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JavaOneSM

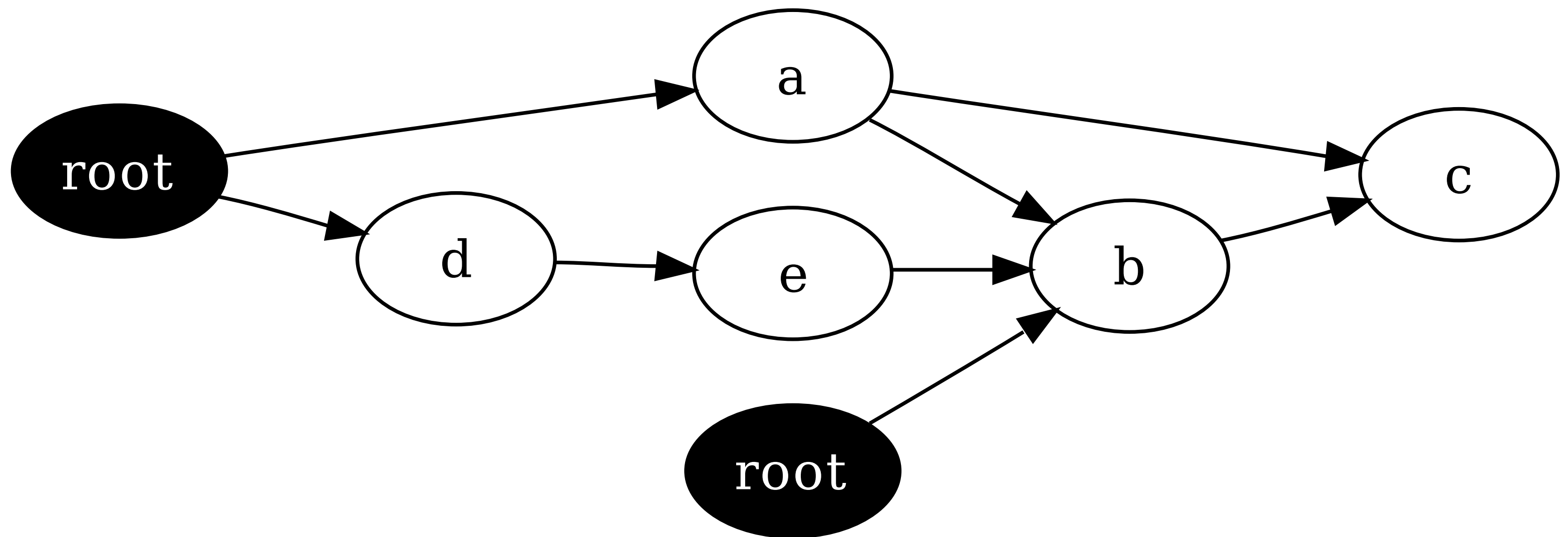
The Ghost in the Virtual Machine A Reference to References

Bob Lee
Google Inc.

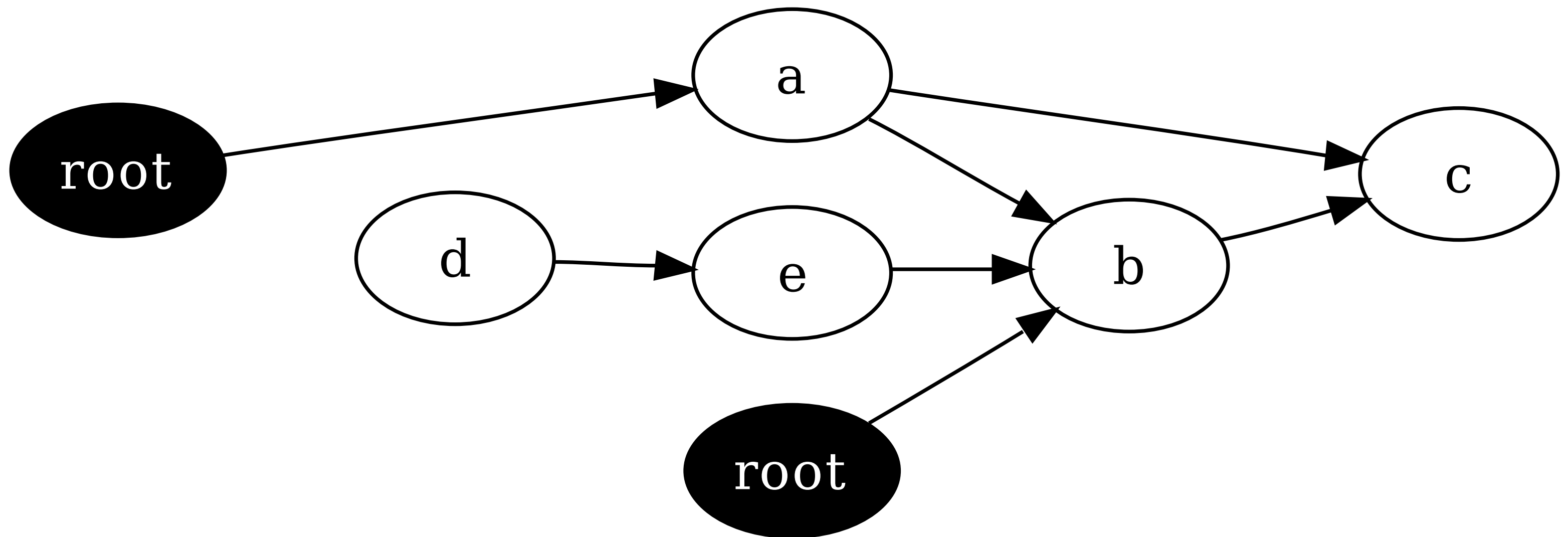
Goals

- > Take the mystery out of garbage collection.

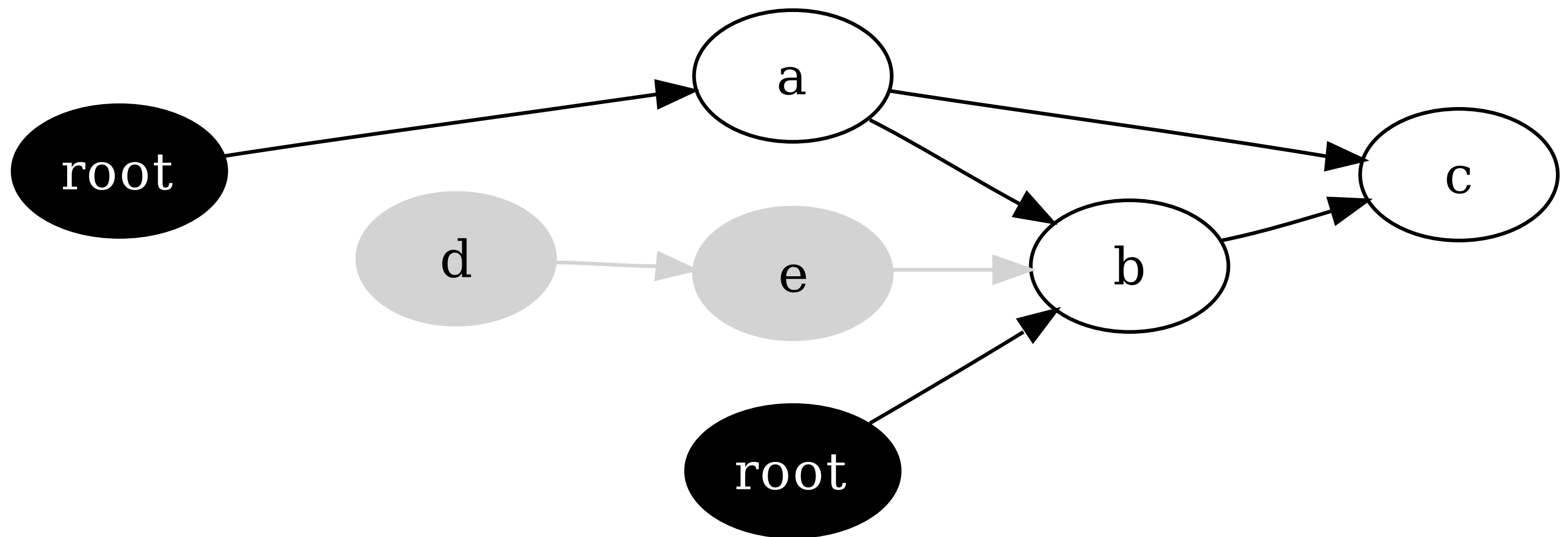
How does garbage collection work?



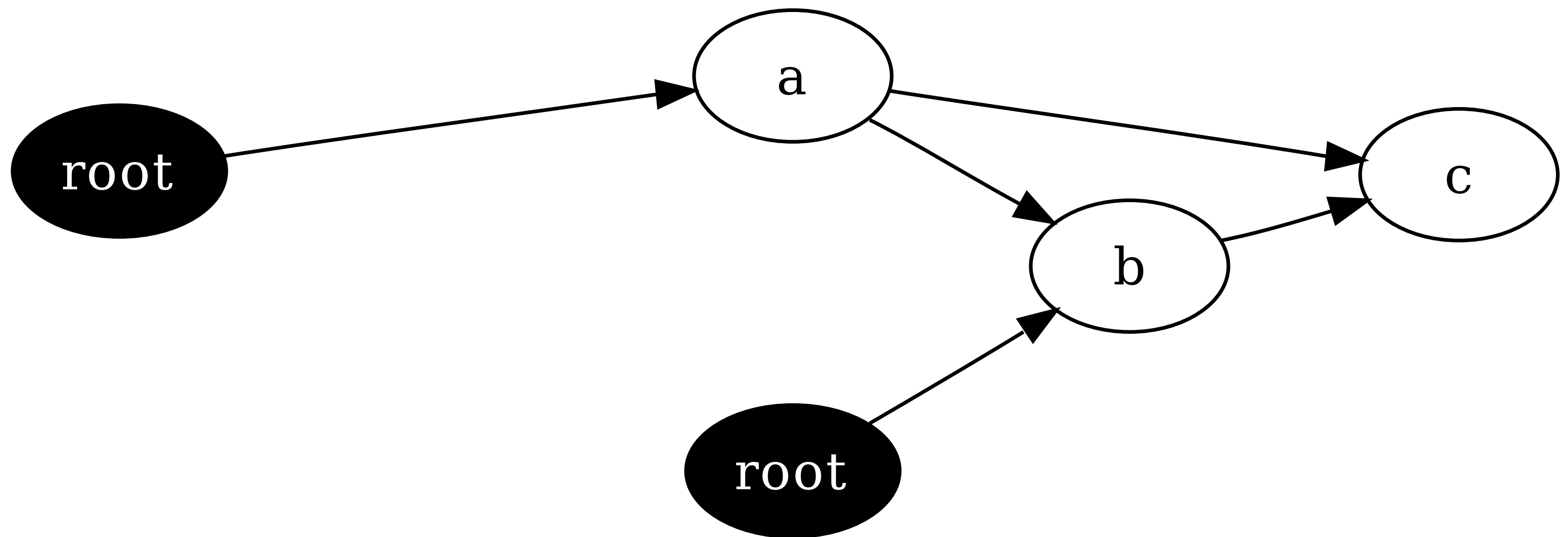
If the reference to D goes away...



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 state)
 - Thread stacks
 - In-flight exceptions
 - JNI global references
 - The finalizer queue
 - Interned strings
 - etc. (VM-dependent)

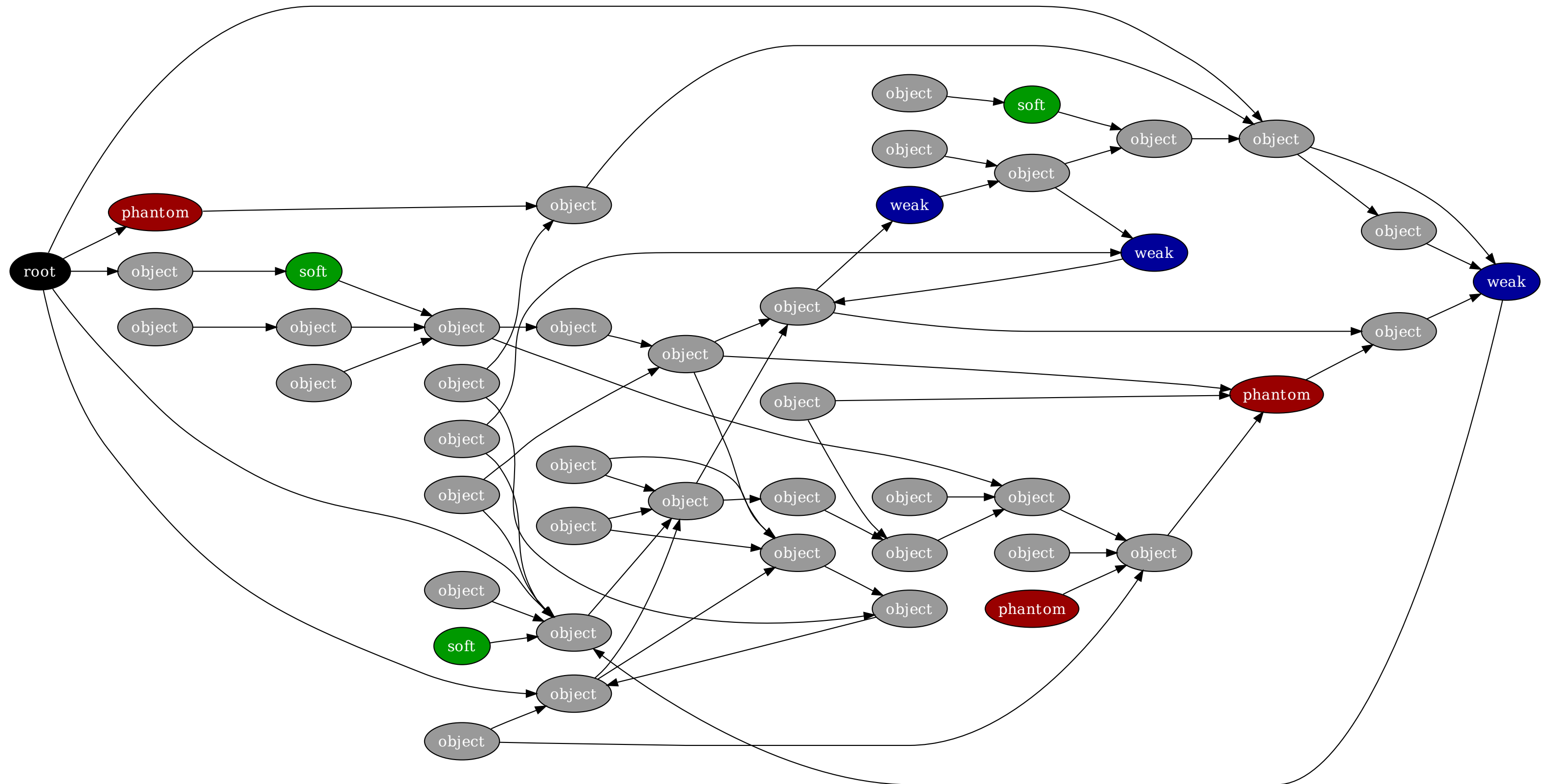
In the beginning, there was the finalizer...

```
public class Foo extends Bar {  
    @Override protected void finalize() throws Throwable {  
        try {  
            ... // Clean up Foo.  
        } finally {  
            super.finalize(); // Clean up Bar.  
        }  
    }  
}
```

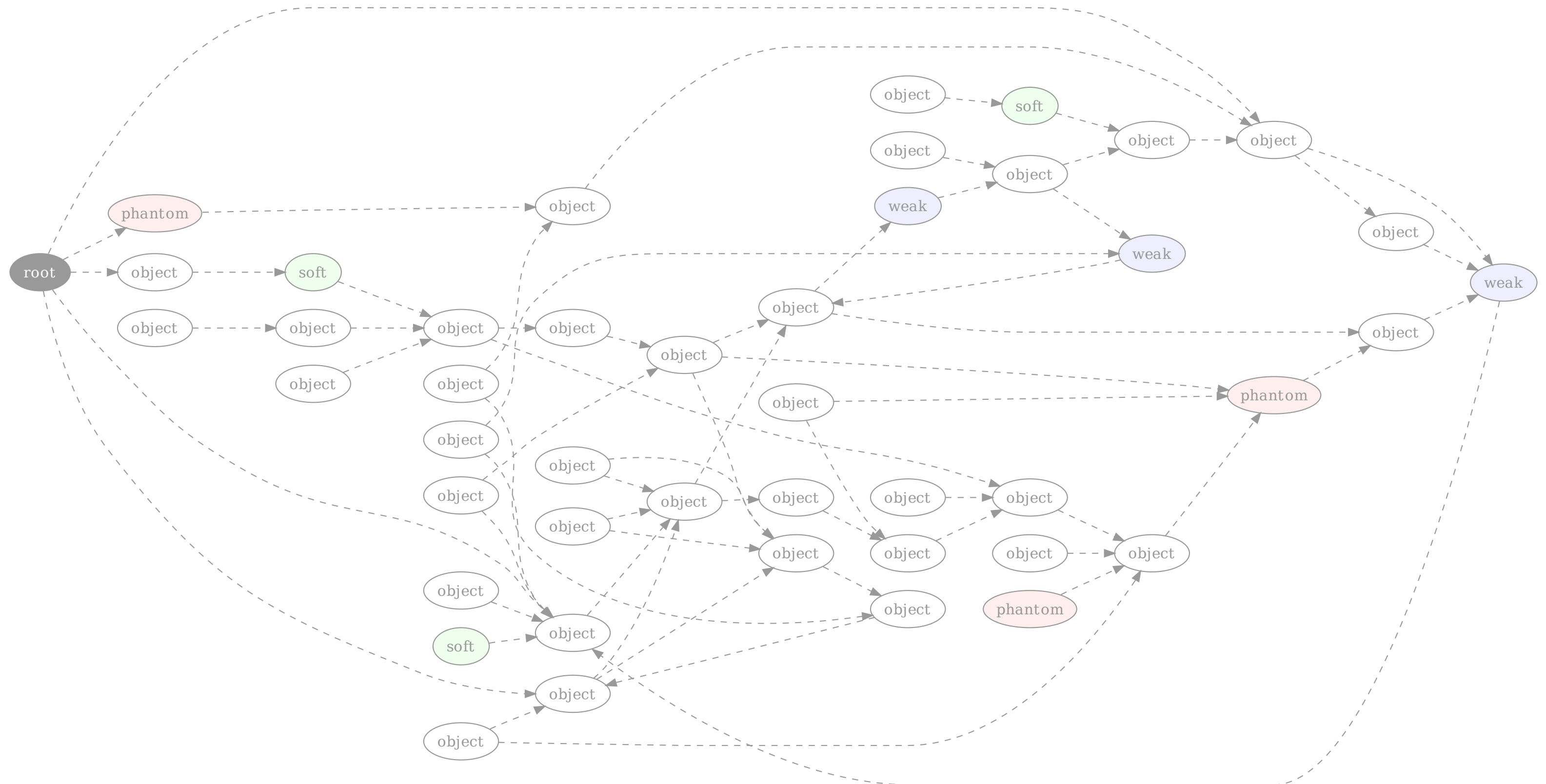

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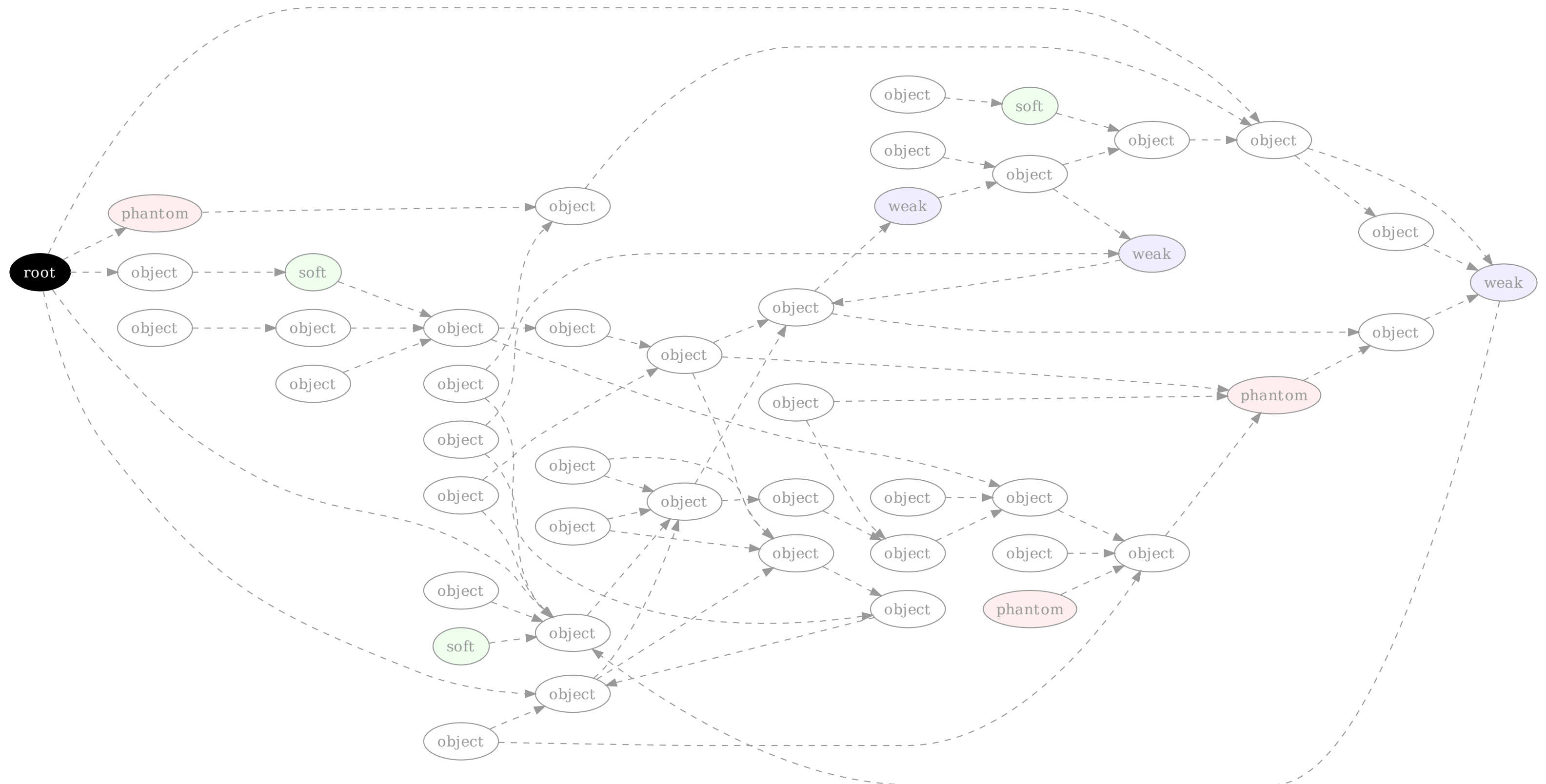
Let's mark and sweep a heap!



No objects are marked at first.



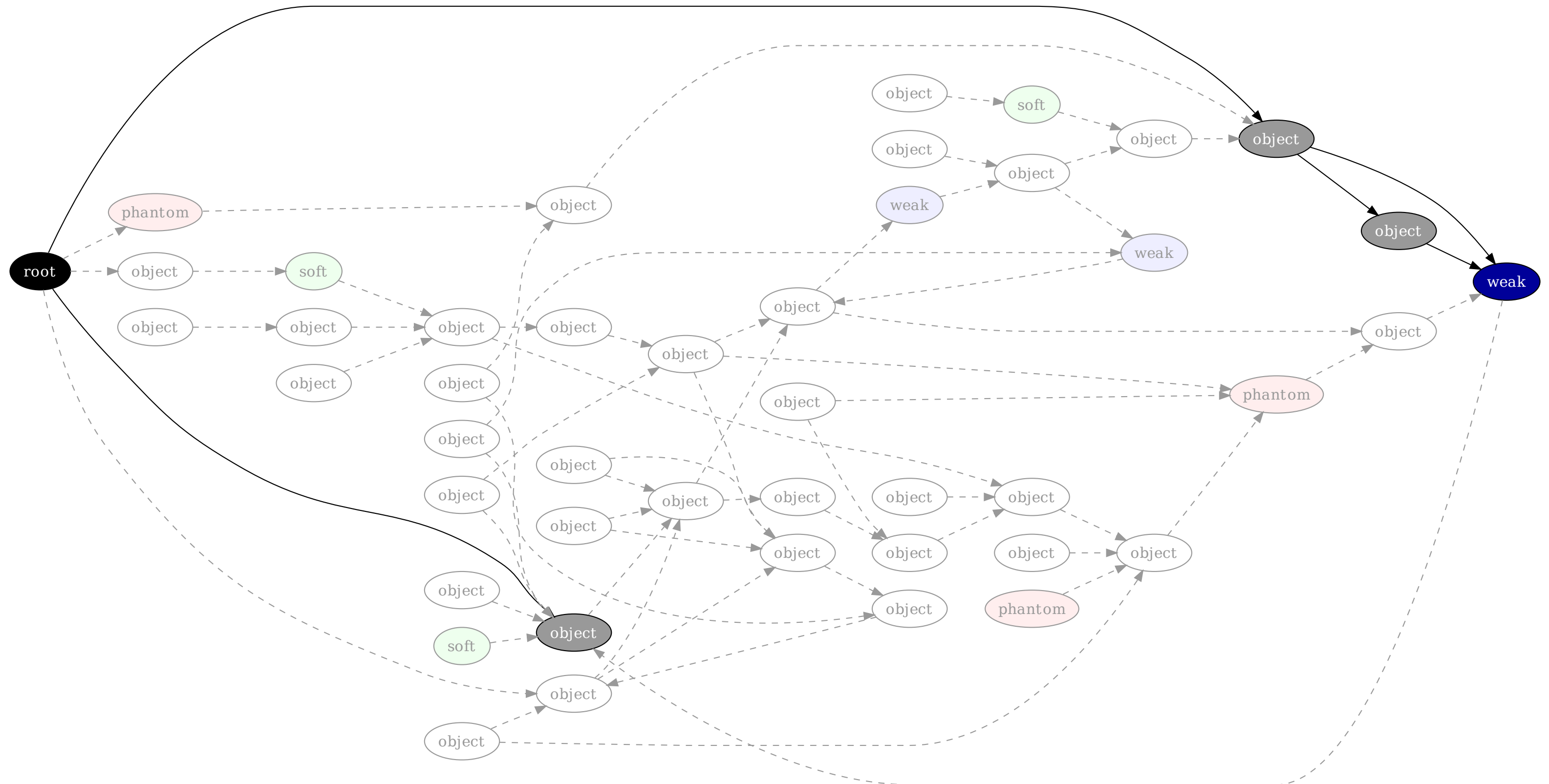
1. Start at a root.



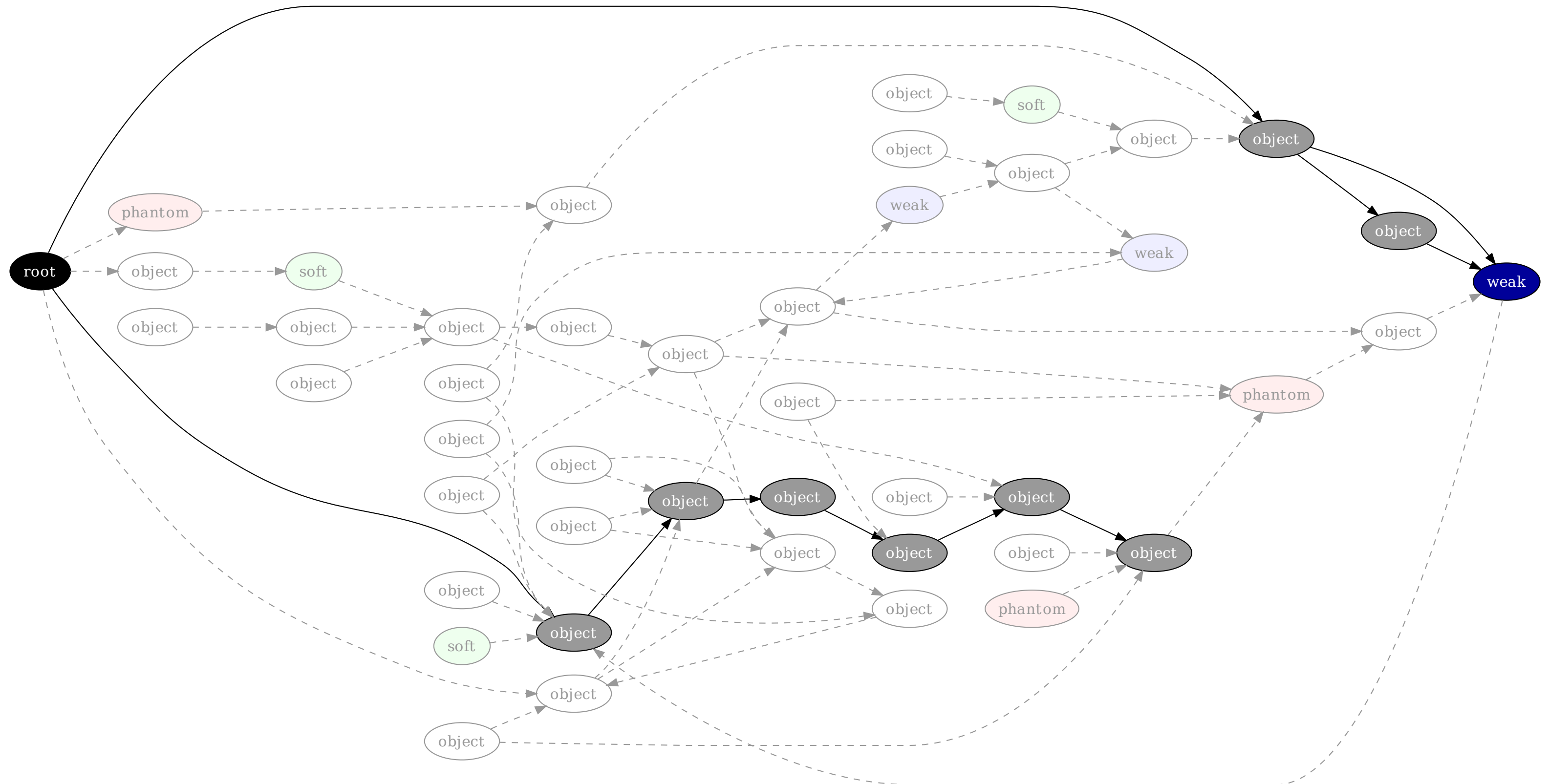
2. Trace and mark strongly-referenced objects.



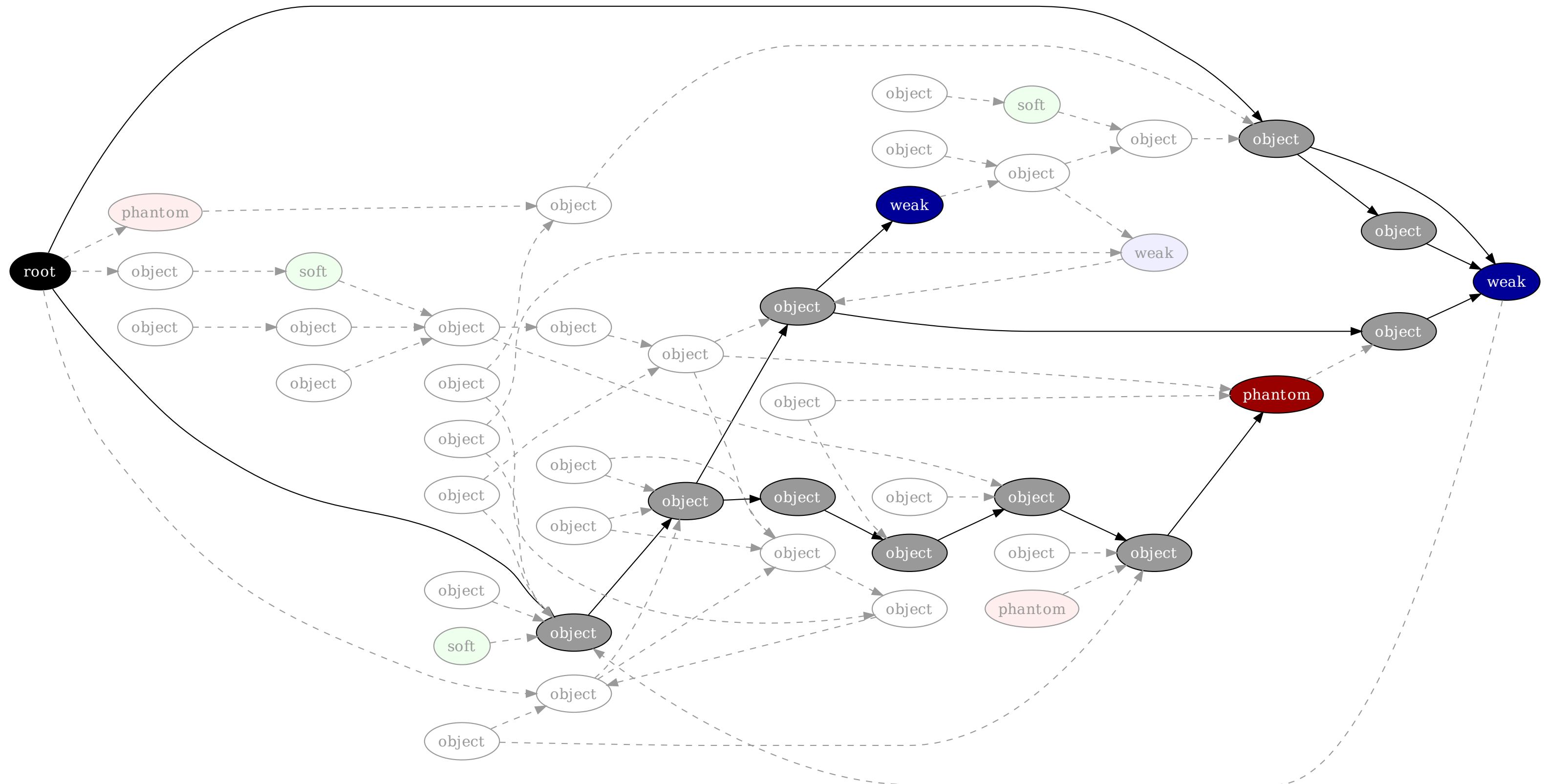
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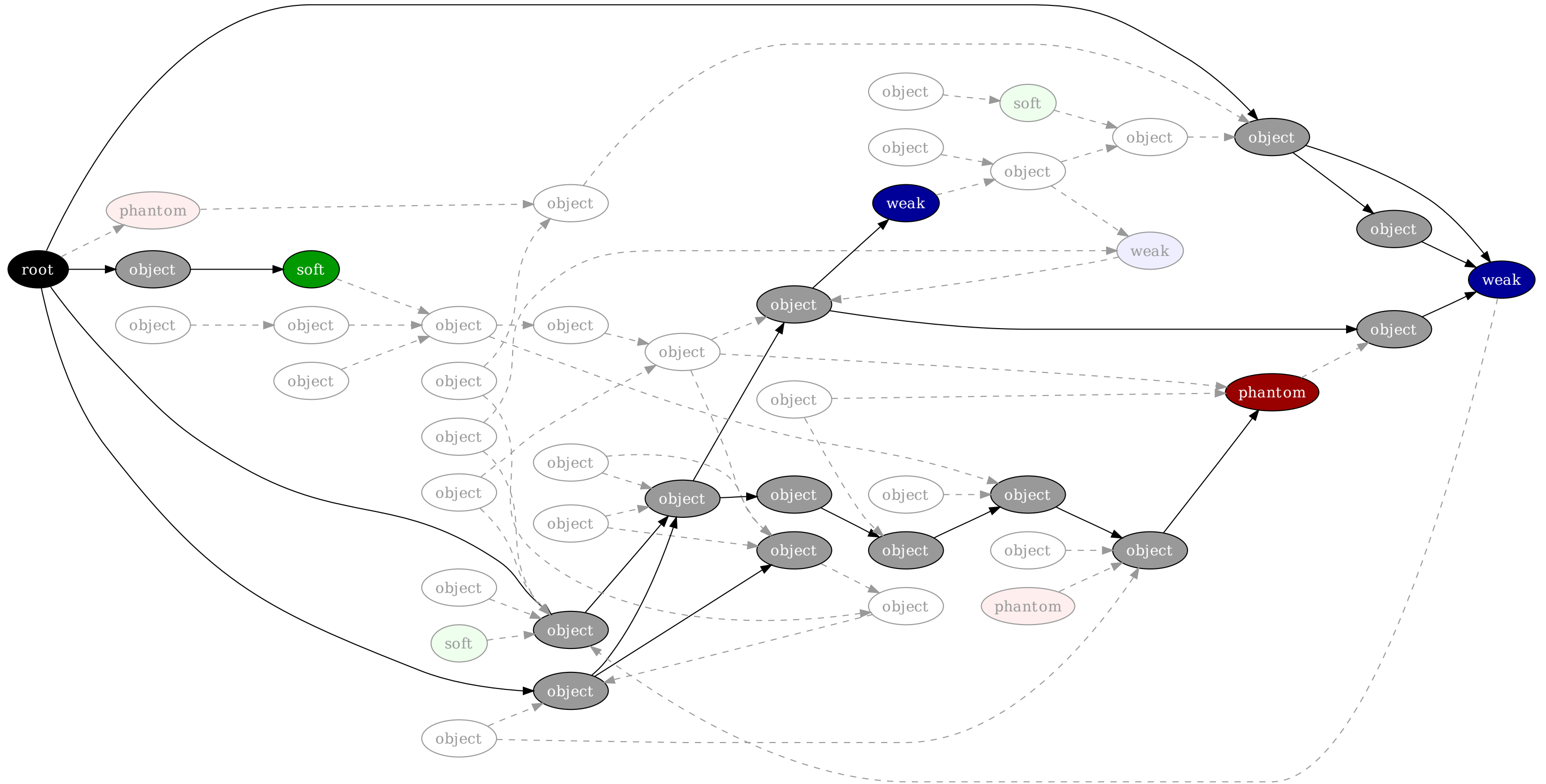
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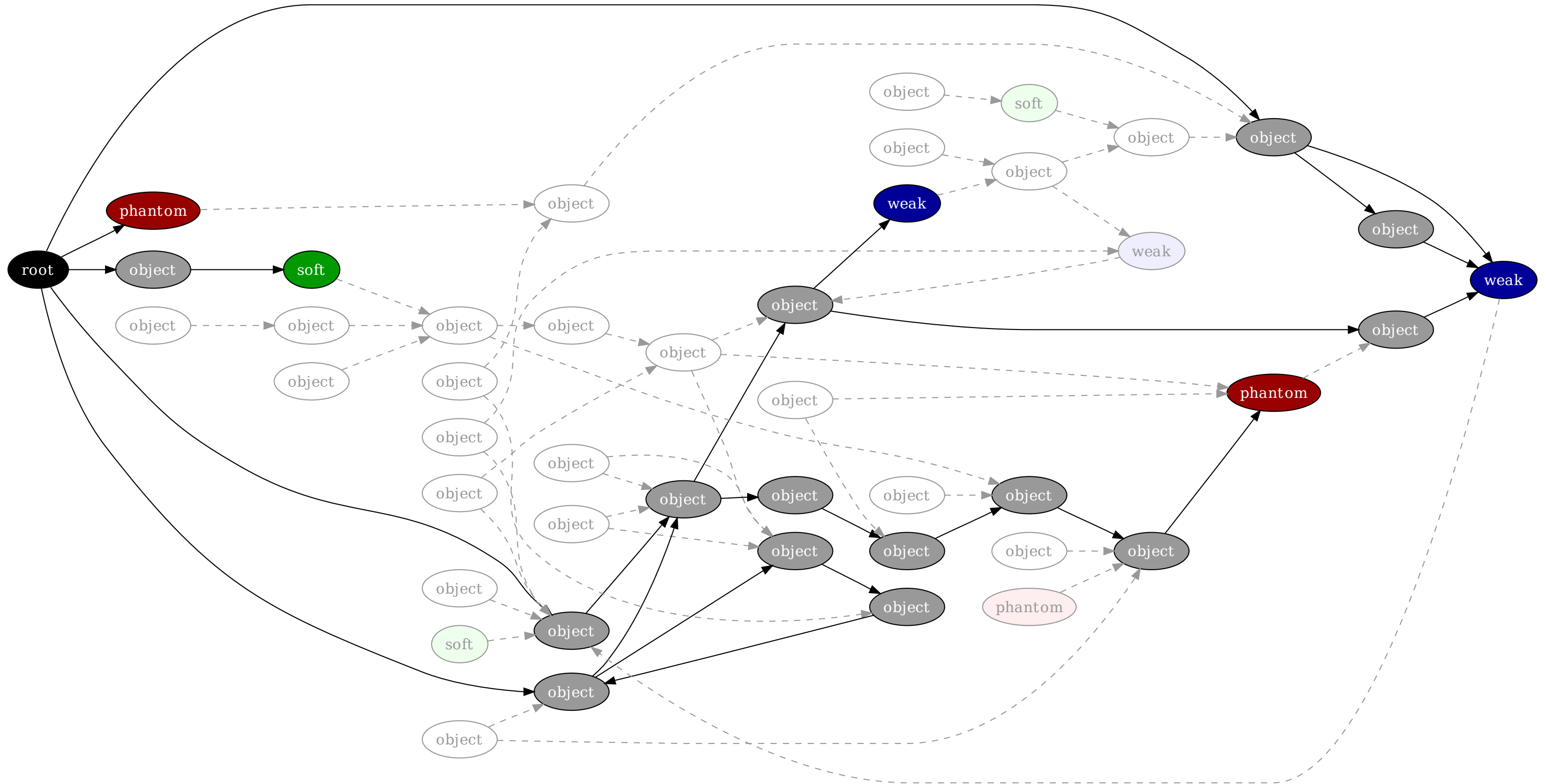
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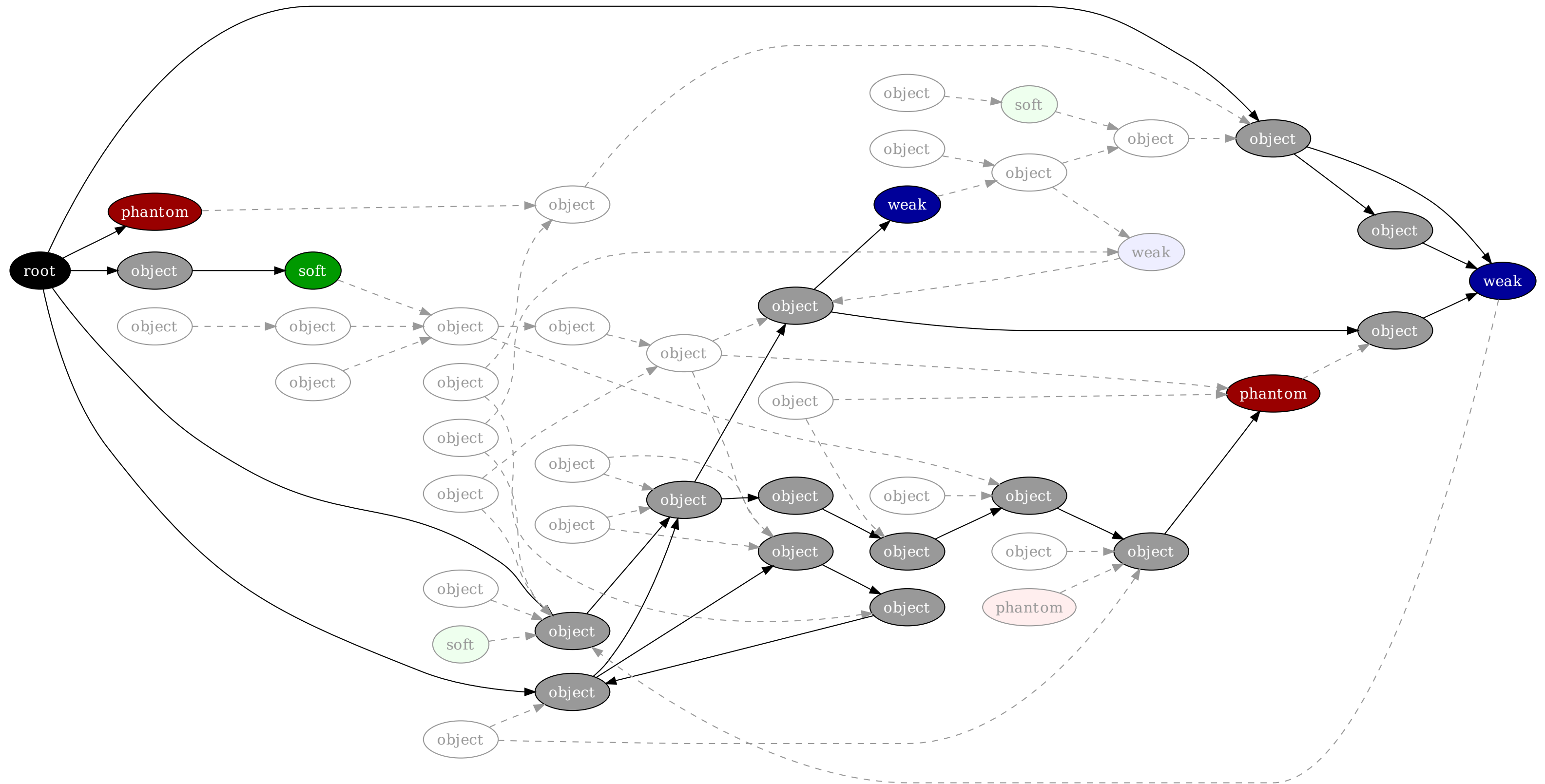
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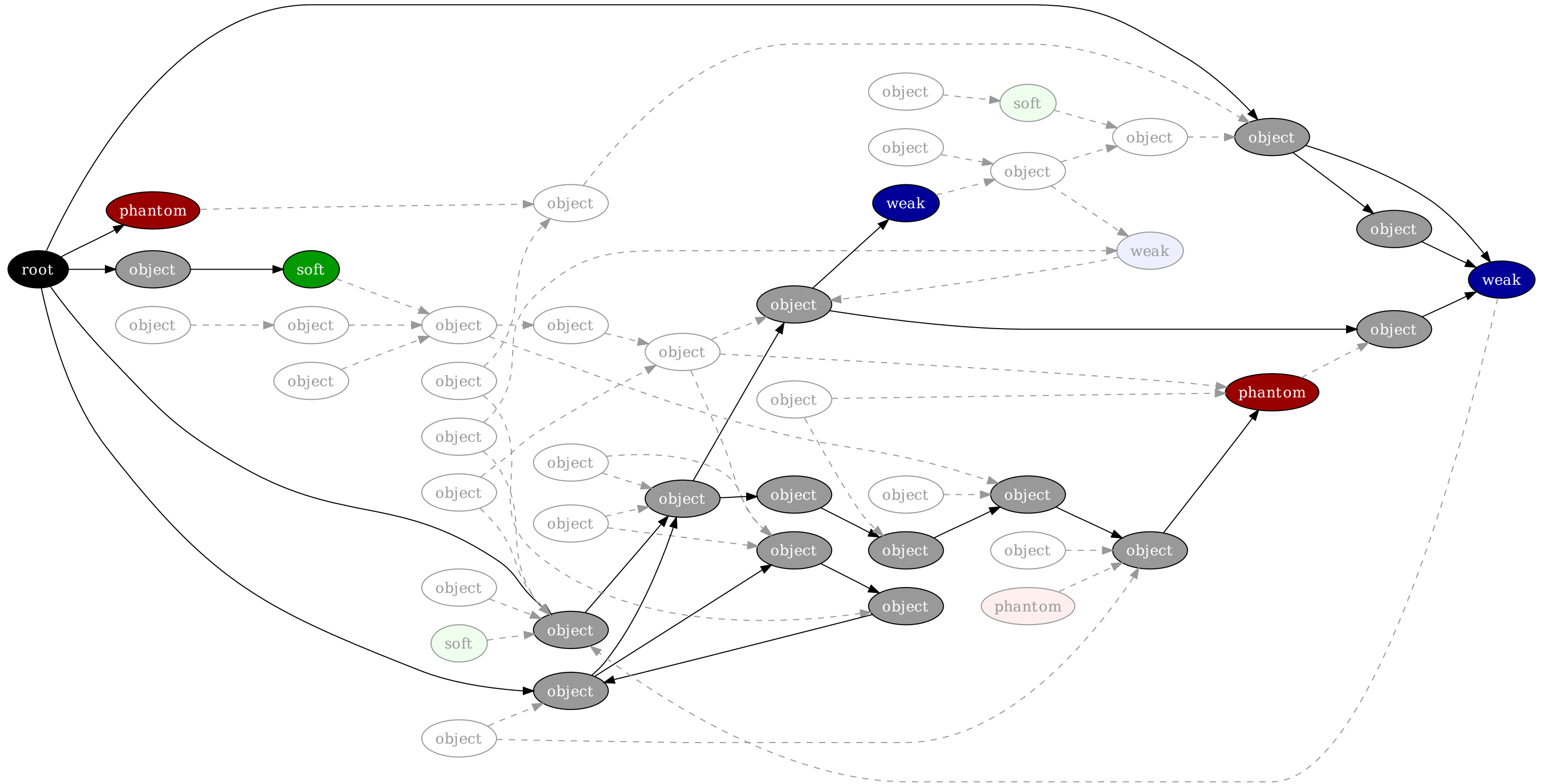
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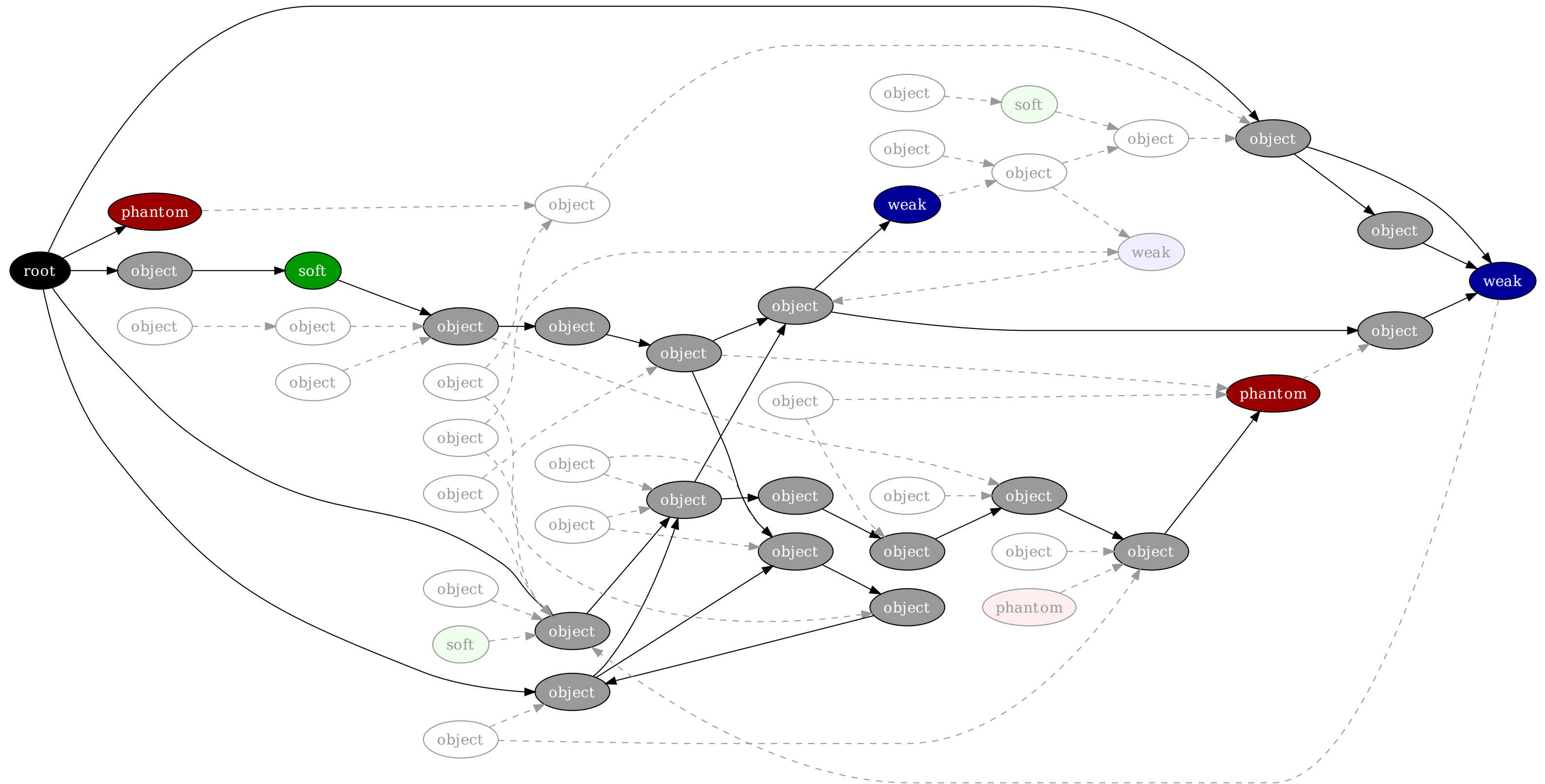
3. Optionally clear soft references.



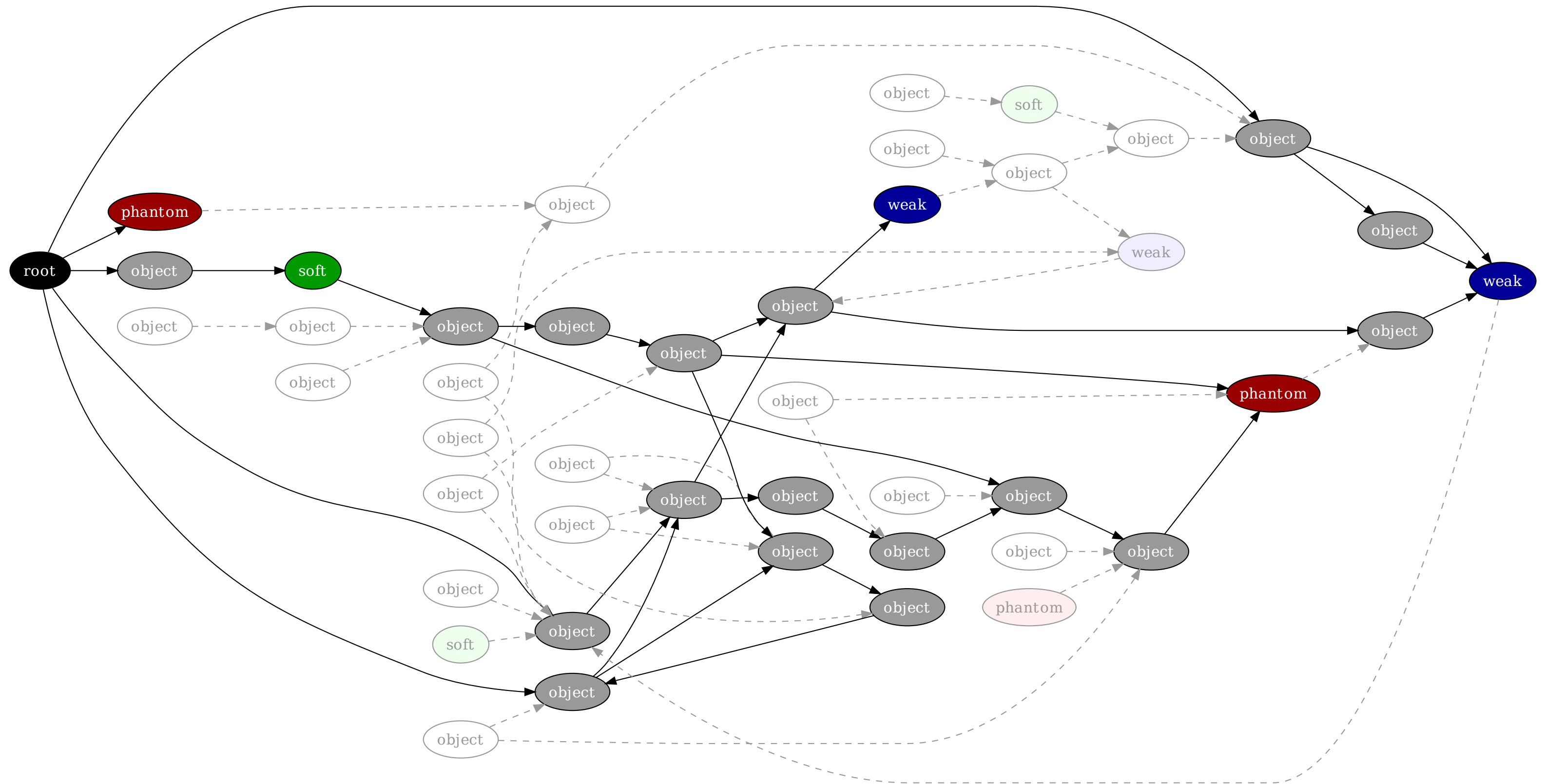
4. Trace and mark softly-referenced objects.



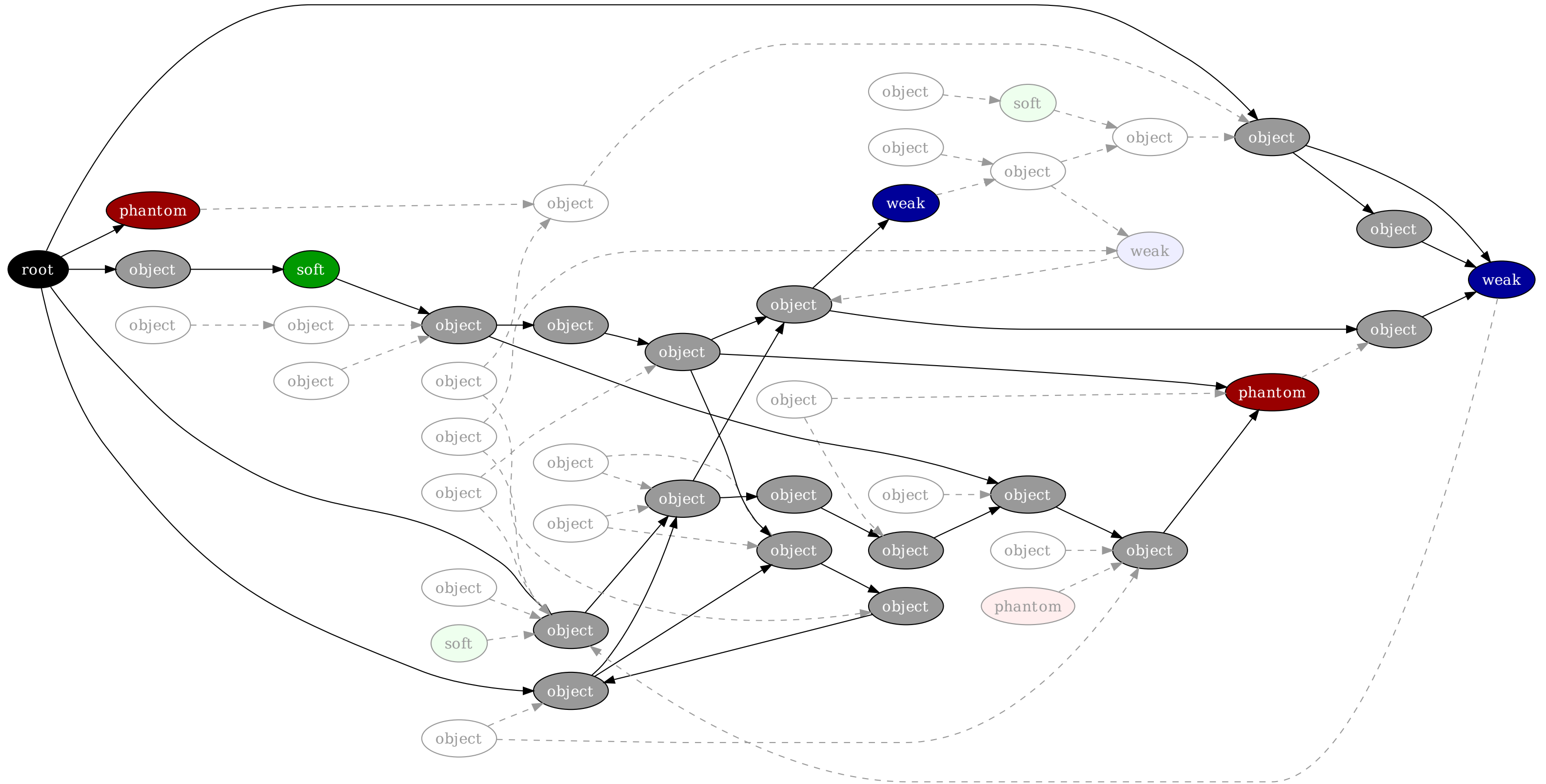
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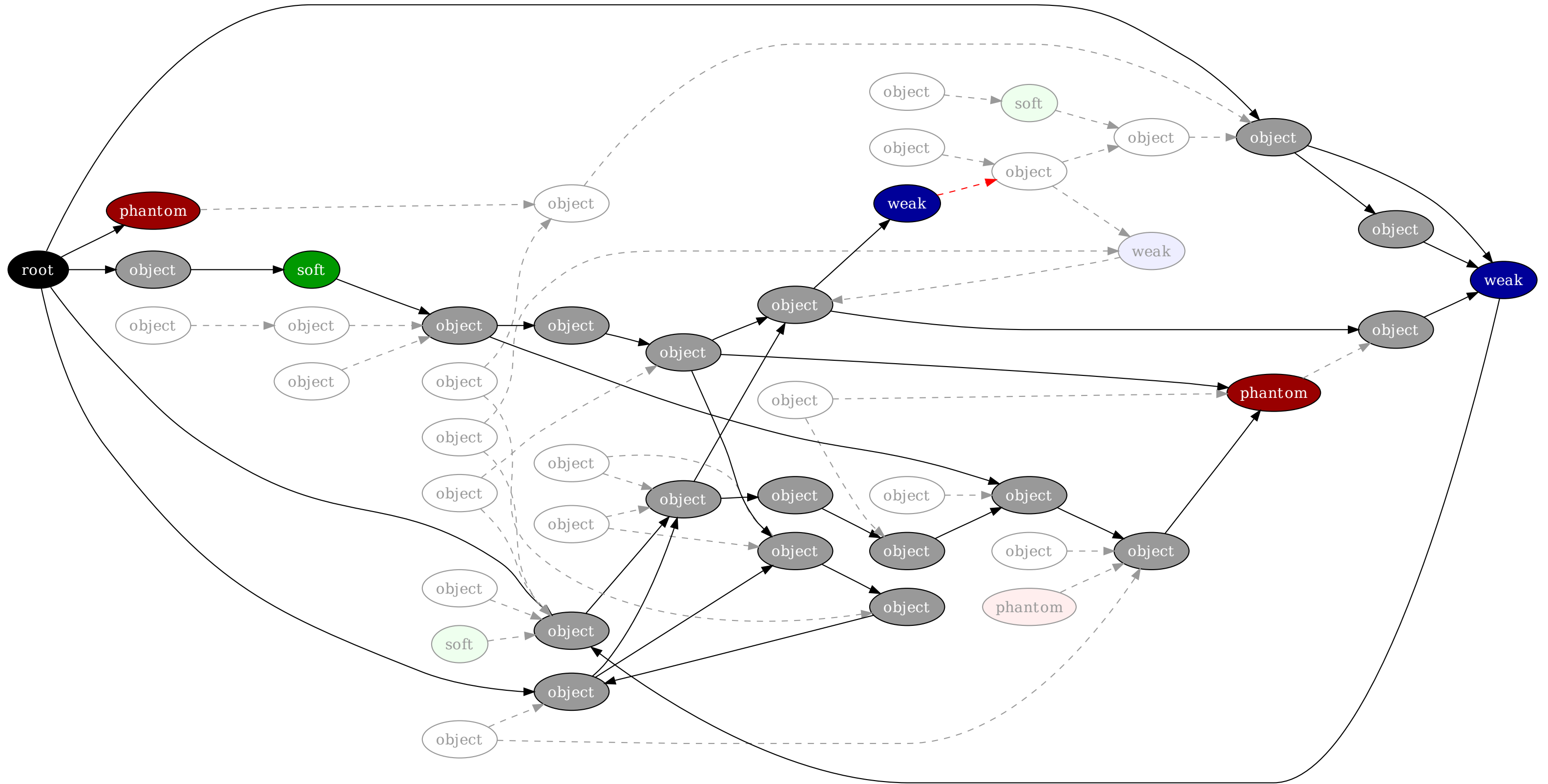
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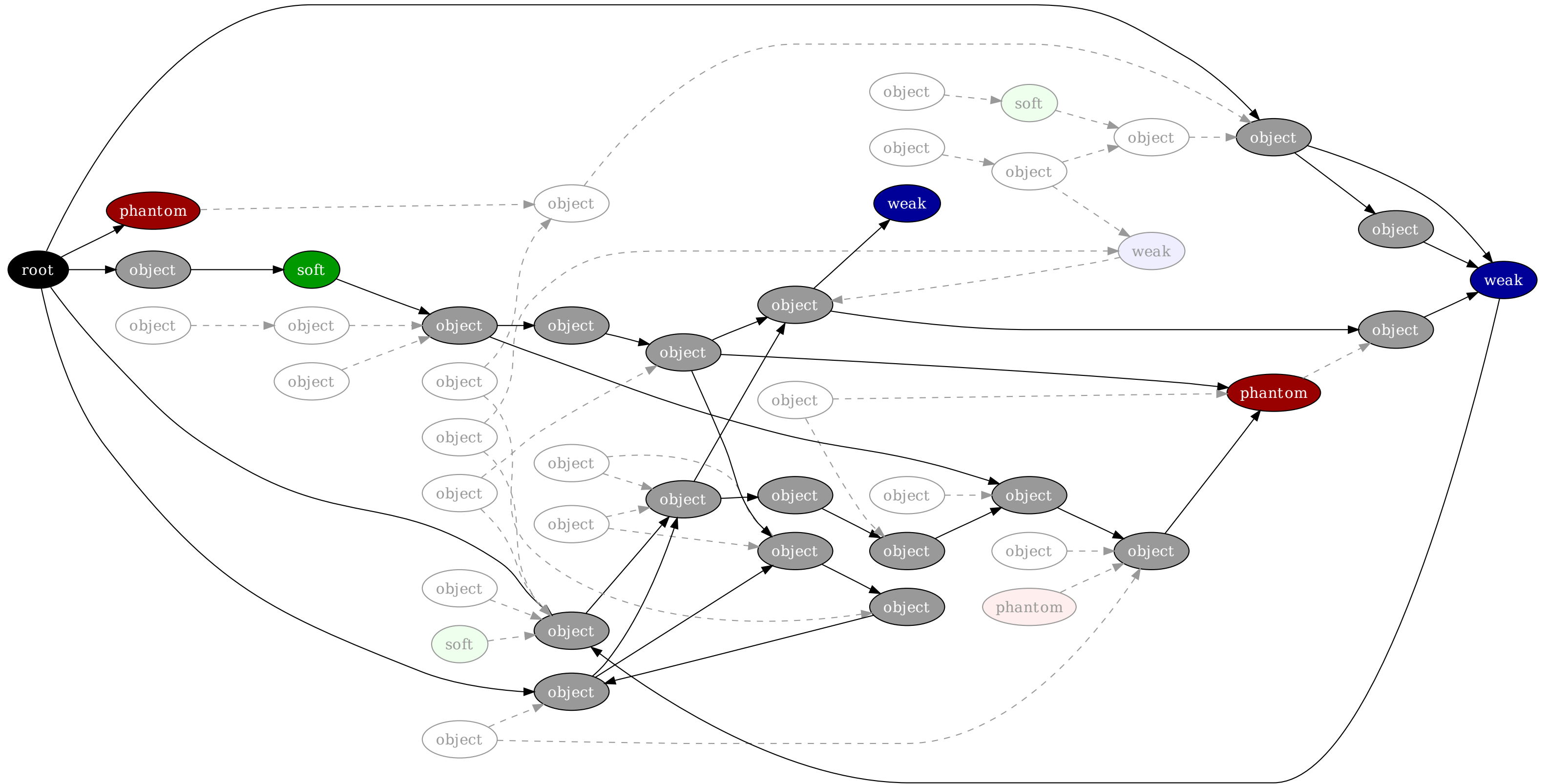
5. Clear weak references.



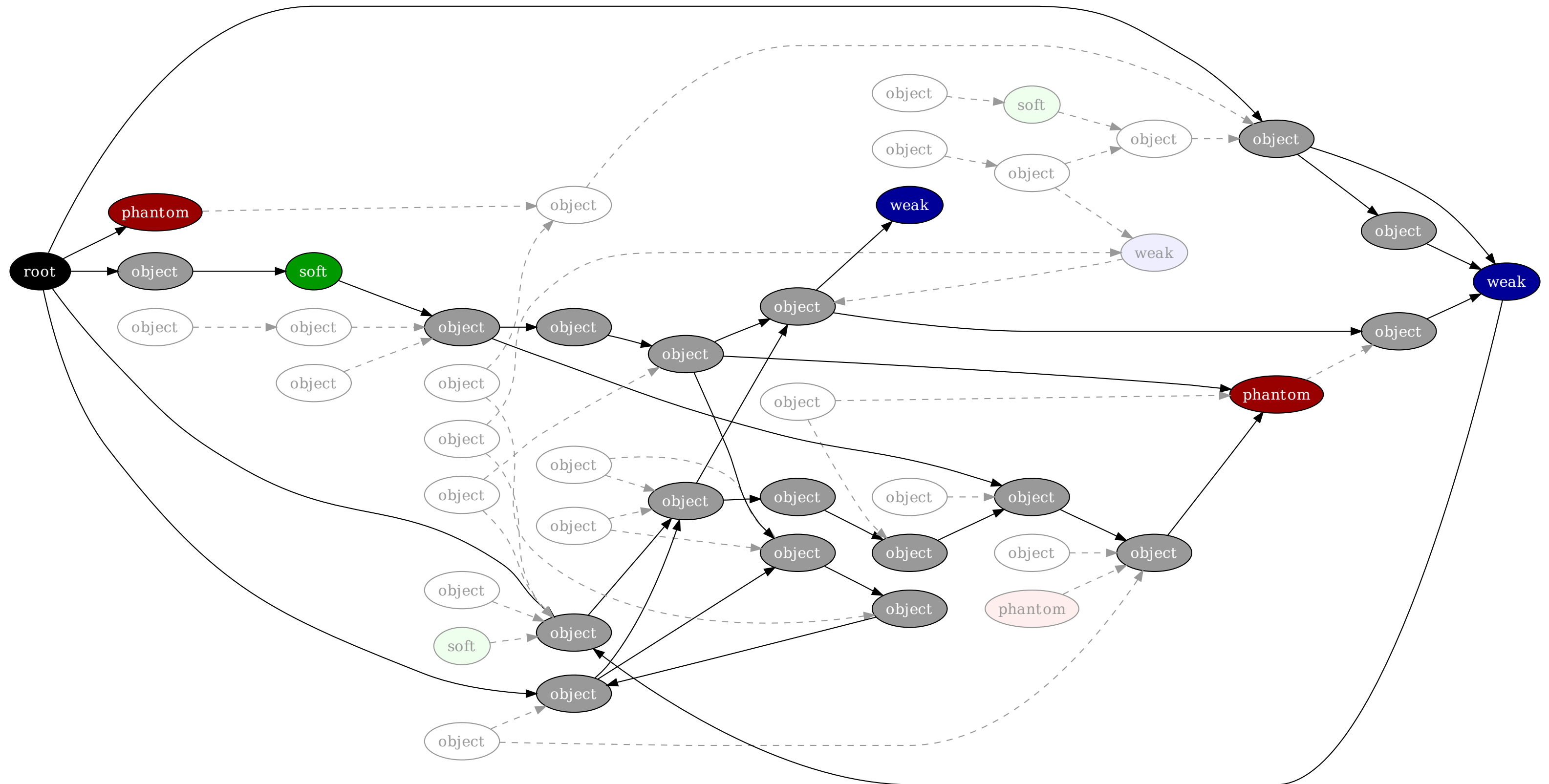
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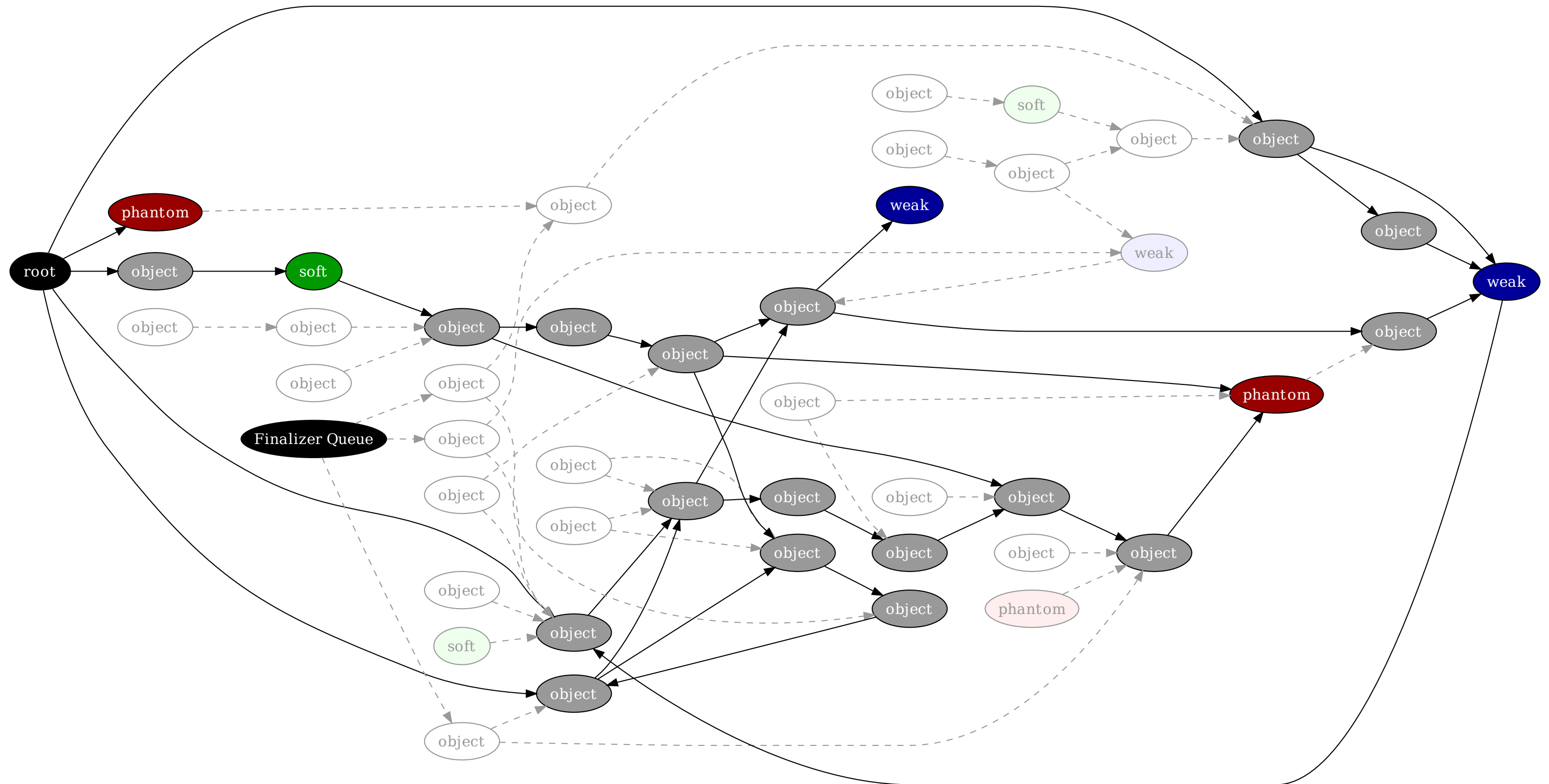
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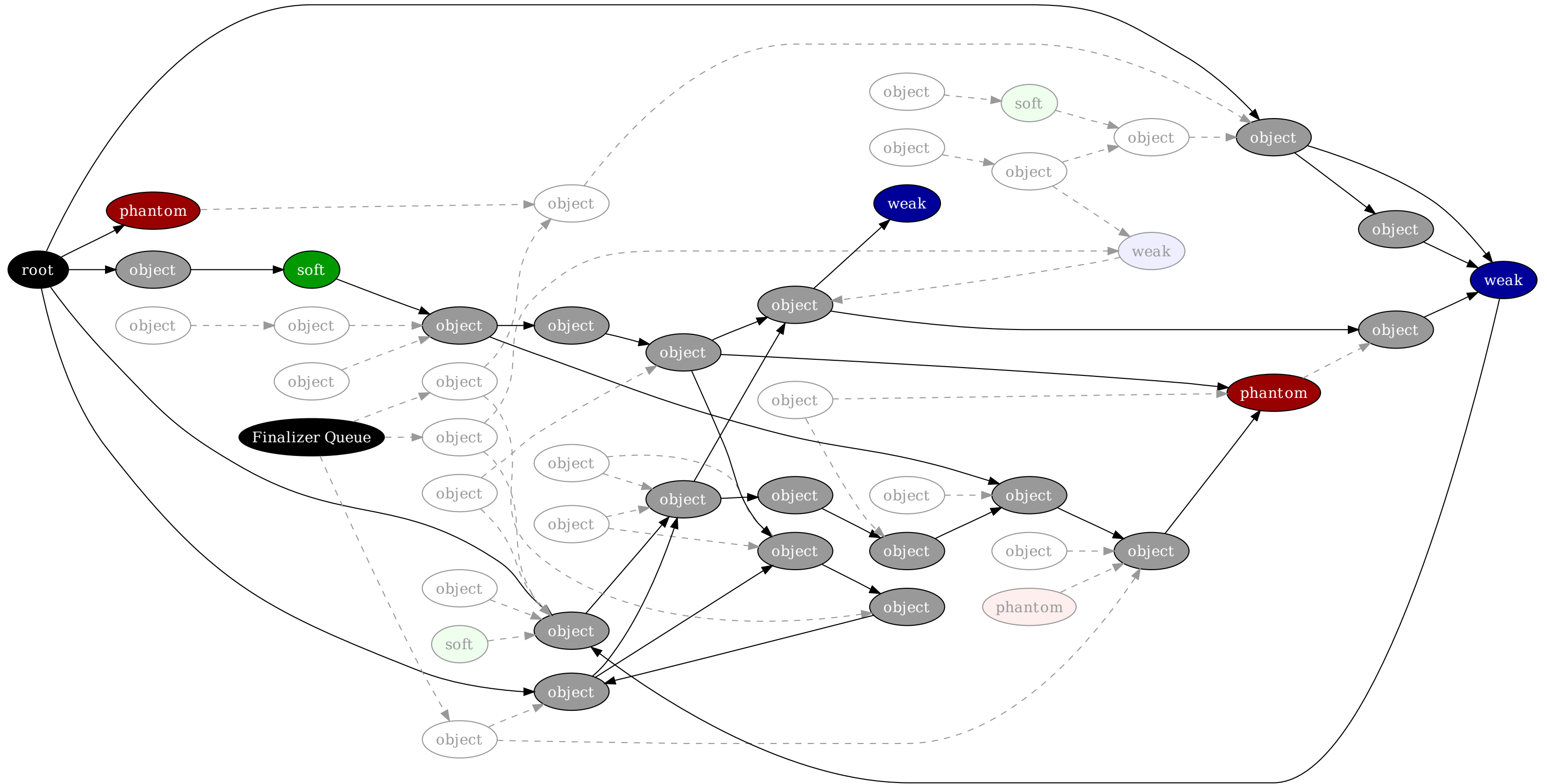
6. Enqueue finalizable objects.



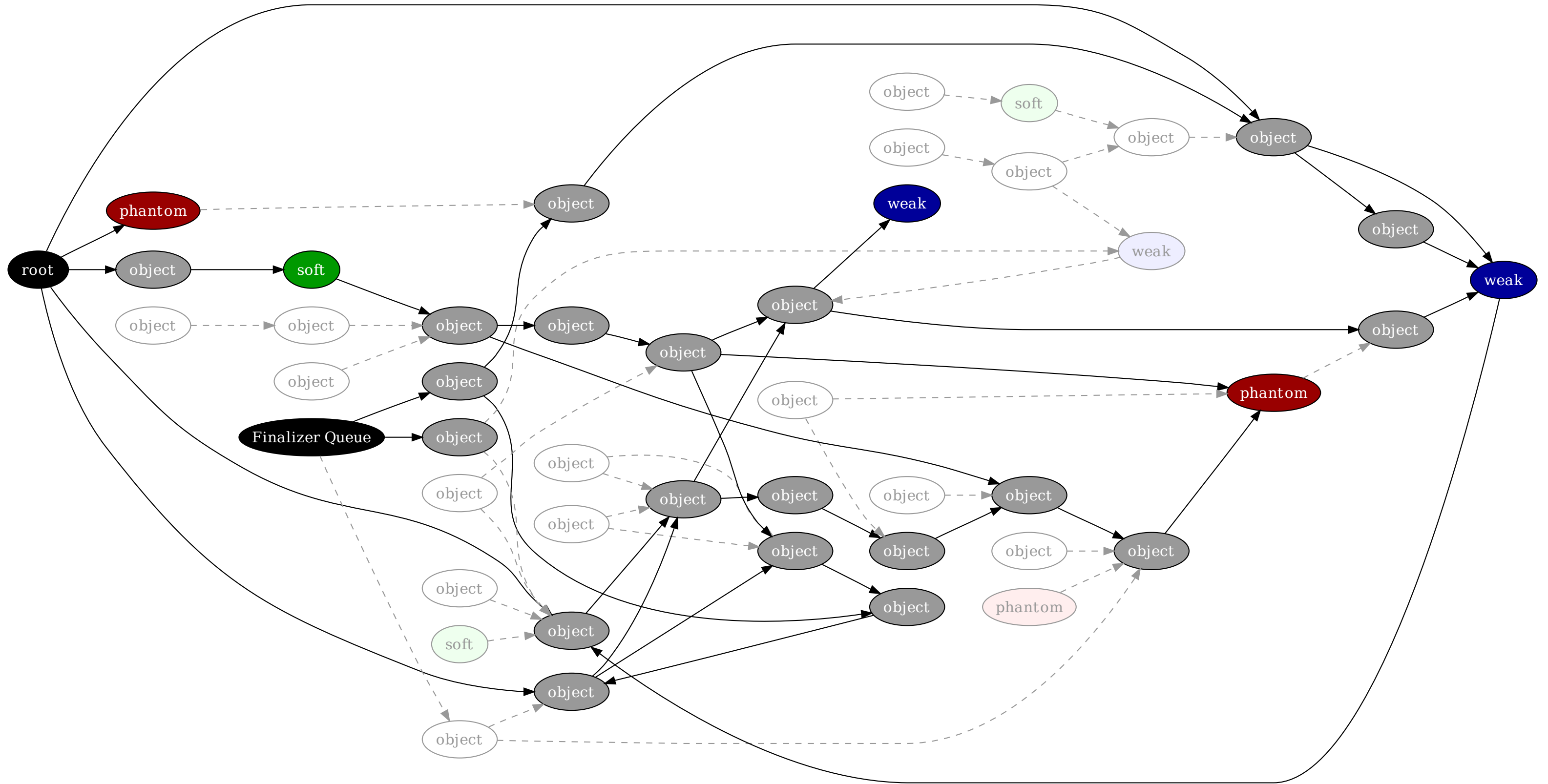
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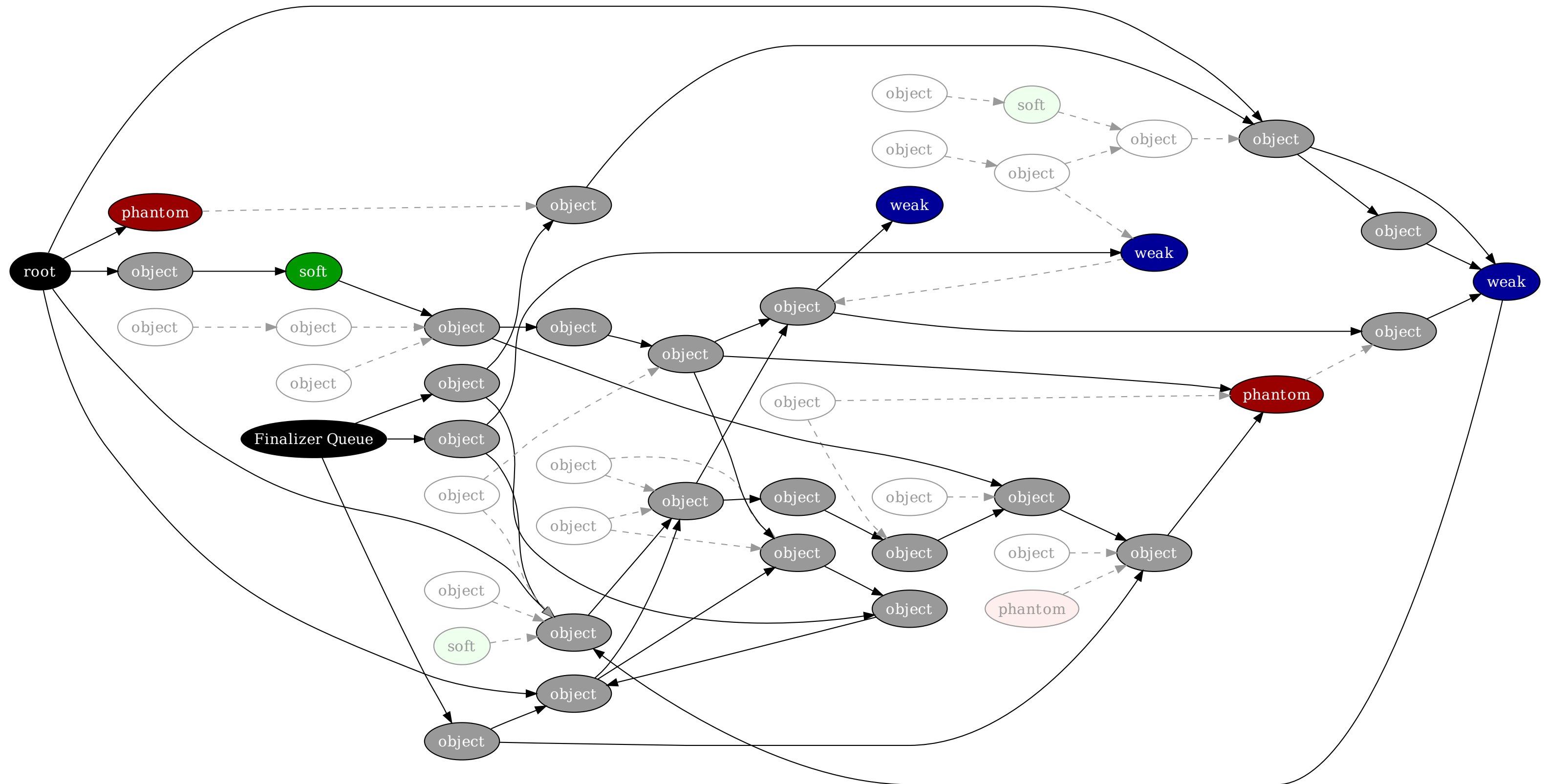
7. Repeat steps 1 through 5 for the queue.



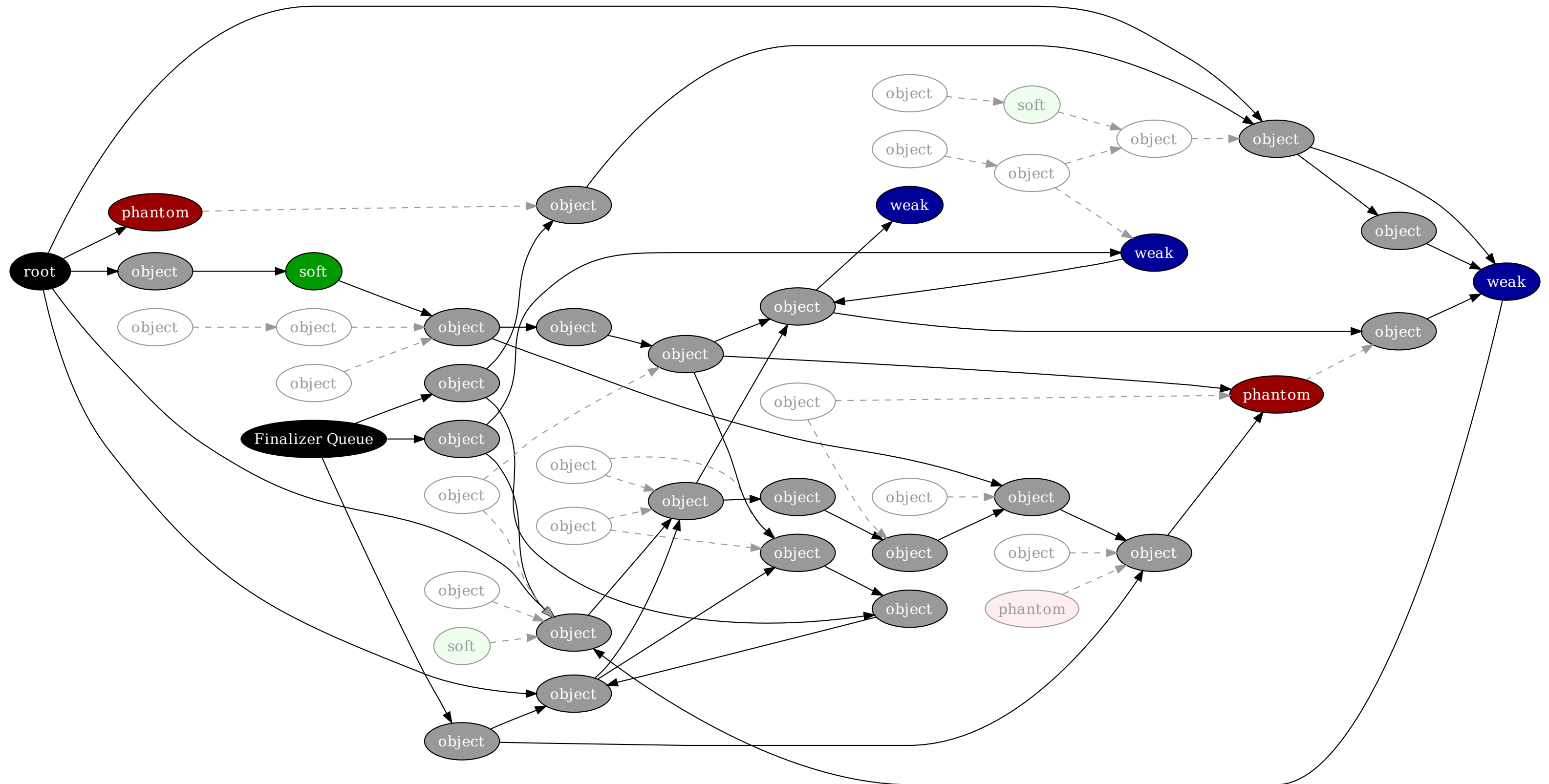
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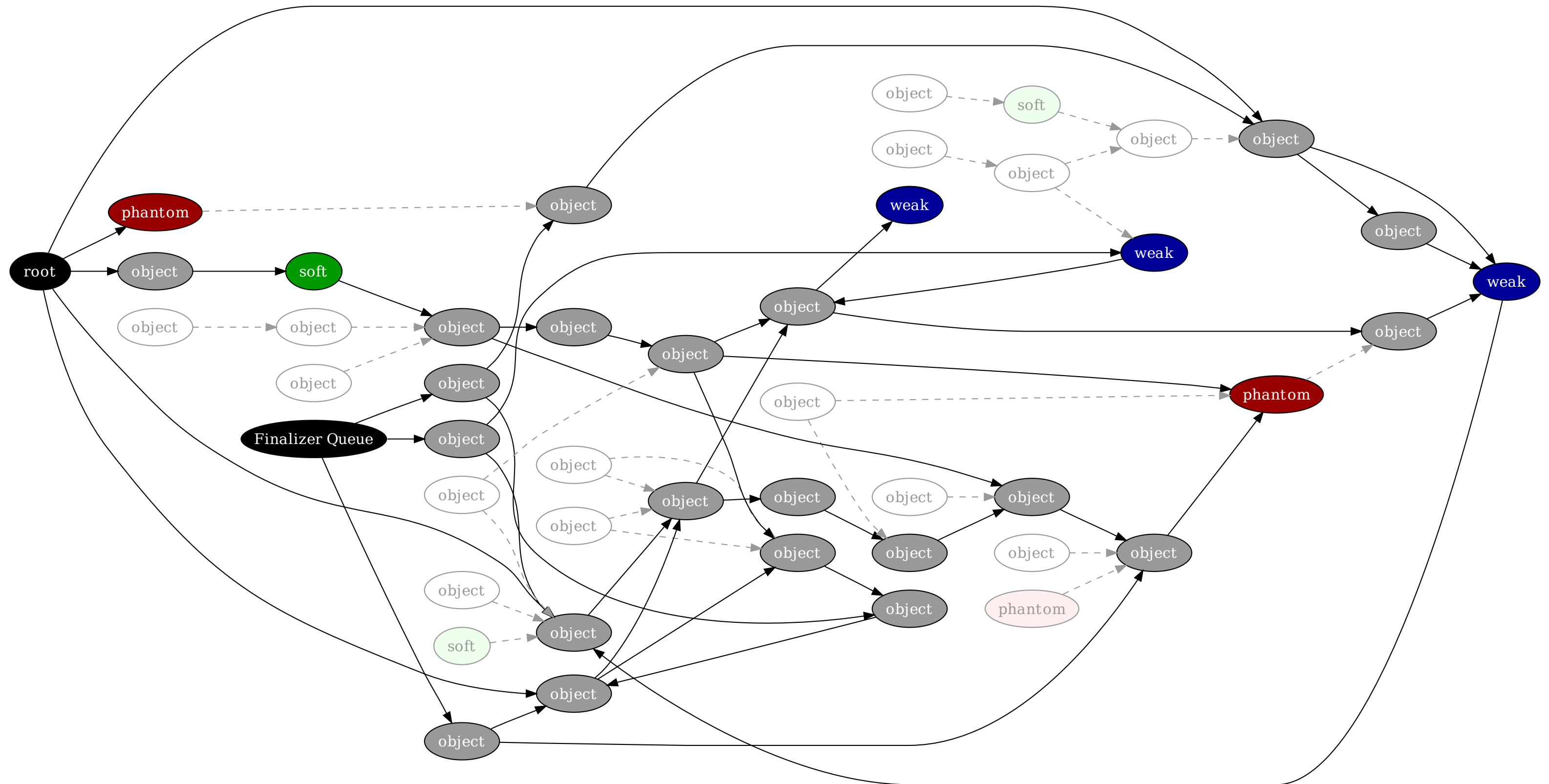
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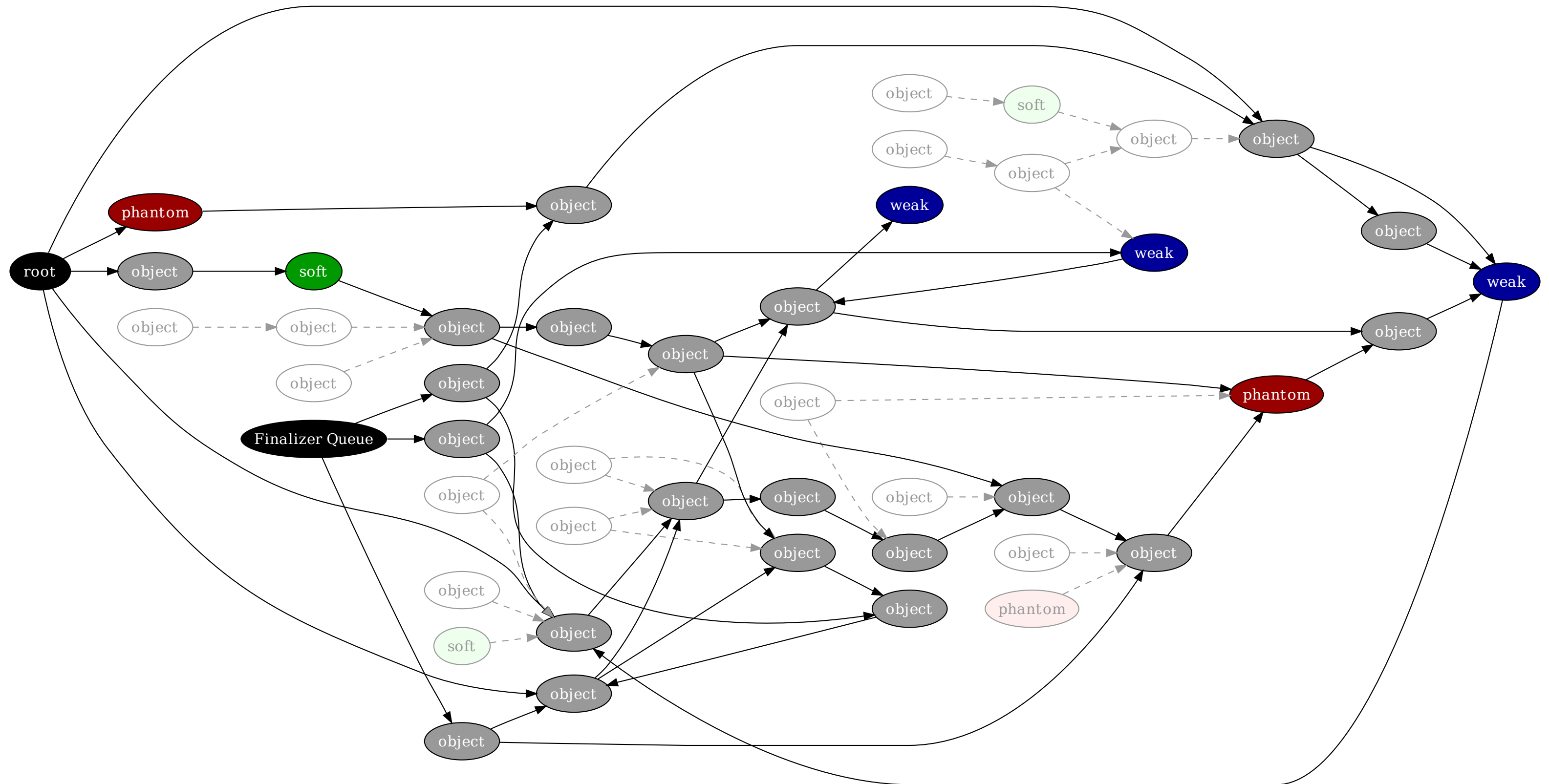
7. Repeat steps 1 through 5 for the queue.



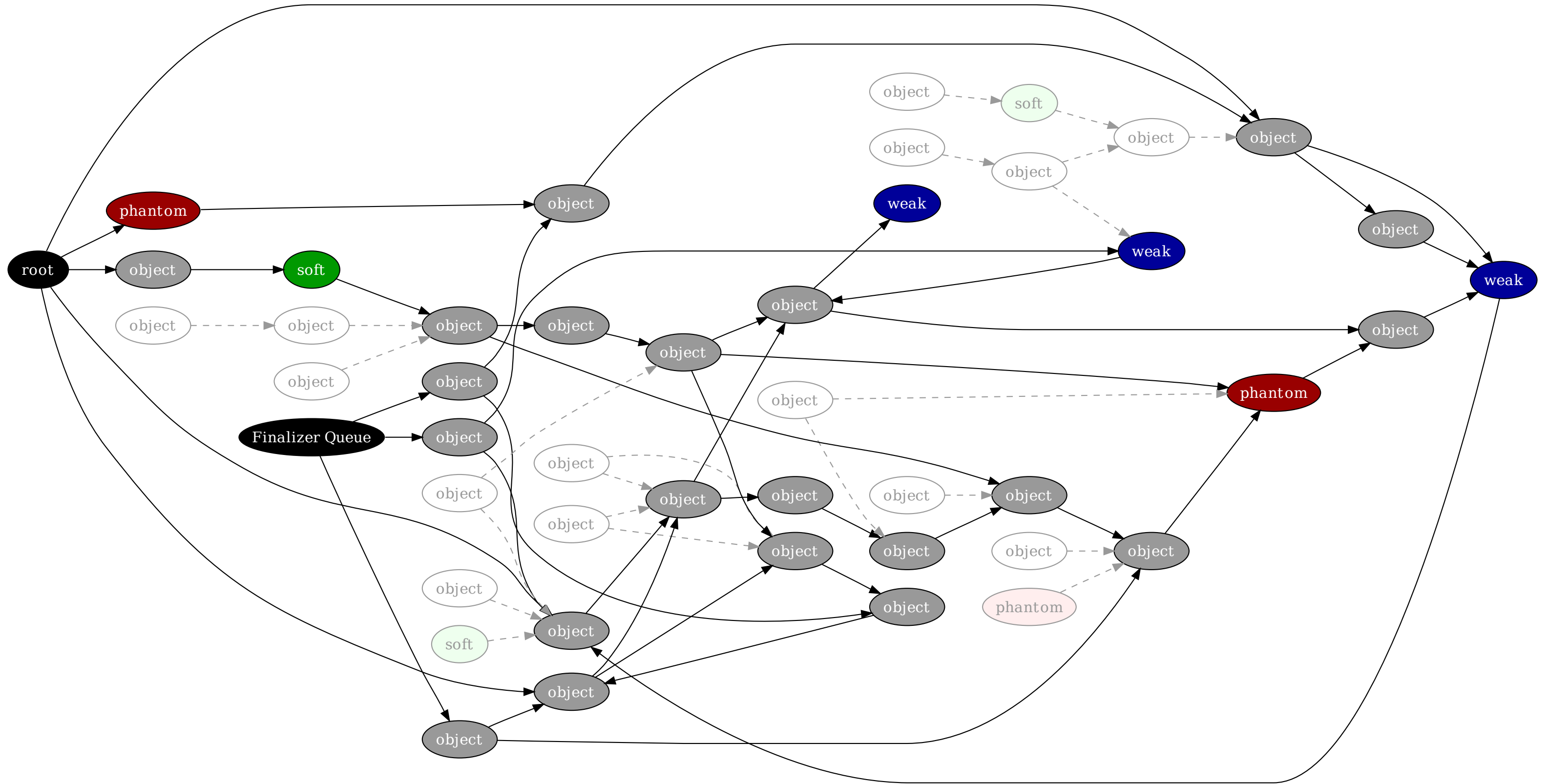
8. Enqueue phantom references.



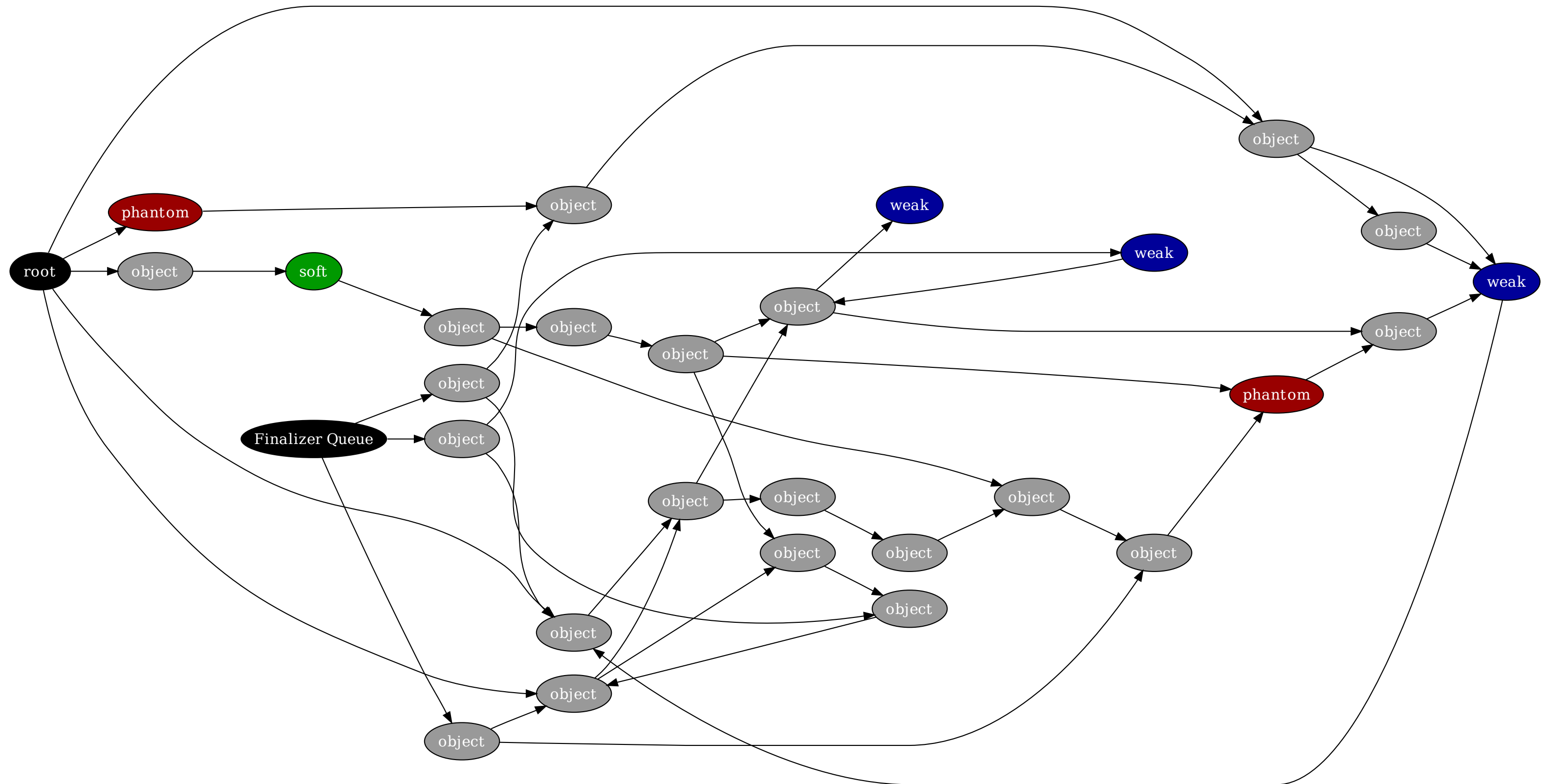
8. Enqueue phantom references.



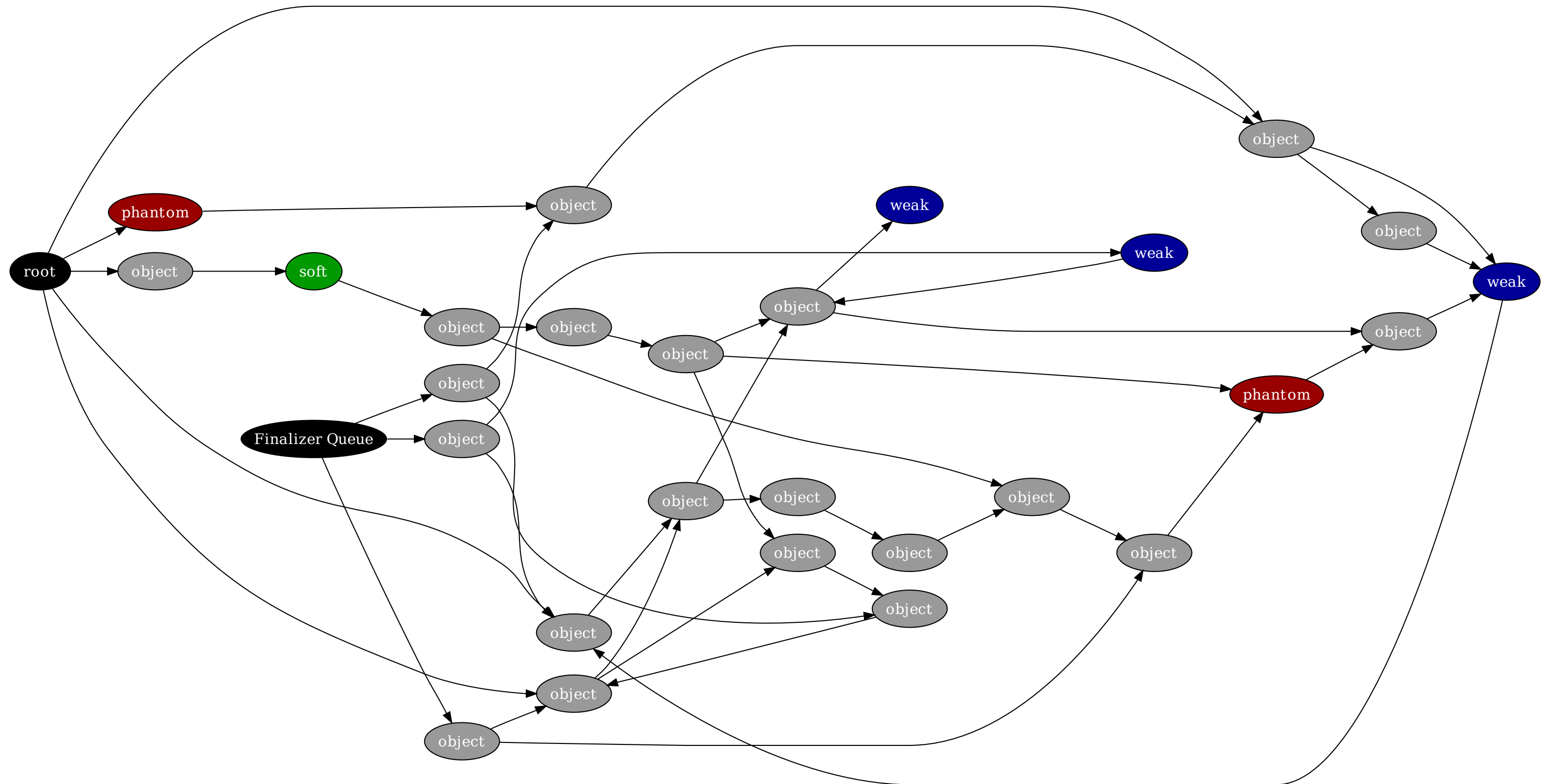
9. The remaining objects are dead.



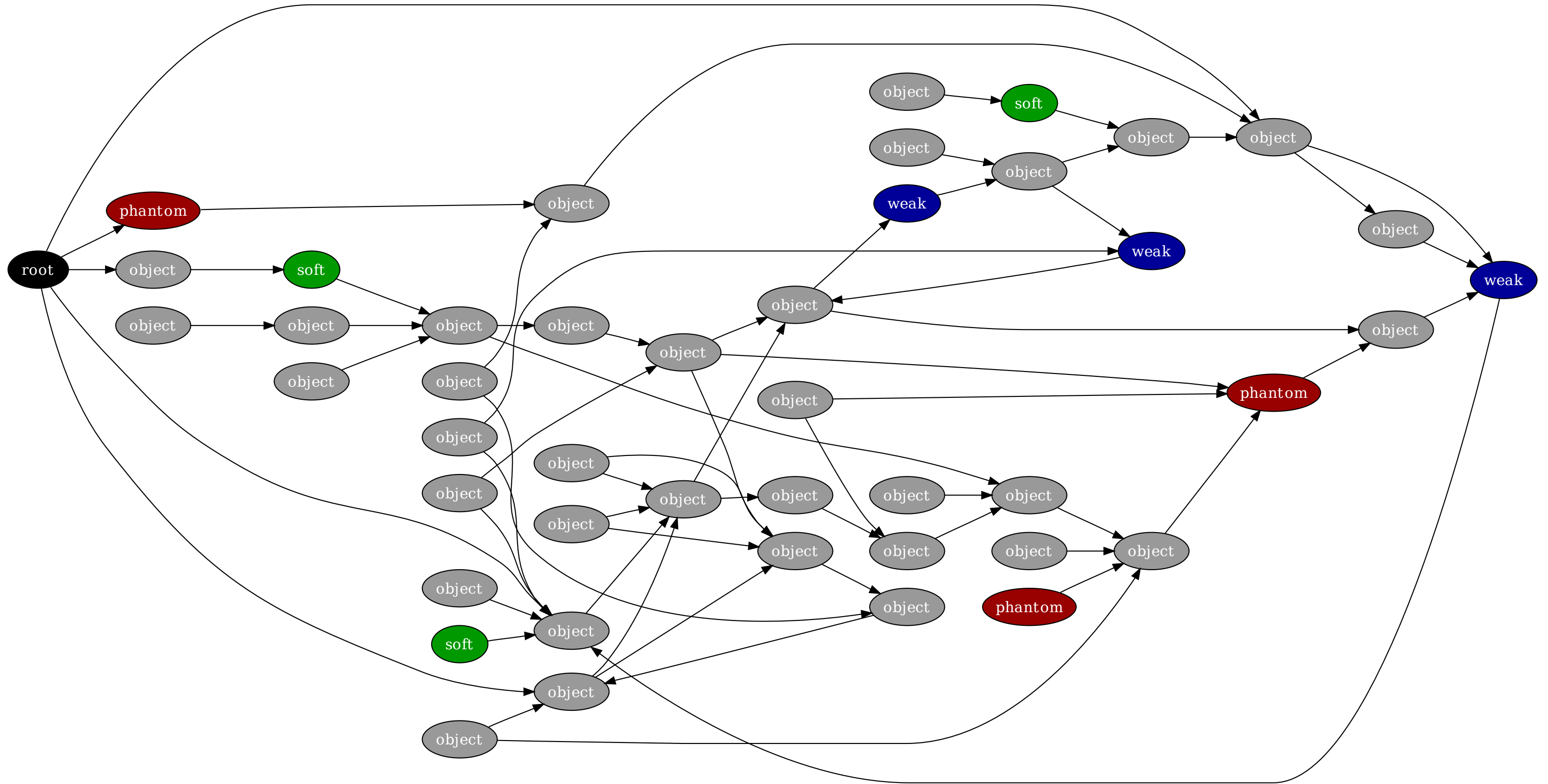
9. The remaining objects are dead.



10. Repeat.



Here's the before snapshot for comparison.



Recap

1. Start at a root
1. Start at a root

Two options for freeing native resources

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