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Java

JavaOne℠

The Ghost in the Virtual Machine
A Reference to References

Bob Lee

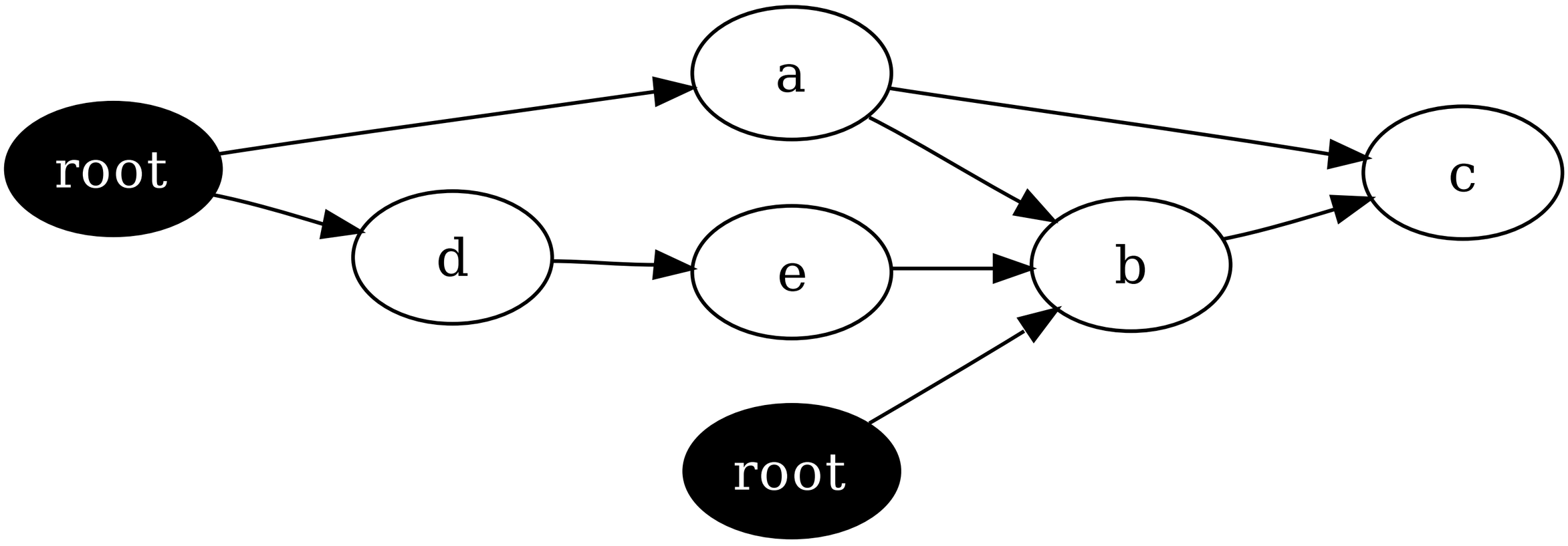
Google Inc.

Google

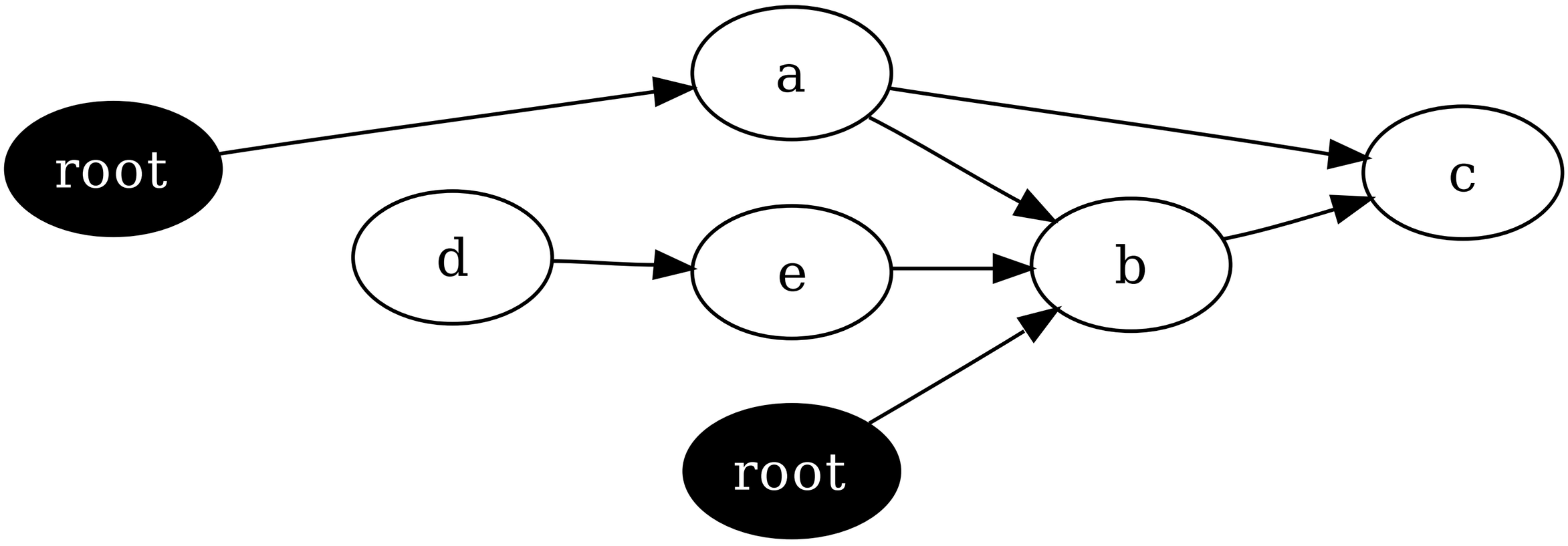
Goals

- Perform manual cleanup the right way.
- Take the mystery out of garbage collection.
- Become honorary VM sanitation engineers.

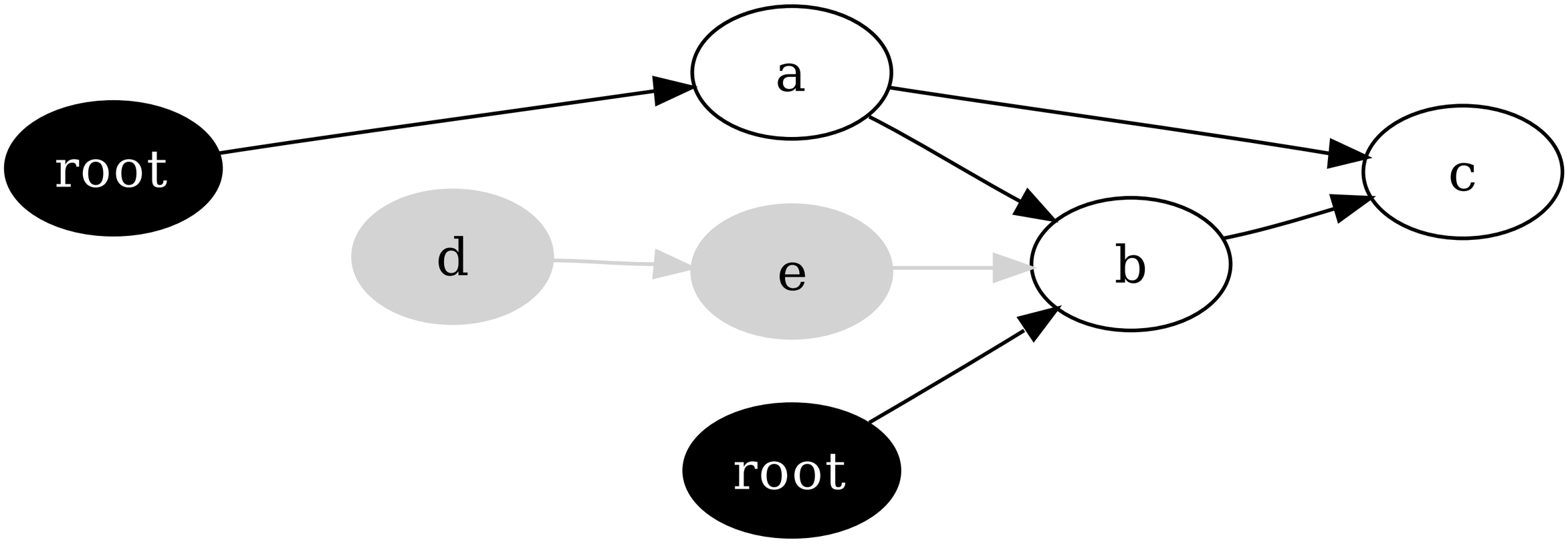
How does garbage collection work?



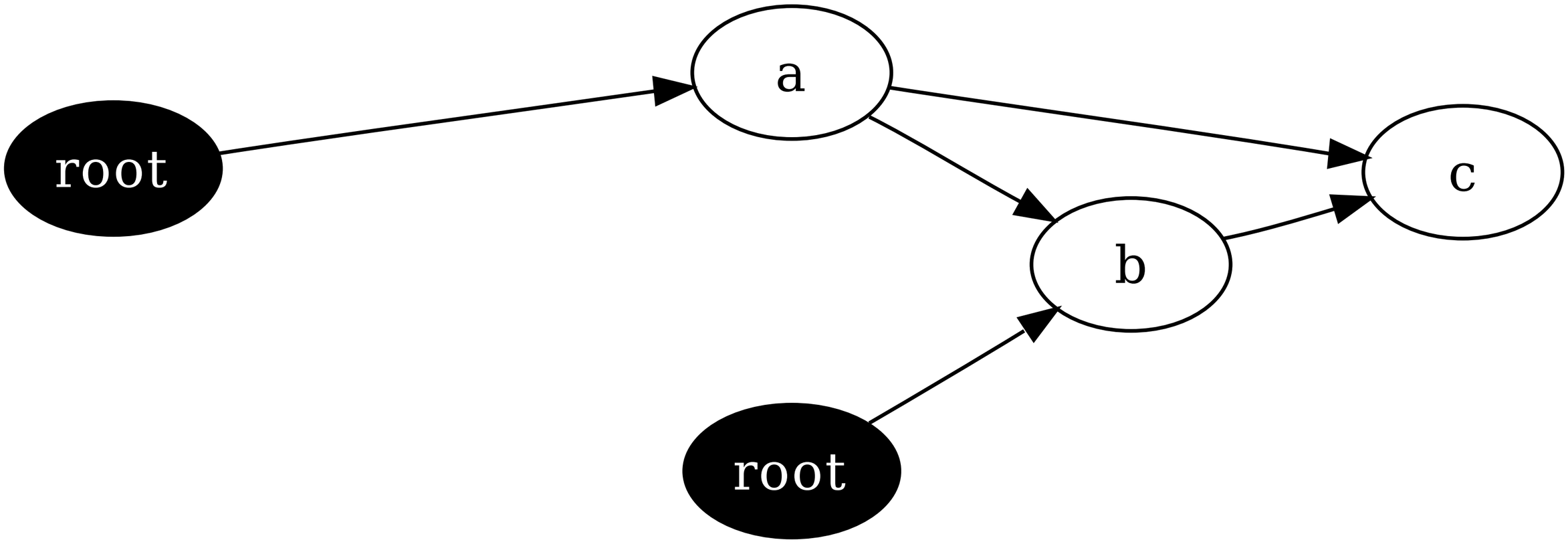
If the reference to D goes away...



We can no longer reach D or E.



So the collector reclaims them.



Reachability

- An object is *reachable* if a live thread can access it.
- Examples of heap roots:
  - System classes (which have static fields)
  - Thread stacks
  - In-flight exceptions
  - JNI global references
  - The finalizer queue
  - The interned String pool
  - etc. (VM-dependent)

Dante's Heap - The Levels of Reachability

- Strong
- Soft
- Weak
- Finalizer
- Phantom, JNI weak
- Unreachable

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Dante's Heap - The Levels of Reachability

- Strong
- Soft
- Weak
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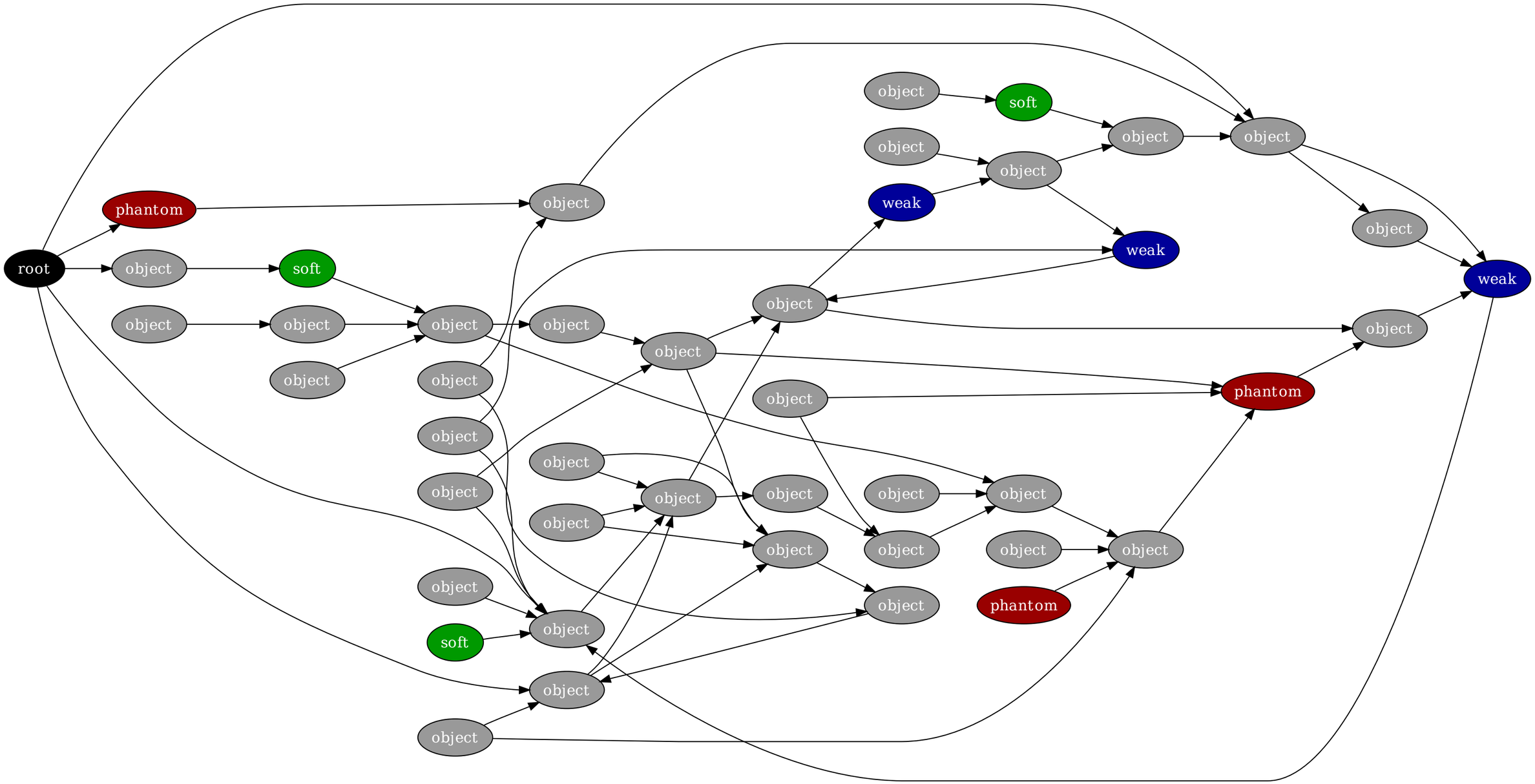
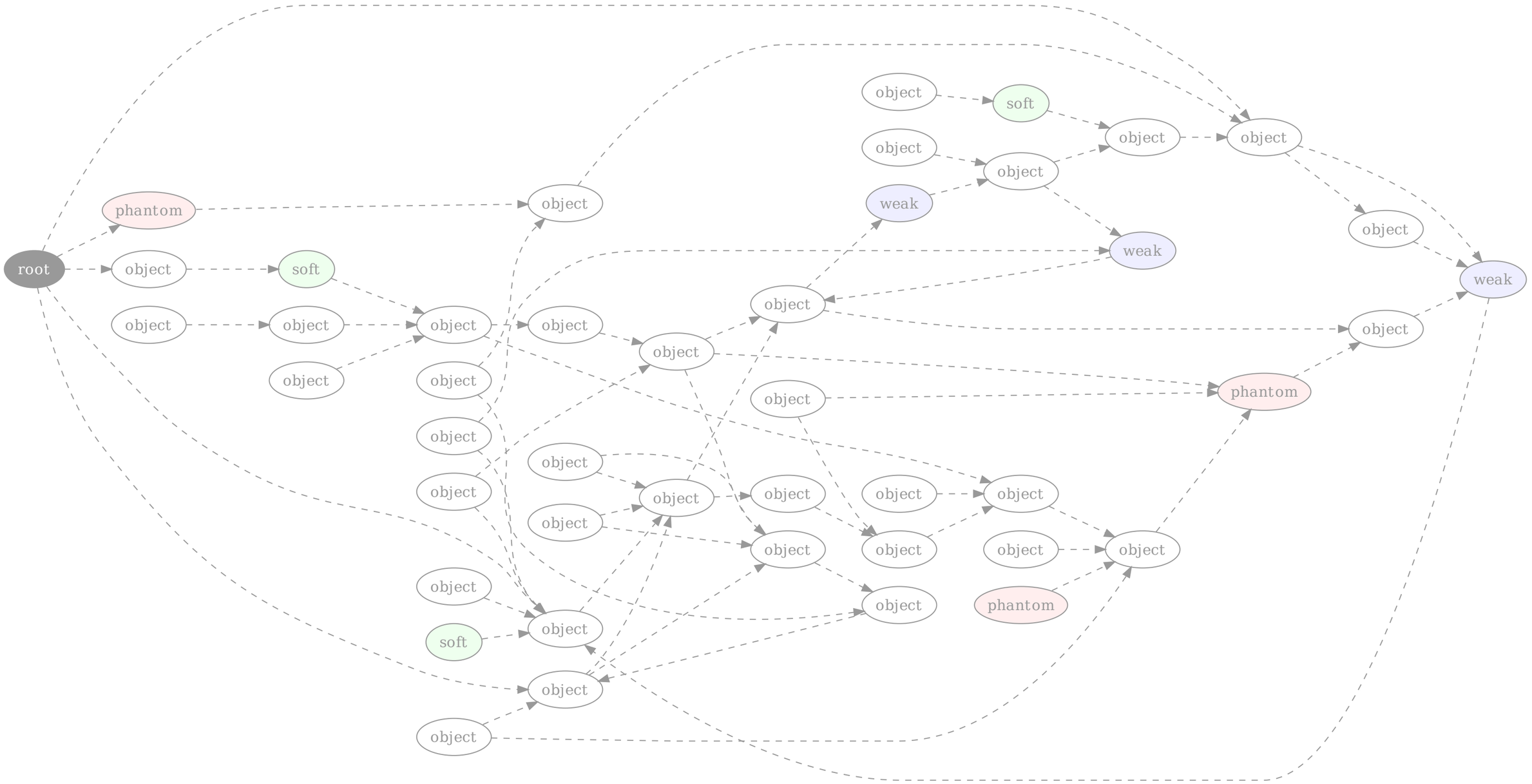
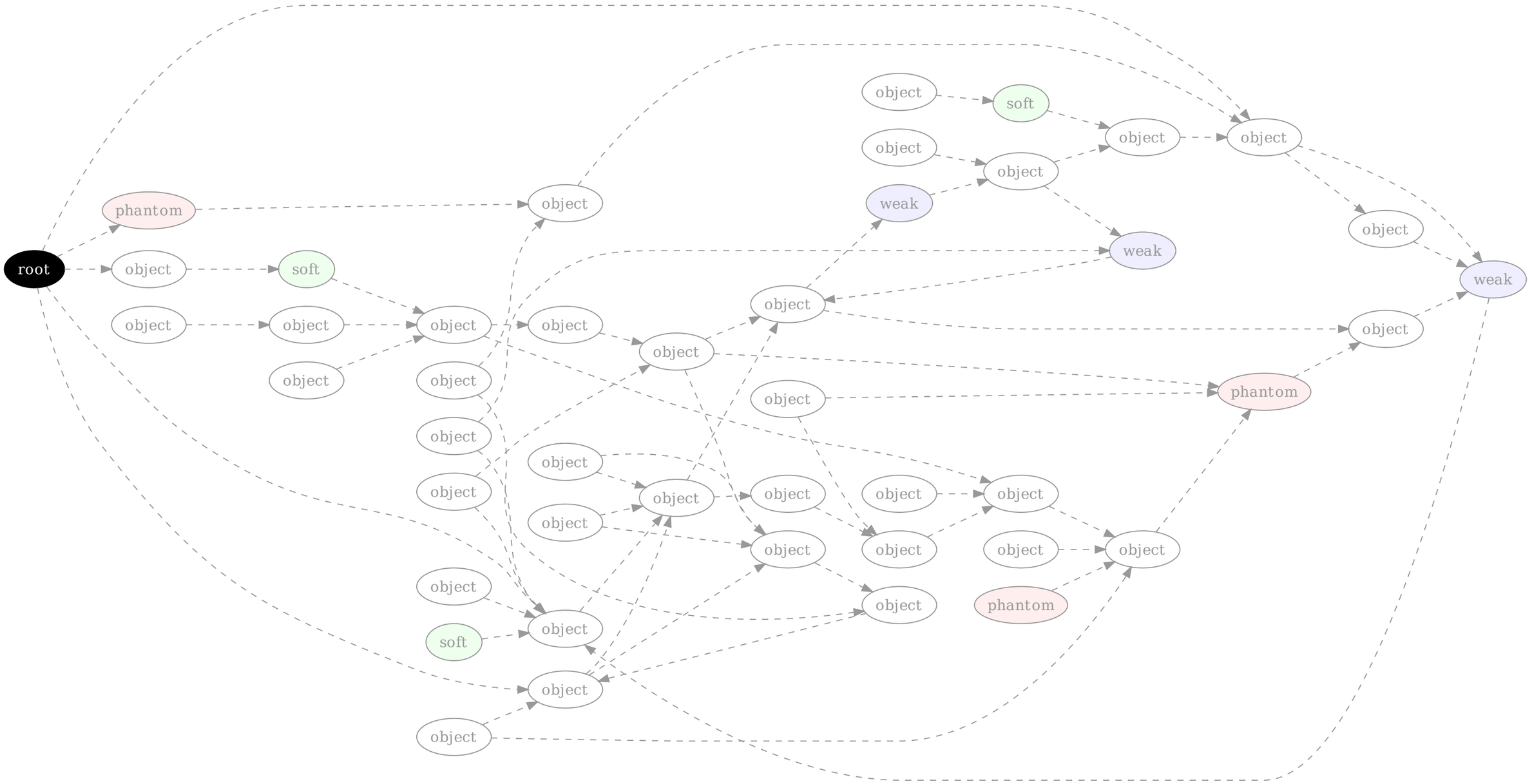
Let's mark and sweep a heap!



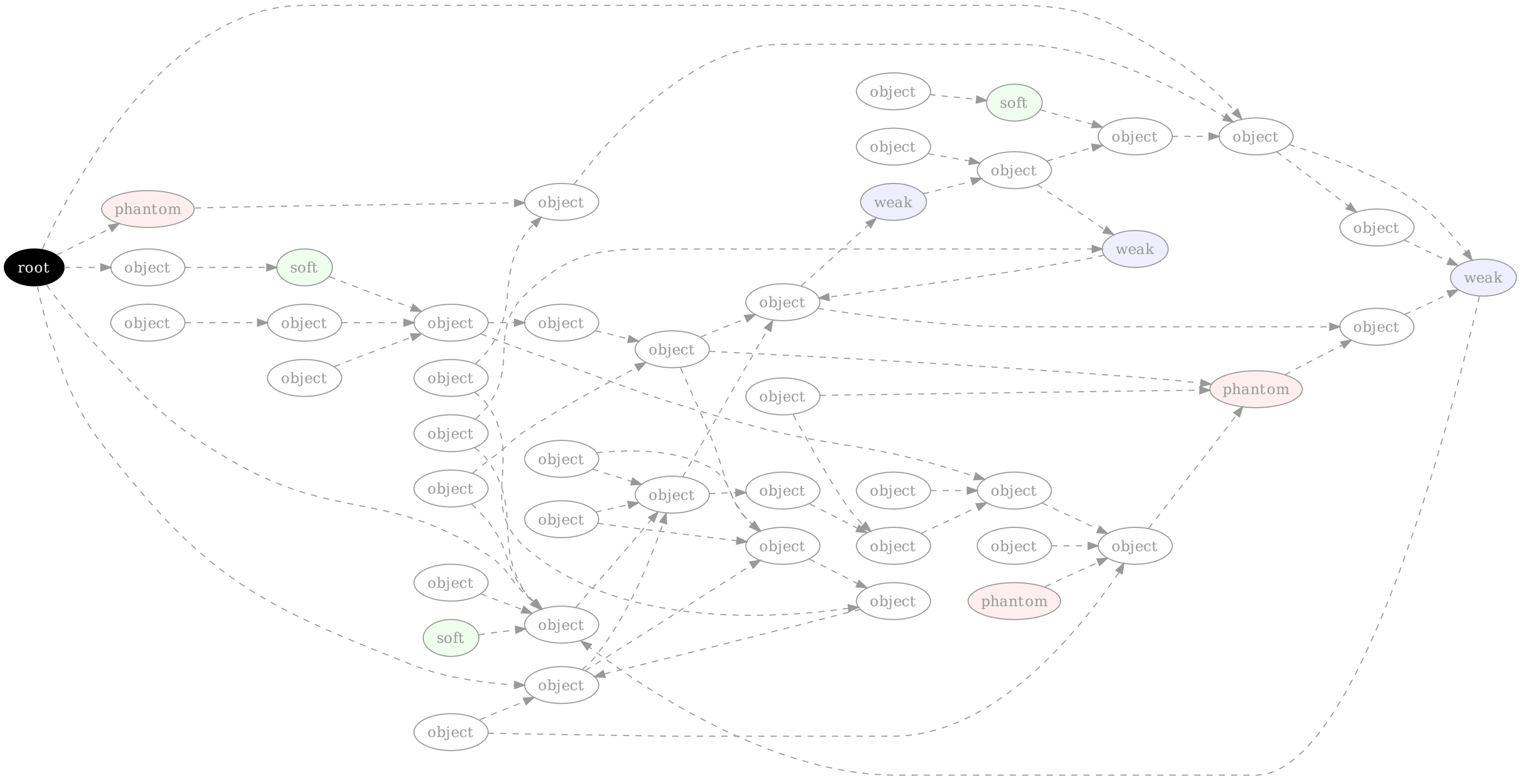
No objects are marked at first.



1. Start at a root.



2. Trace and mark strongly-referenced objects.



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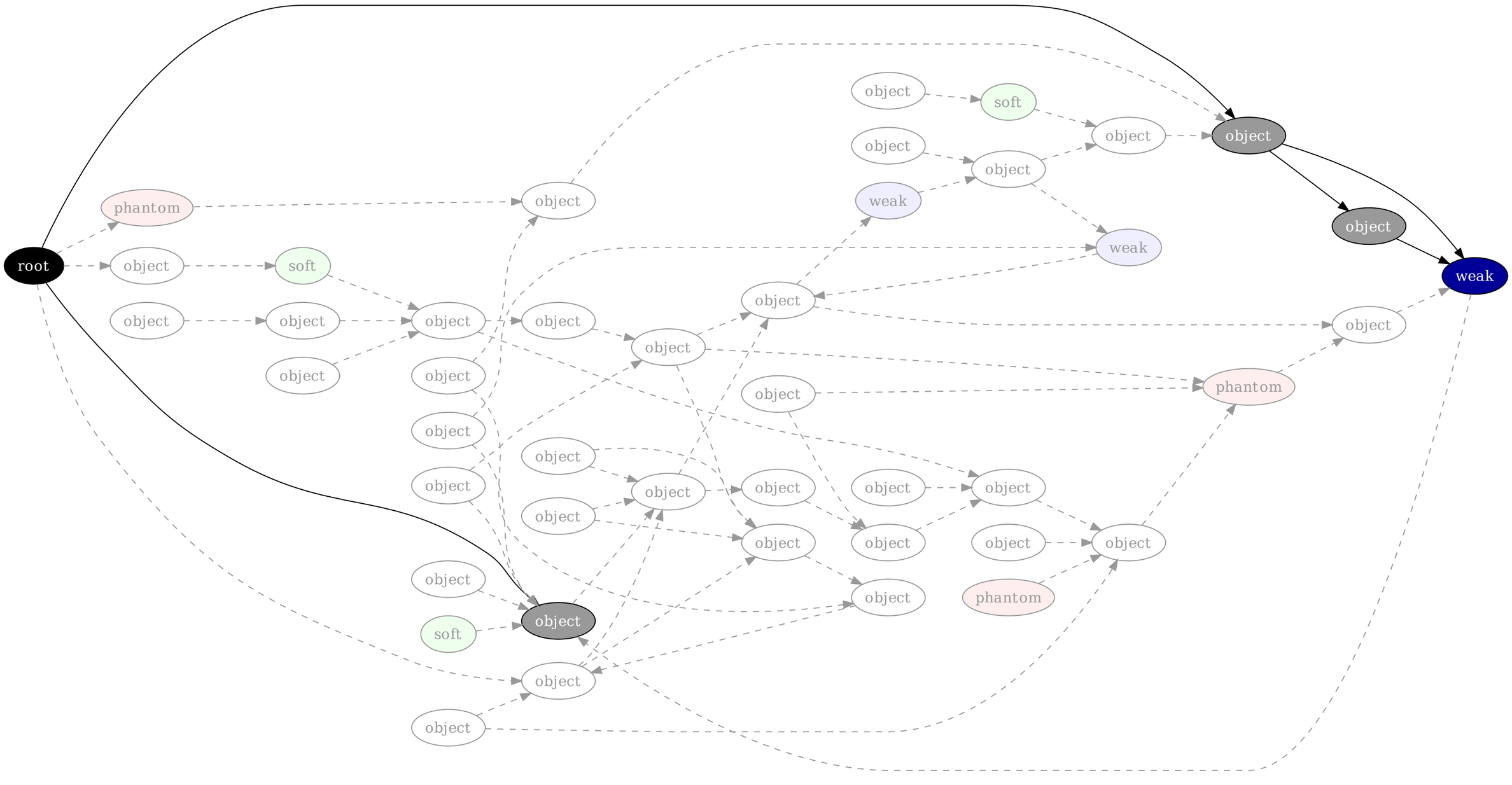

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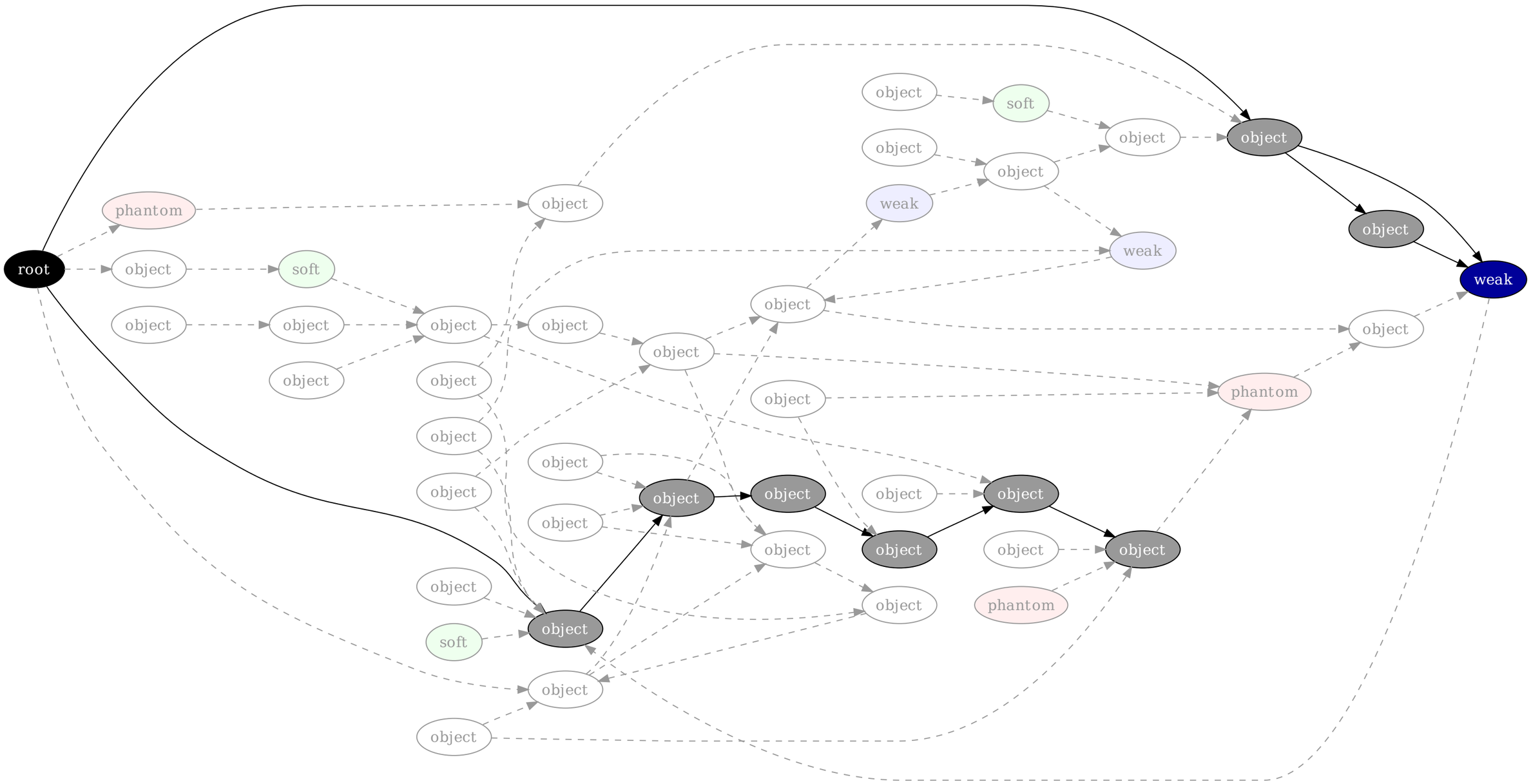

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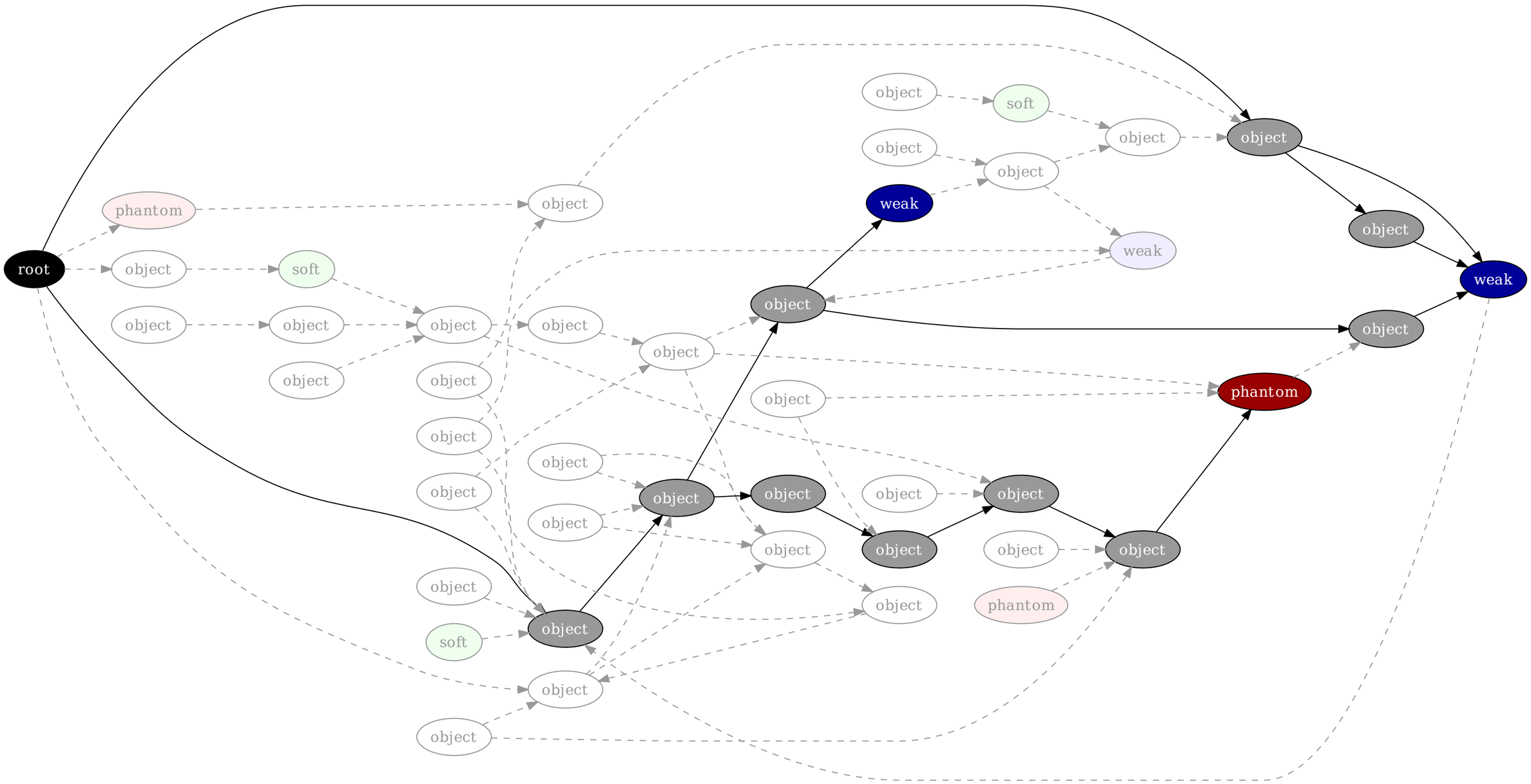

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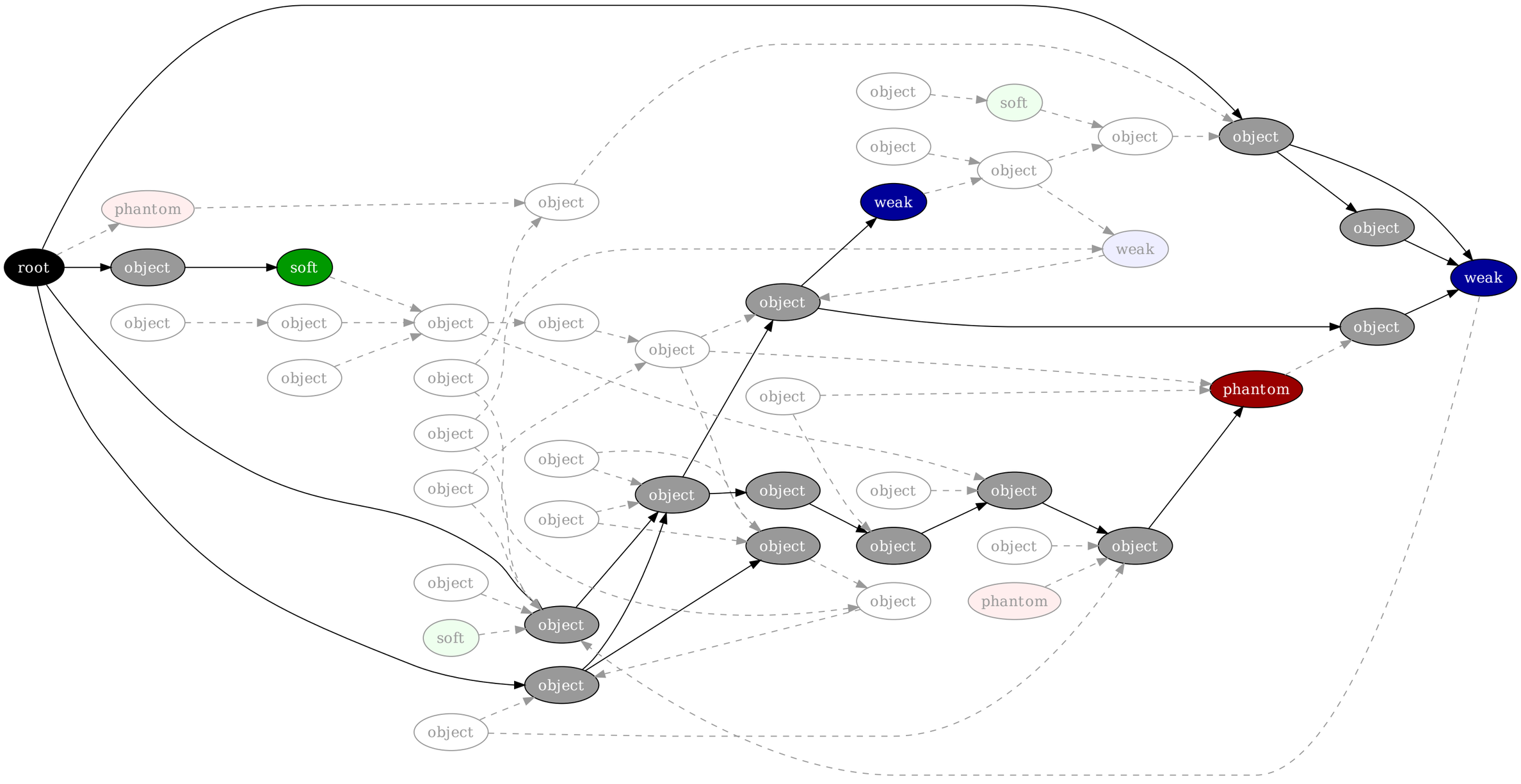

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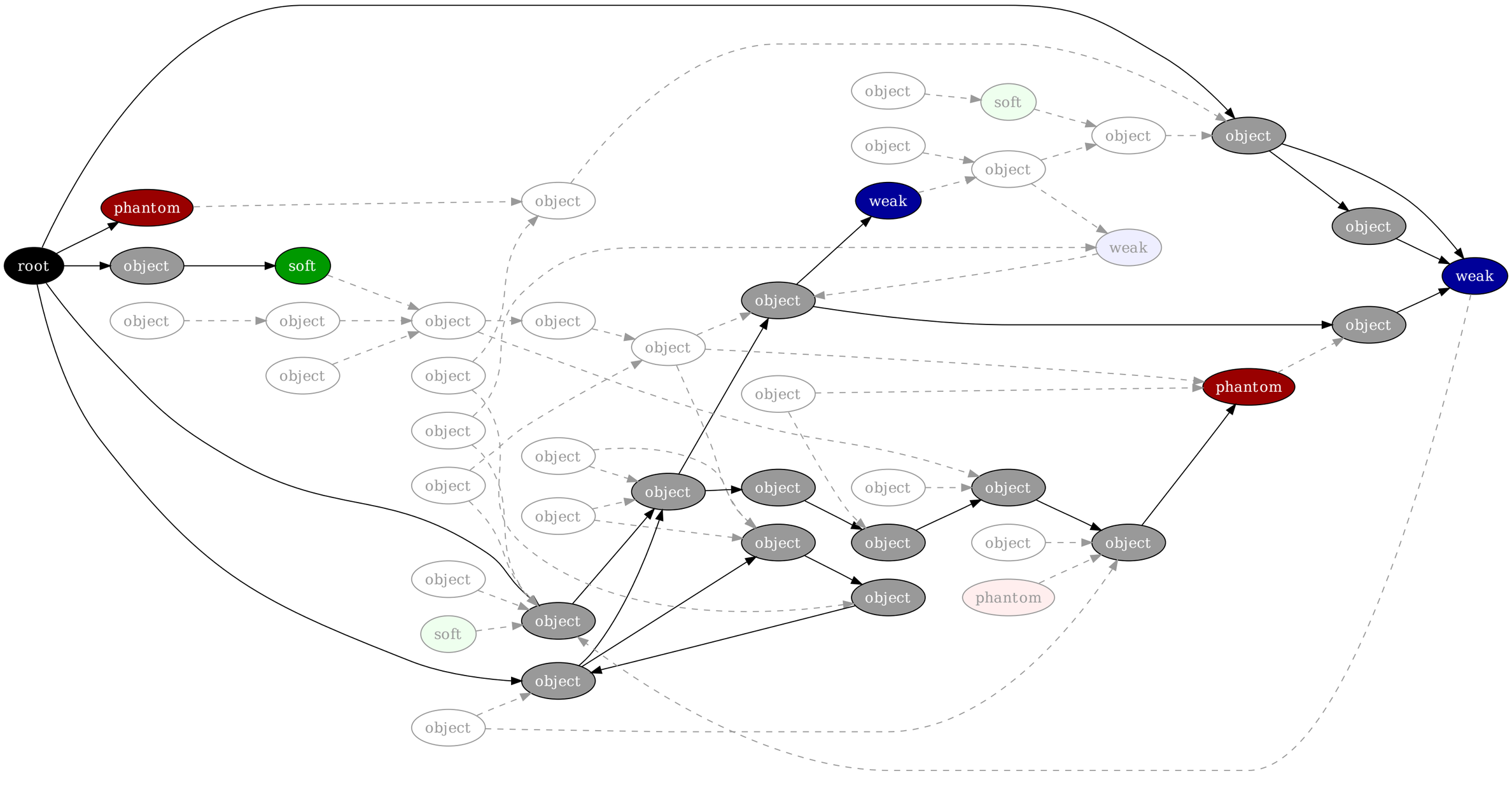
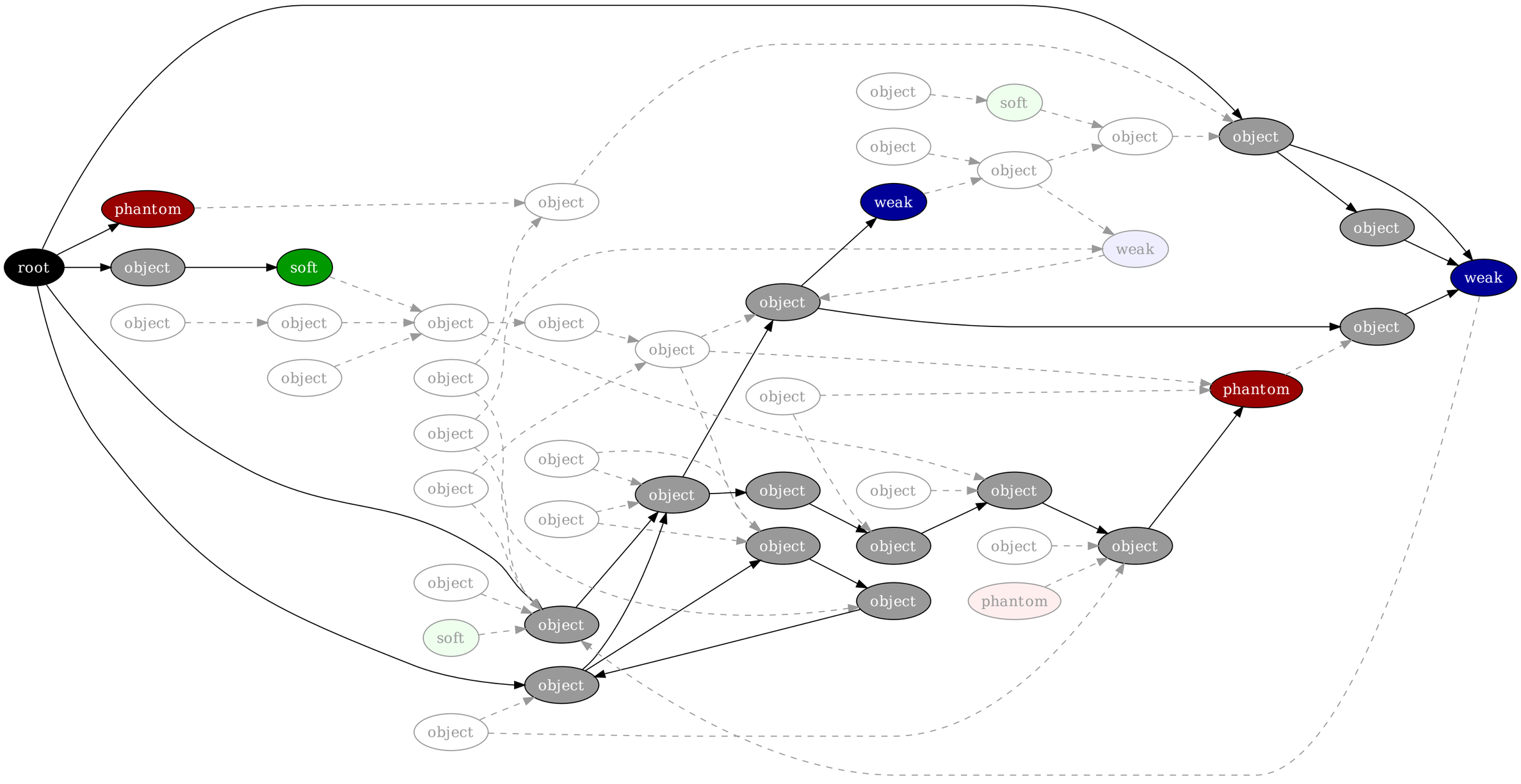
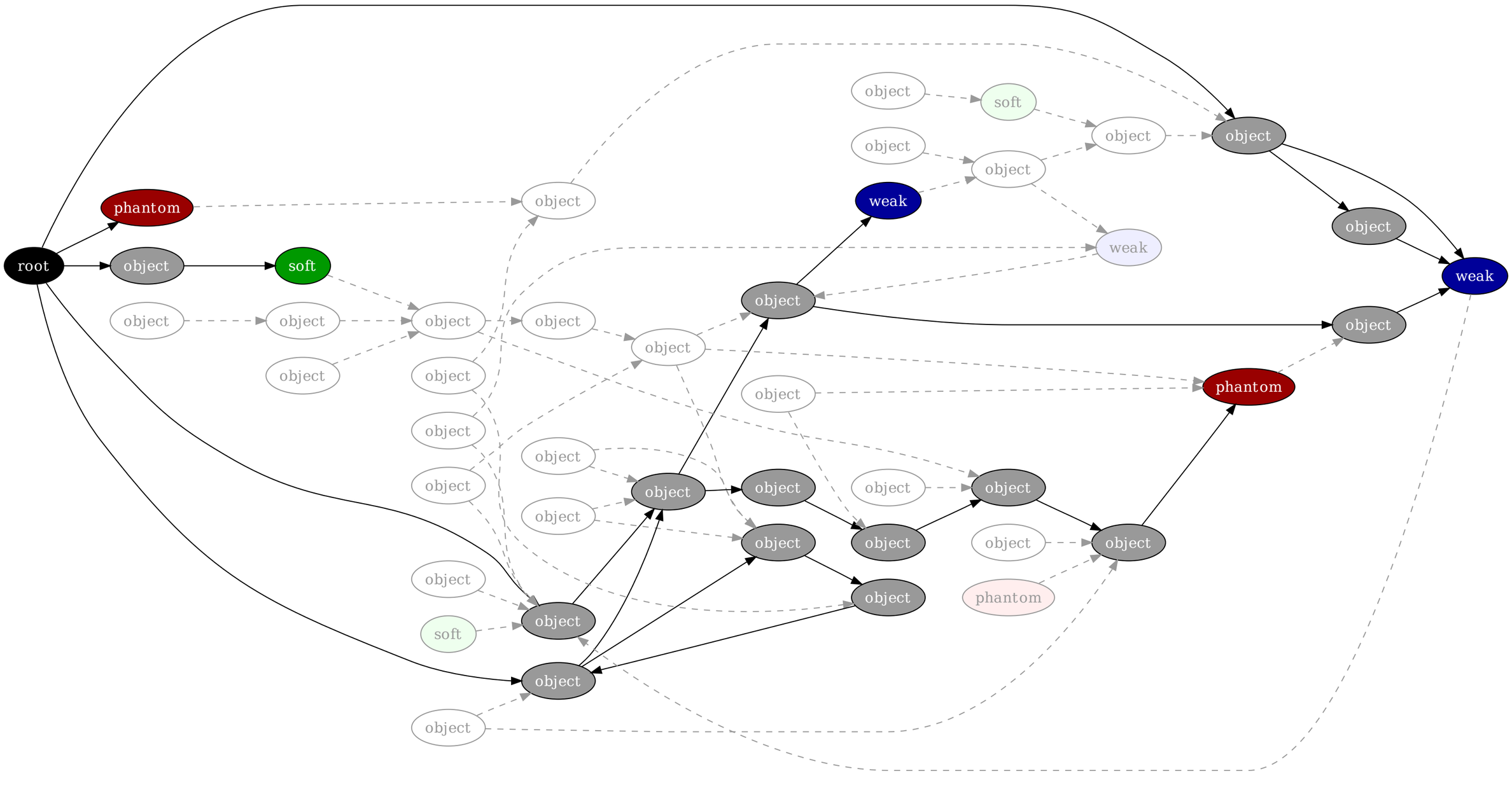


3. Optionally clear soft references.



4. Trace and mark softly-referenced objects.



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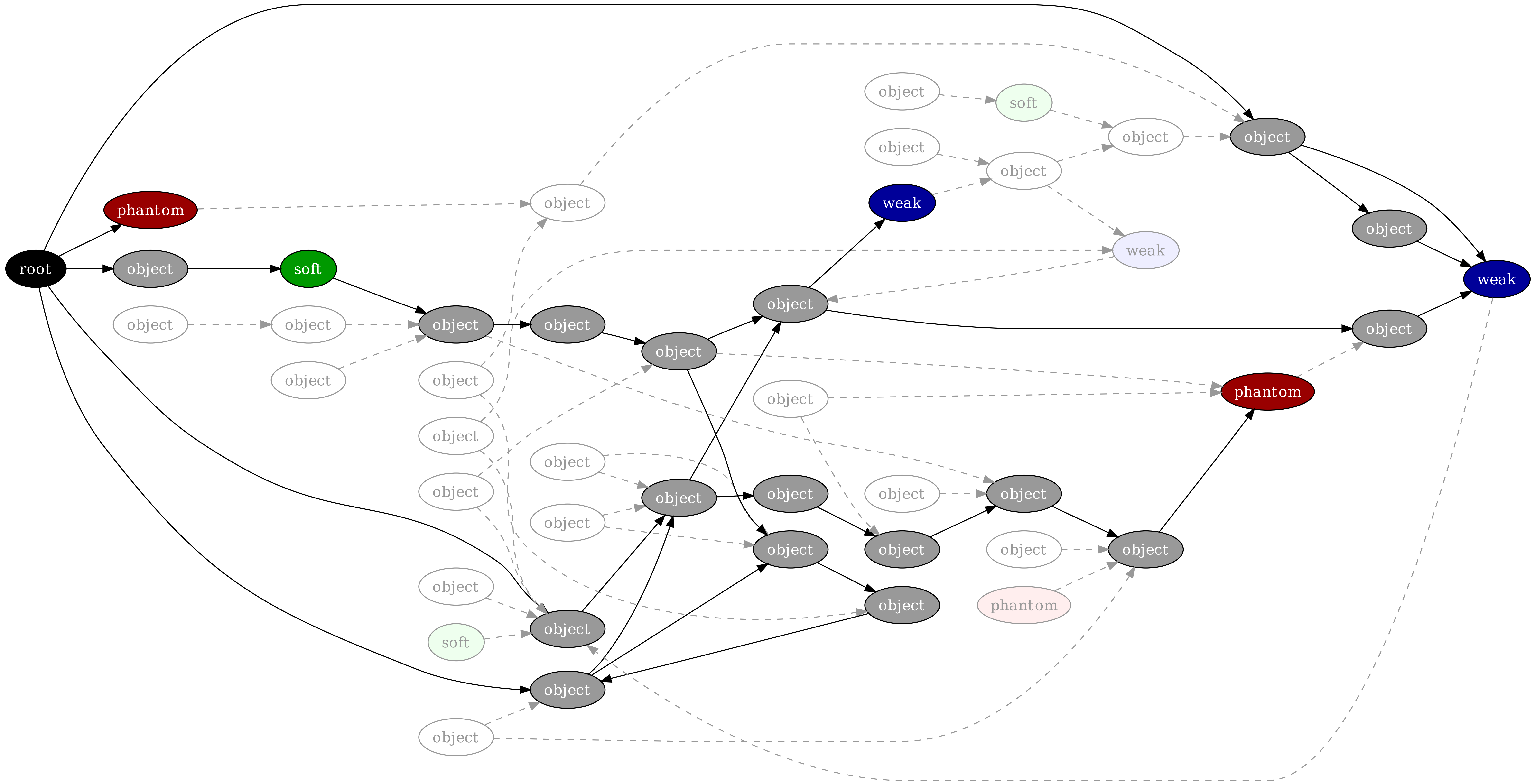
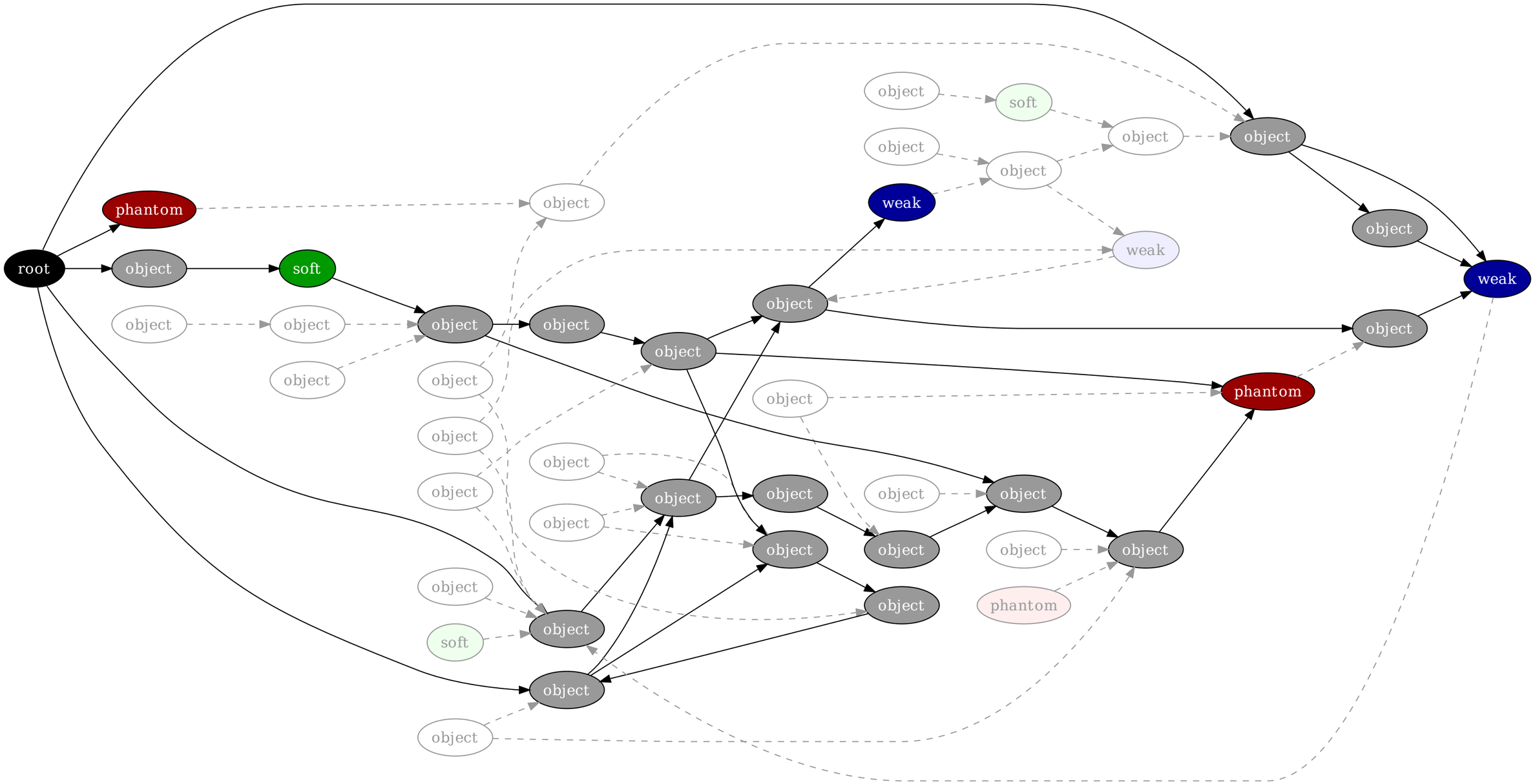
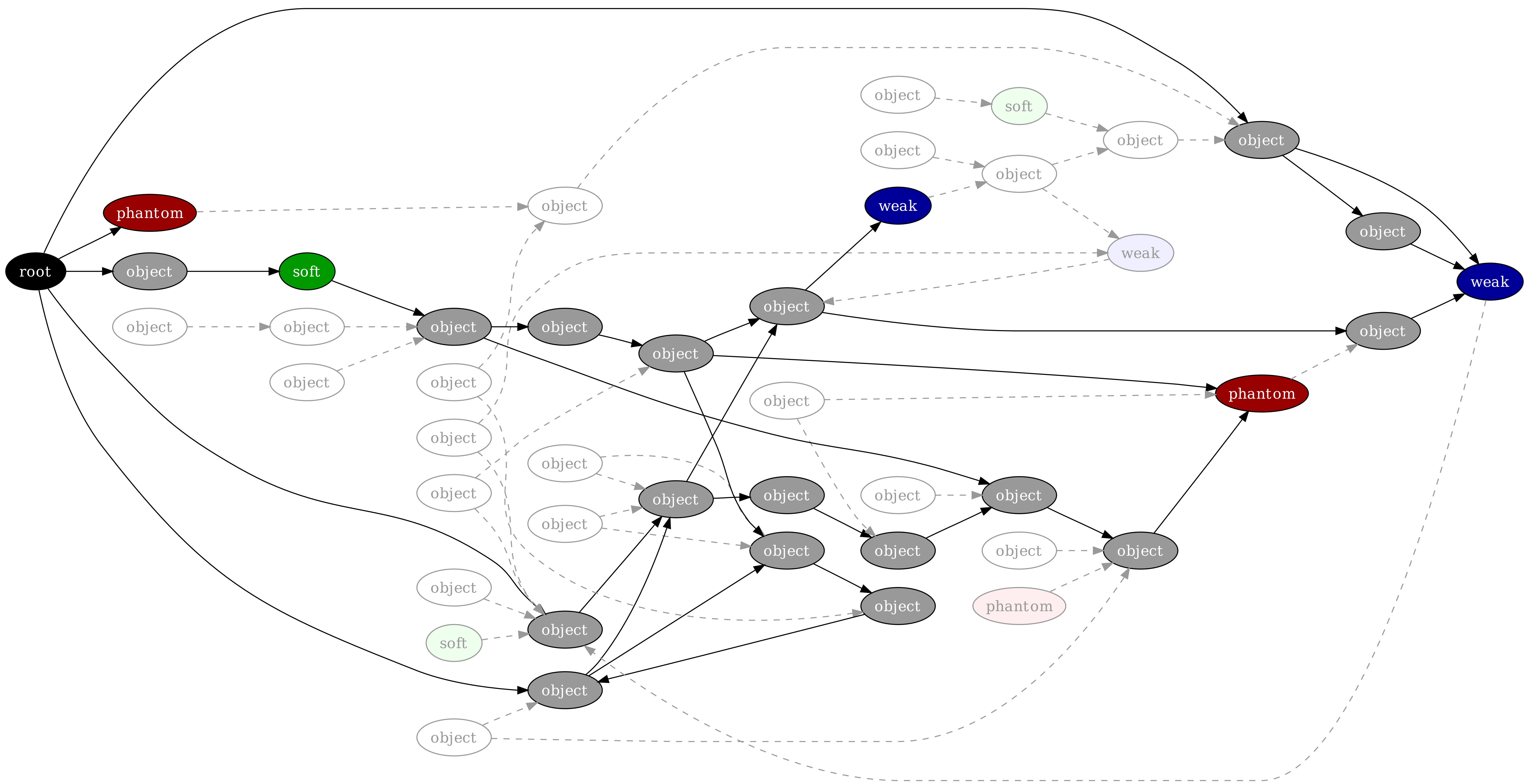


4. Trace and mark softly-referenced objects.



5. Clear weak references.



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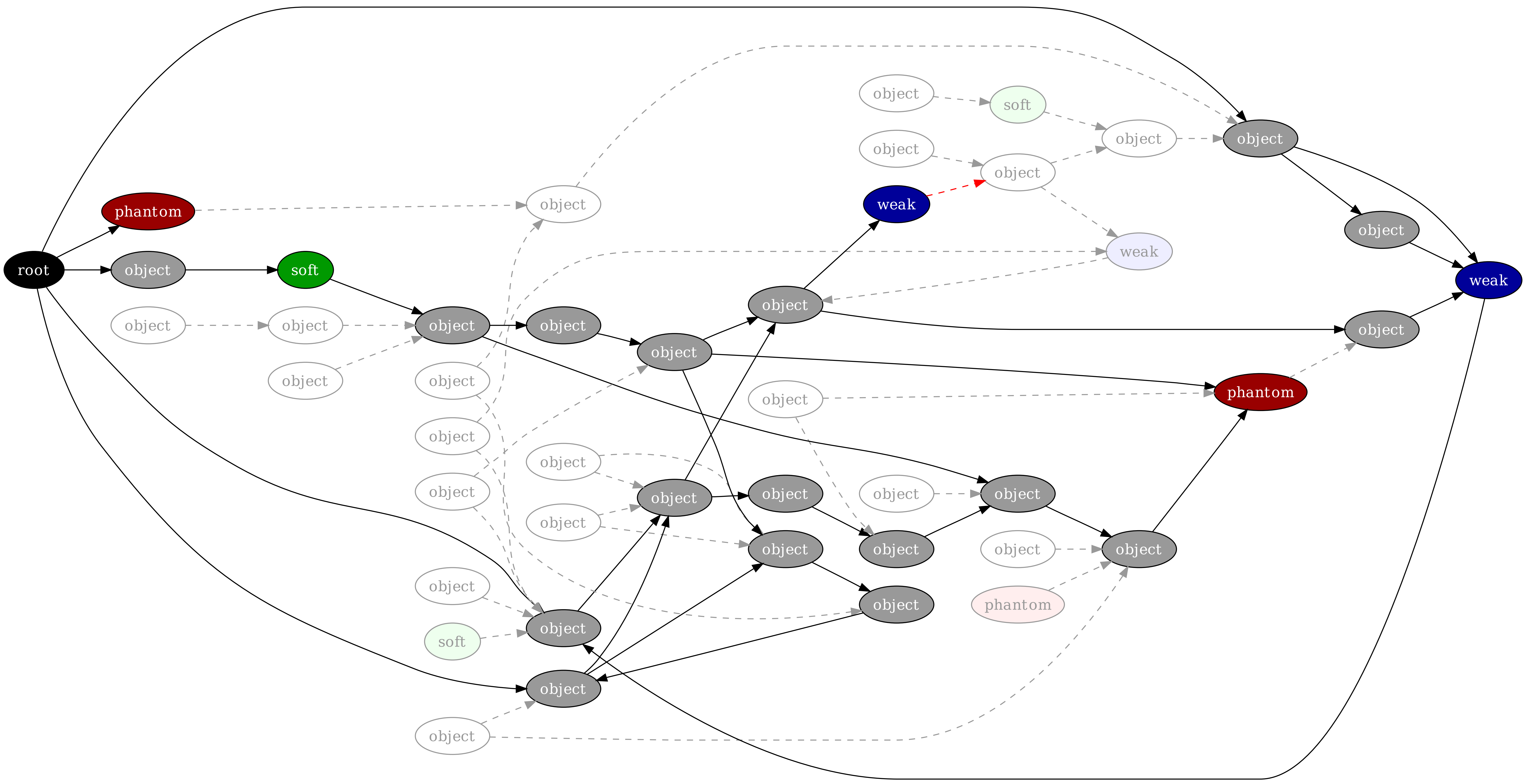

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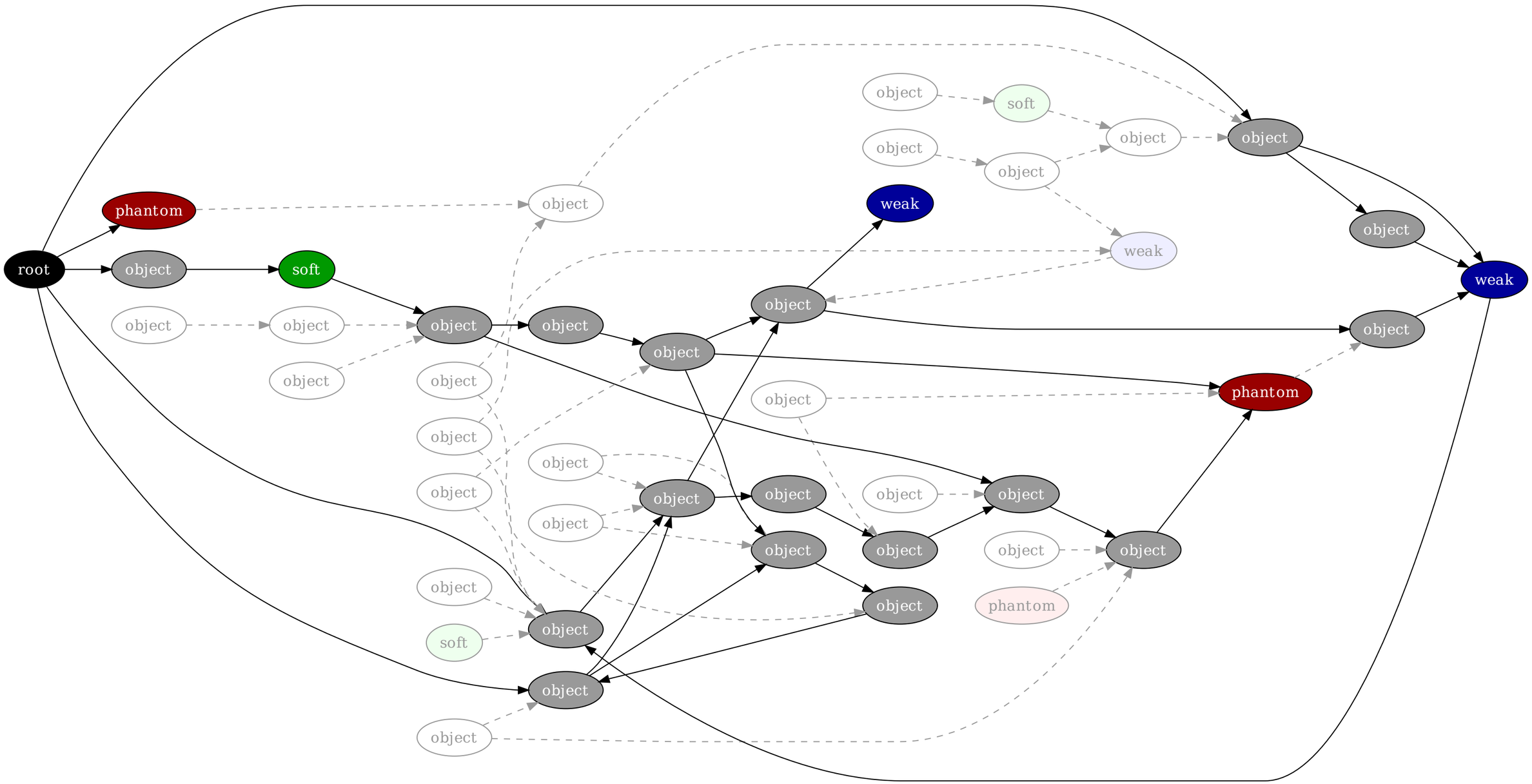
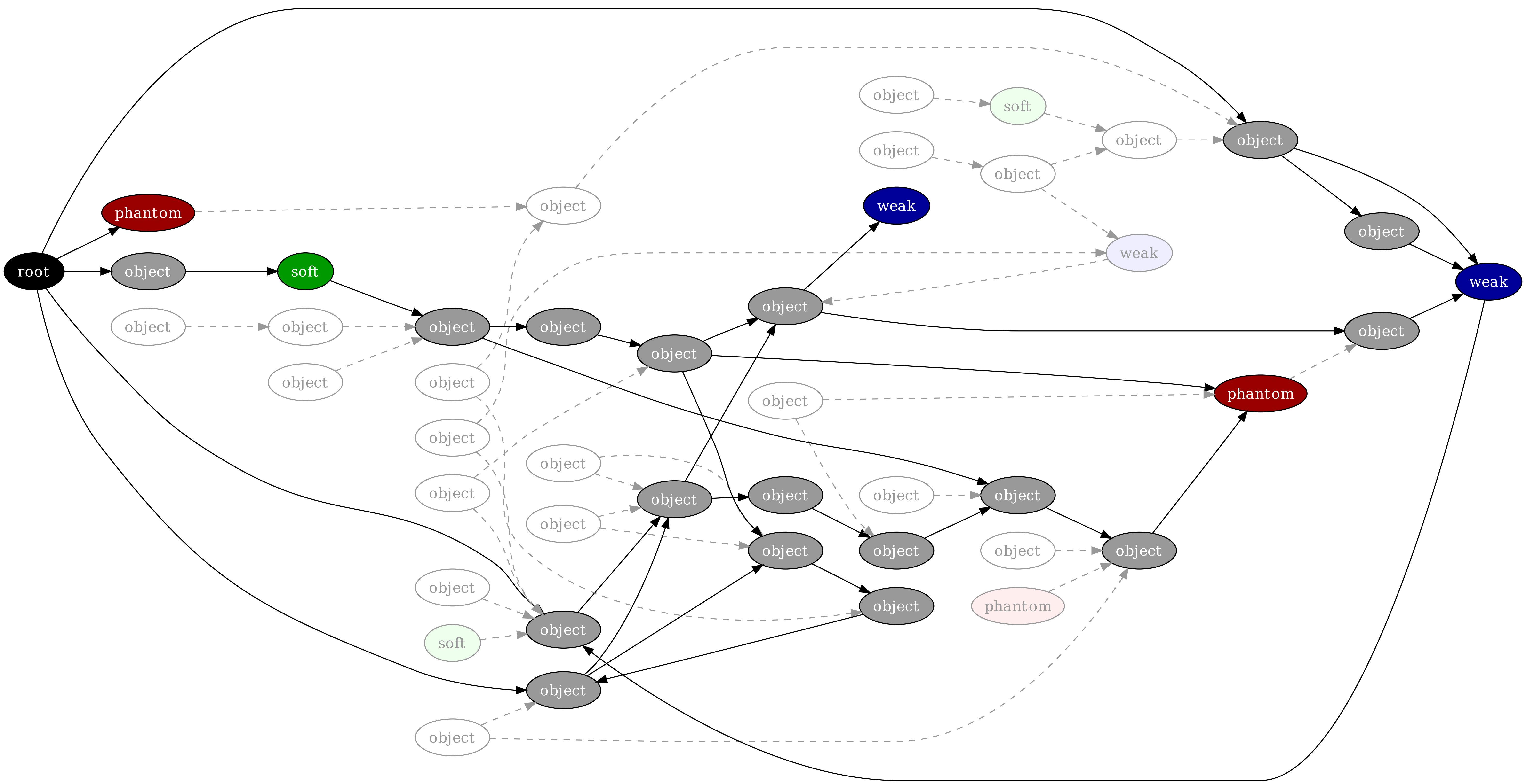


6. Enqueue finalizable objects.



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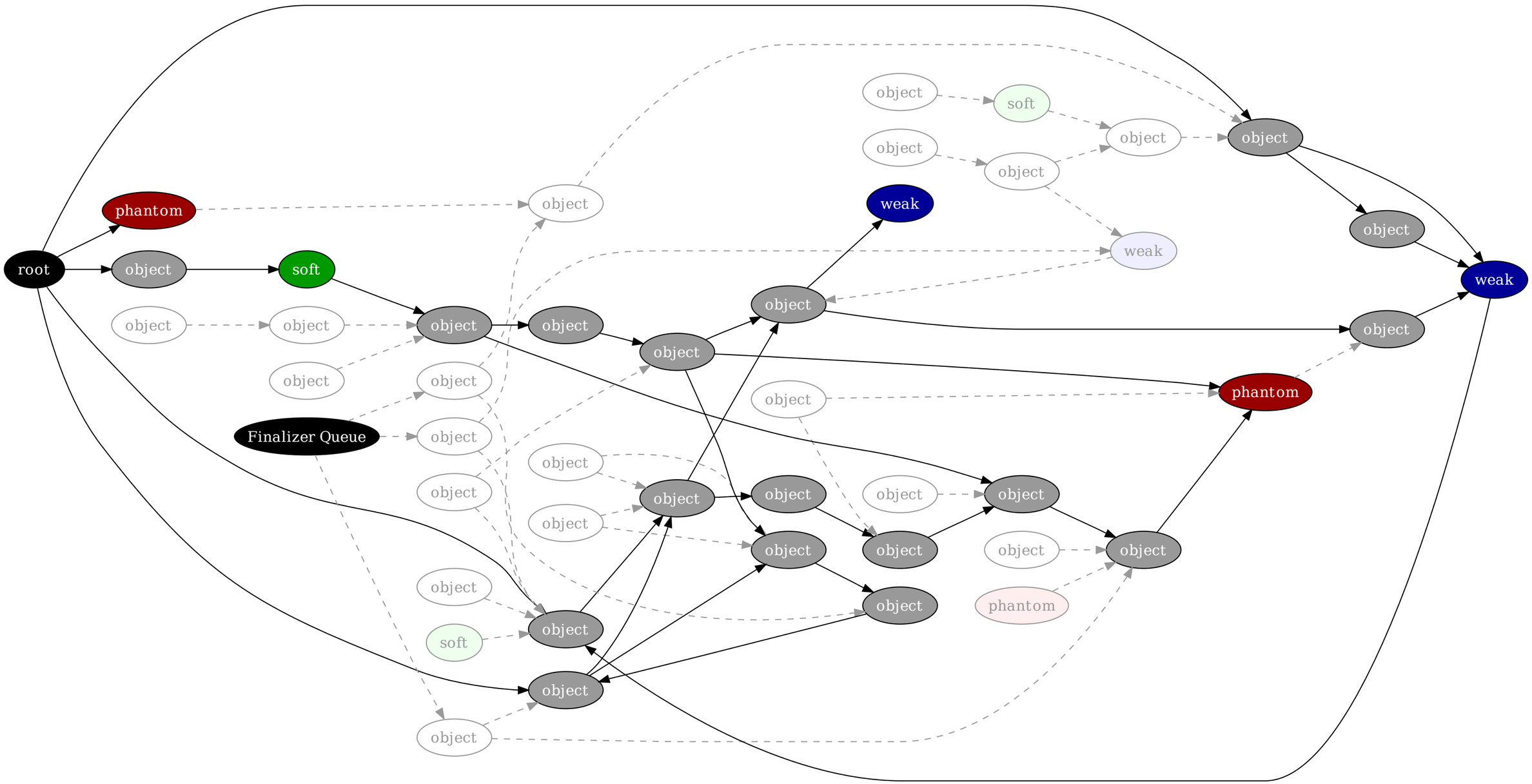
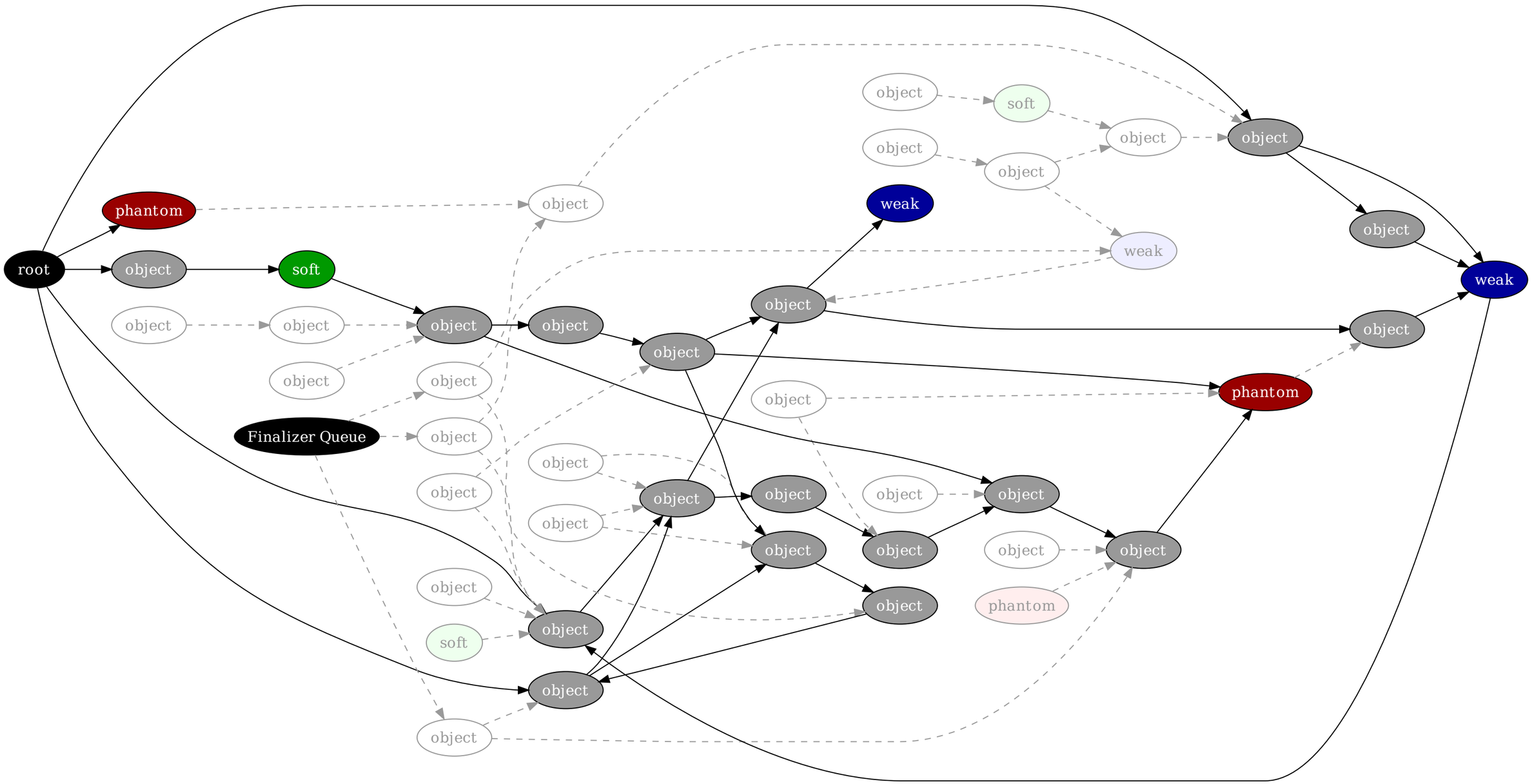


7. Repeat steps 1 through 5 for the queue.



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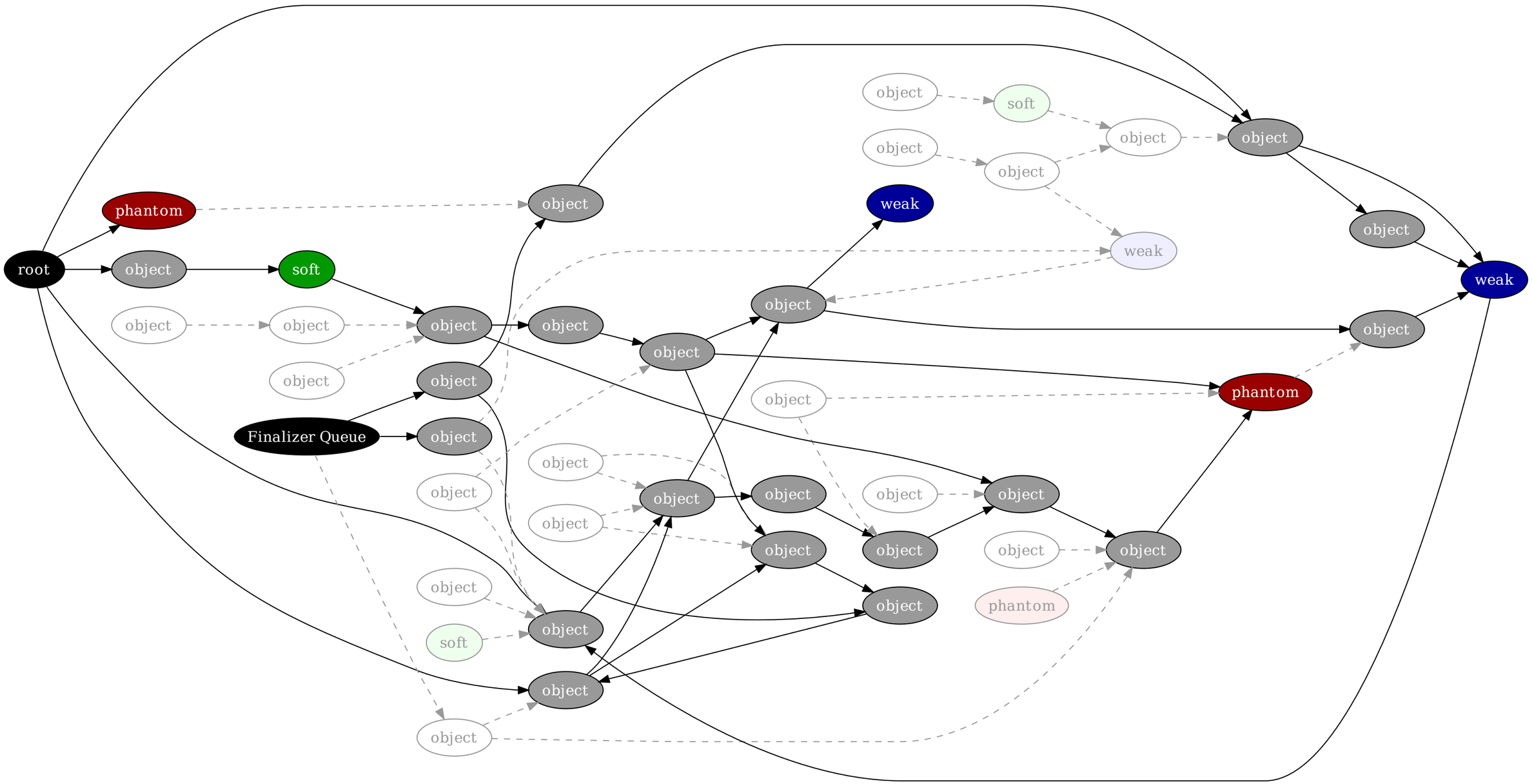

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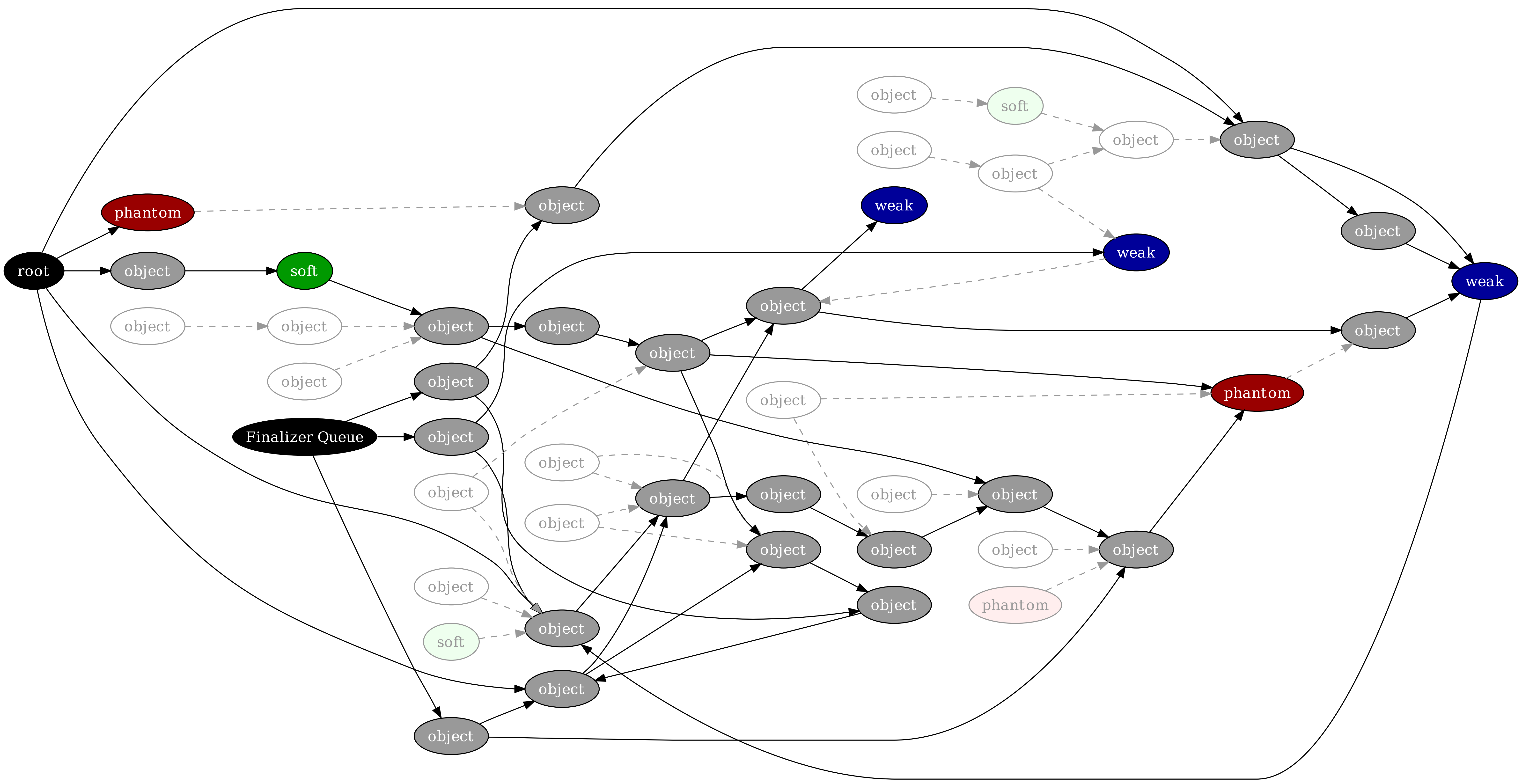

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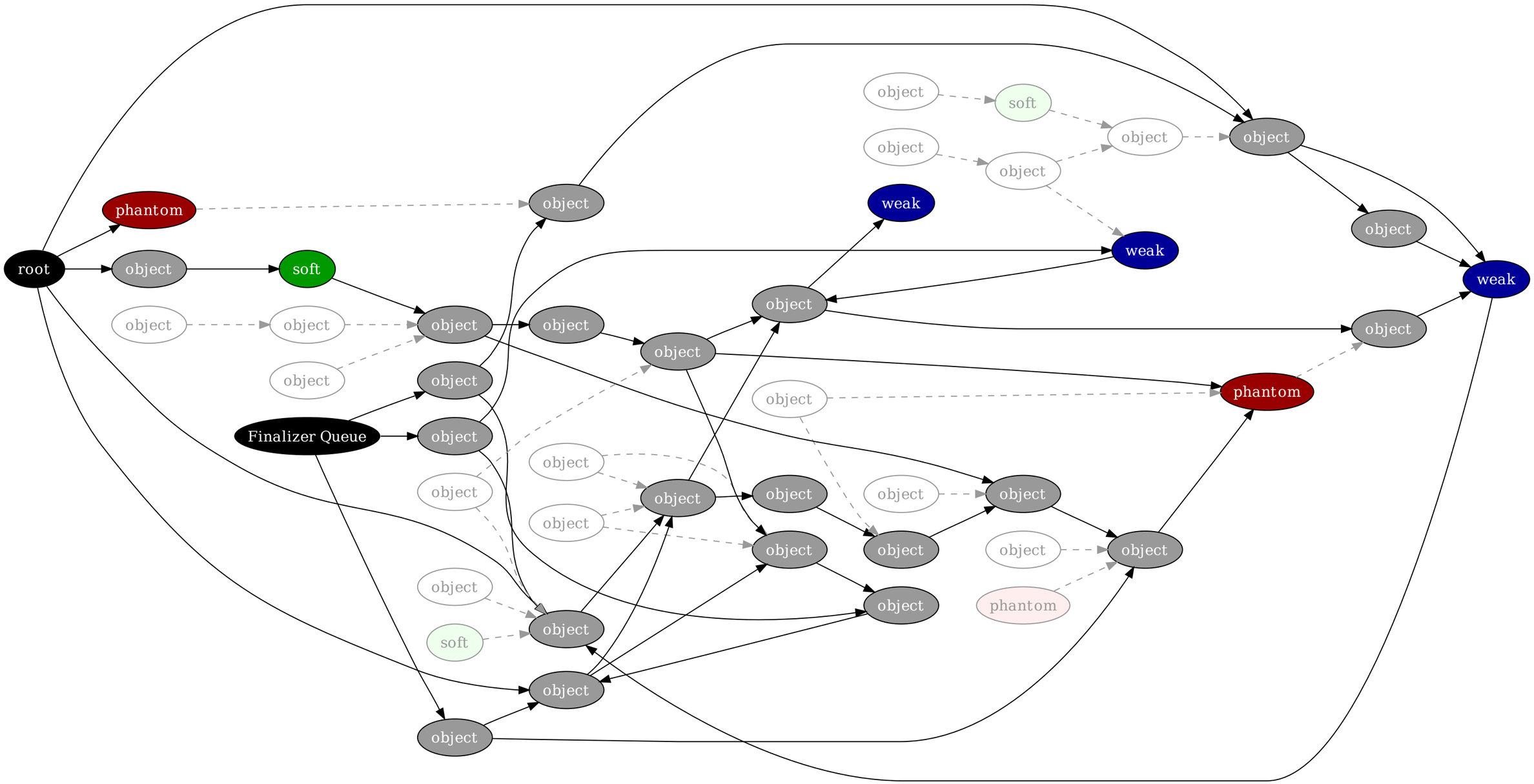
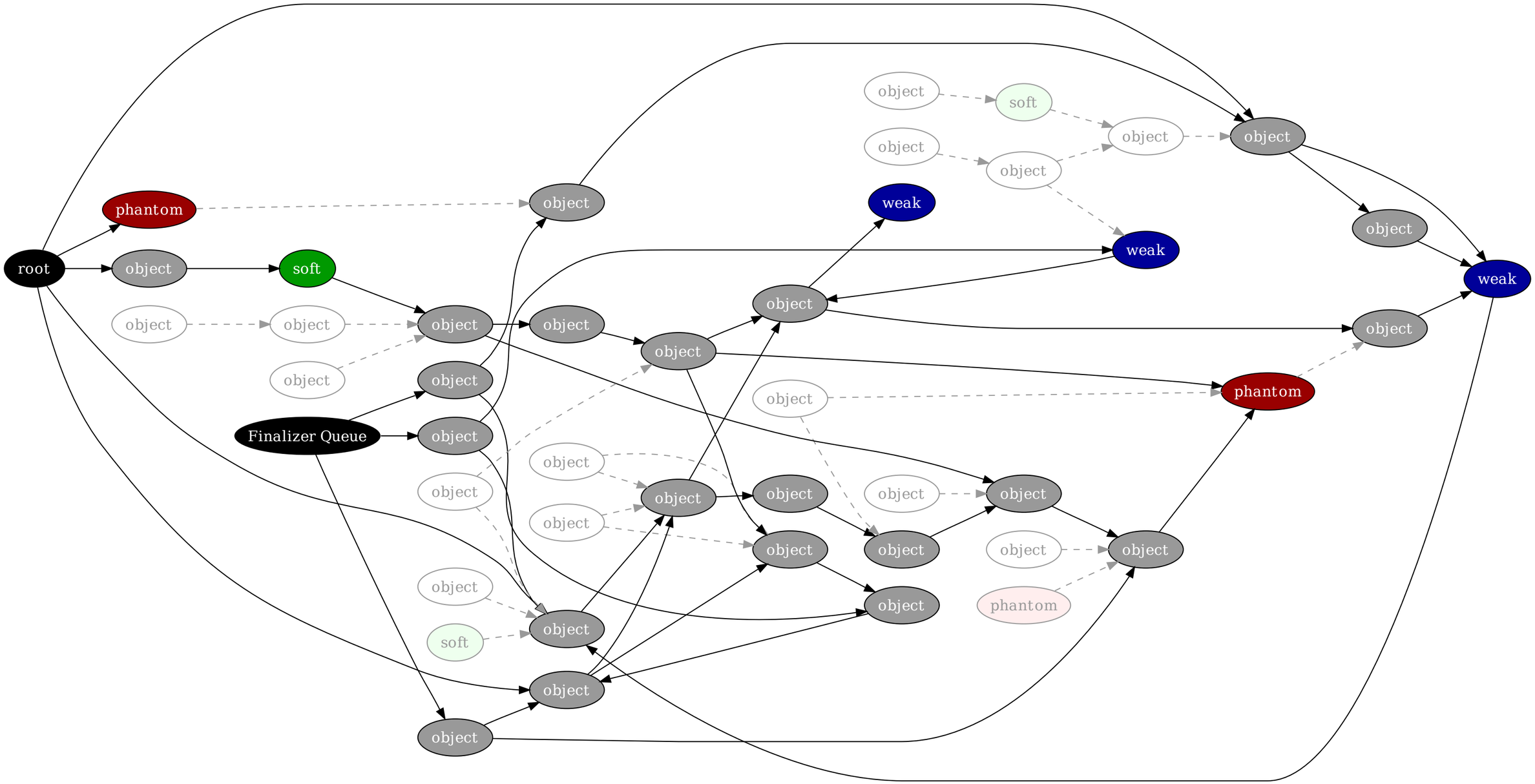


8. Possibly enqueue phantom references.



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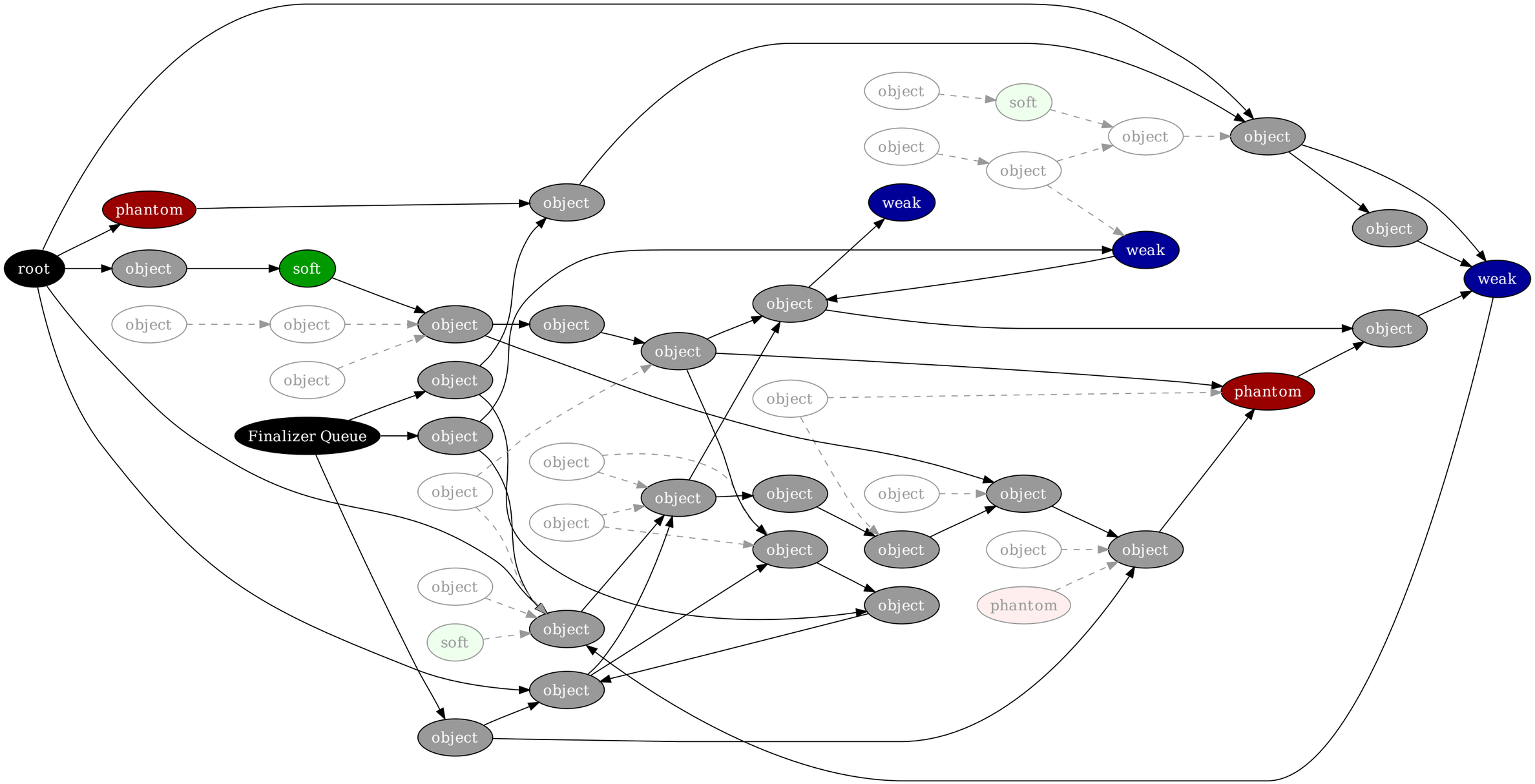
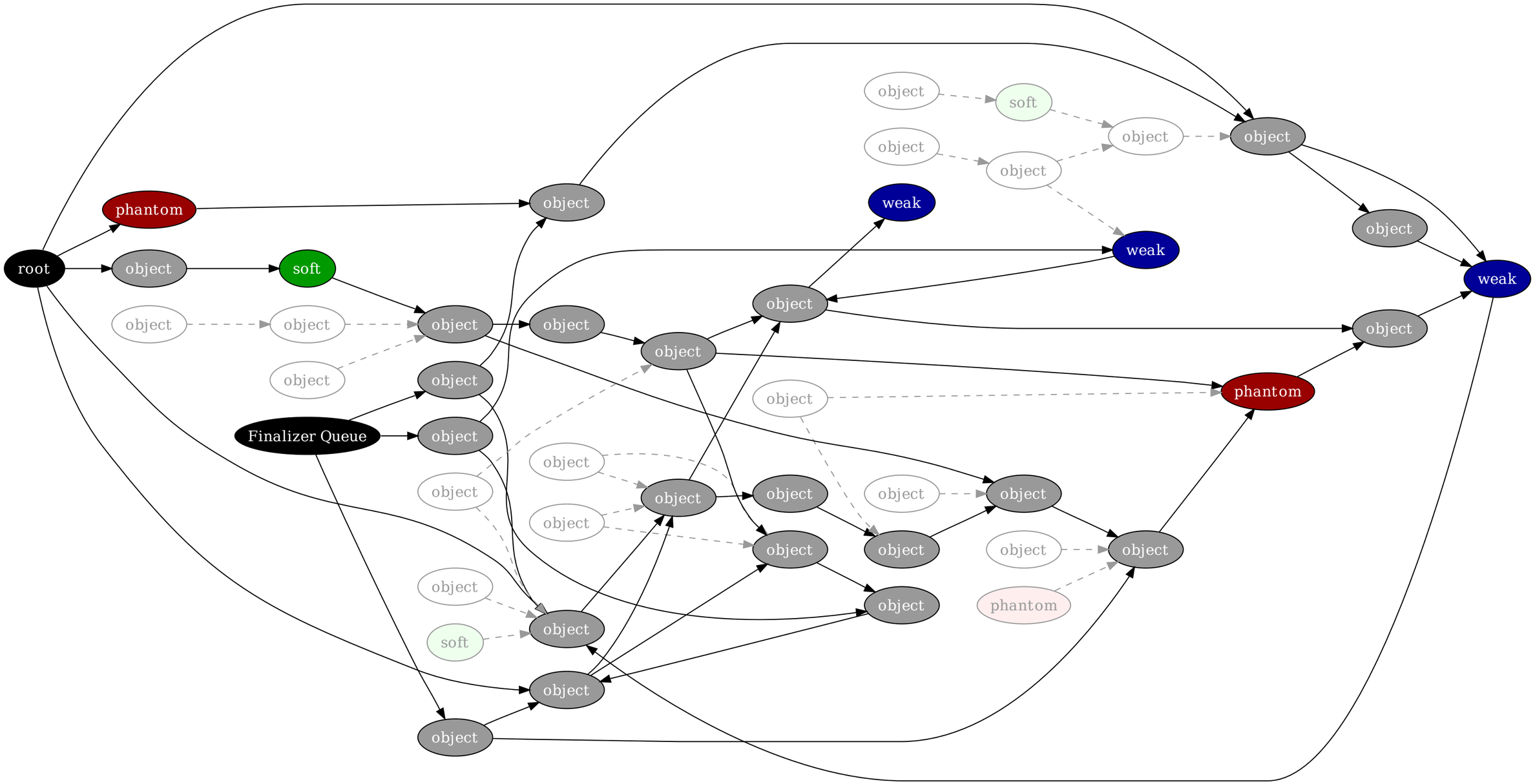


9. The remaining objects are dead.



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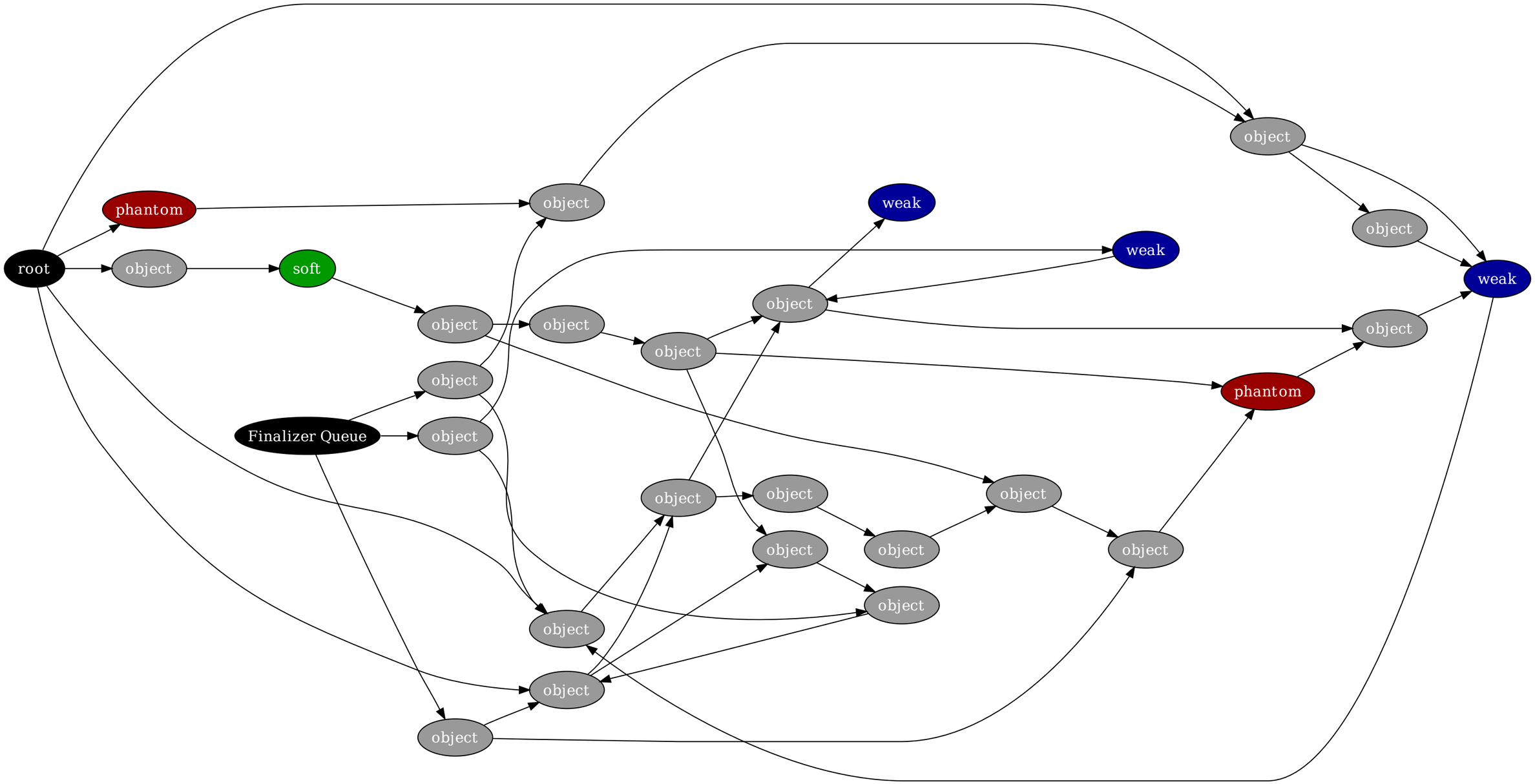
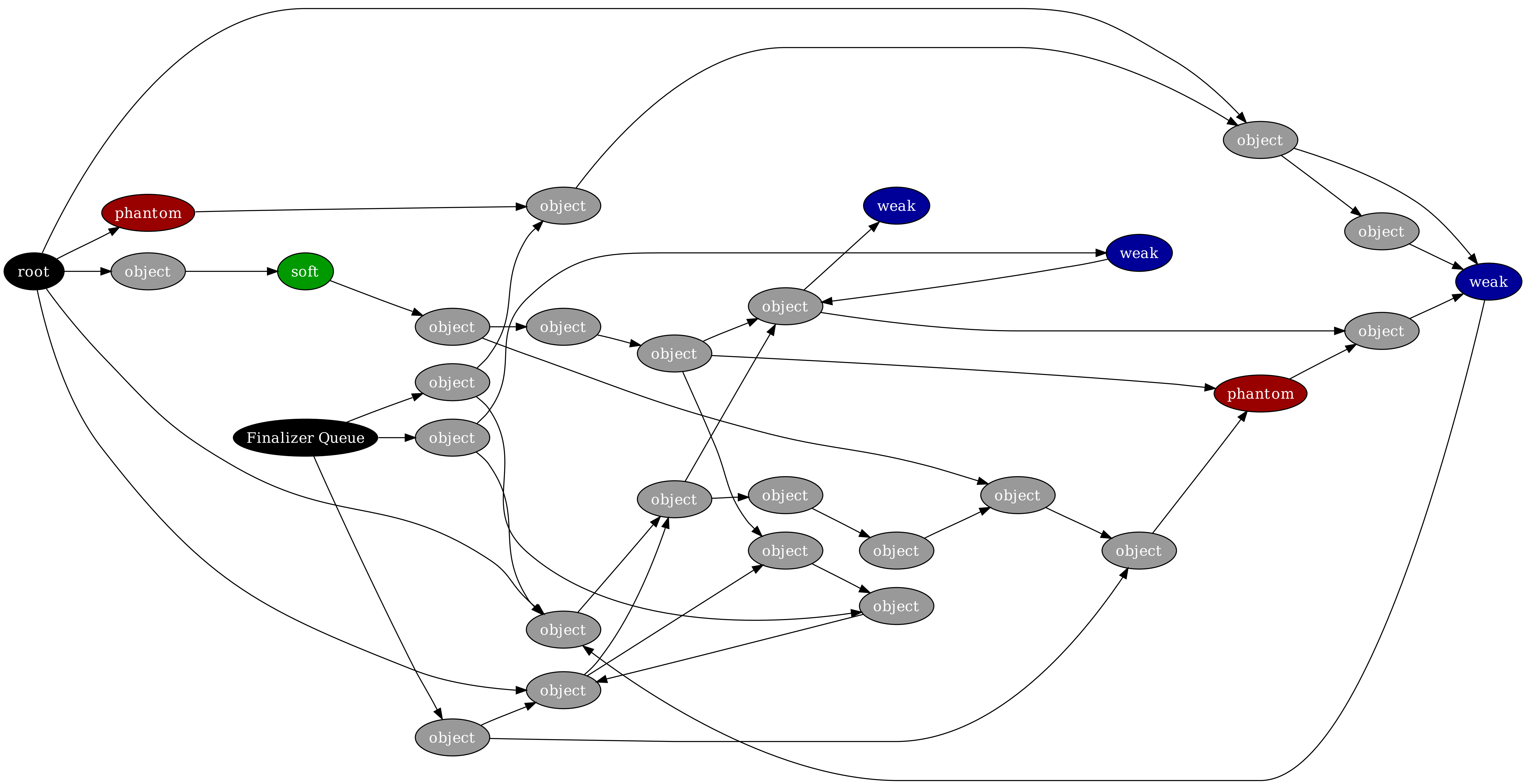


10. Repeat.


root
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Recap

1. Start at a root.

2. Trace and mark strongly-referenced objects.

3. Optionally clear soft references.

4. Trace and mark softly-referenced objects.

5. Clear weak references.

6. Enqueue finalizable objects.

7. Repeat steps 1 through 5 for the queue.

8. Possibly enqueue phantom references.

9. The remaining objects are dead.

10. Repeat.

Two options for freeing native resources

> Use a finalizer.
  - You must defend against subsequent use!
> Or use a phantom reference.