Improving Pharo Snapshots

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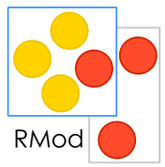

2022 VM+ Team


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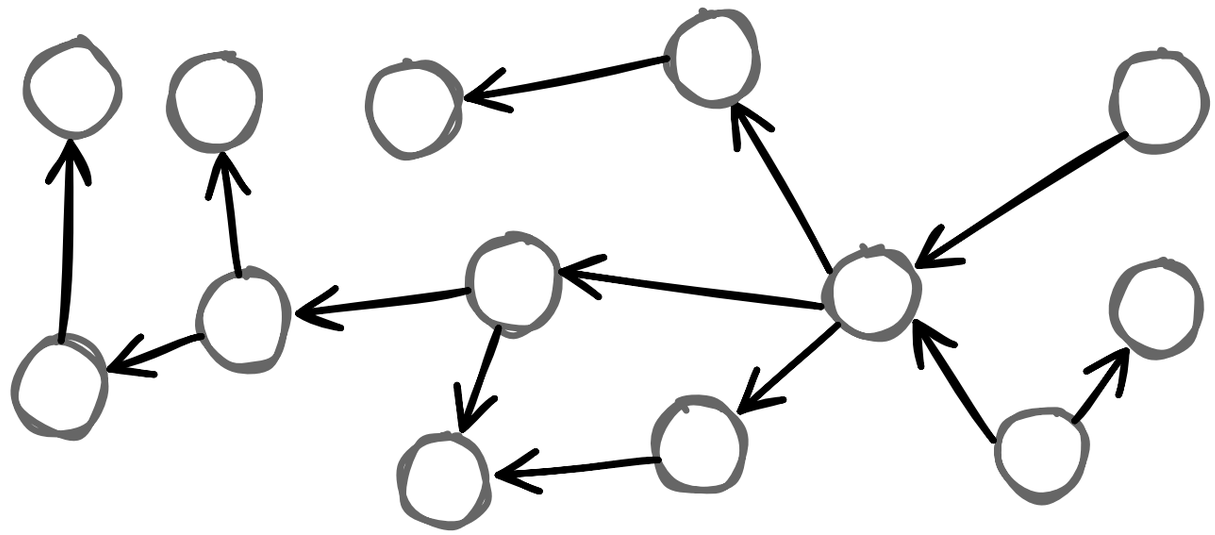
Everything is an Object

- Numbers
- Characters
- Strings
- Arrays



Everything is an Object

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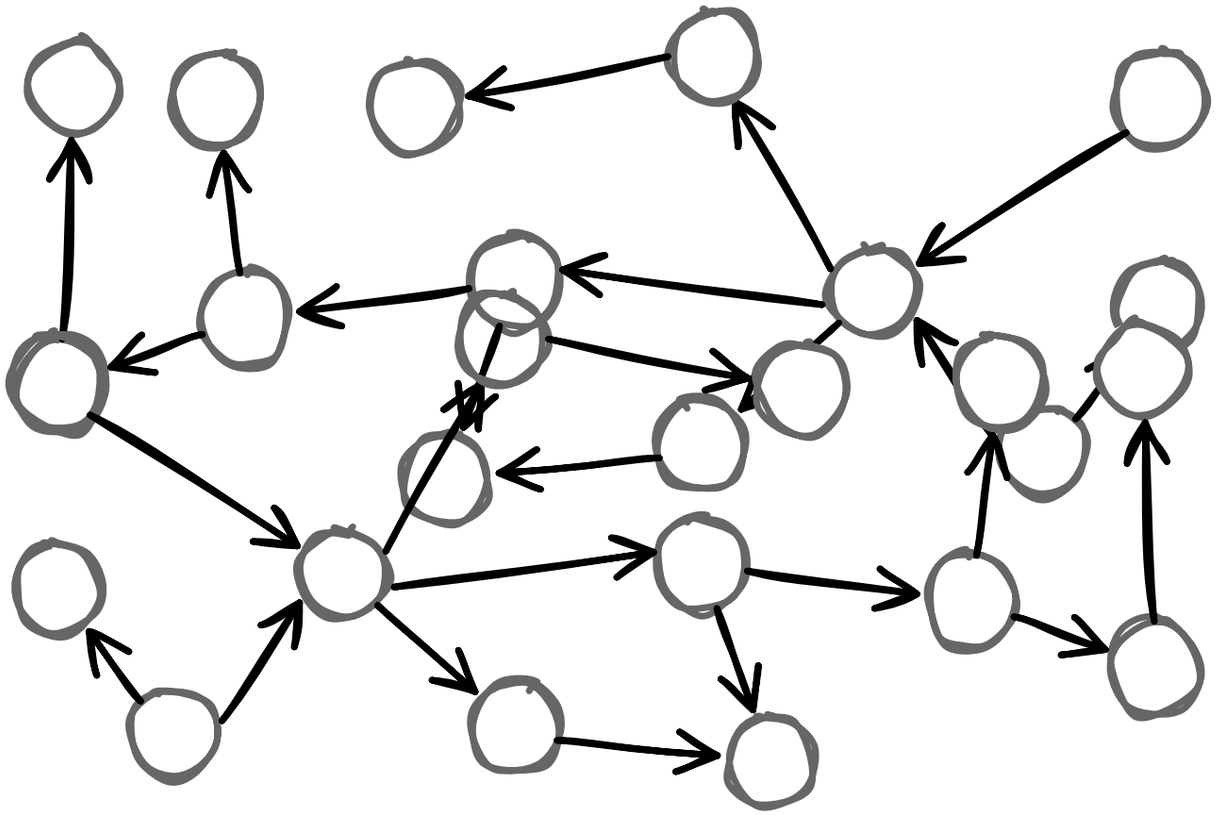

Everything is an Object

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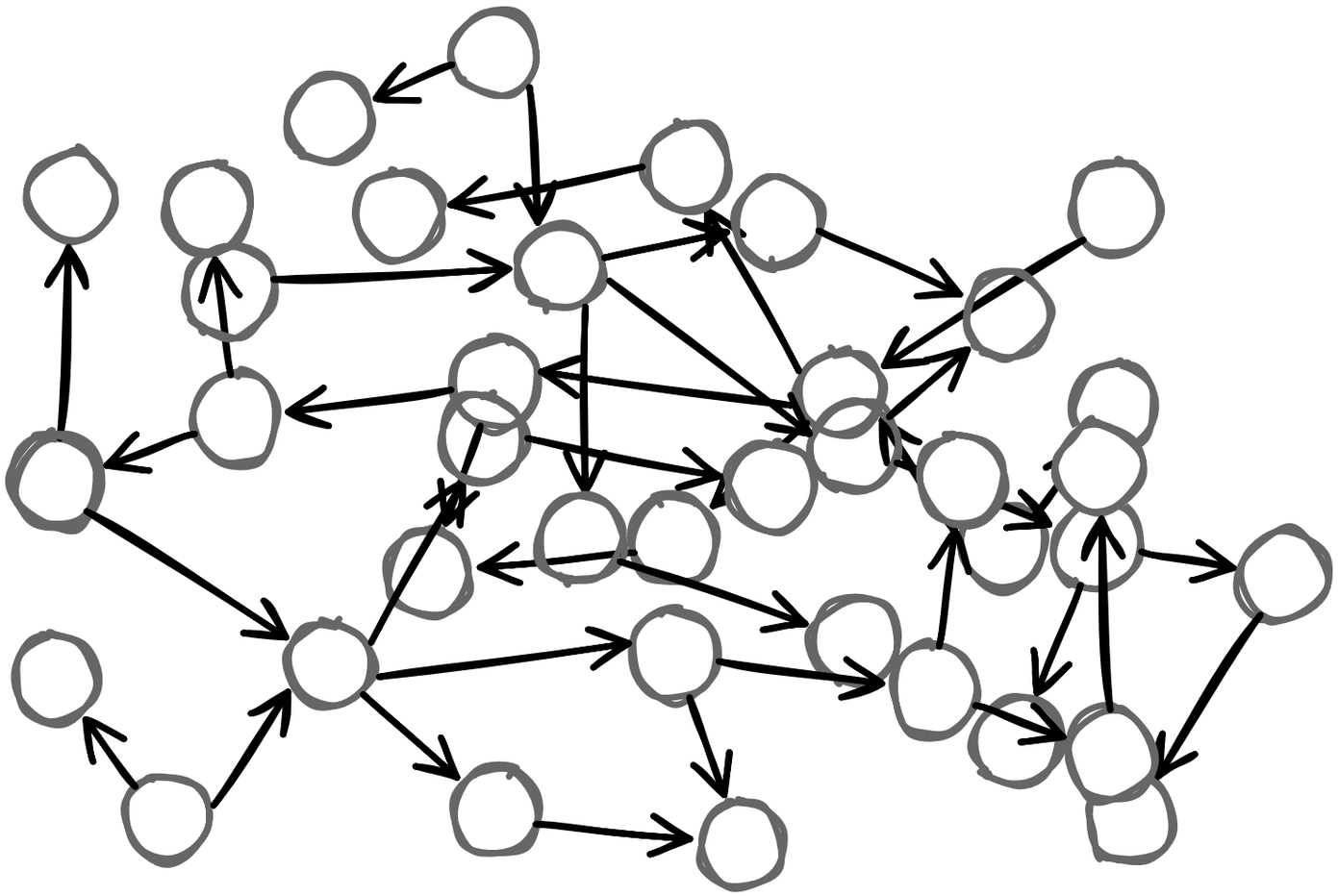
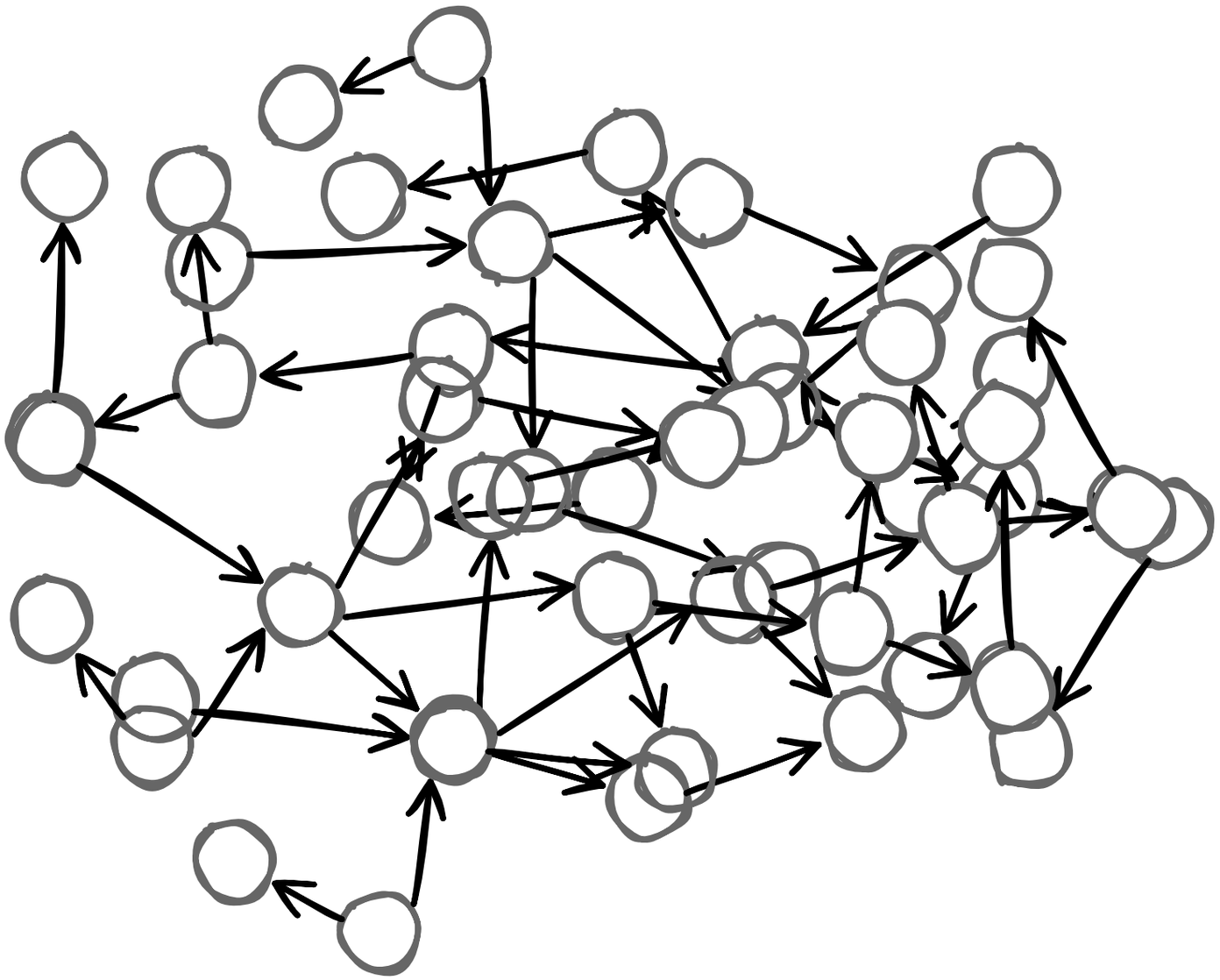
- Classes



Everything is an Object

- Numbers
- Characters
- Strings
- Arrays
- Closures
- Classes
- Methods



Everything is an Object

- Numbers
- Characters
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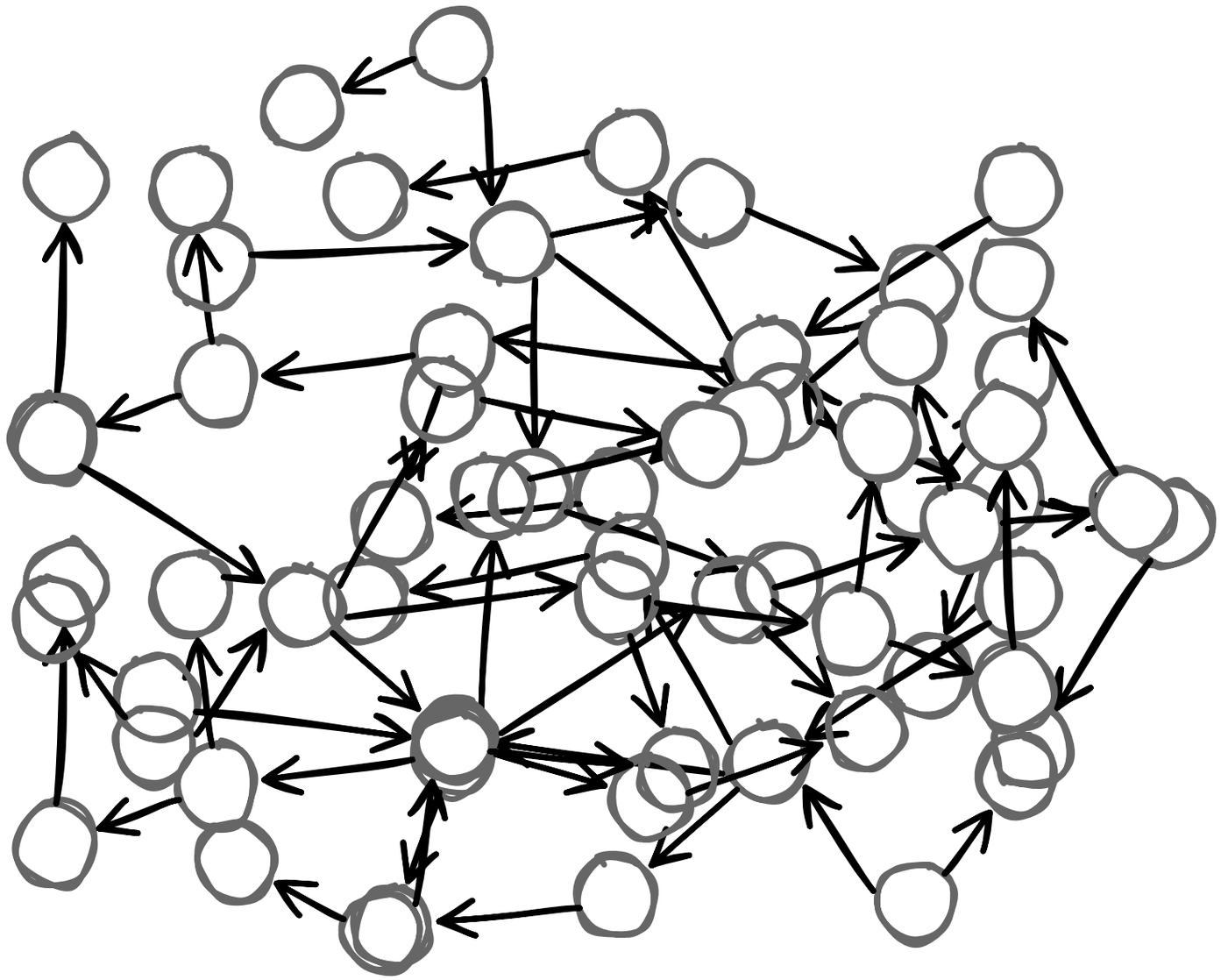
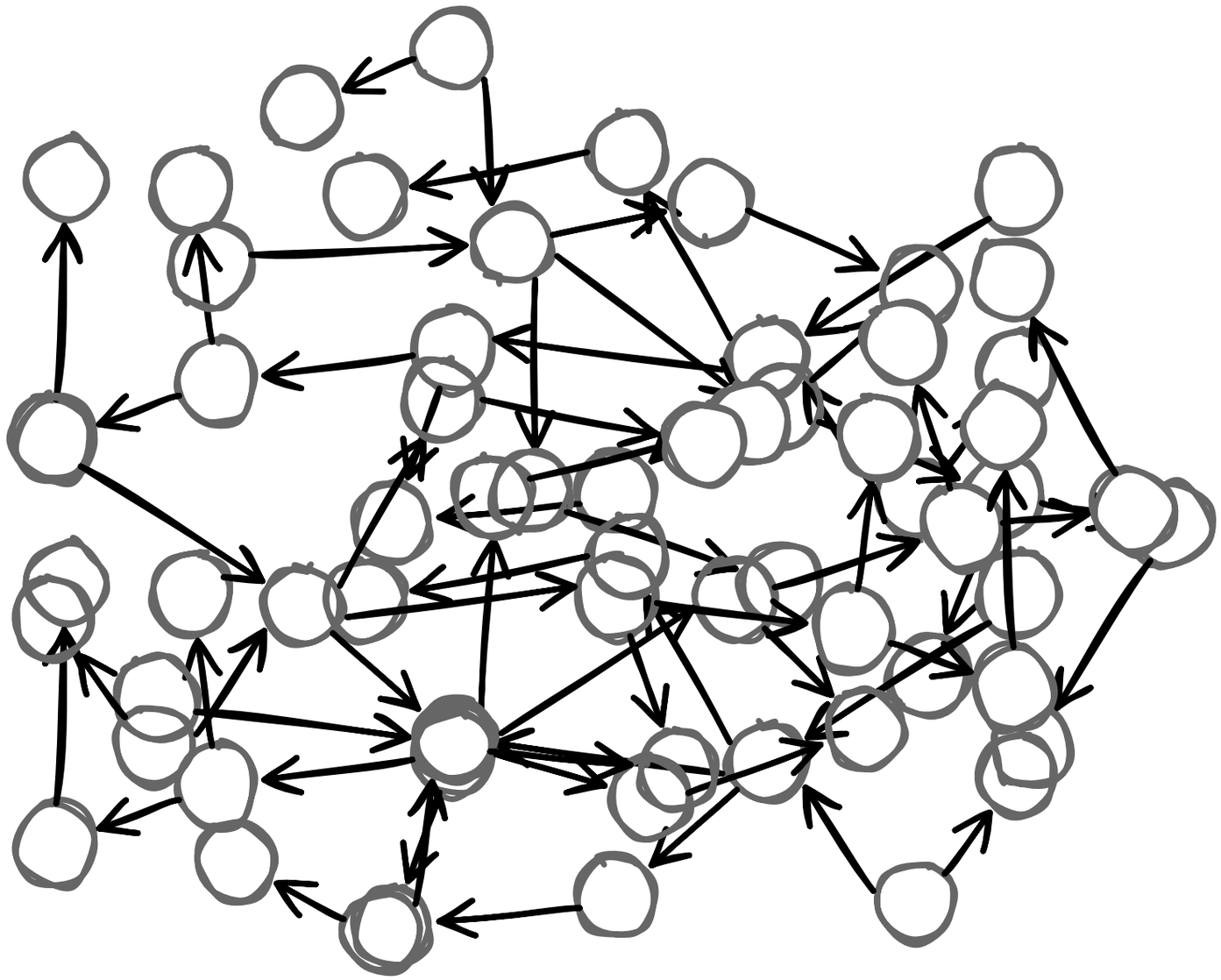
- Arrays
- Closures
- Classes
- Methods
- …



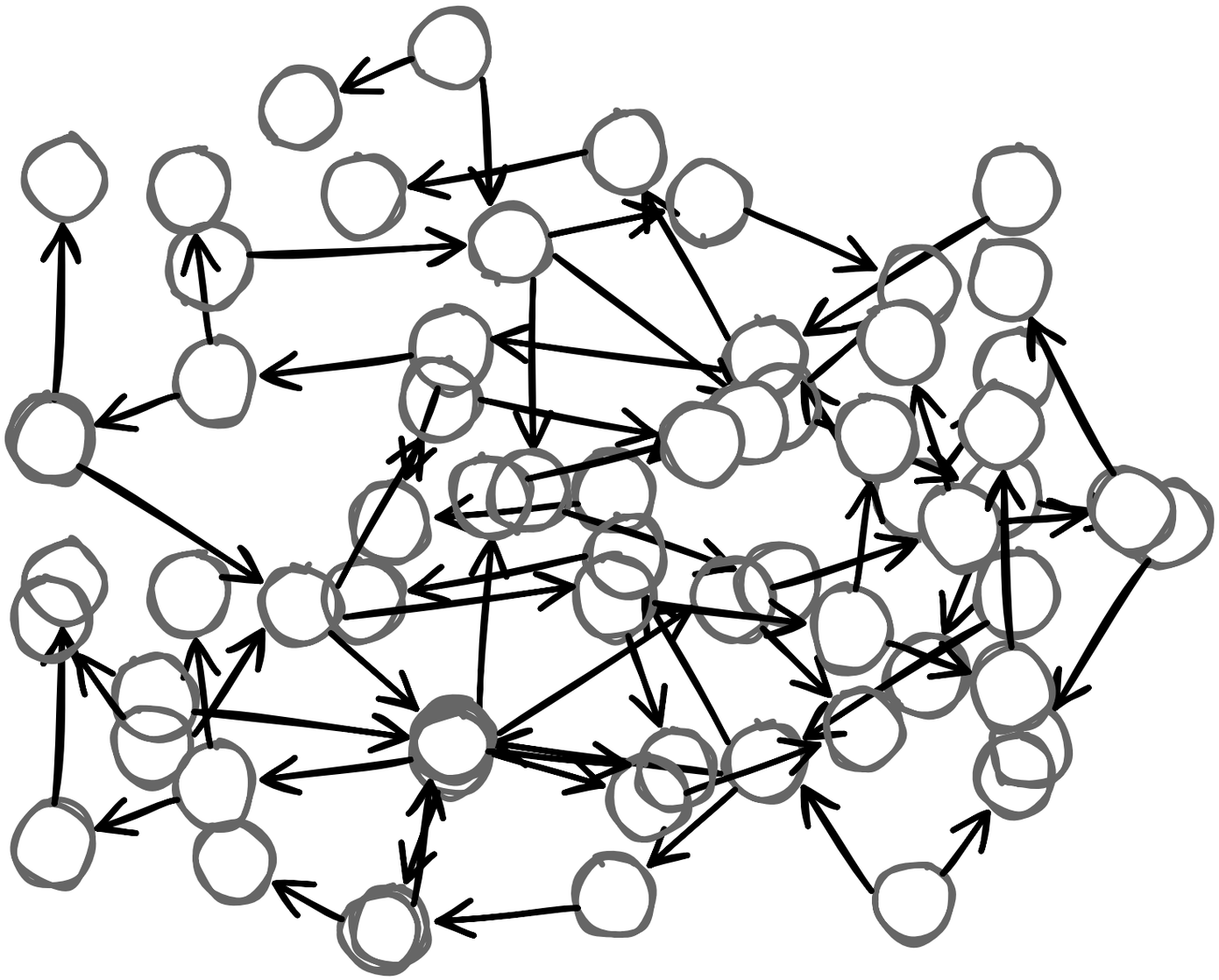
Lots of Objects

- Numbers
- Characters
- Strings
- Arrays
- Closures
- Classes
- Methods
- …



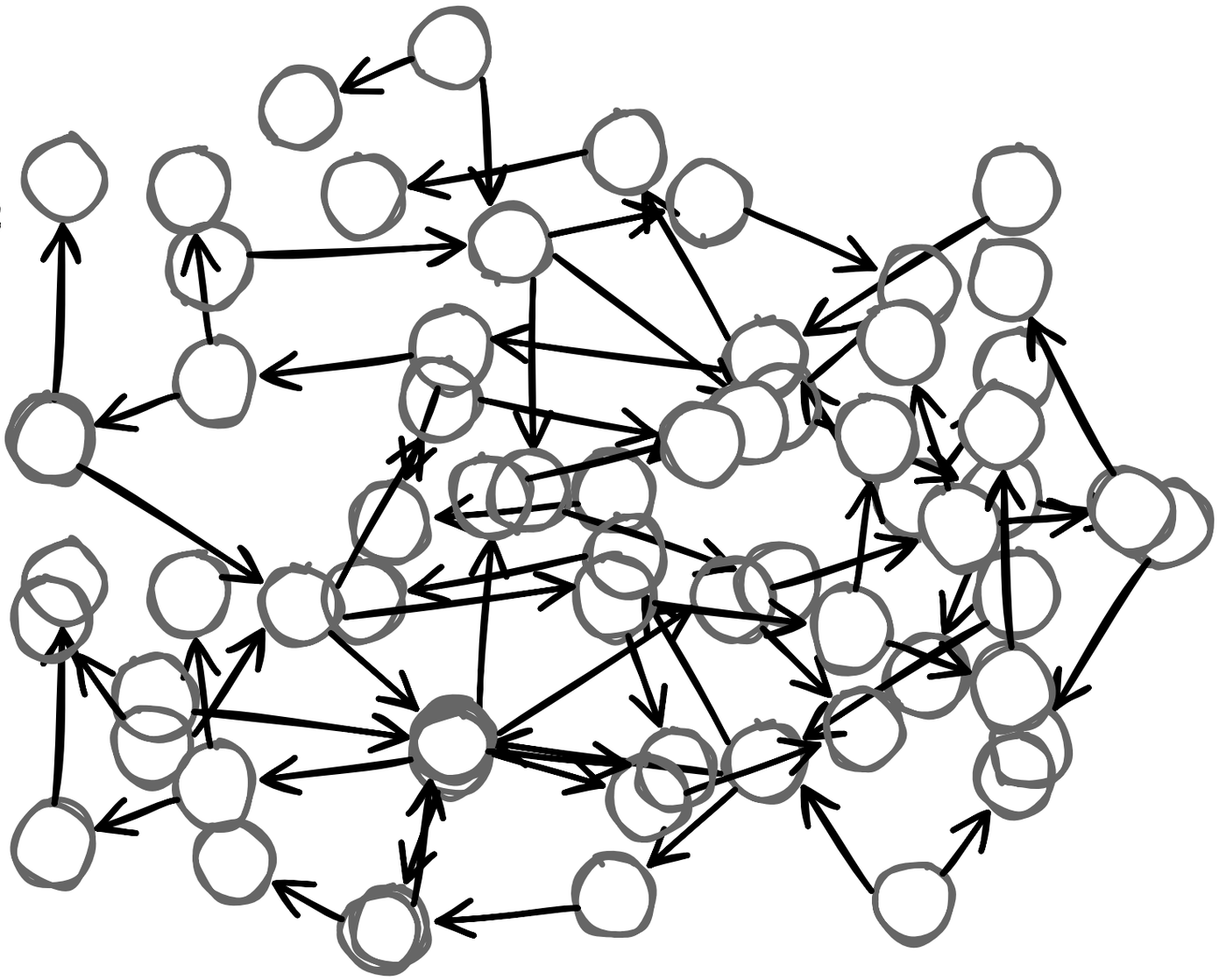
~~Lots of Objects~~
Lots of Stress

- Numbers
- Characters
- Strings
- Arrays
- Closures
- Classes
- Methods
- …



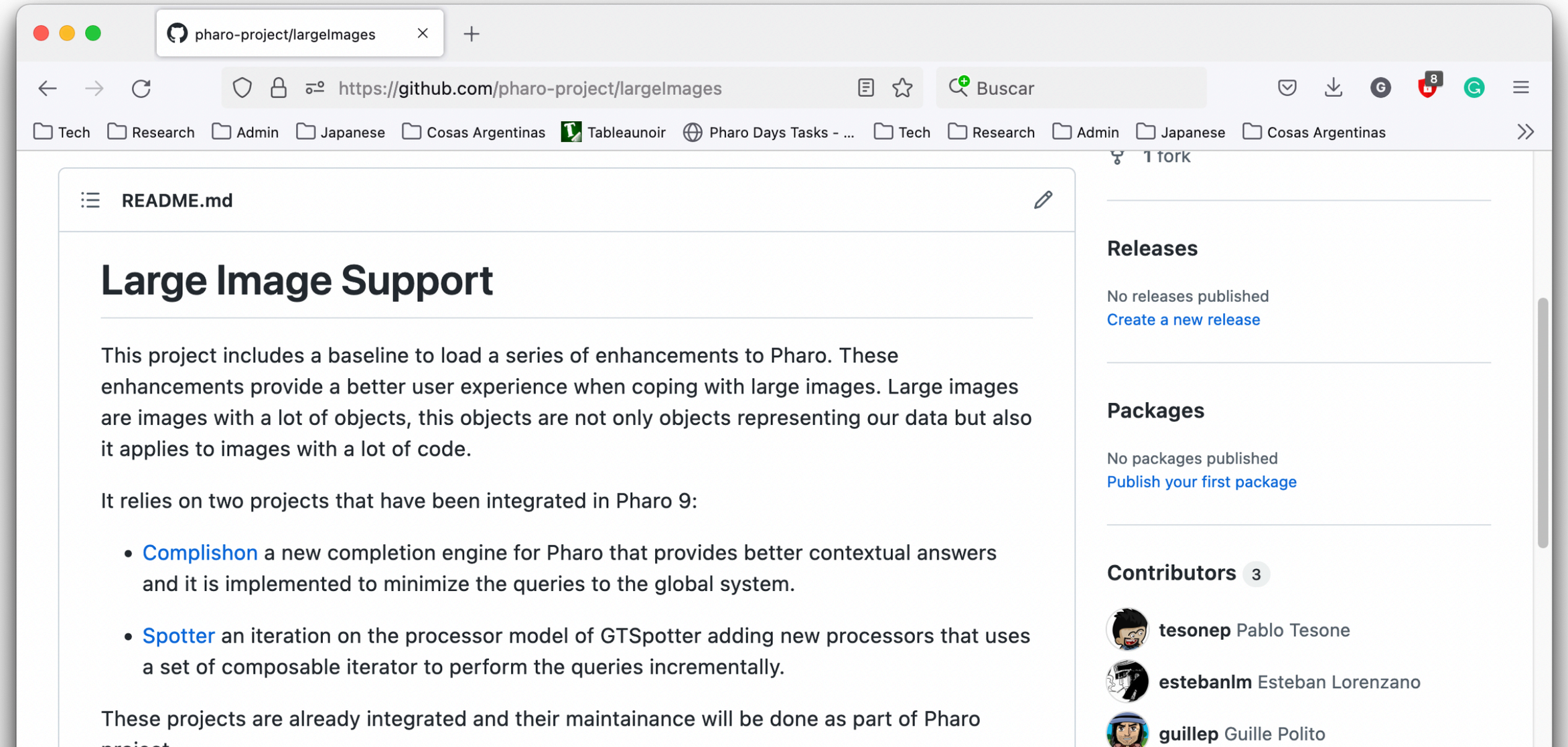
~~Lots of Objects~~
Lots of Stress

- GC Stress
- Autocompletion Stress
- Search Stress
- Spotter Stress
- Startup Stress



Large Image Support

- https://github.com/pharo-project/largeImages
- **MIT Licenced**



Large Image Support: Highlights

- Generator based searches
  - Spotter
  - Code Completion

```
generator
   ^ generator ifNil: [
      generator := Generator on: [ :g |
         self entriesDo: [ :entry |
            (self acceptsEntry: entry)
               ifTrue: [ g yield: entry ] ] ] ]
```

- GC Fine Tuning API

GC Fine Tuning

- Configure
    - Eden Size
    - Full GC Ratio
    - Growth Headroom
    - Shrink Threshold

```
GCConfiguration readFromVM
        fullGCRatio: 1.0;
        activeDuring: [ “something" ].
```

Lots of Objects

- Numbers
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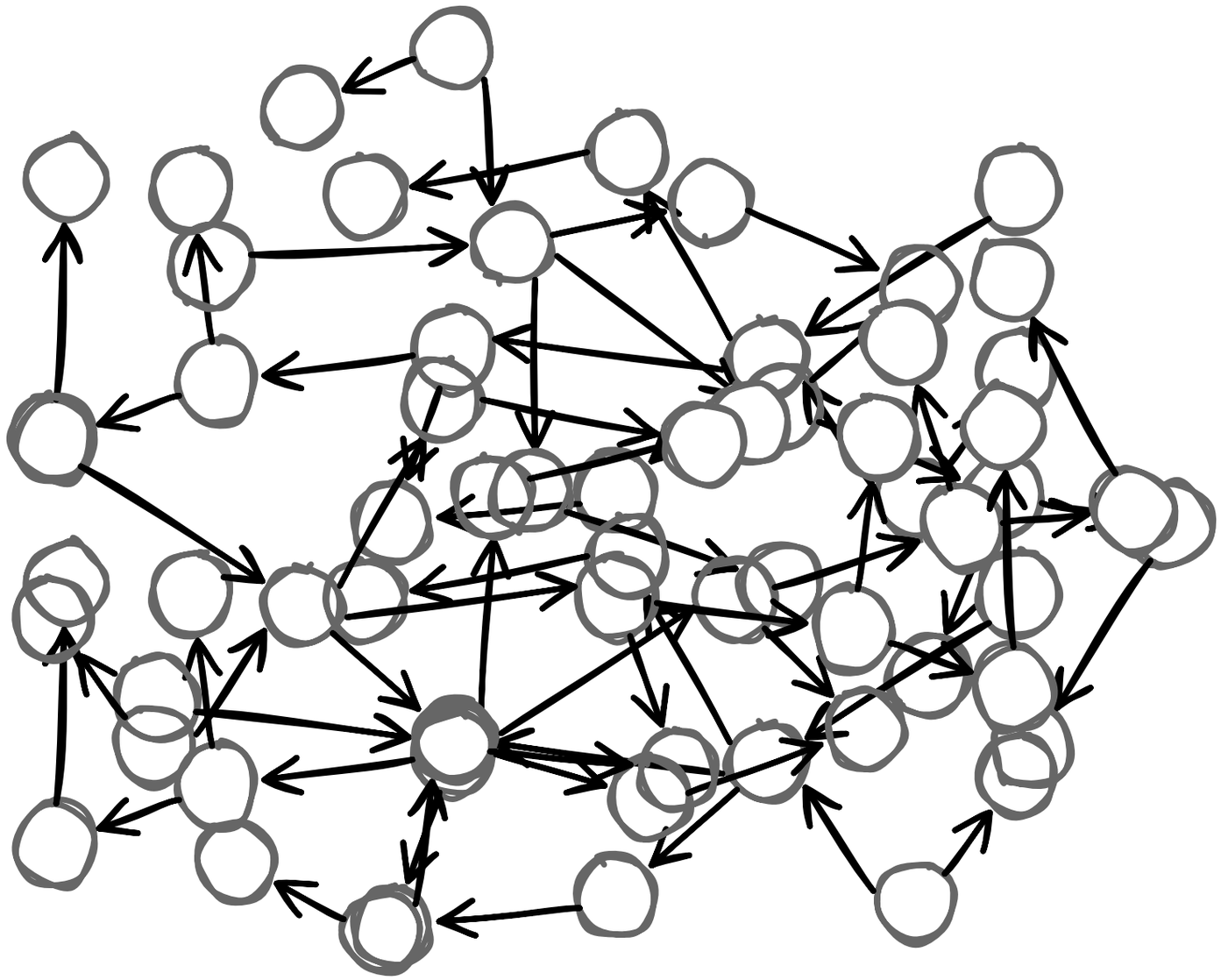
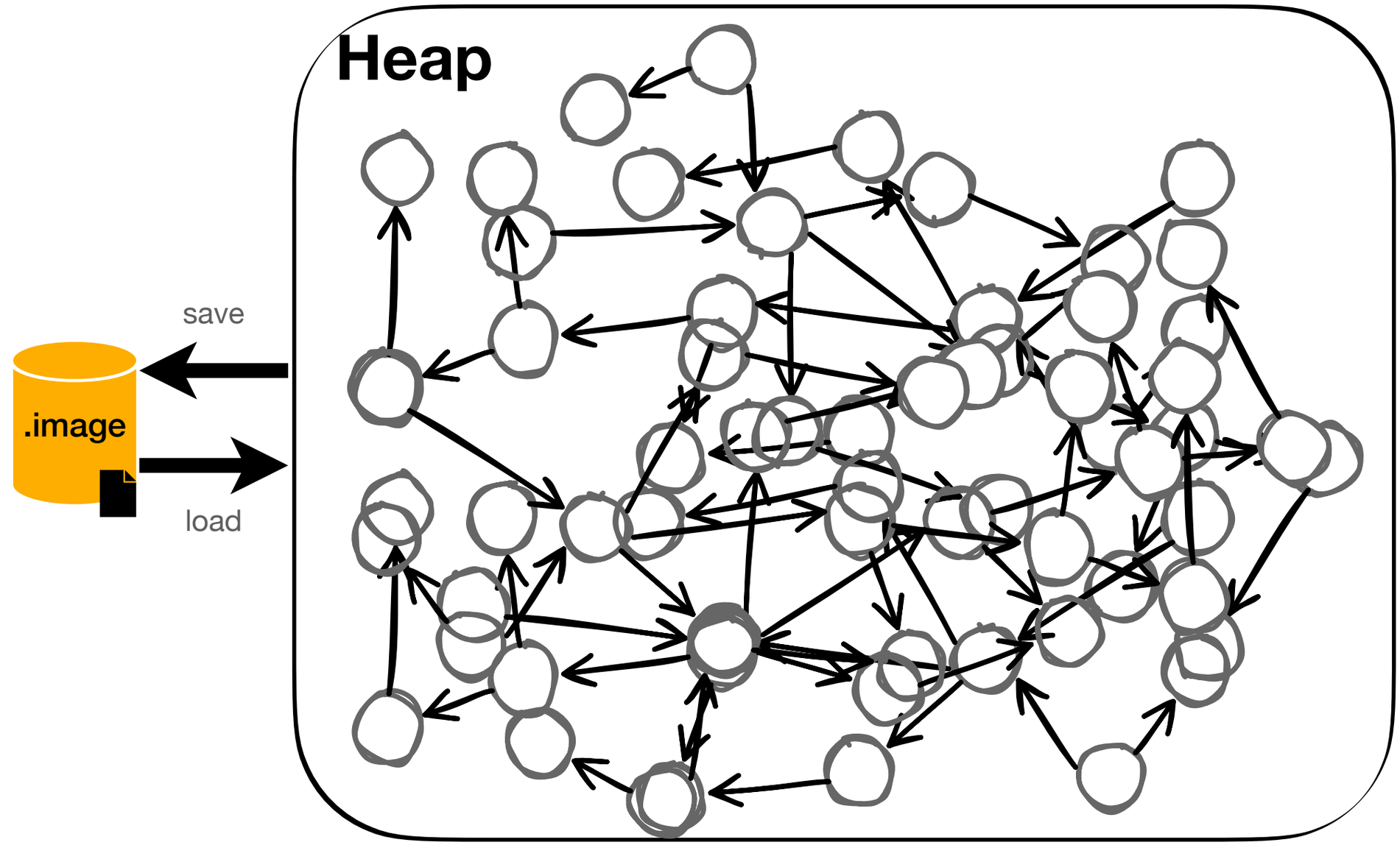
- Closures
- Classes
- Methods
- …



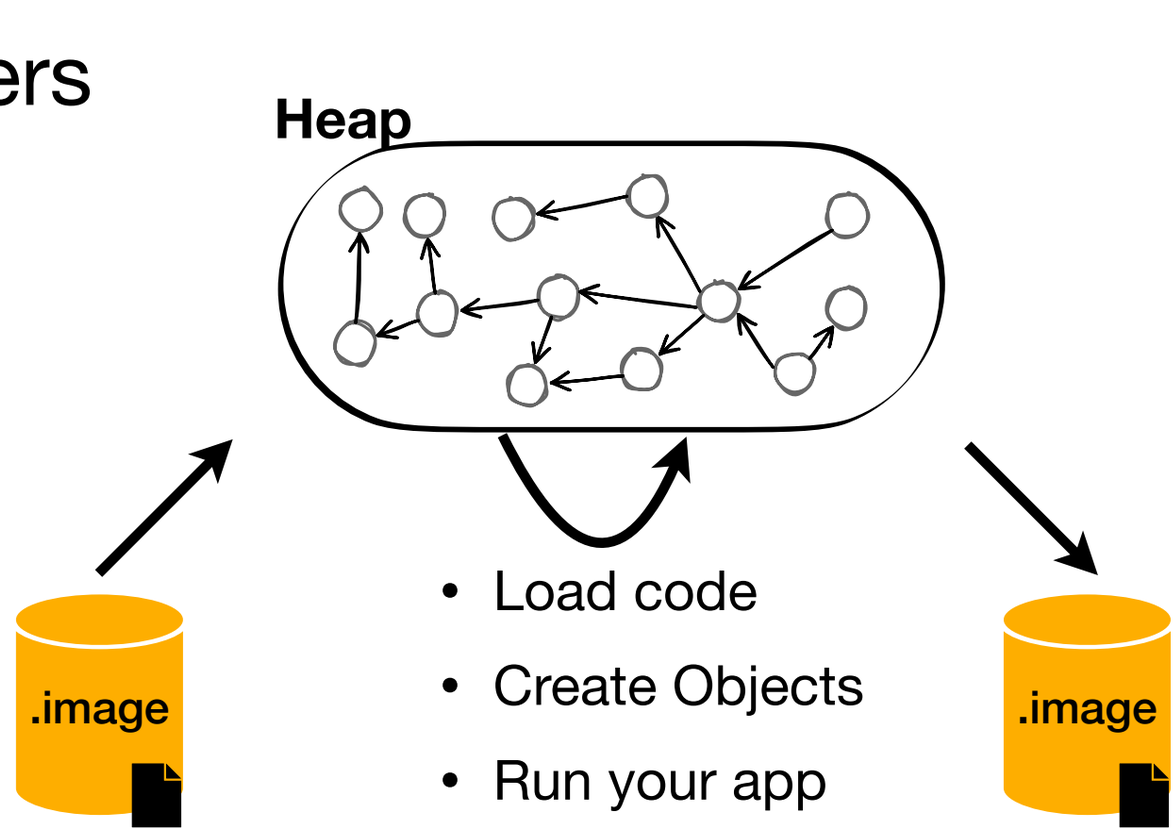
Images = Heap Snapshots

- Numbers
- Characters
- Strings
- Arrays
- Closures
- Classes
- Methods
- …



Snapshot Current Design Points

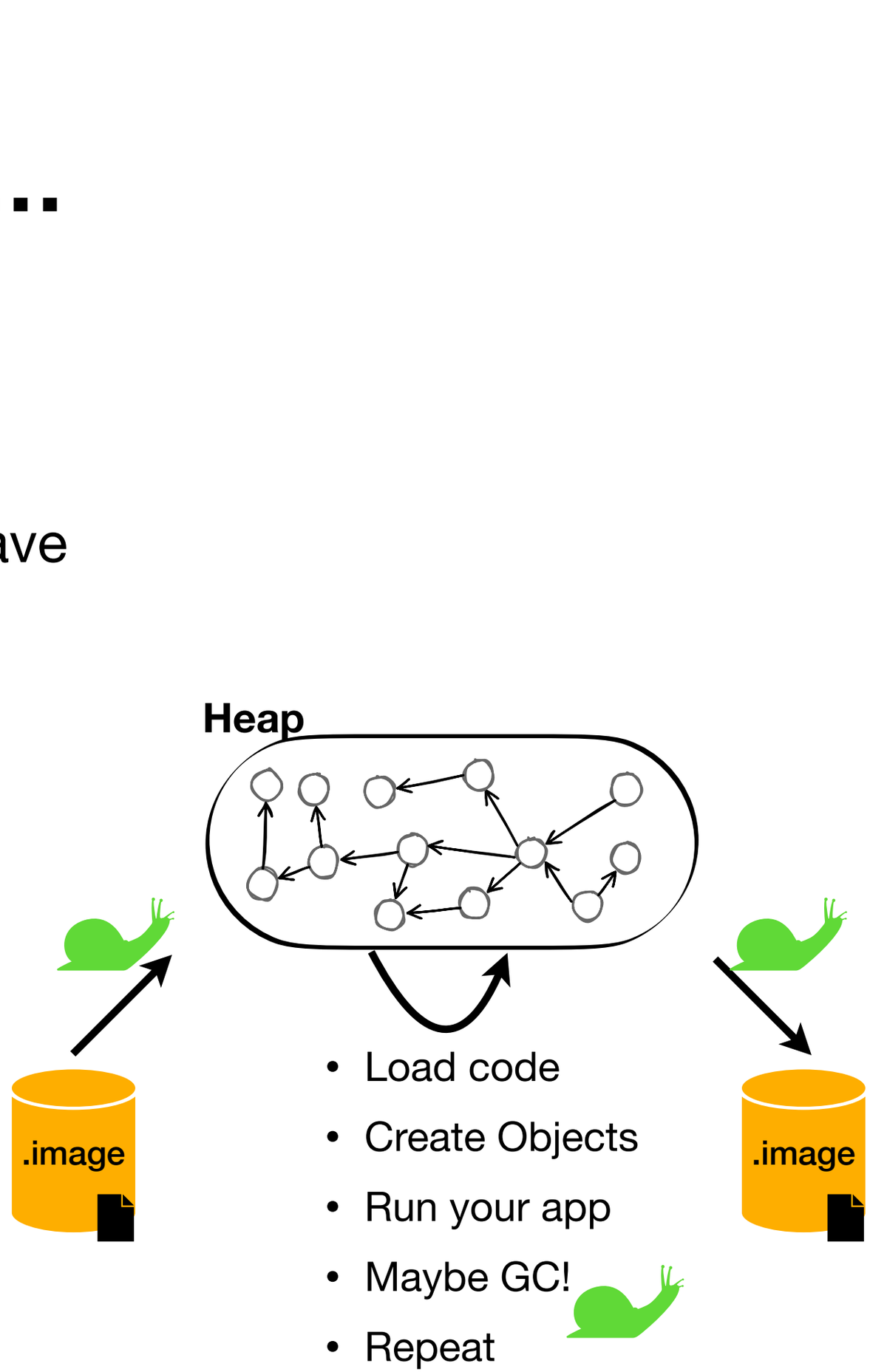
- Bootstrap once, then mutate
- Portable
- Object References are pointers



But it could be better…

- VM startup is bound by disk!
- Large heaps take long to load/save

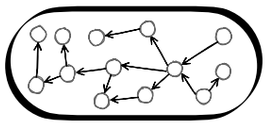
- 3-4GB heaps = seconds to GC
  - pauses
  - long pauses



Snapshots vs Runtime Memory Mismatch

App and System Objects

Threads State as Objects



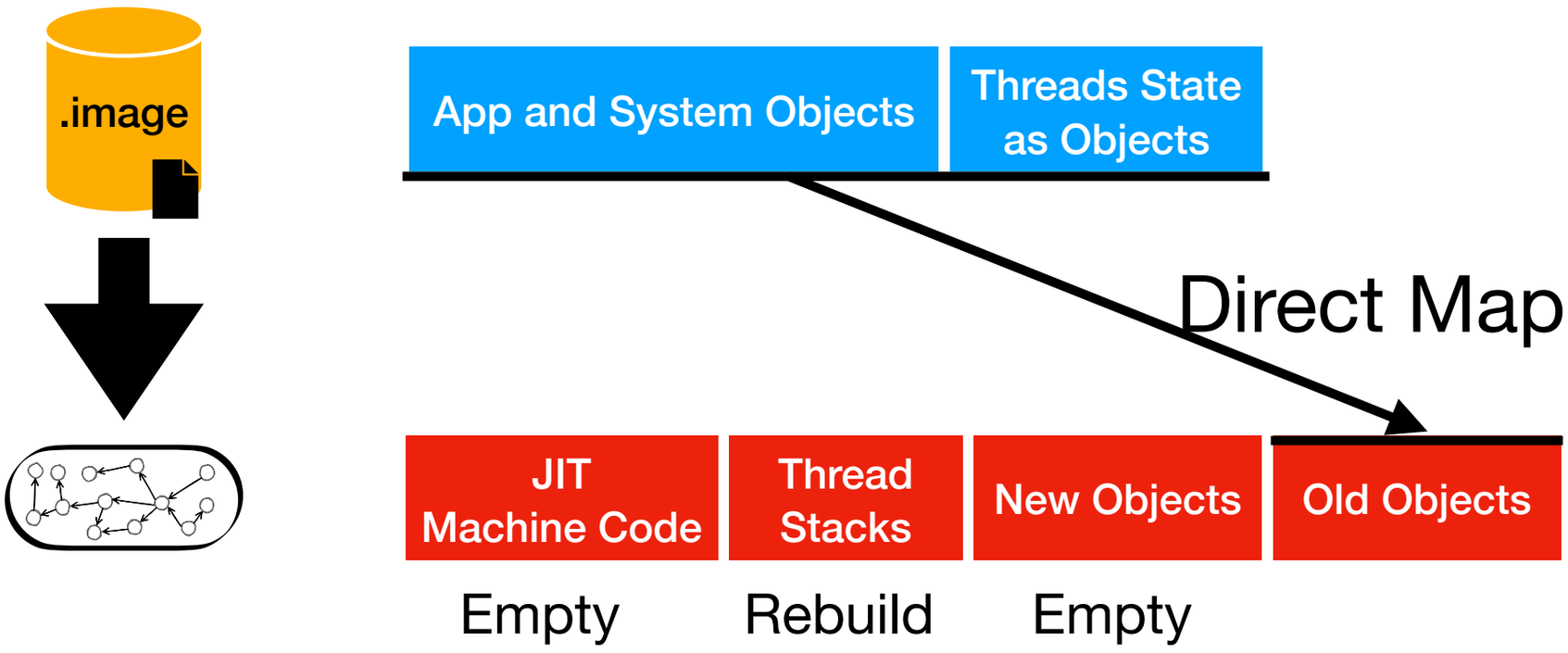
JIT Machine Code

Thread Stacks

New Objects

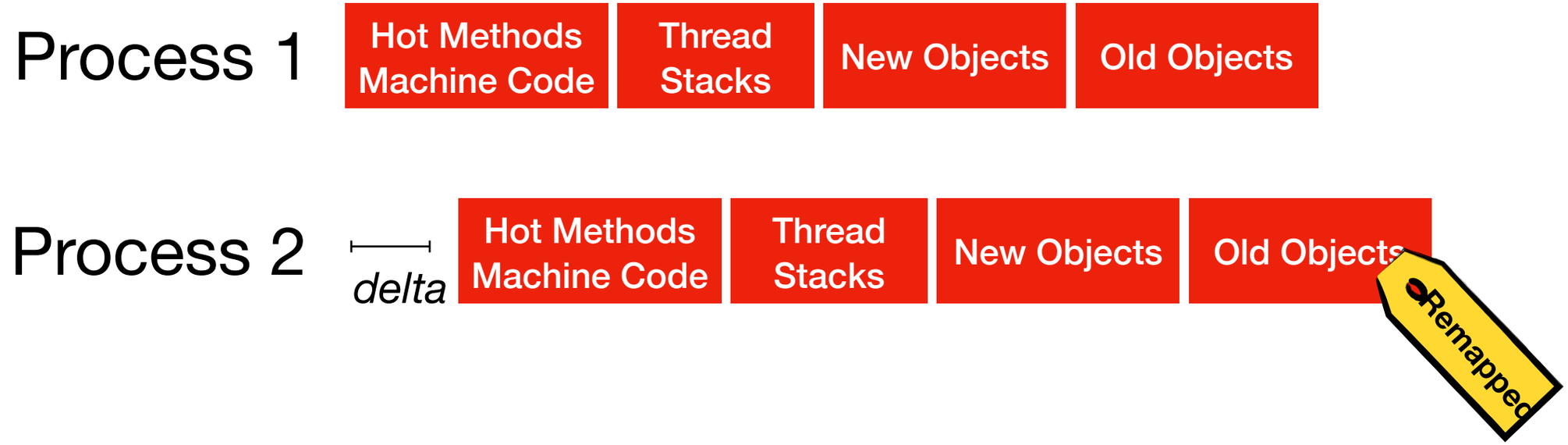
Old Objects

Current Loading Snapshot to Memory



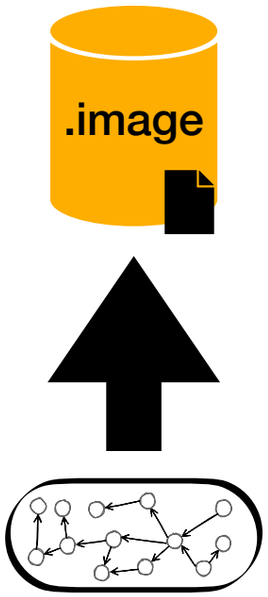
Start with a cold VM, startup is slow

Reference Swizzling



- Traverse the heap to remap old references by *delta*
- Slow for large heaps (2/4GB)

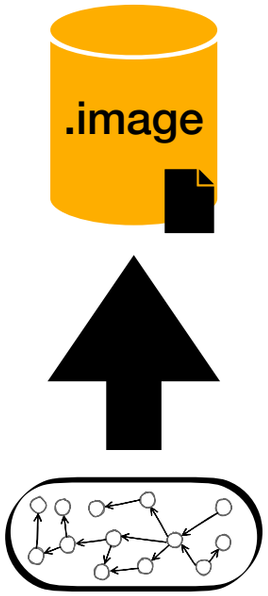
Current Snapshot to Disk



App and System Objects | Threads State as Objects

JIT Machine Code | Thread Stacks | New Objects | Old Objects

Current Snapshot to Disk

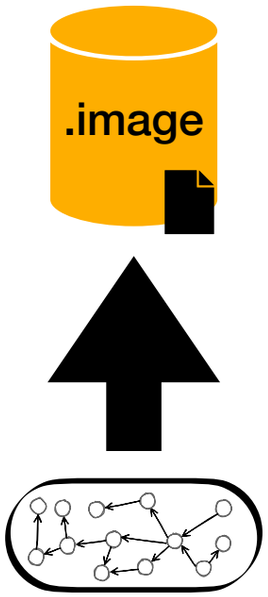


App and System Objects | Threads State as Objects

JIT Machine Code | Thread Stacks | New Objects | Old Objects

1.Discard

Current Snapshot to Disk



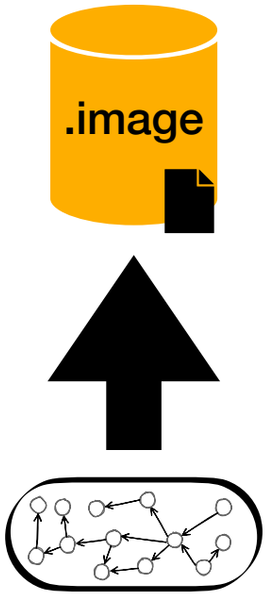
App and System Objects | Threads State as Objects

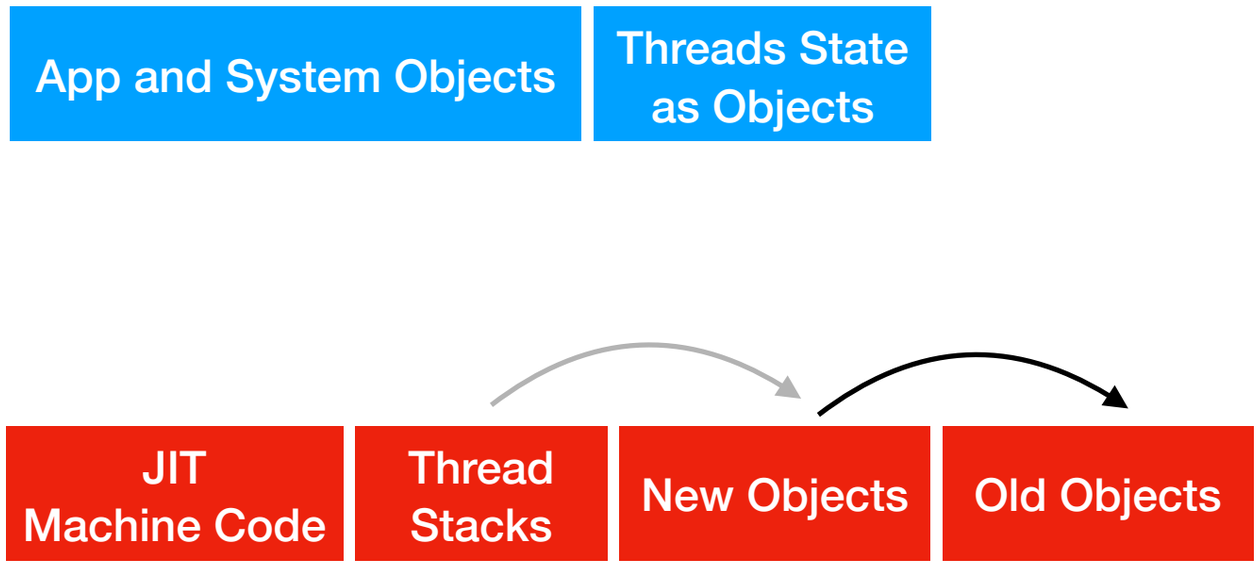
JIT Machine Code | Thread Stacks | New Objects | Old Objects

1.Discard

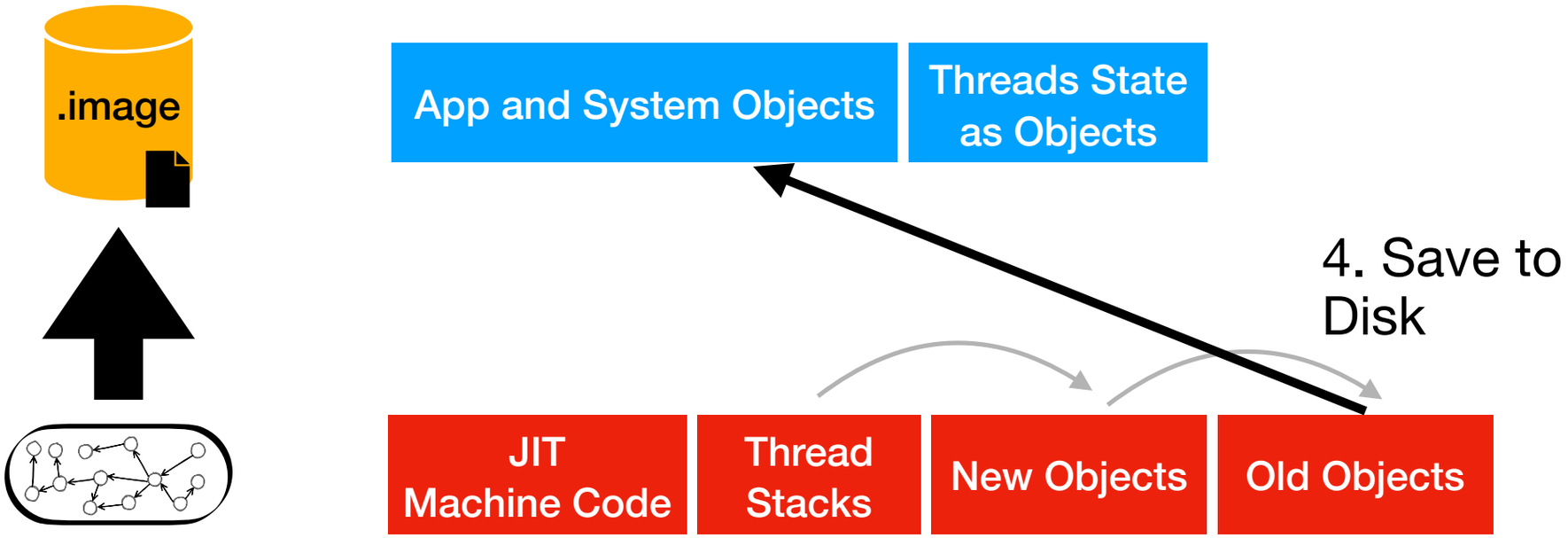
2. Save as objects

Current Snapshot to Disk

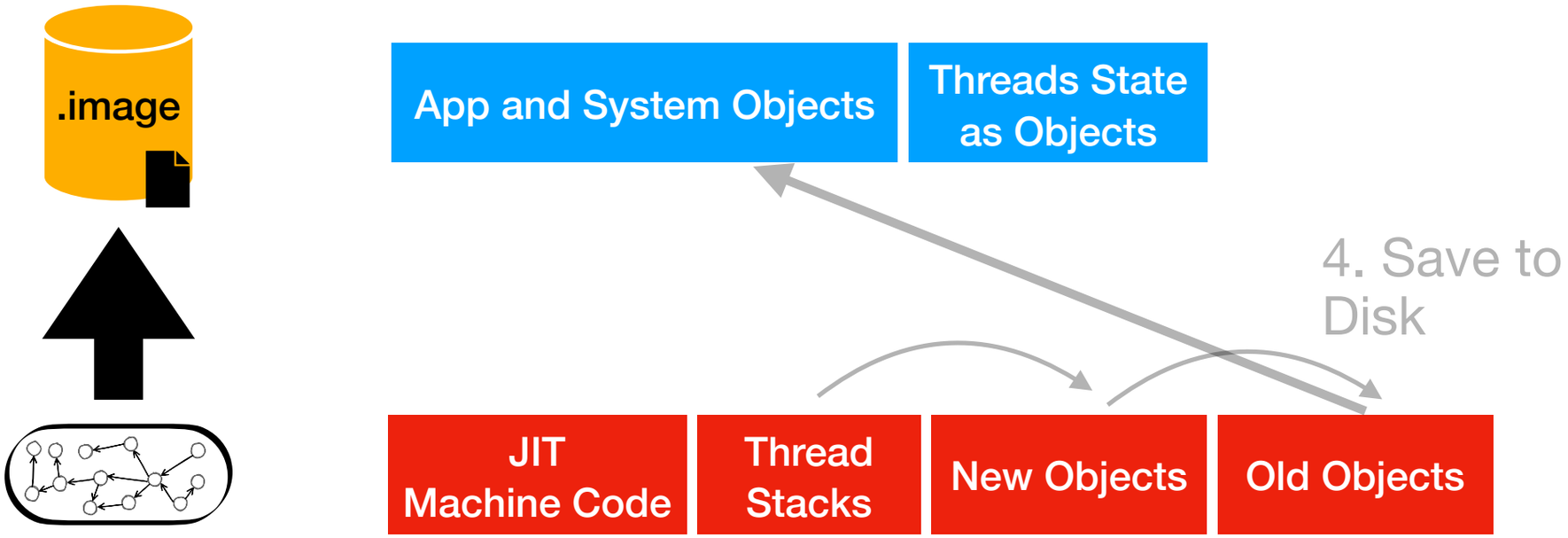




Current Snapshot to Disk



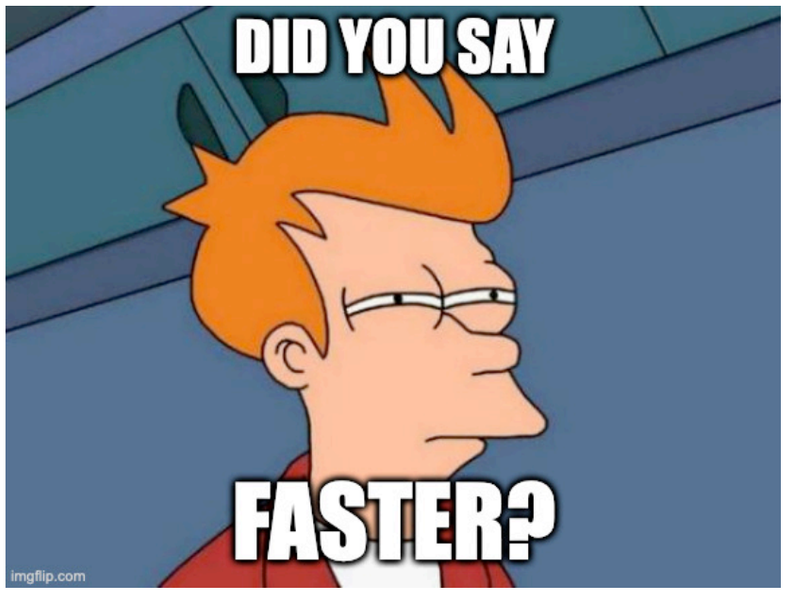
Current Snapshot to Disk

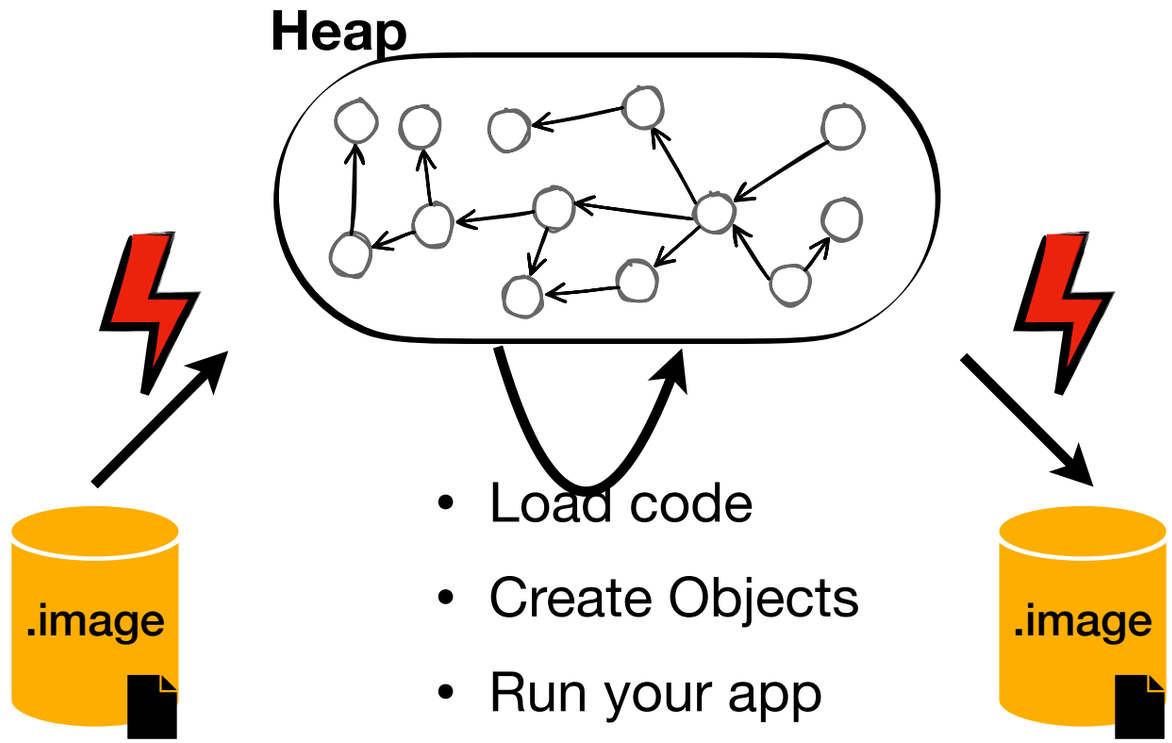


Discards all optimisations: slow shutdown => slow startup

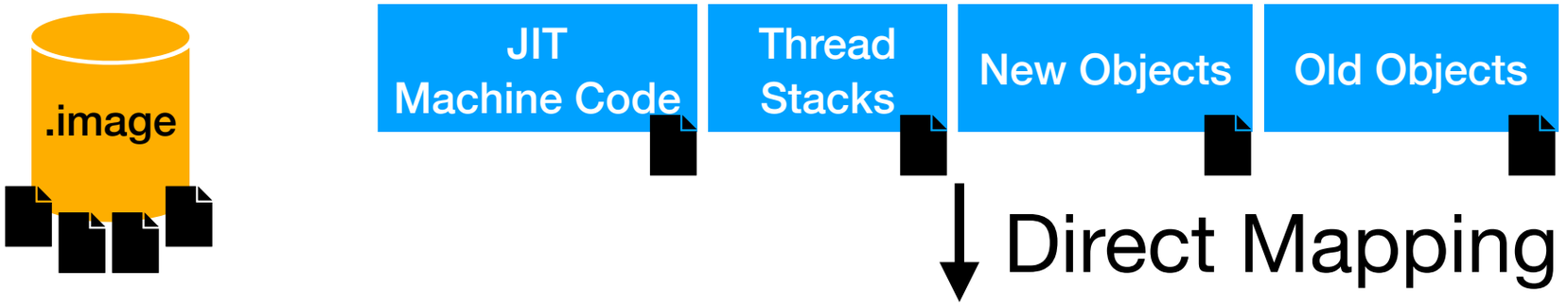
Goals

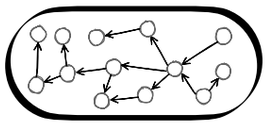
- *Faster* loading
- *Faster* snapshot
- *Faster* Multi-GB Heaps





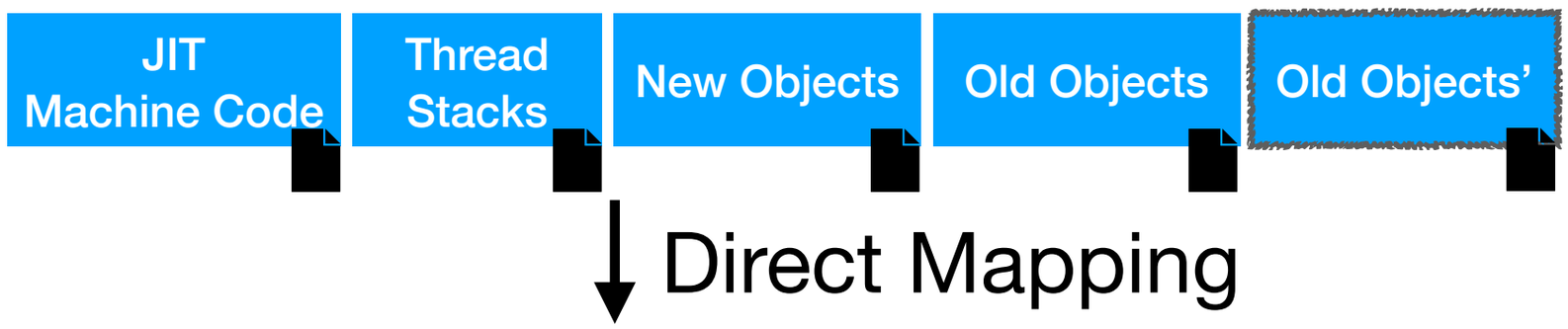
Towards a Multi-file Snapshot Format

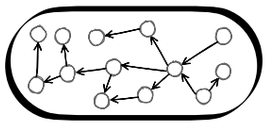




- System memory mapping
- Minimize Swizzling
- Lazy loading of memory segments

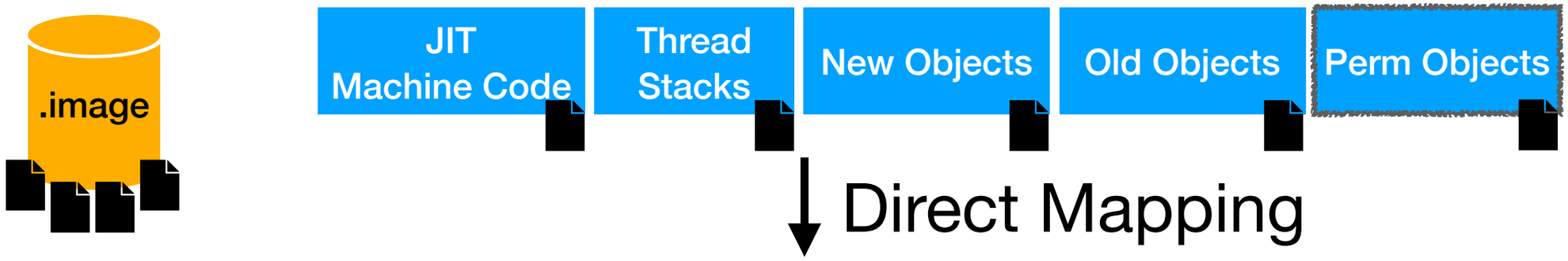
Multiple Memory Segments

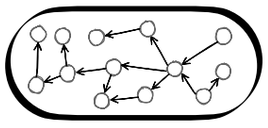




- Independently and *lazy* loadable ϟ
- Independently storable ϟ

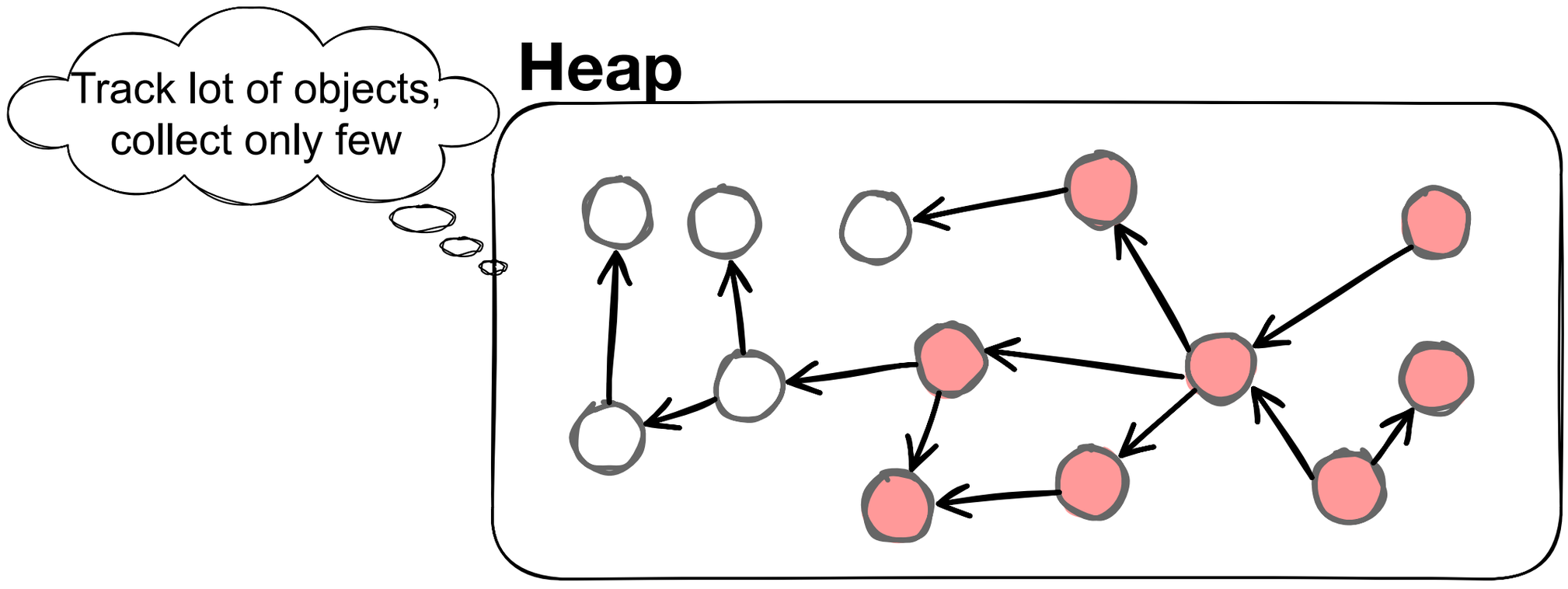
New Memory Segments





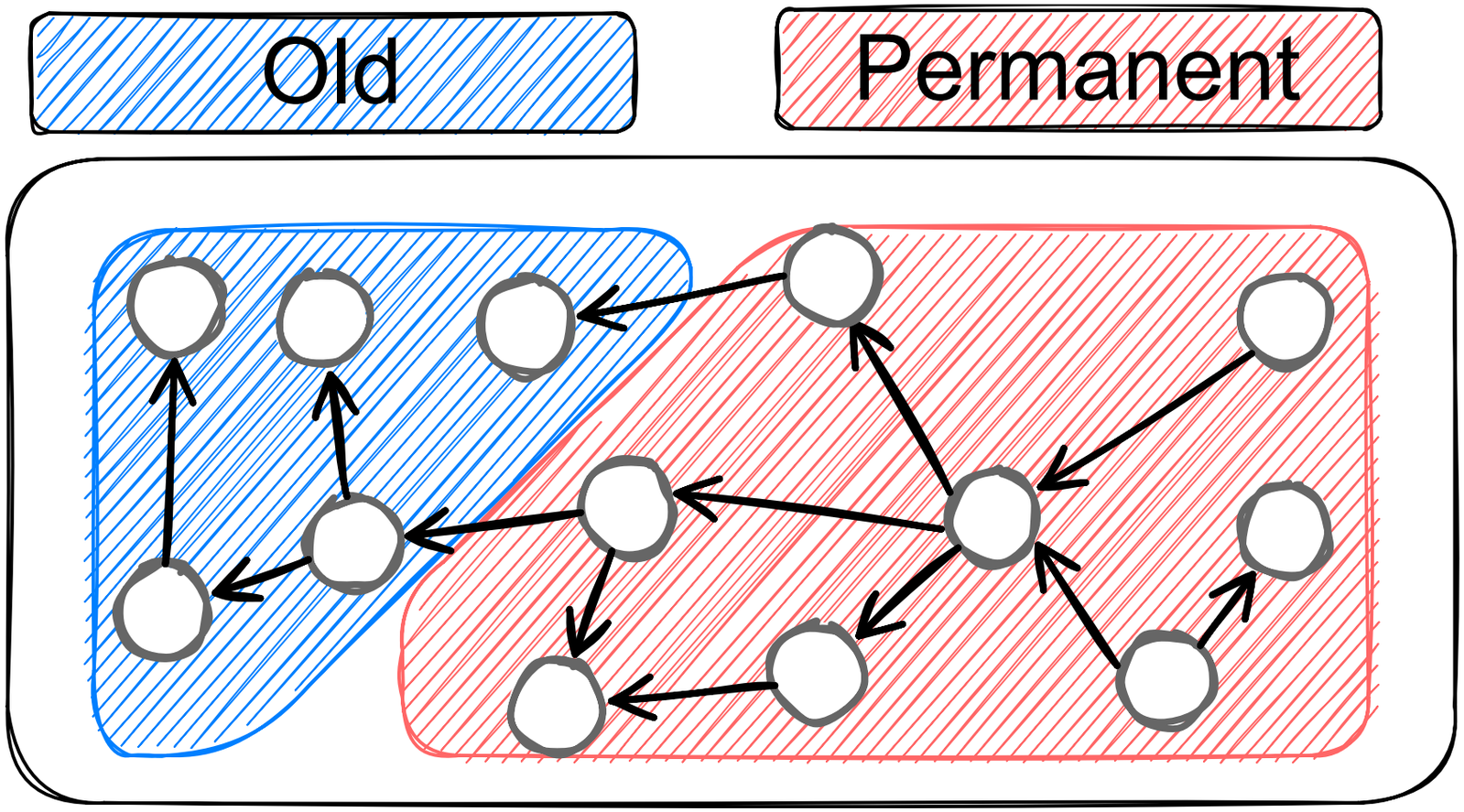
- Reduced garbage collection pressure
- Great for opaque objects, and rarely changing objects (code, literals…)

Semi-permanent Heap Segments



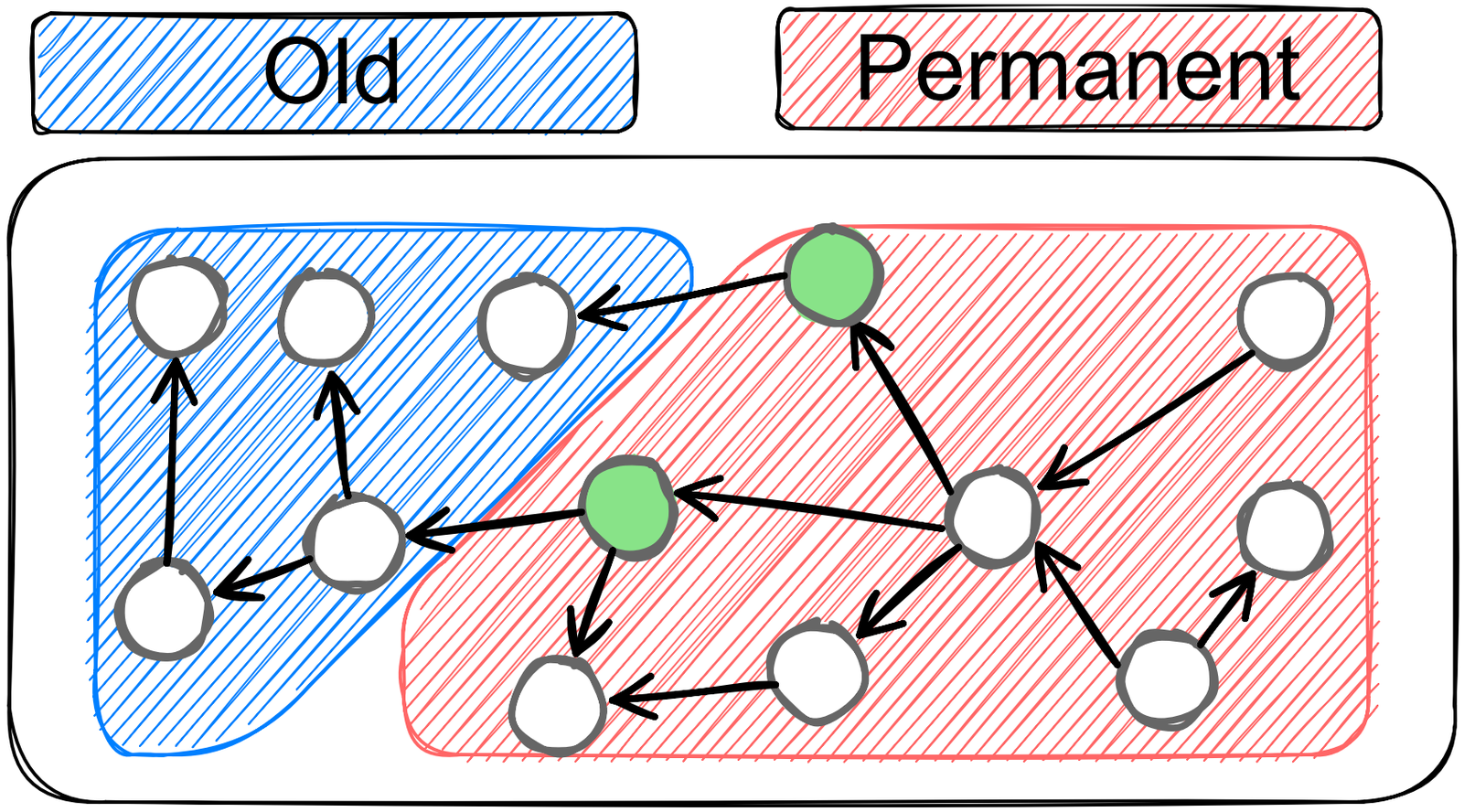
Separating Permanent Objects

- Permanent objects are ***roots***
- But ***not all of them*** are roots
- We don’t want to iterate all permanent objects!

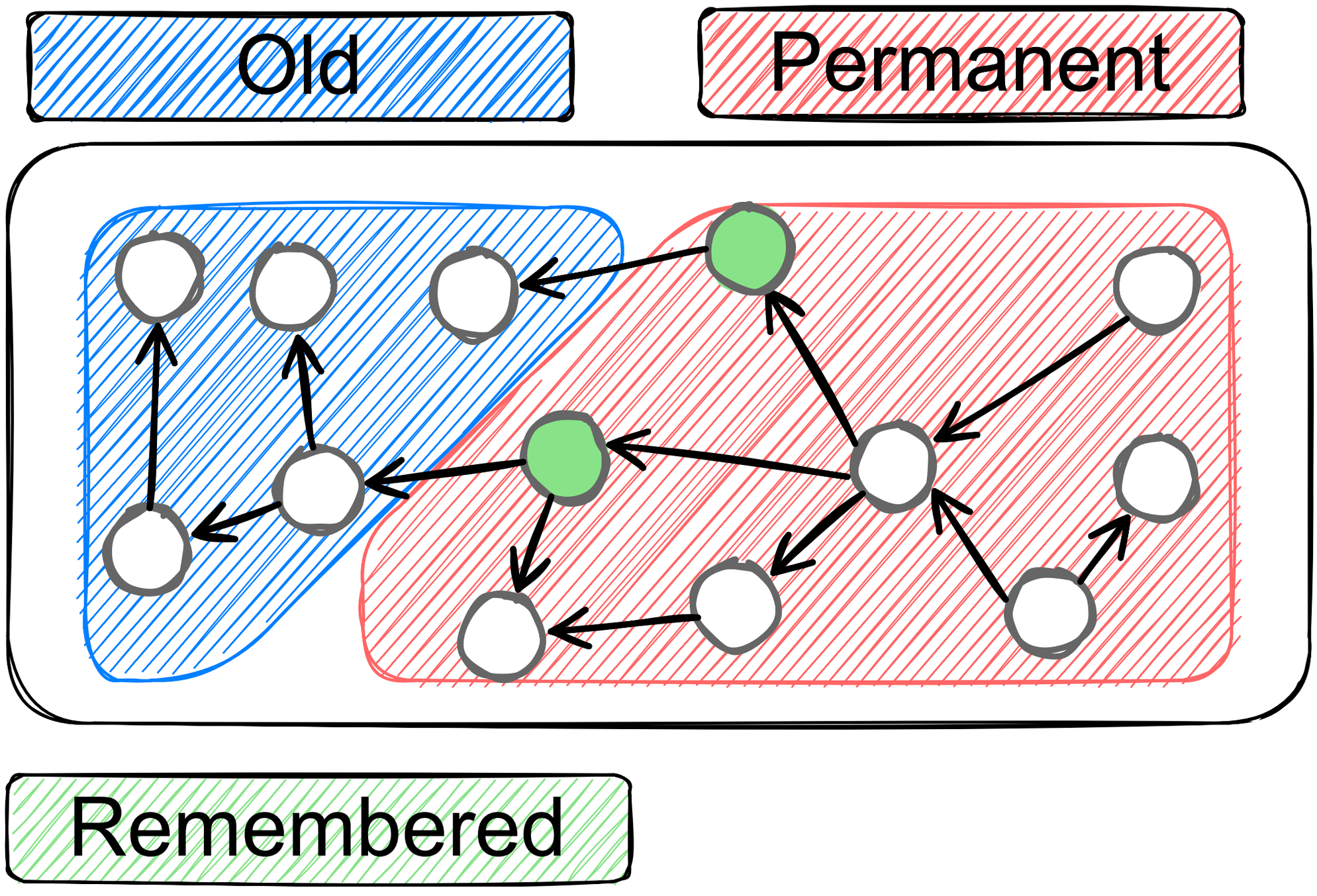


Maintaining a Remembered Set

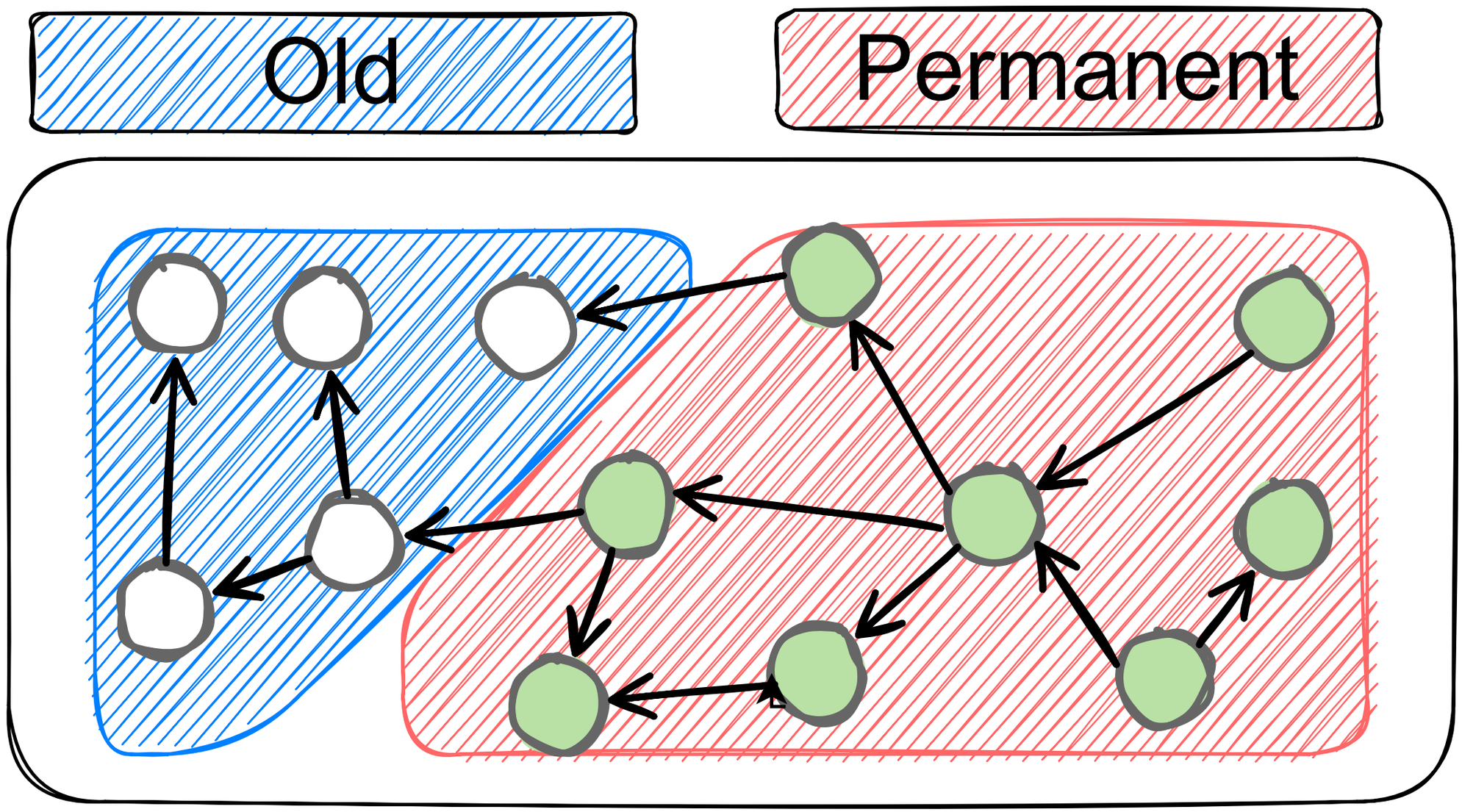
- Get the real roots in a *remembered set*
- Updated with a write barrier and cleaned at GC



Semi-permanent Object Selection



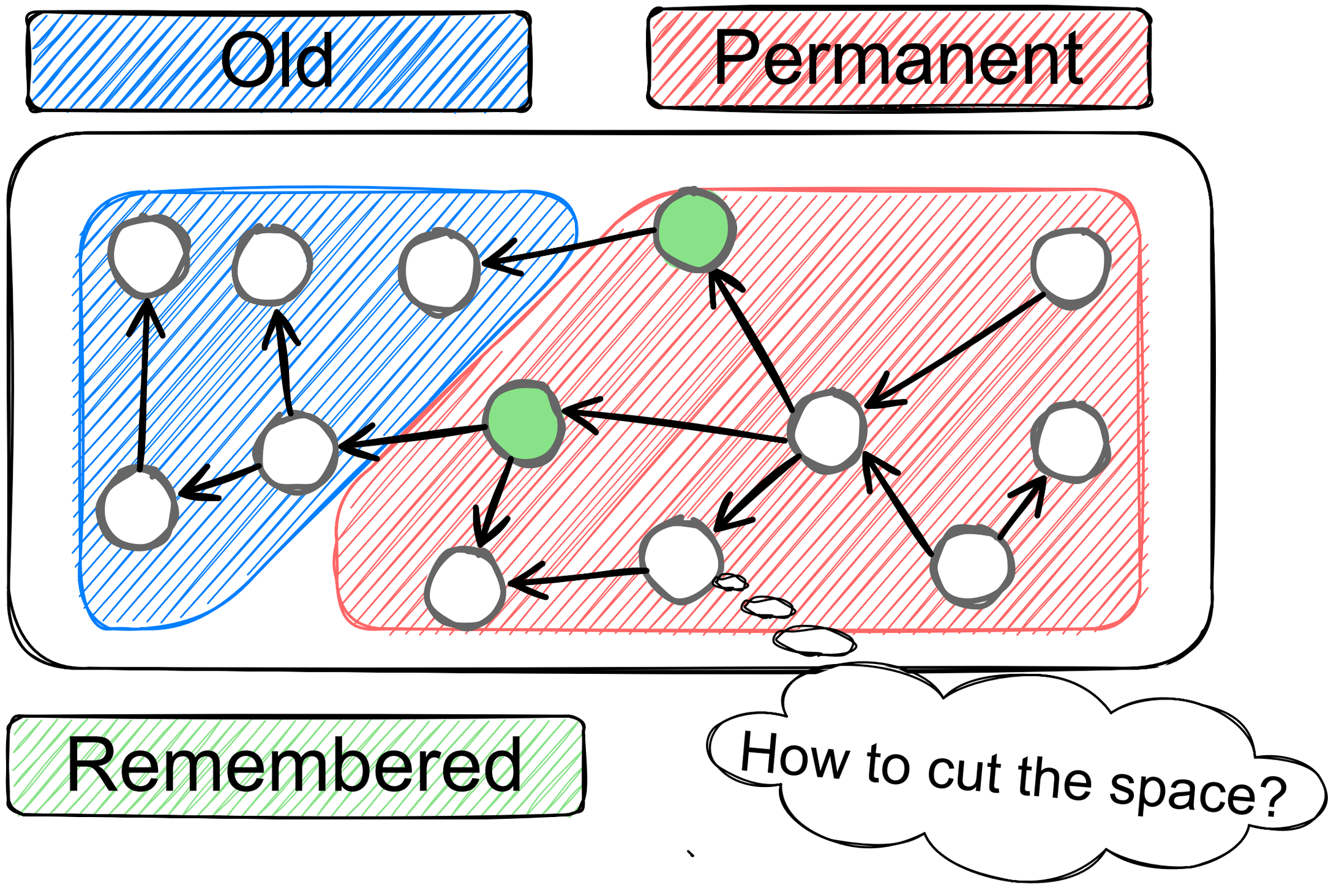
Bad Semi-permanent Object Selection



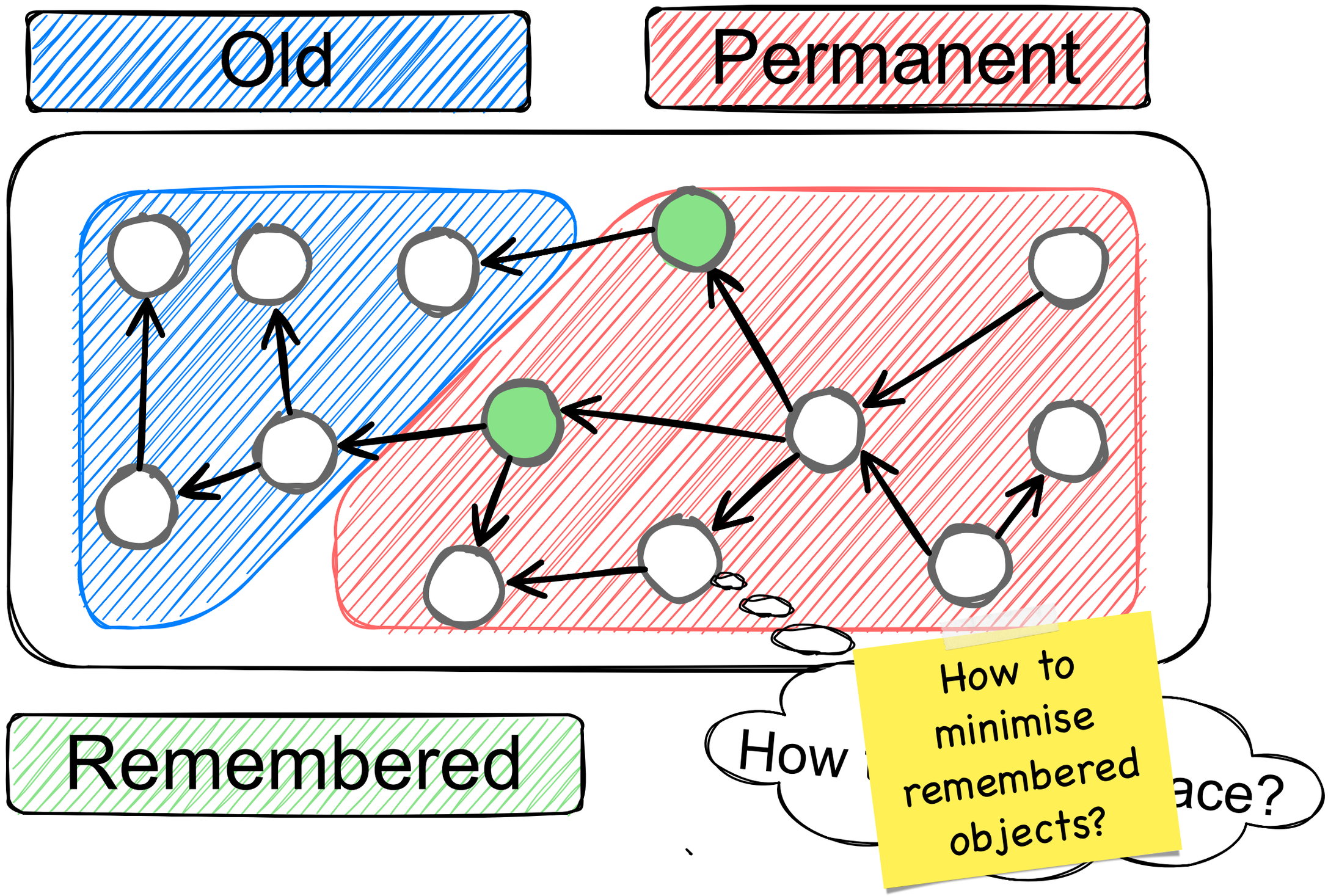
Remembered

Worst case: all permanent are remembered (!!)

What objects should be permanent?



What objects should be permanent?

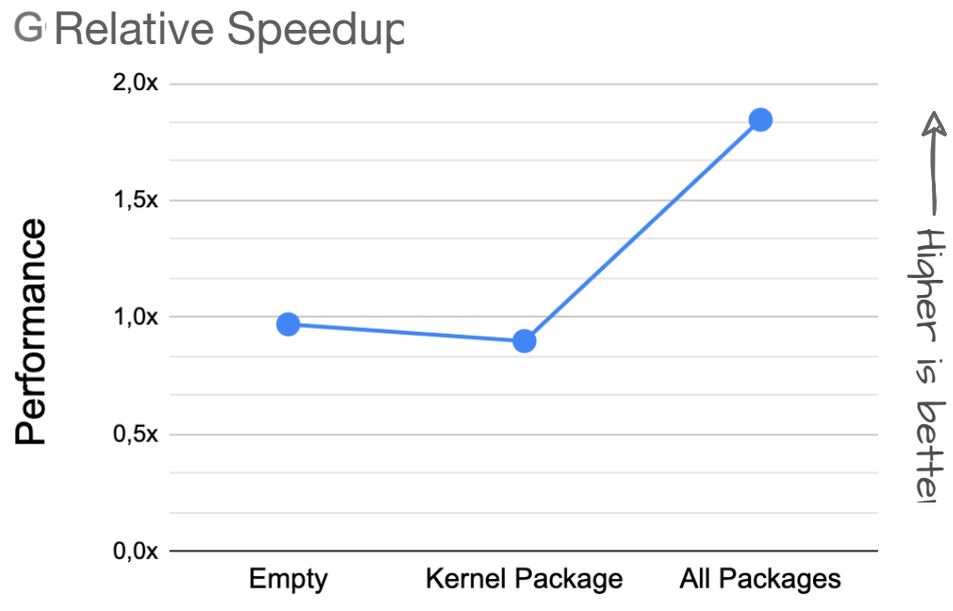


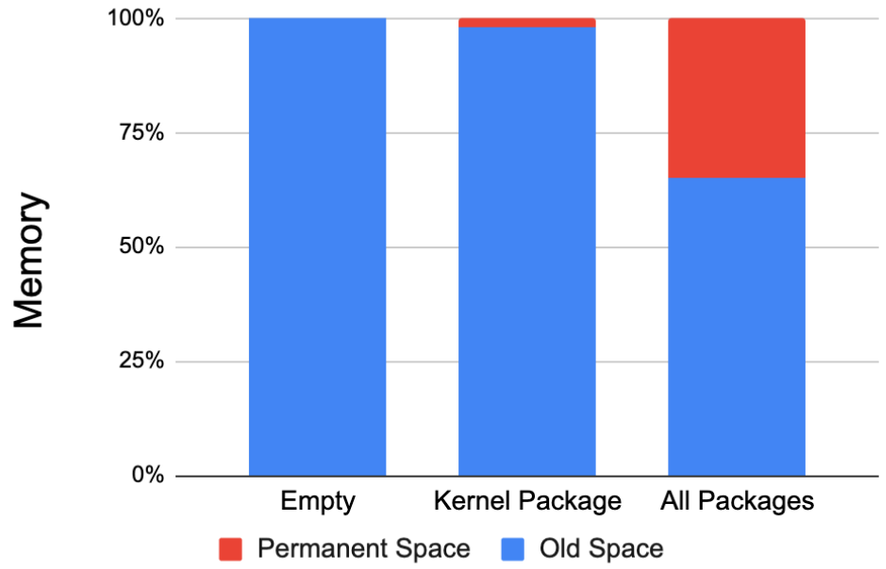
Pitfalls of Semi-permanent Object Selection

- The remembered set can *explode* easily. E.g.,
    - Objects that reference `nil`, `true`, `false` are ***always remembered***
    - If you make a *class* permanent
        - => you probably want to make its method dictionary too
        - => and its methods, and literals
        - => and …

Potential: GC cut by half

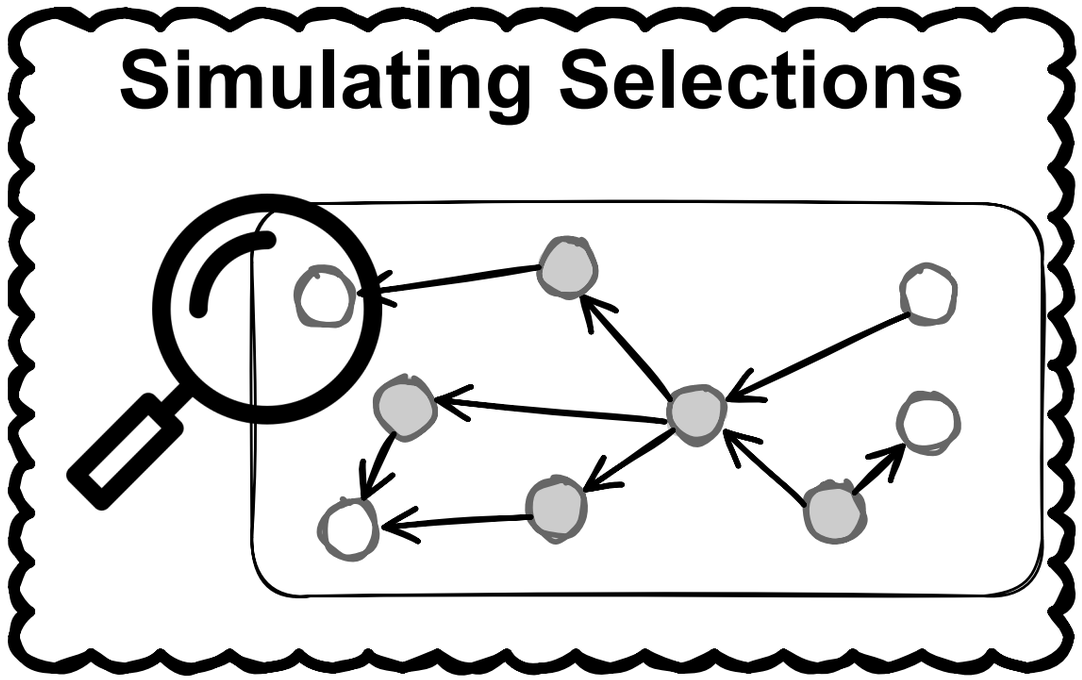
- For production Apps!
- Some Heuristics:
  - Code (+related) is semi-permanent
  - Collections go with their inner array
  - Association values are not (!!)





Automatic Object Selection via Simulations

- Estimate
  - permanent segment size
  - remembered set size



- Understand the ***leaking*** reasons
- And *extract better heuristics for* **production code**
  (e.g., better move all classes with all method dictionaries…)

Future Perspectives

- **Sharing** permanent immutable objects, copy on write
- **Scaling** multi-process applications
- **Application-specific** permanent object selection

We are hiring!

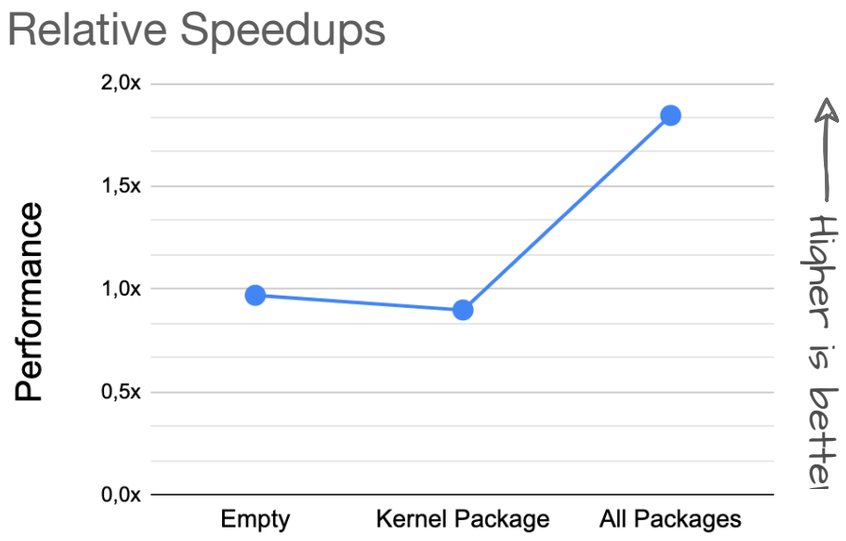
- We have
    - Engineer Positions
    - Phd Positions

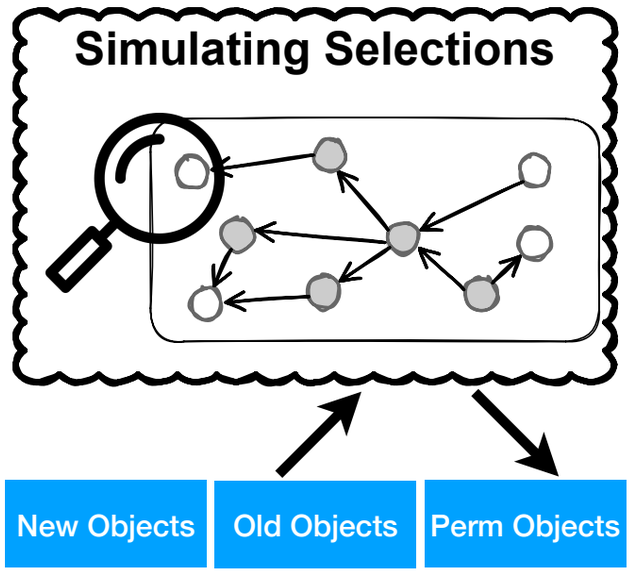
- Keywords: *Compilers, Interpreters, Memory Management, Security*

- **Come talk to us!**

Conclusion

- Multi-file snapshot format
- Permanent Objects and Selection
- 2x GC improvements





- Load code
- Create Objects
- Run your app
- Maybe GC!
- Repeat