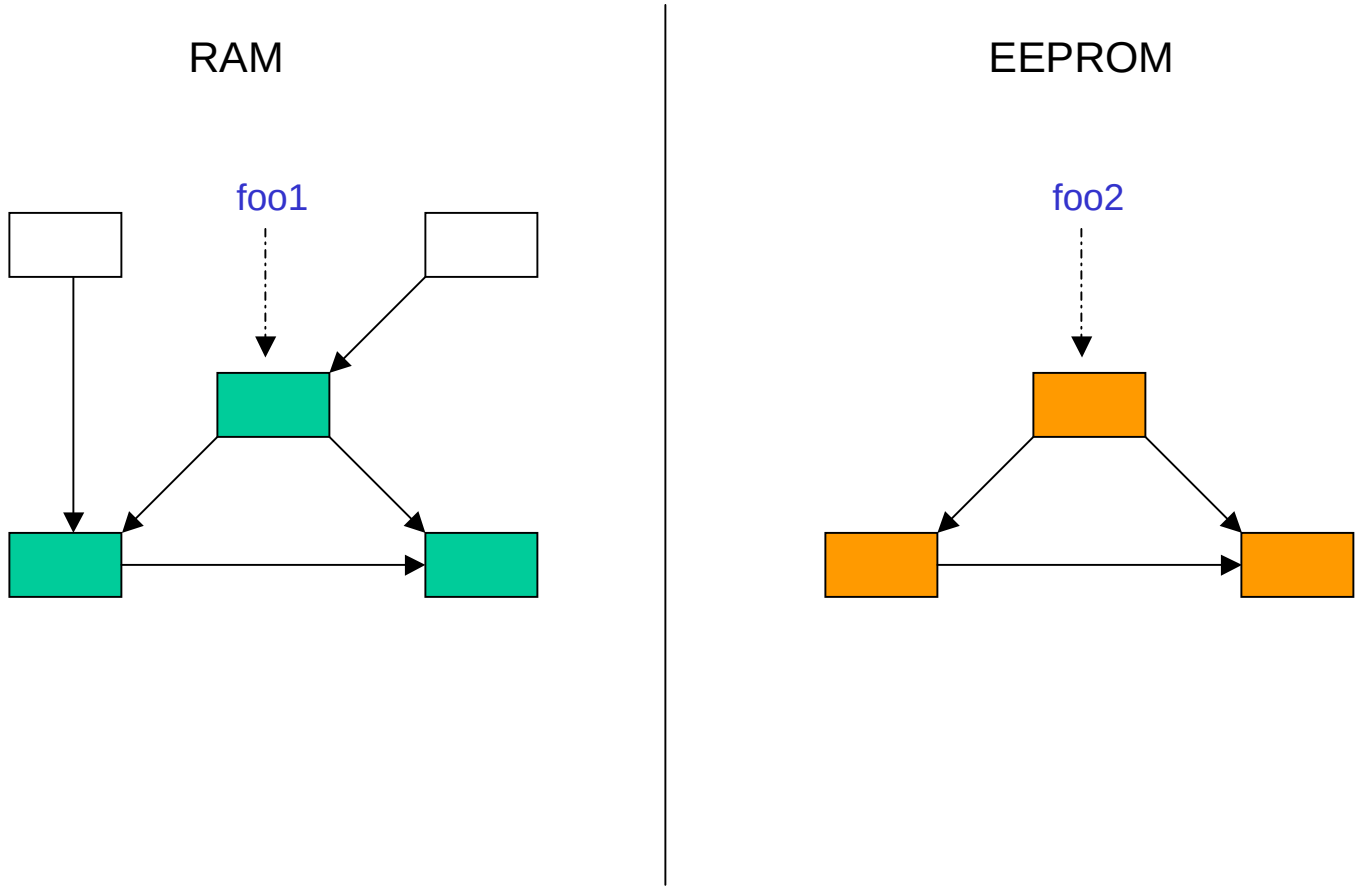


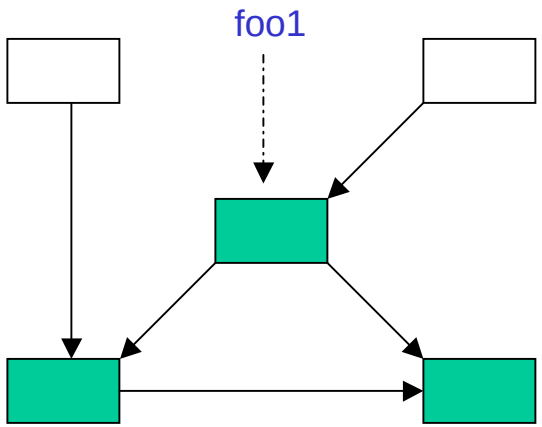
Migrating to EEPROM

Migrating to EEPROM

PersistentMemory.makePersistent(foo1);

RAM

EEPROM



Migrating to EEPROM

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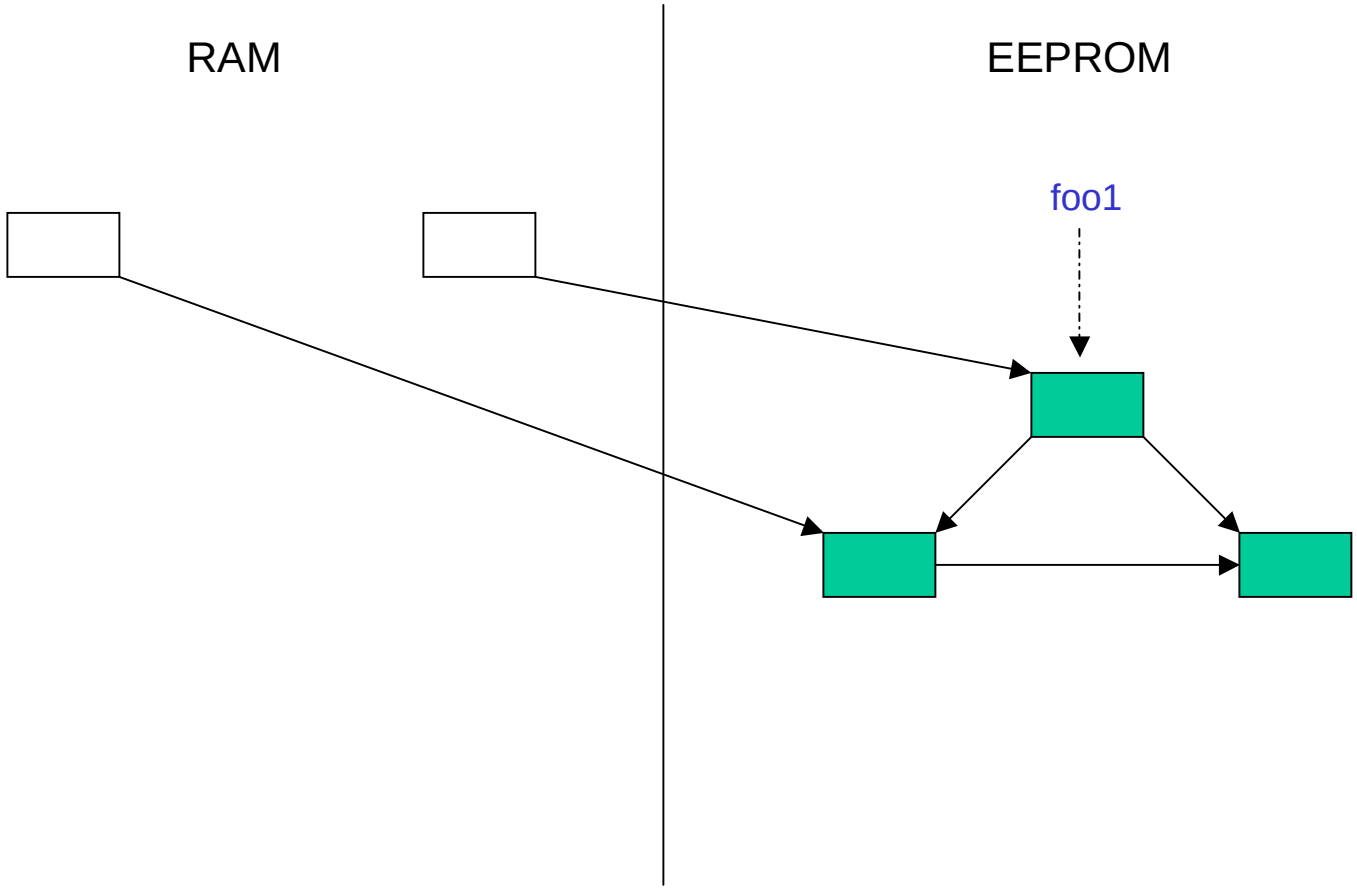
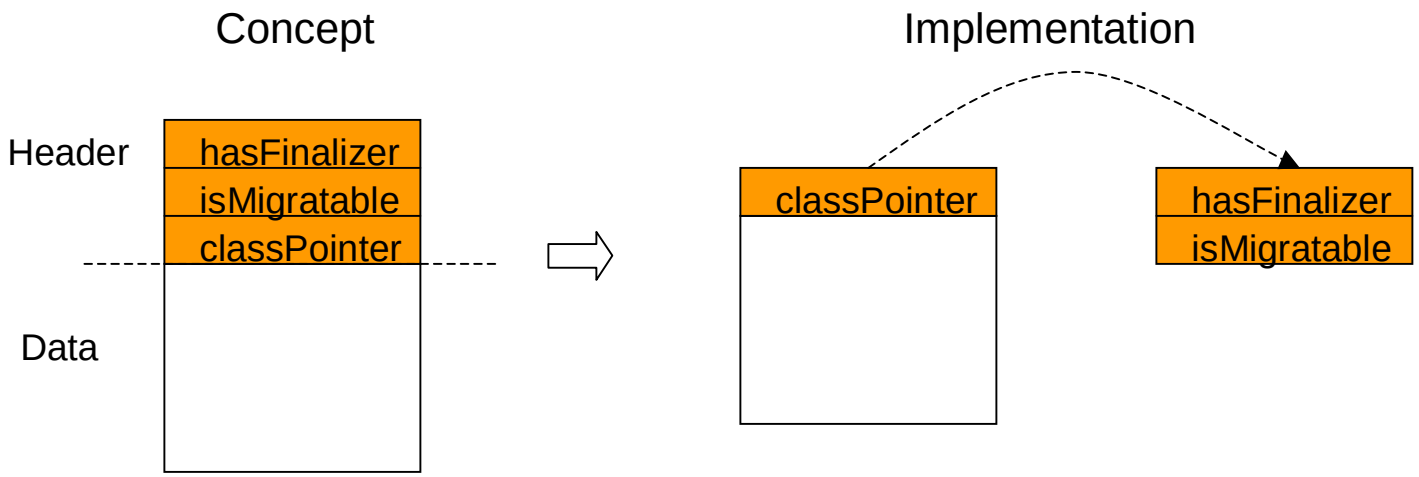


Finalizers and Auto-migration

- Implemented with object associations
- Associations maintained by garbage collector
- Associations created “on-demand” and are rare



Finalizers

- Objects queued for finalization by collector
- Finalizers run at context switch:
  1. `Thread.yield()`
  2. `Thread.sleep()`
  3. Thread dies
- Separate thread for each finalizer – safer!

Auto-migration

```
PersistentMemory.allowMigration(Object obj)
```

- Collector migrates marked objects to EEPROM while insufficient memory reclaimed
- Persistent collector must later be run to reclaim auto-migrated objects