Java is a trademark of Sun Microsystems, Inc.

Java™

JavaOne℠

The Ghost in the Virtual Machine
A Reference to References

Bob Lee

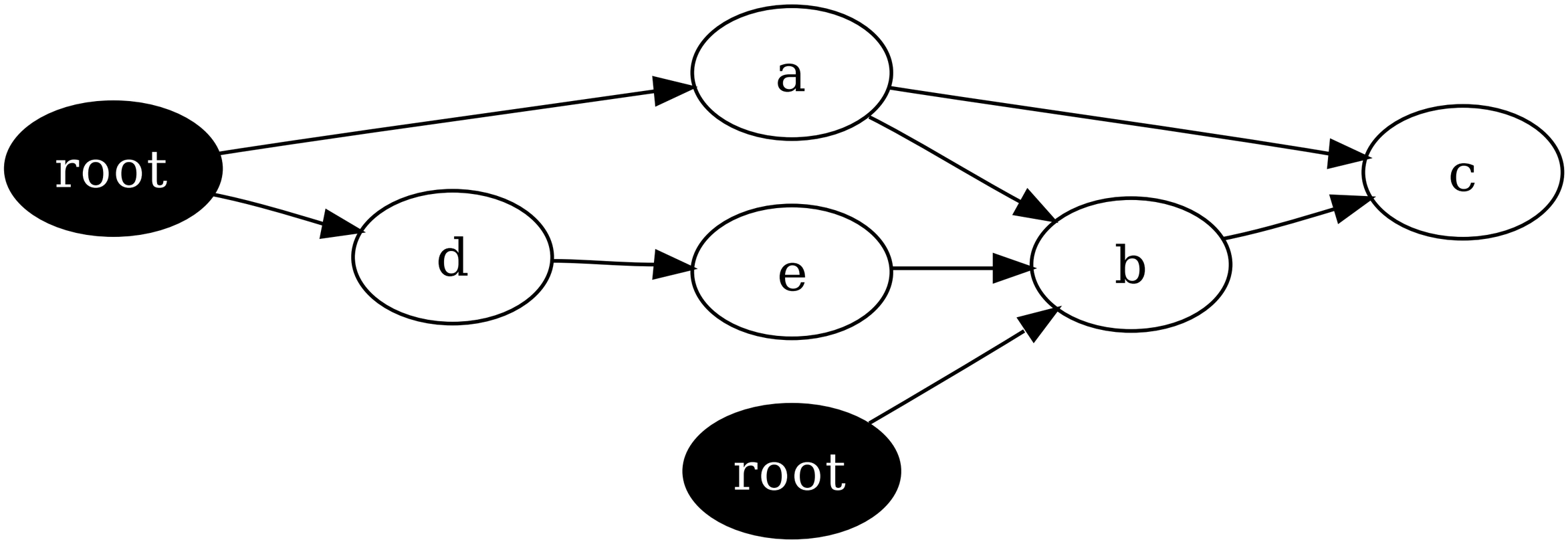
Google Inc.

Google

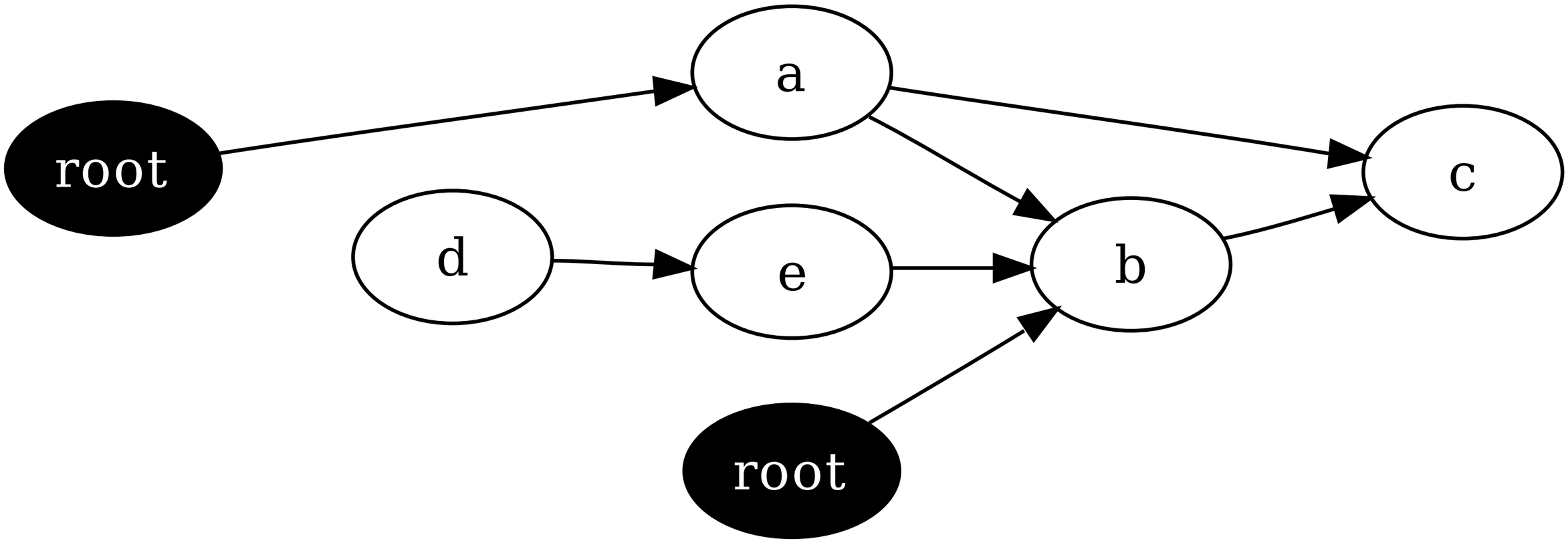
Goals

> Take the mystery out of garbage collection.

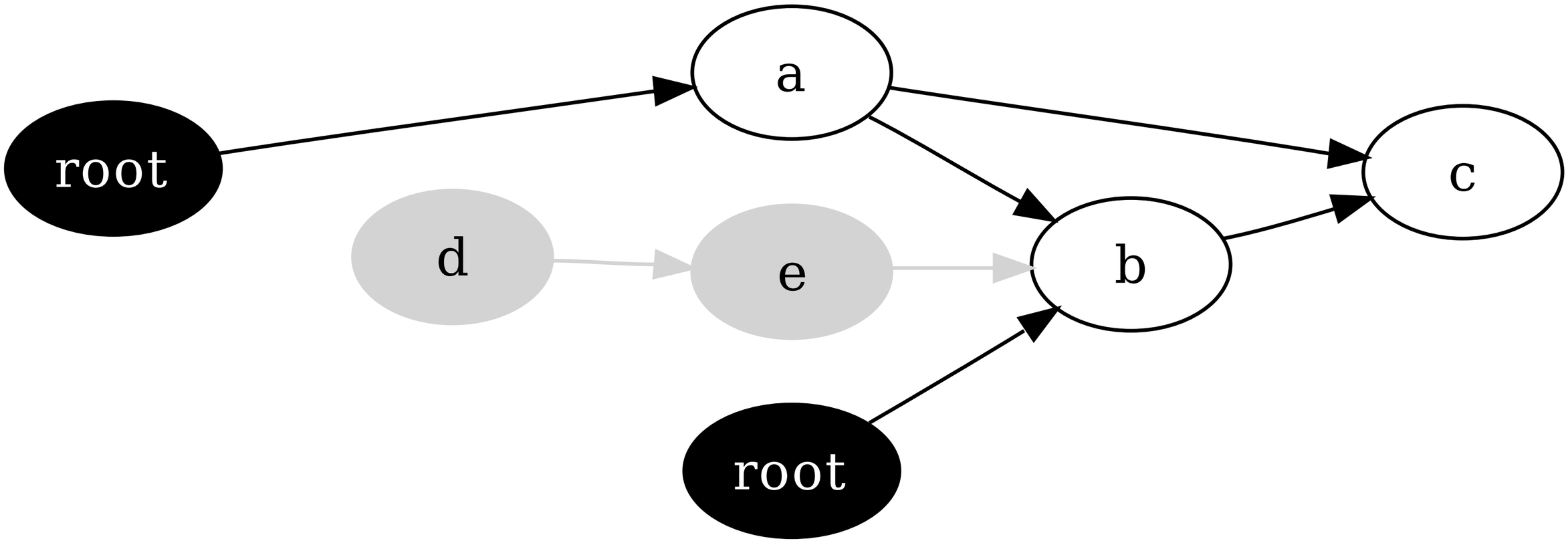
How does garbage collection work?



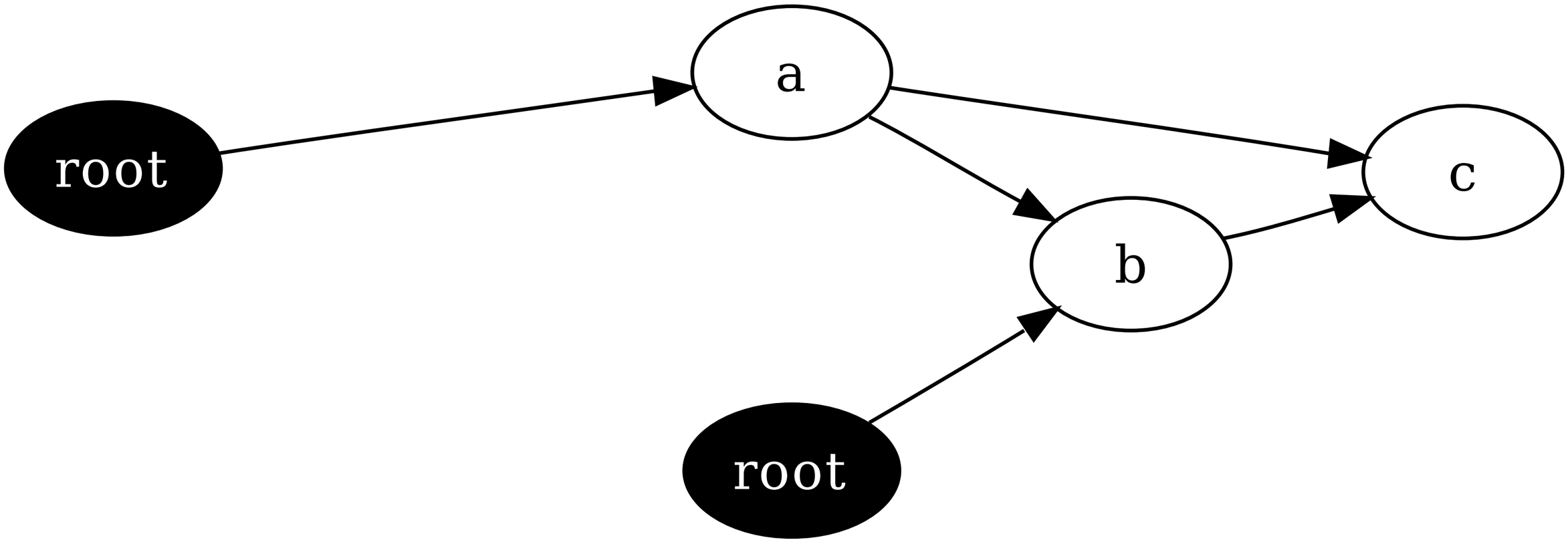
If the reference to D goes away...



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)

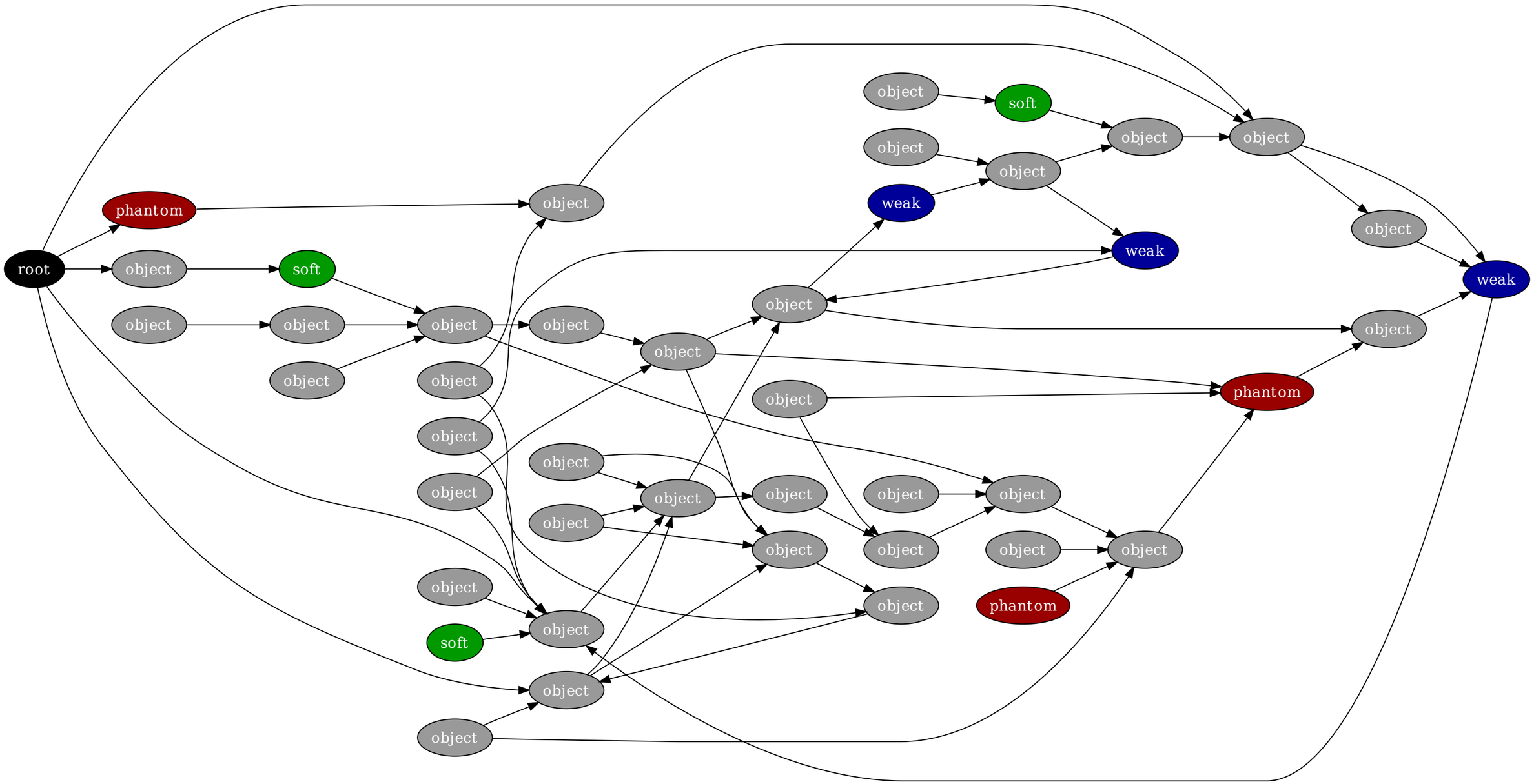
In the beginning, there was the finalizer...

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

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.
    }
  }
}
```

Let's mark and sweep a heap!


root
phantom
object
soft
object
object
object

No objects are marked at first.

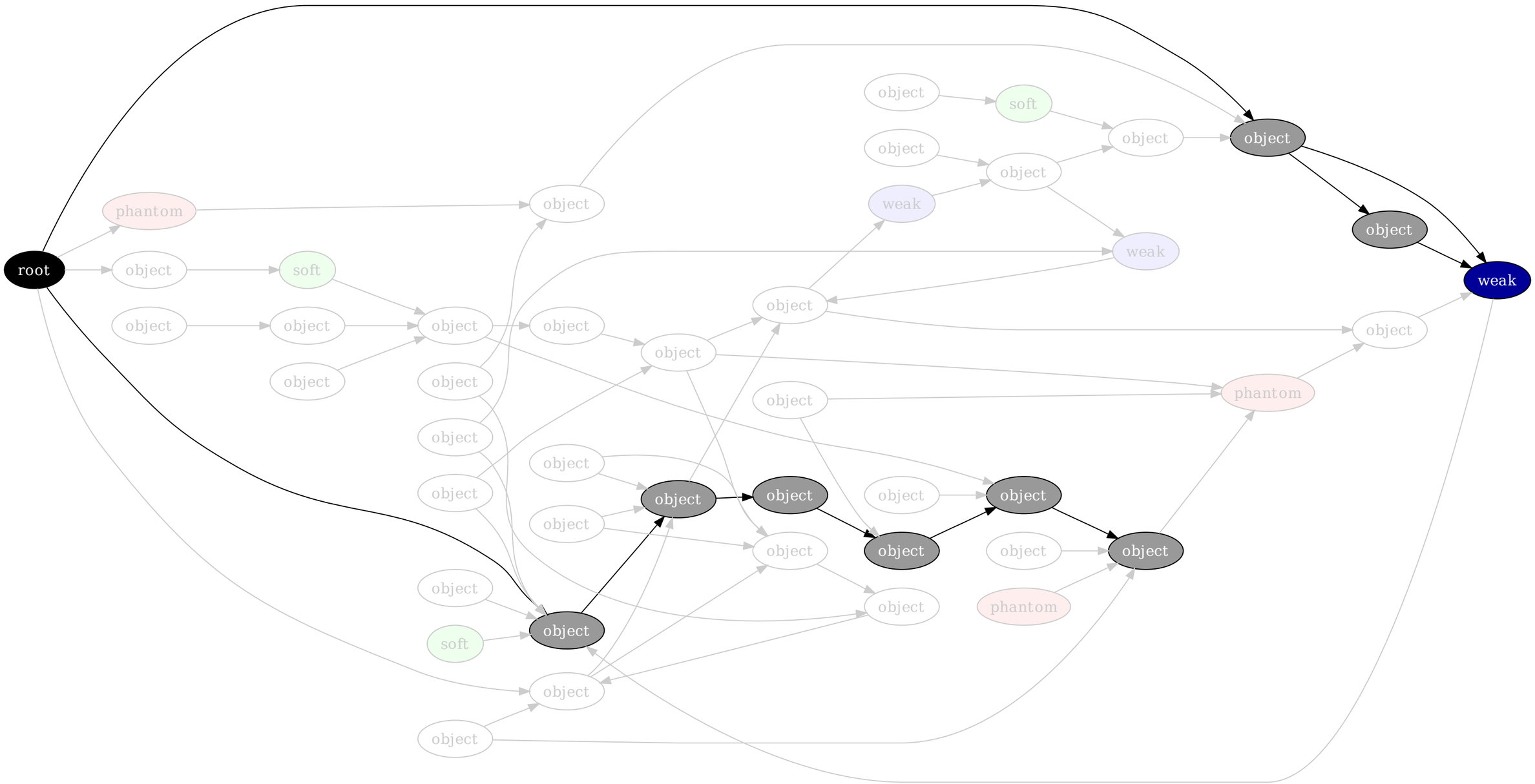
1. Start at a root.

root
phantom
object
soft
object
object
object

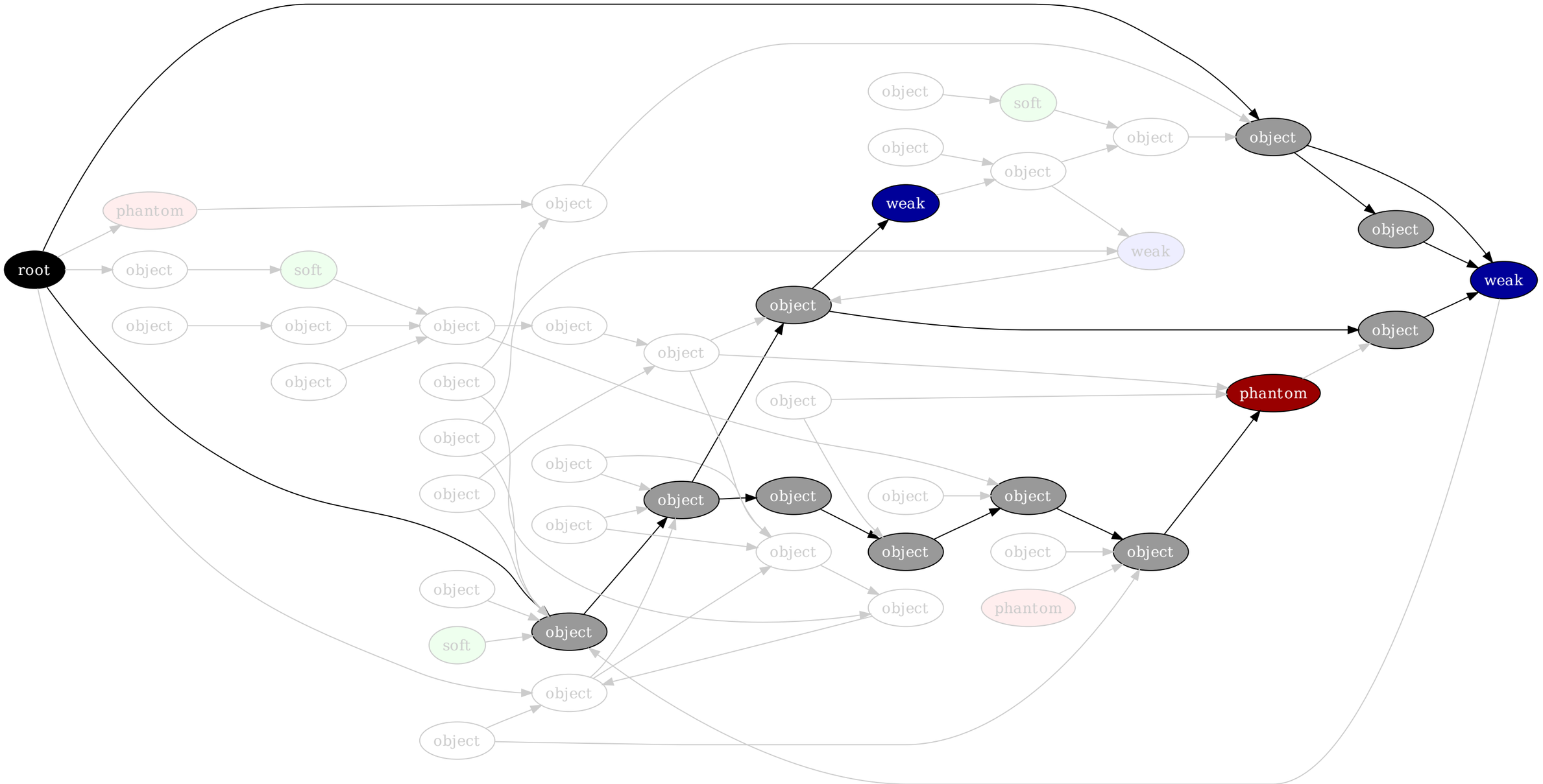
2. Trace and mark strongly-referenced objects.

2. Trace and mark strongly-referenced objects.

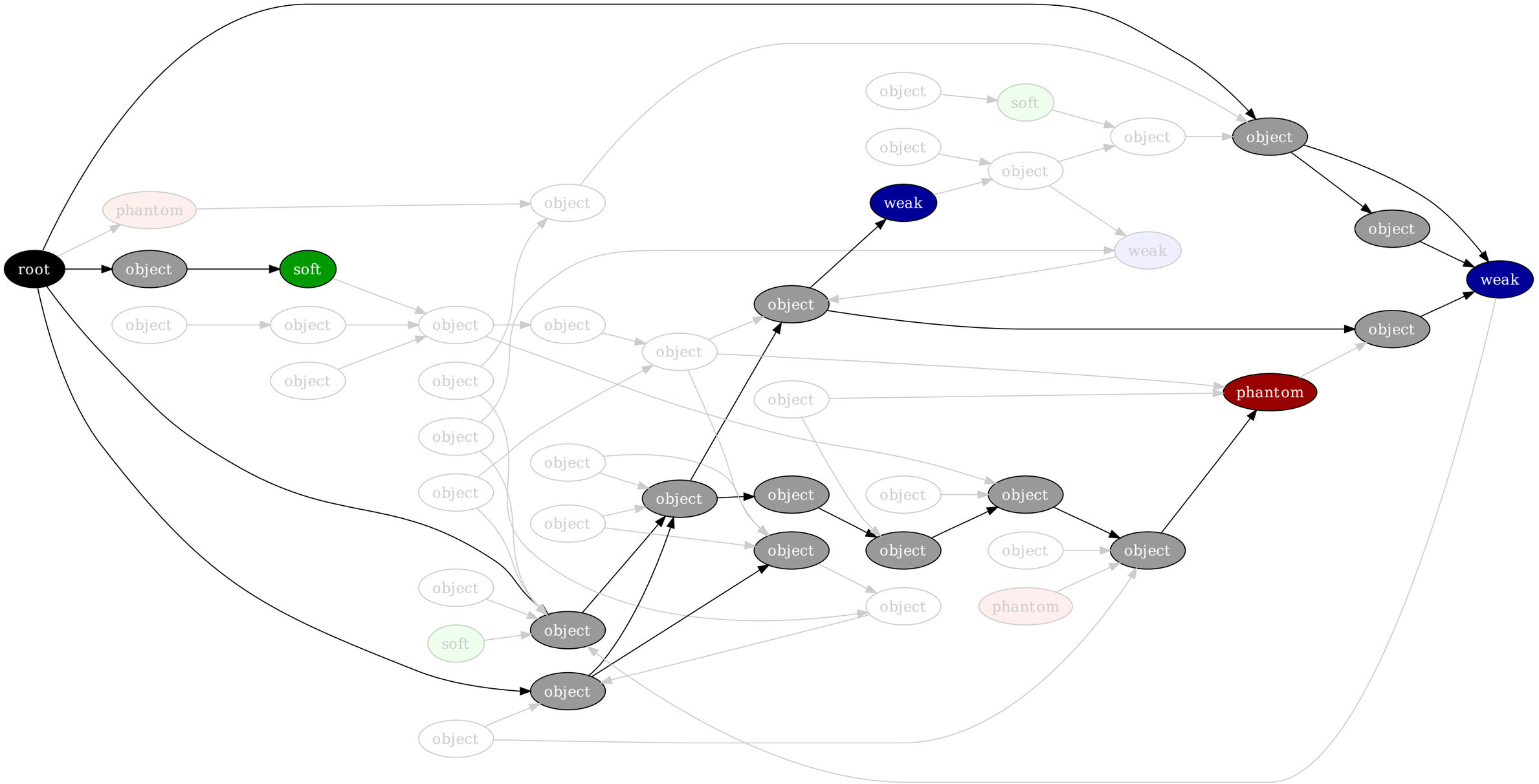
2. Trace and mark strongly-referenced objects.



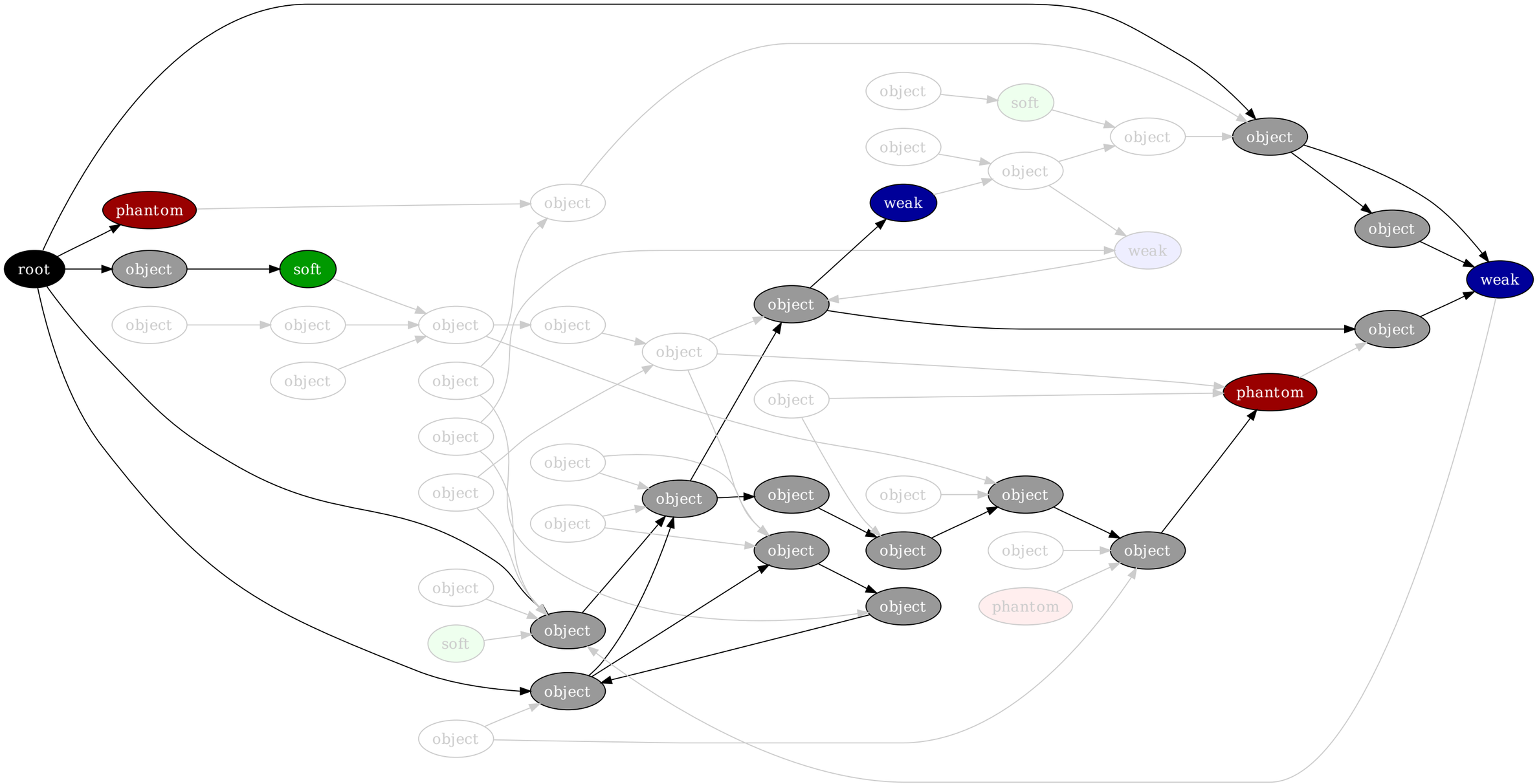
2. Trace and mark strongly-referenced objects.



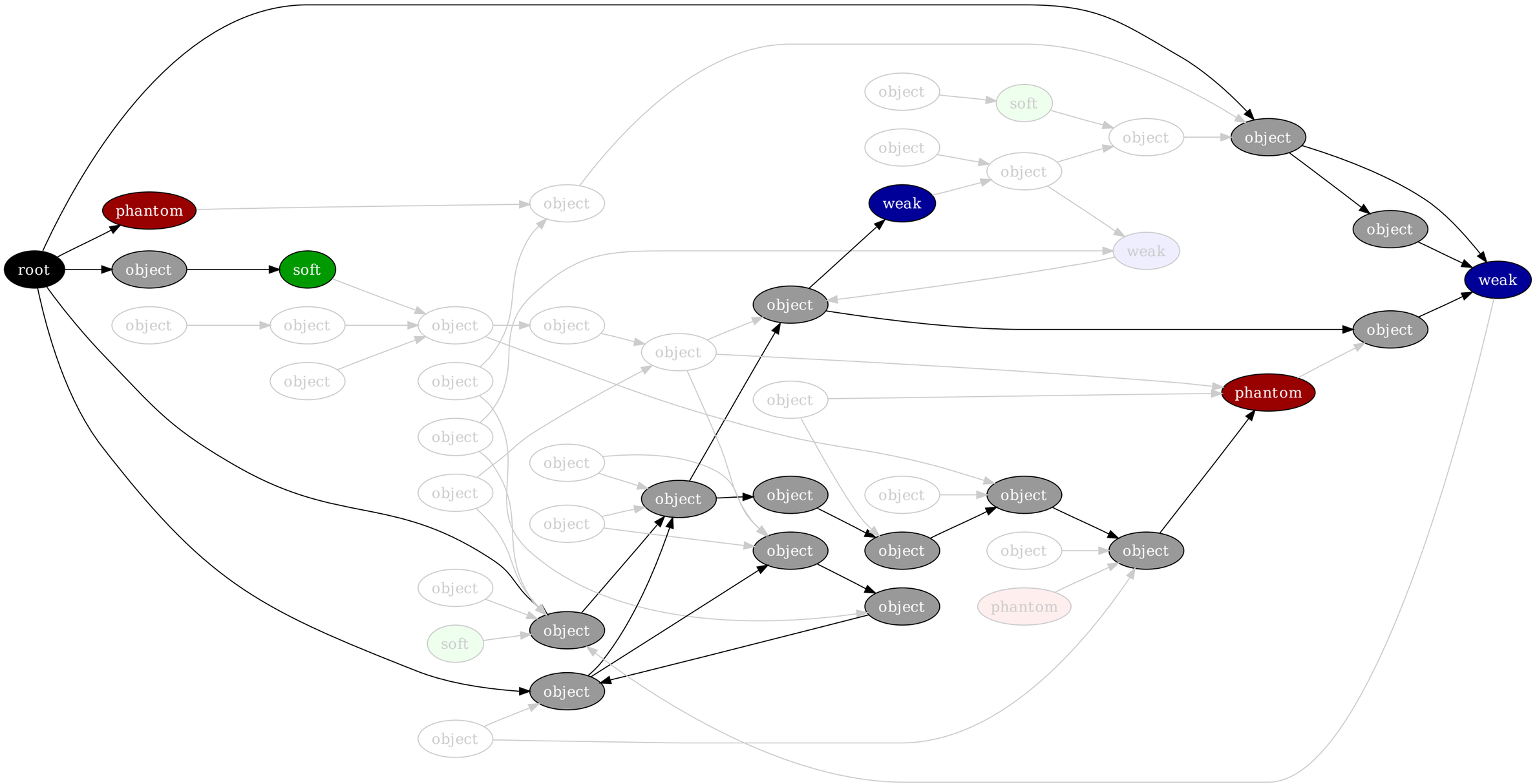
2. Trace and mark strongly-referenced objects.


root
object
soft
phantom
object
object
object

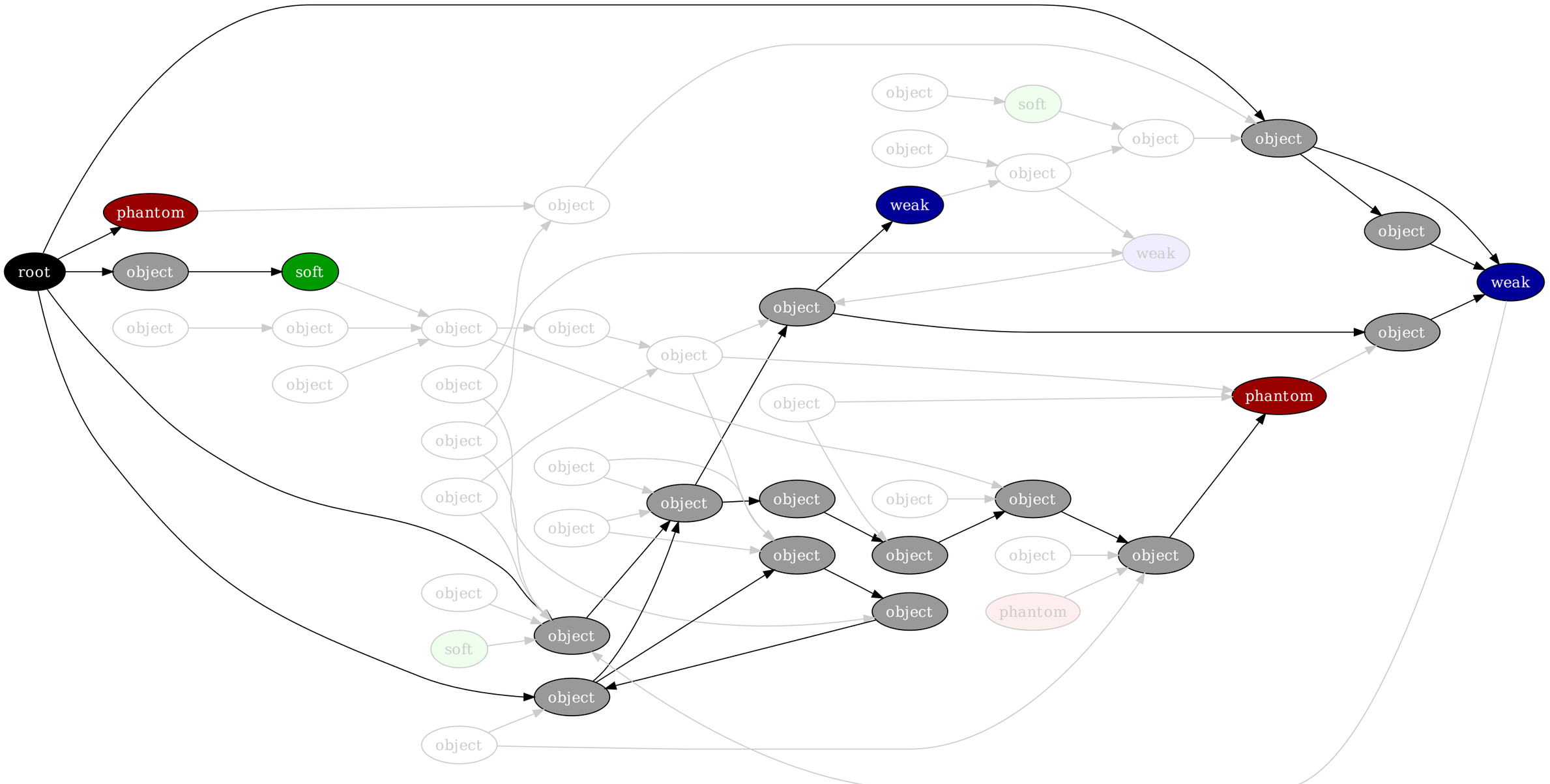
2. Trace and mark strongly-referenced objects.



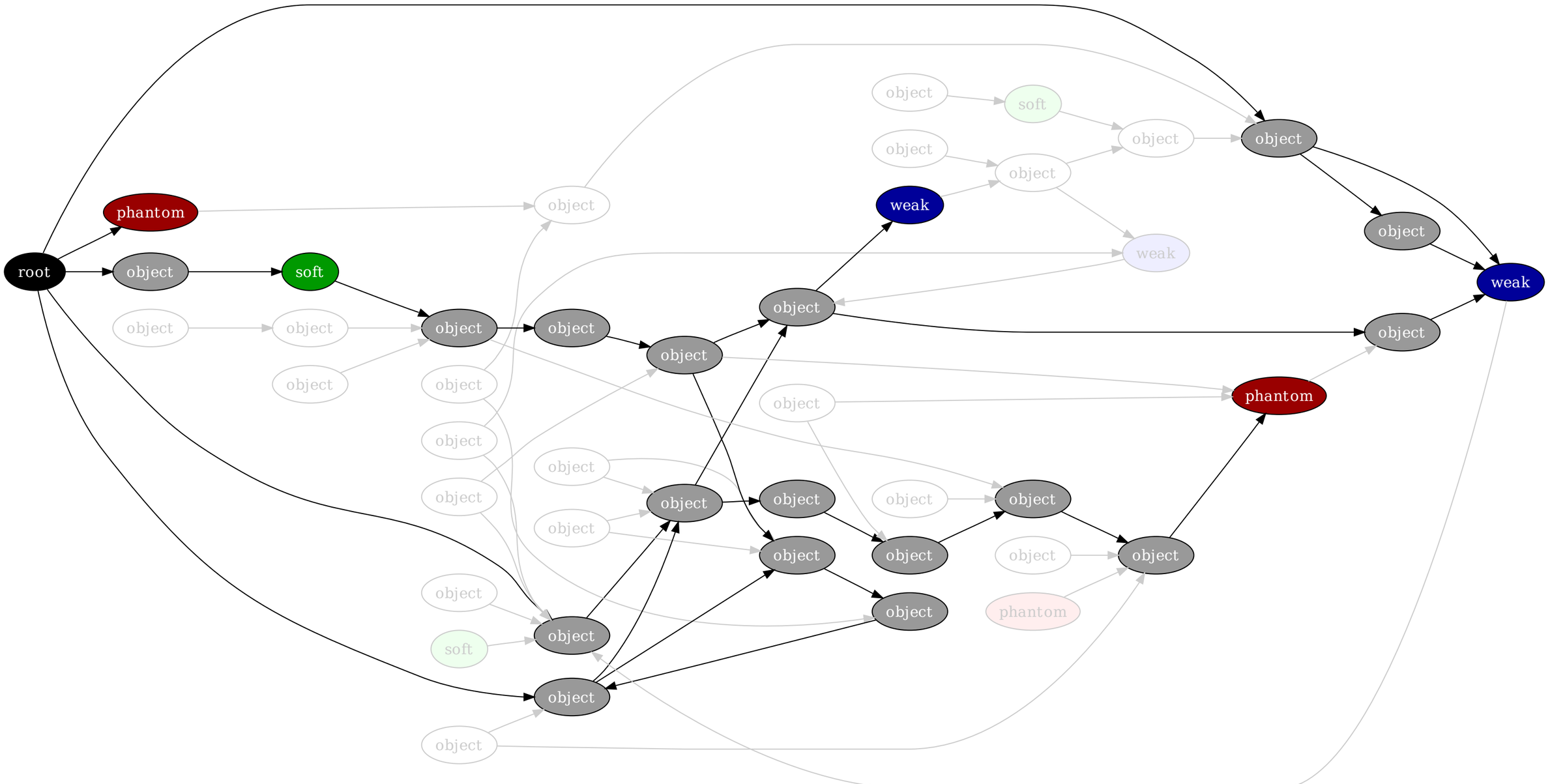
3. Optionally clear soft references.



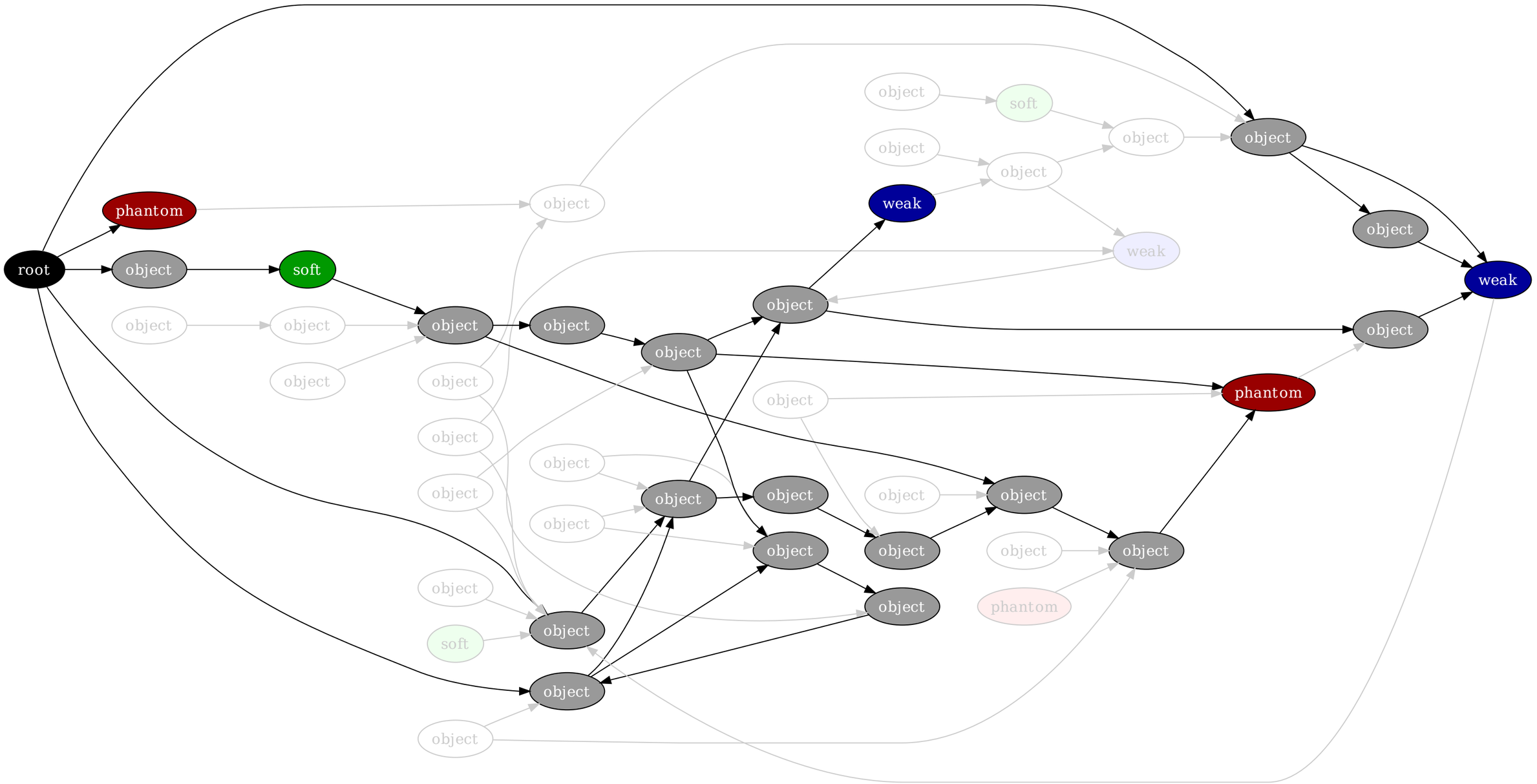
4. Trace and mark softly-referenced objects.



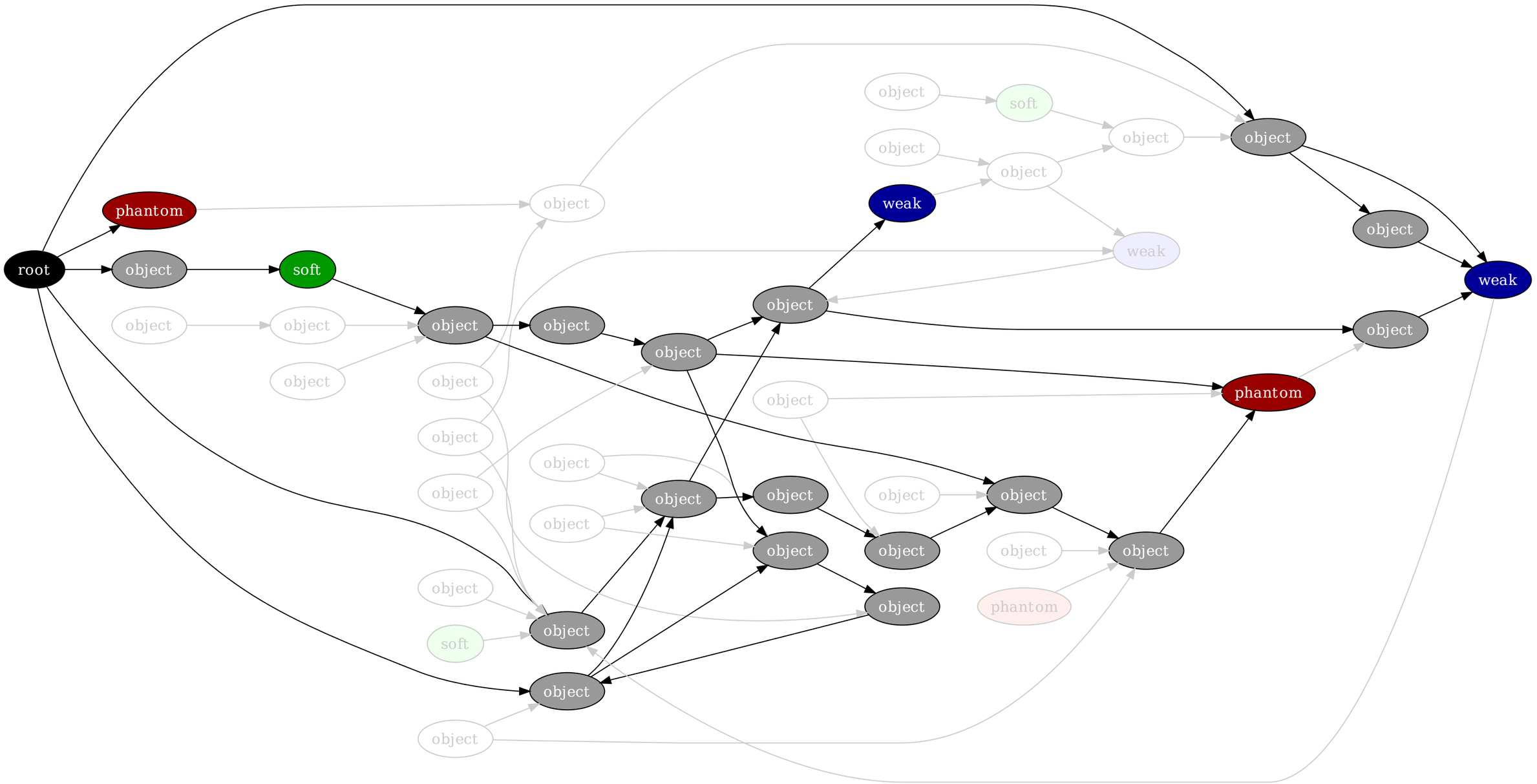
4. Trace and mark softly-referenced objects.



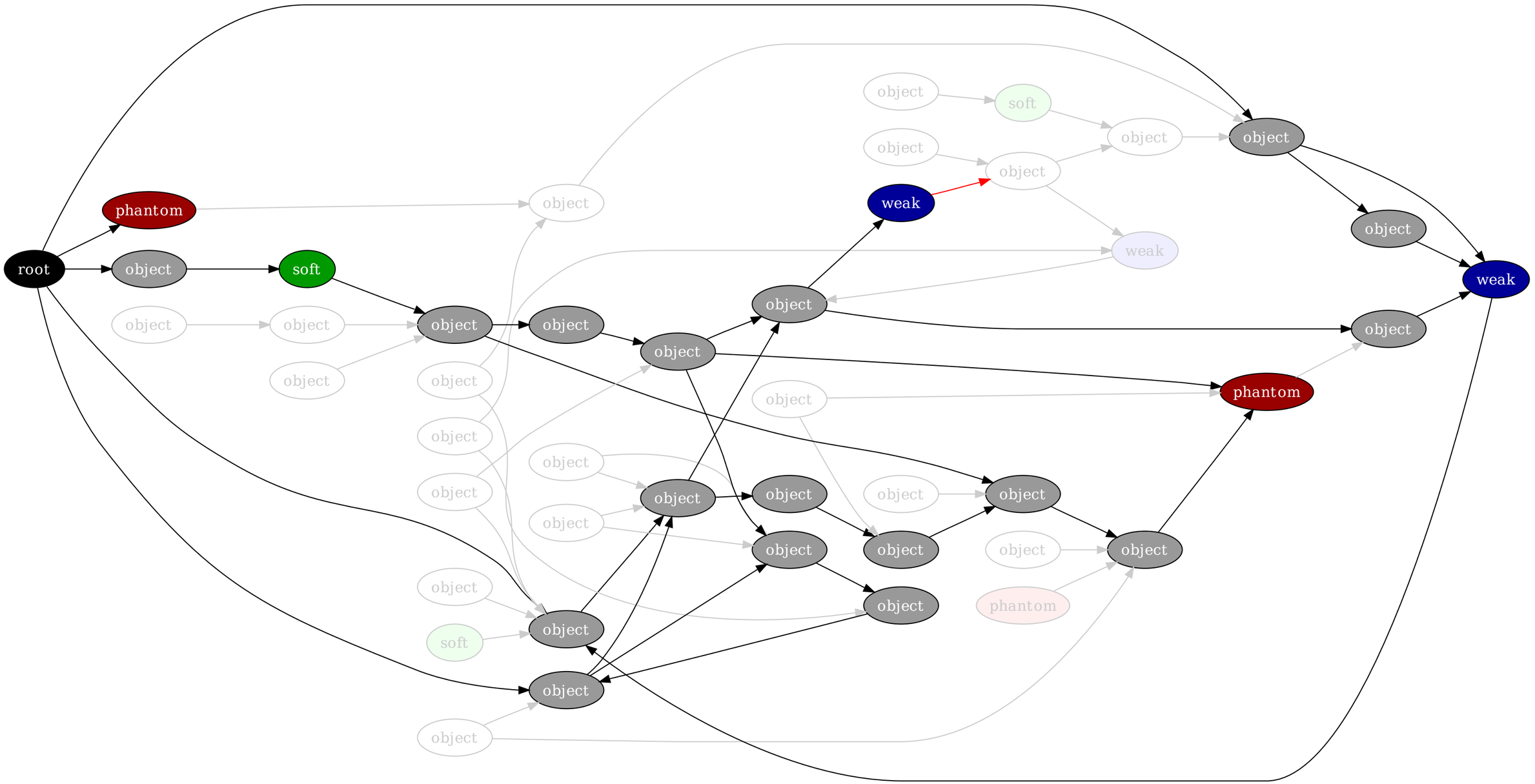
4. Trace and mark softly-referenced objects.



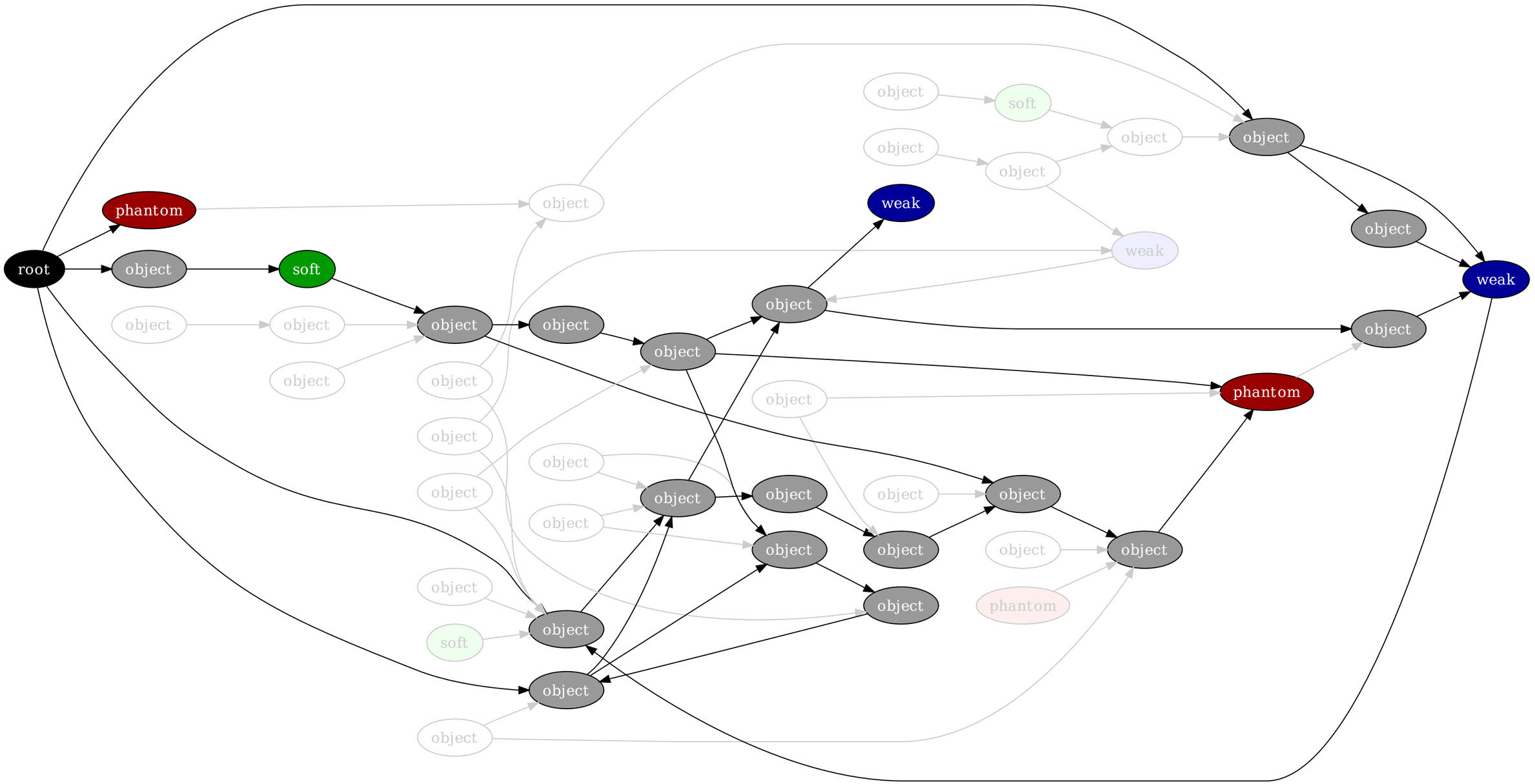
5. Clear weak references.



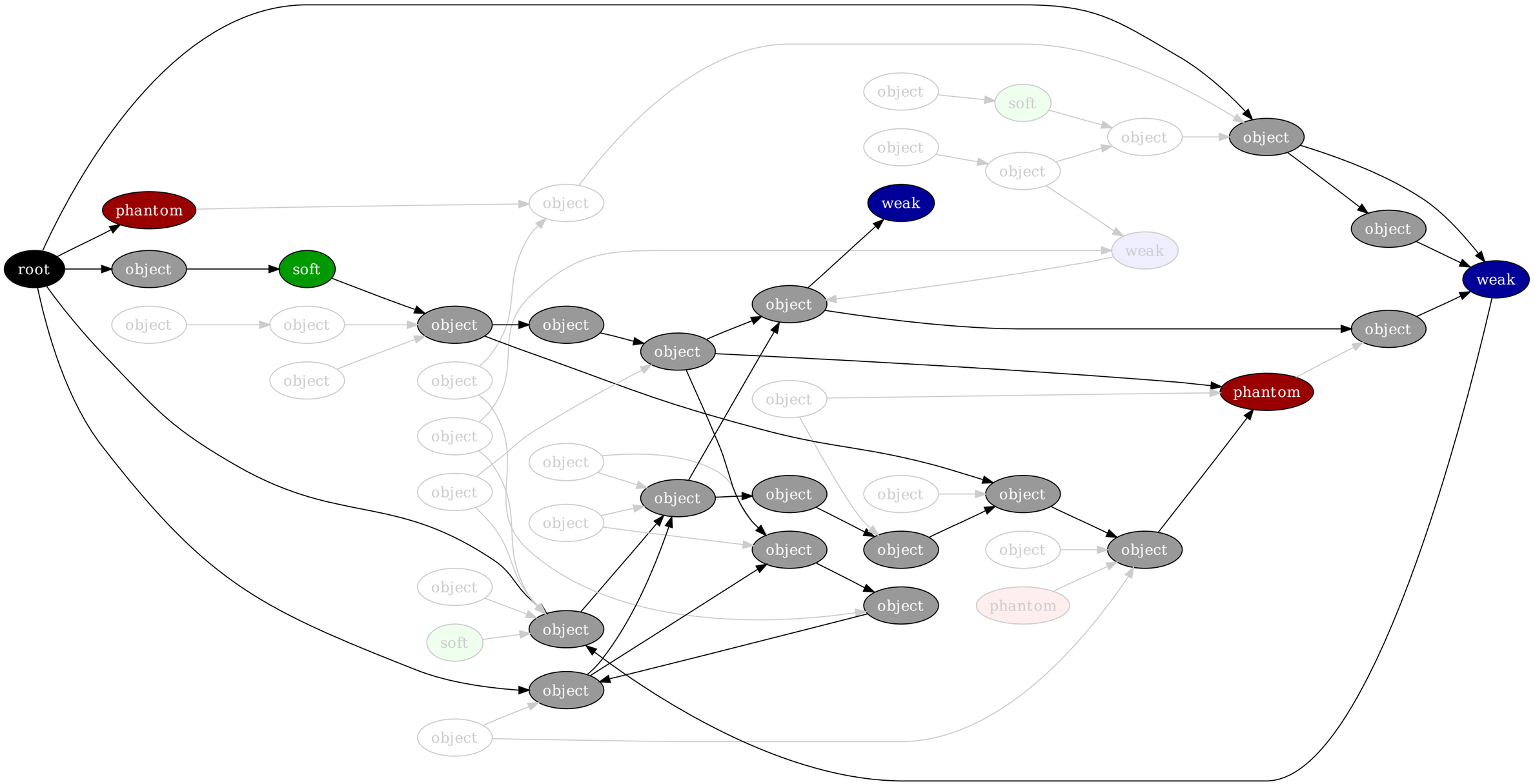
5. Clear weak references.


root
phantom
object
soft
weak
object
object
object

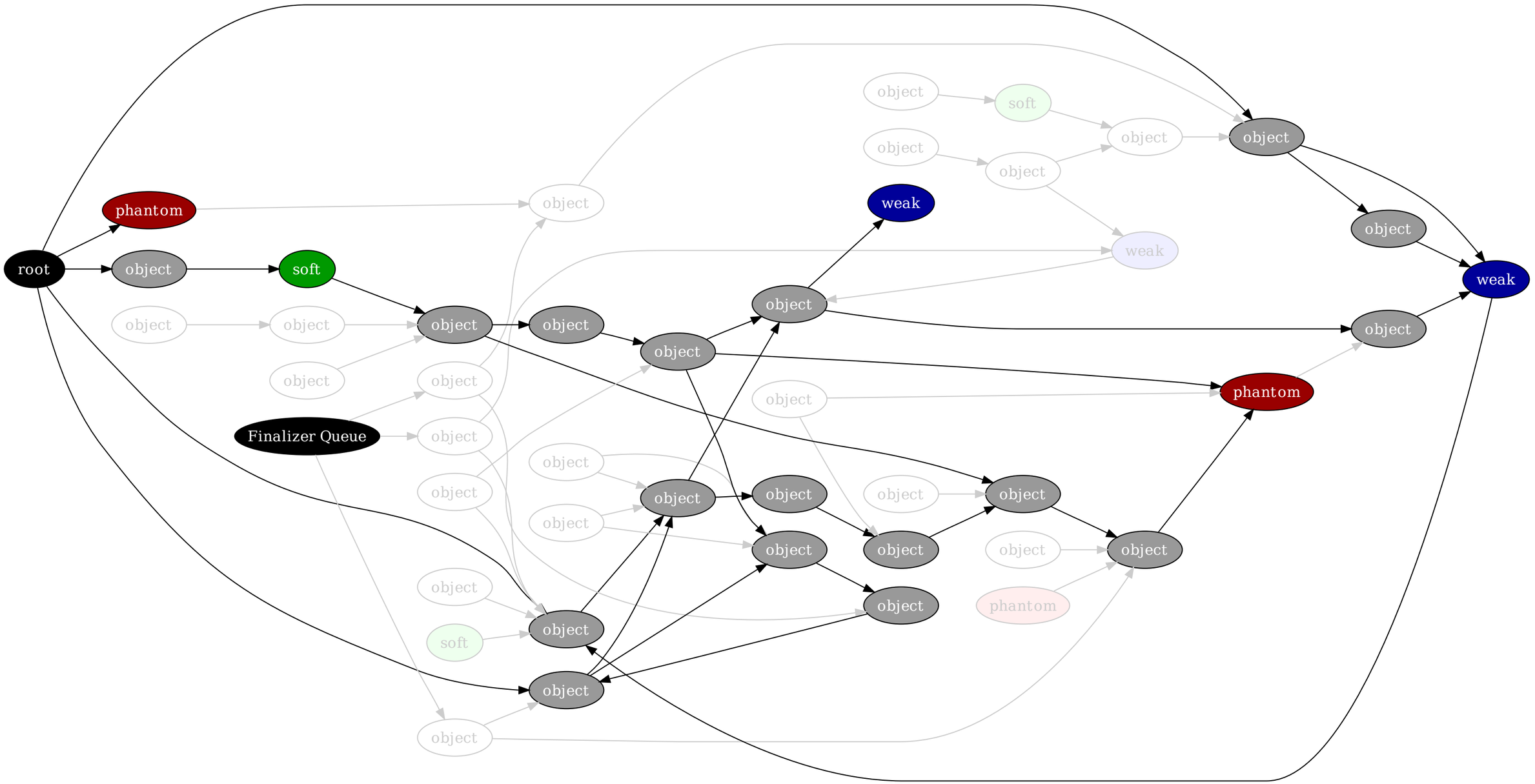
5. Clear weak references.


root
phantom
object
soft
weak
object
object
object

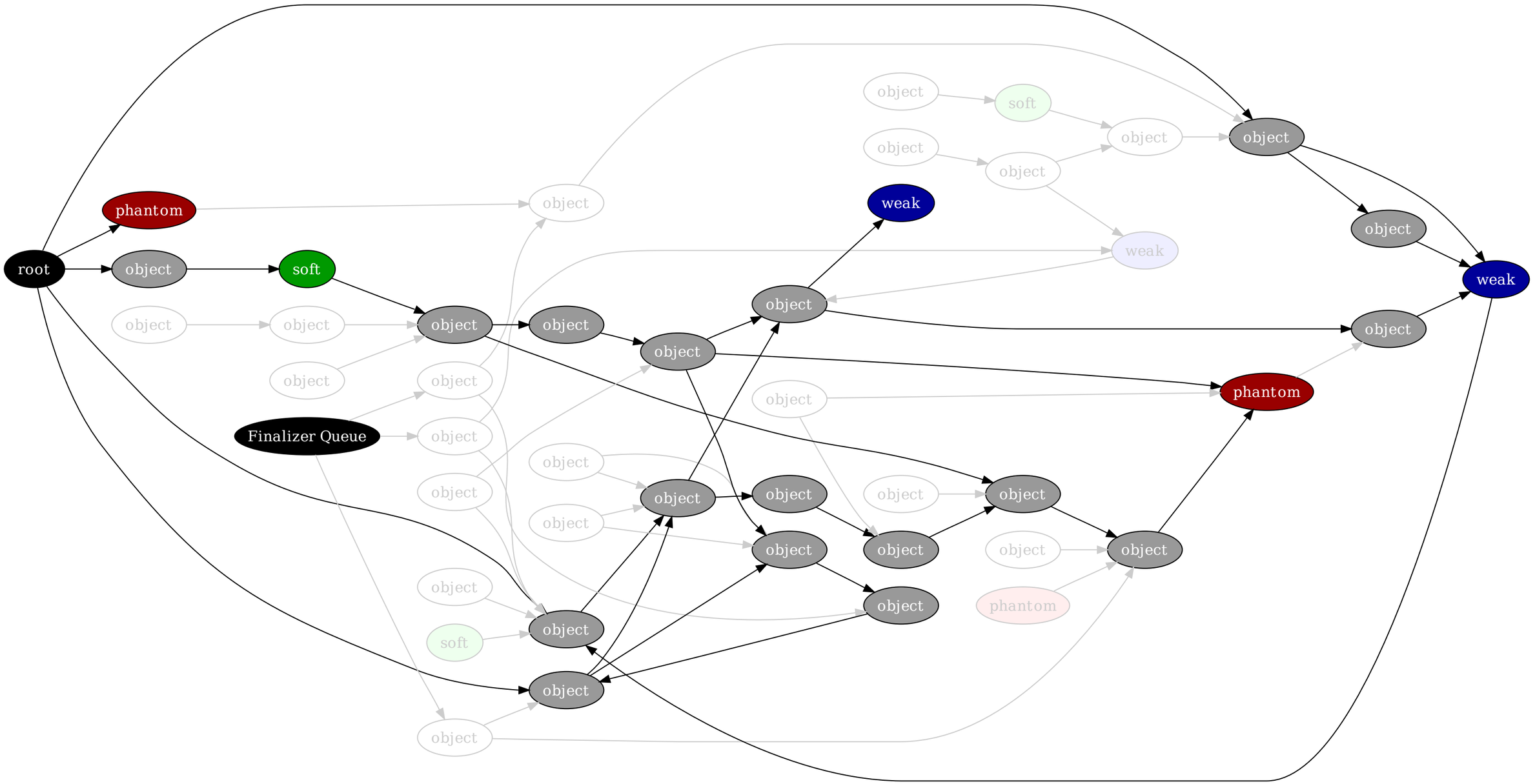
6. Enqueue finalizable objects.



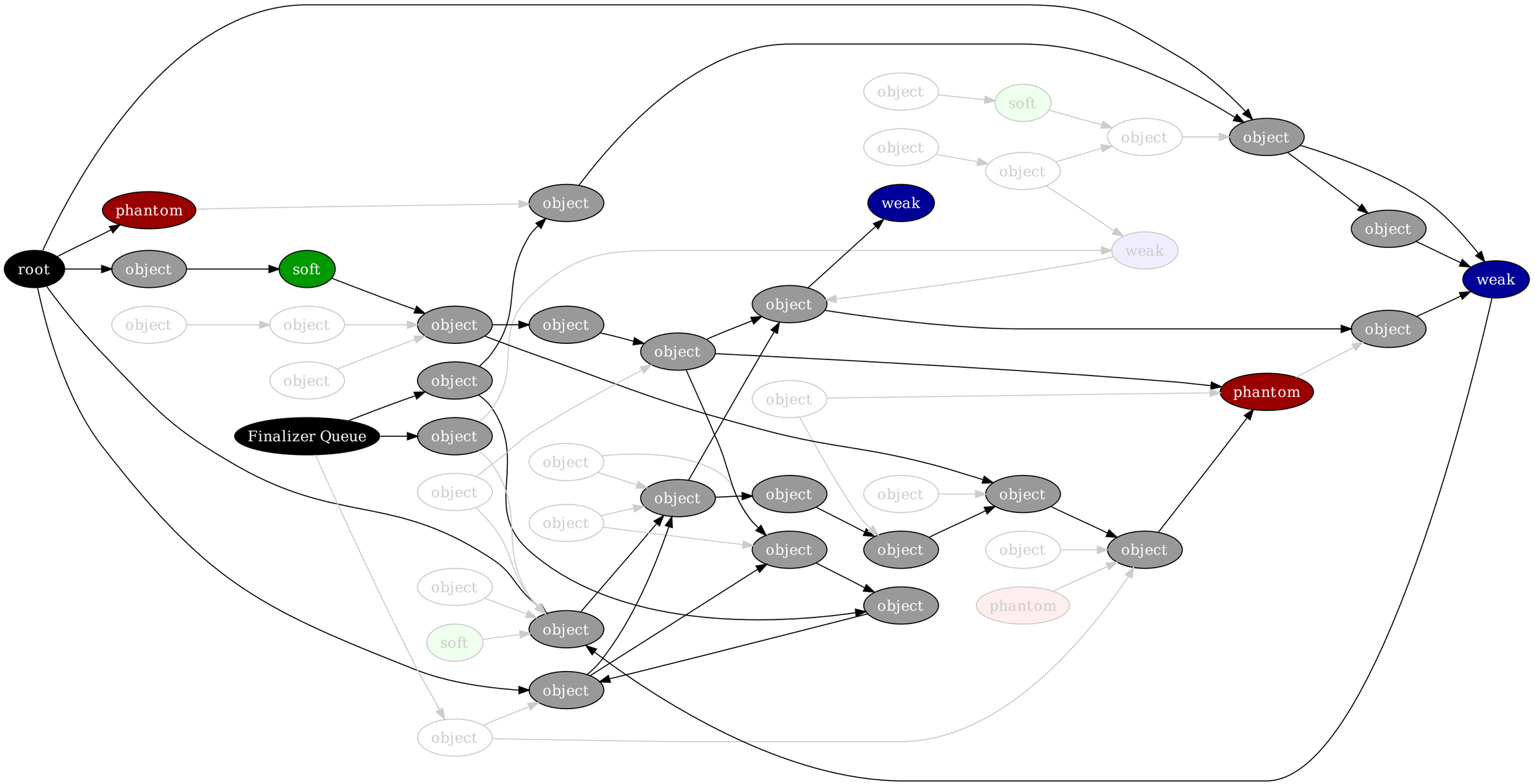
6. Enqueue finalizable objects.



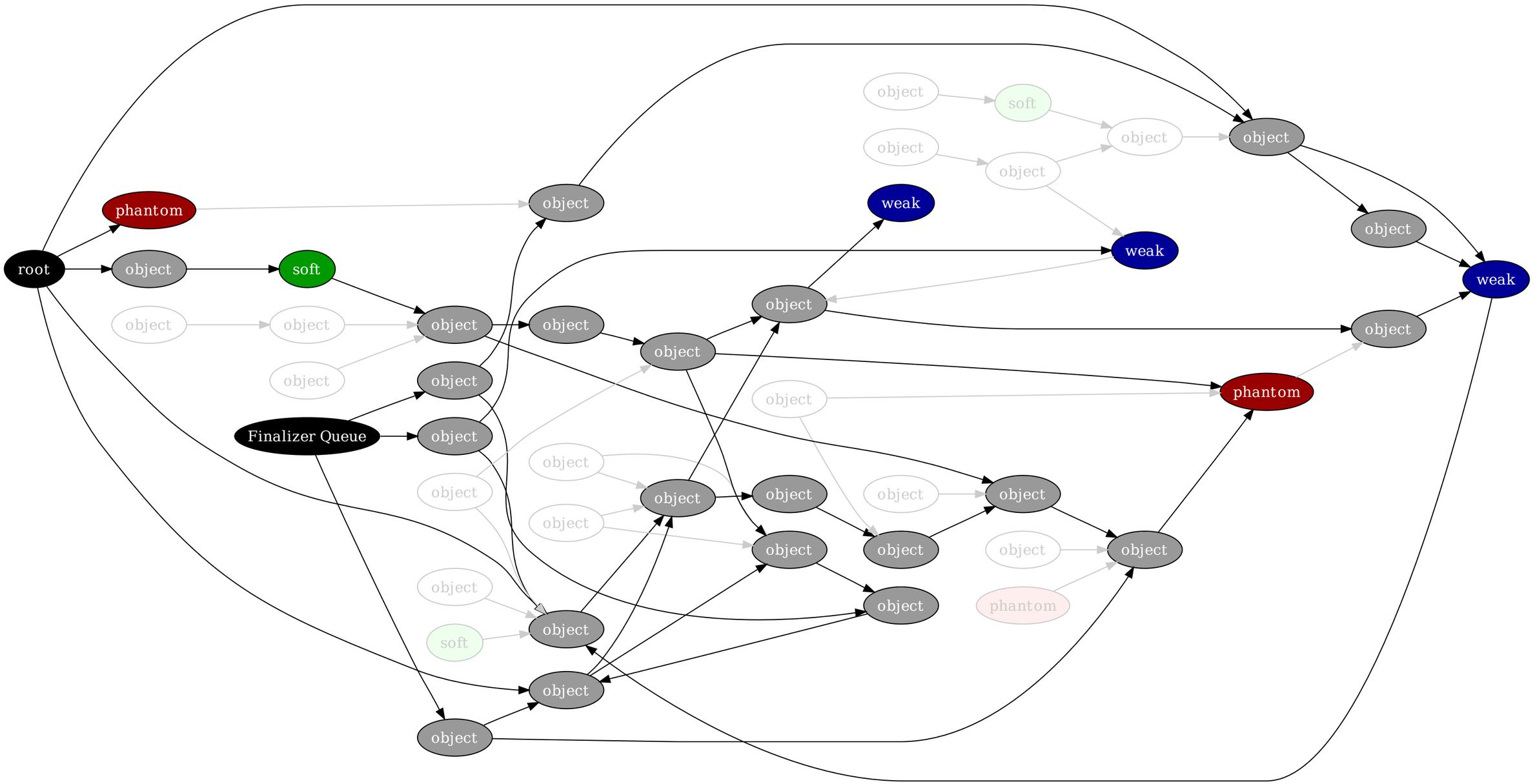
7. Repeat steps 1 through 5.



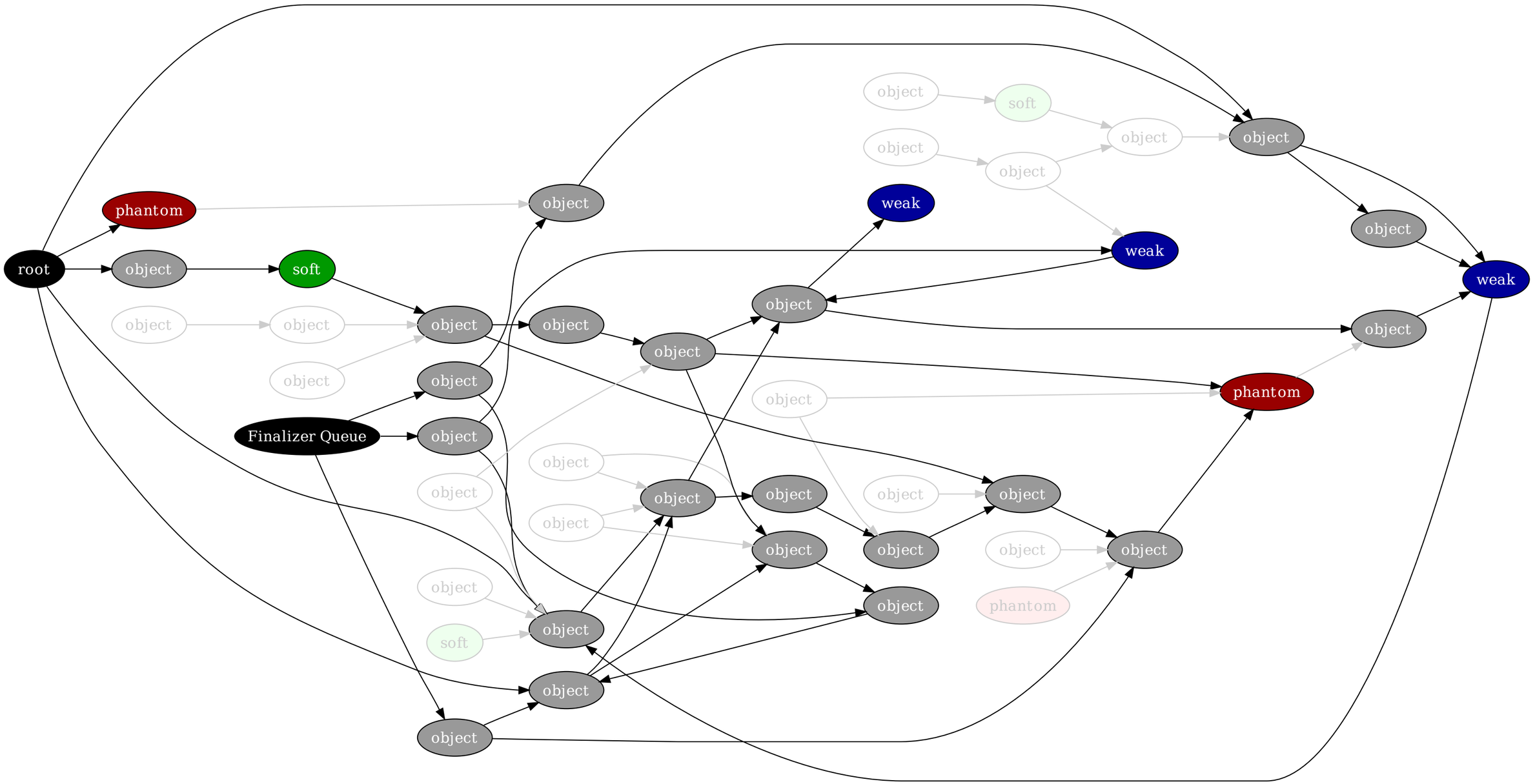
7. Repeat steps 1 through 5.



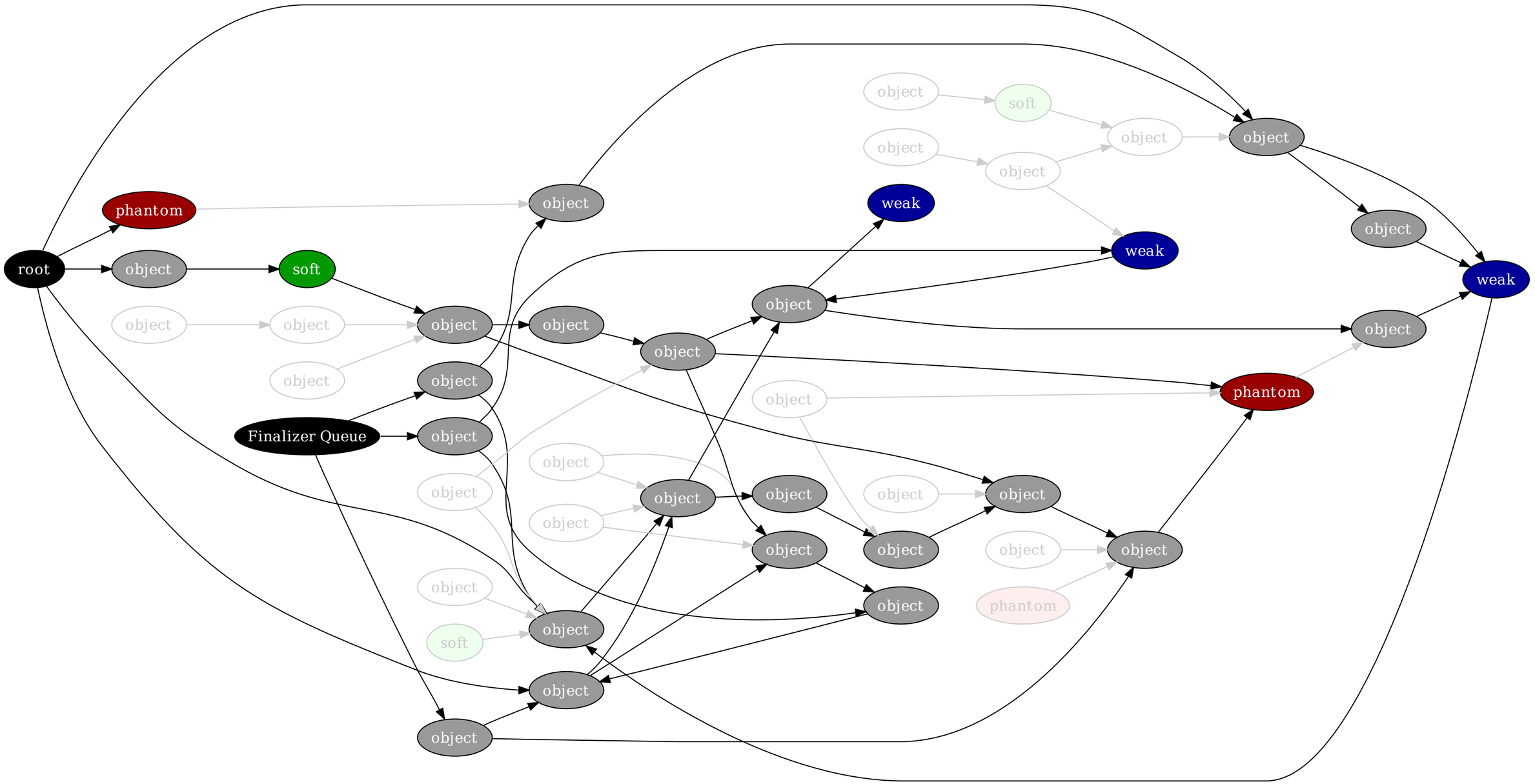
7. Repeat steps 1 through 5.



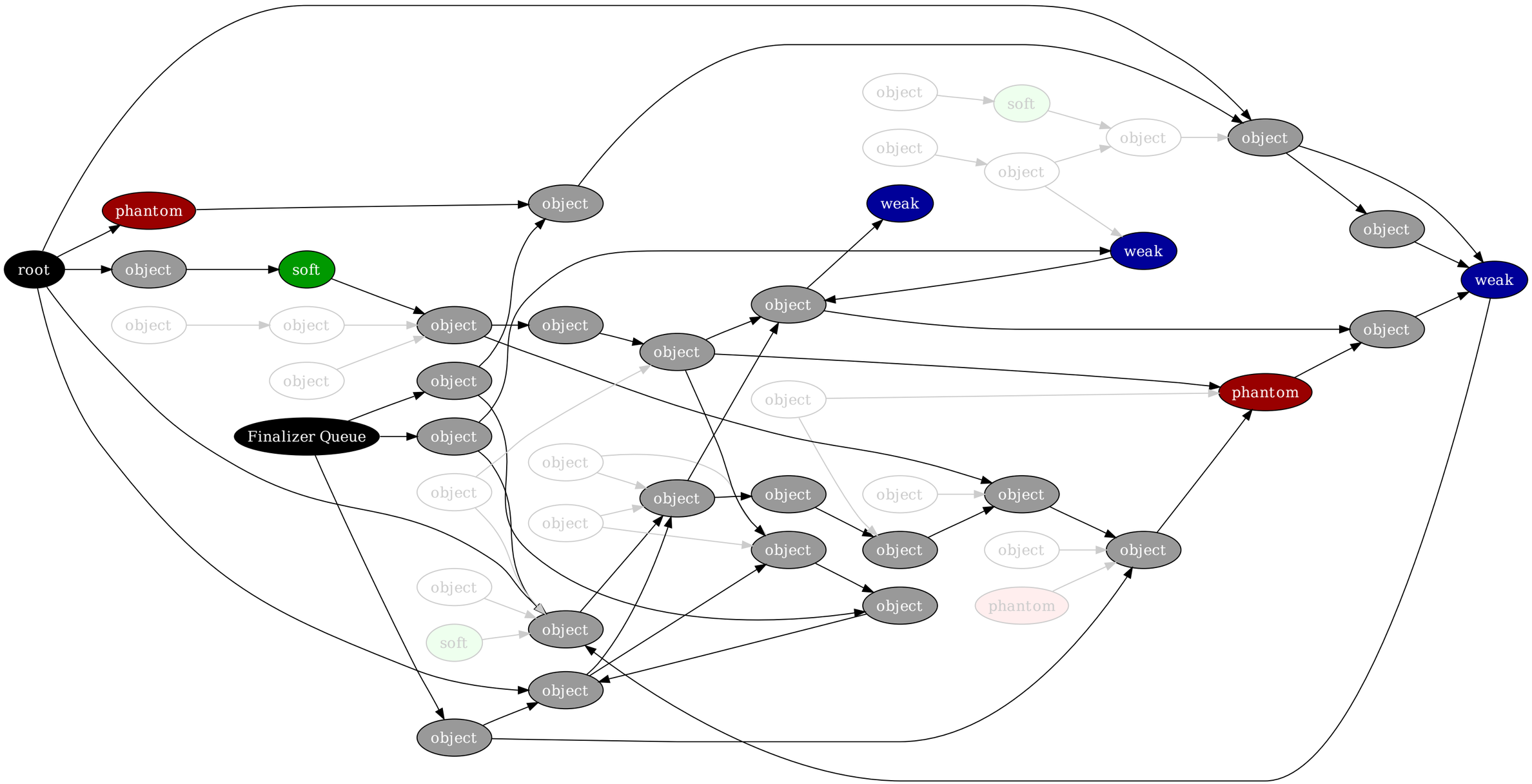
7. Repeat steps 1 through 5.



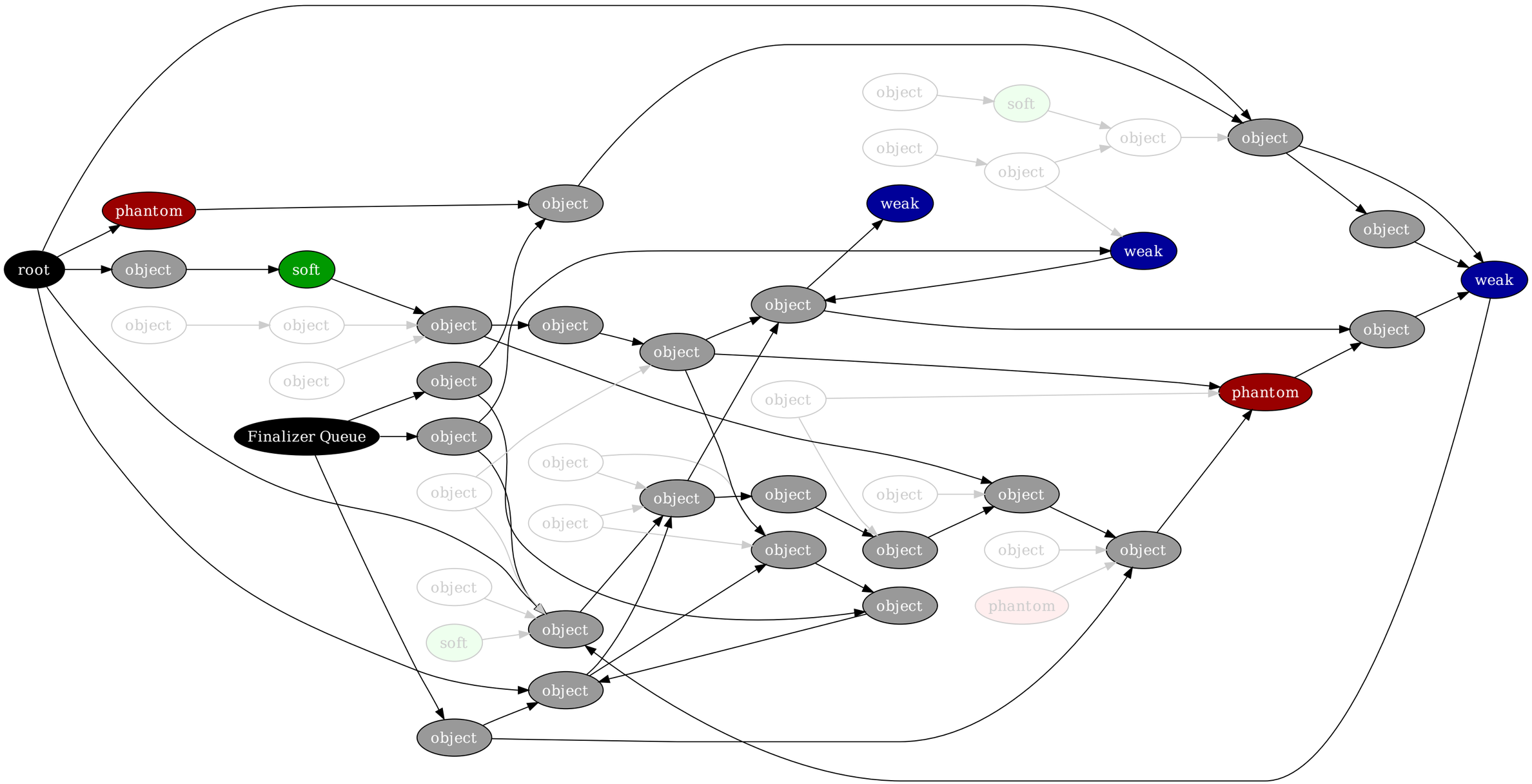
8. Trace phantom references.



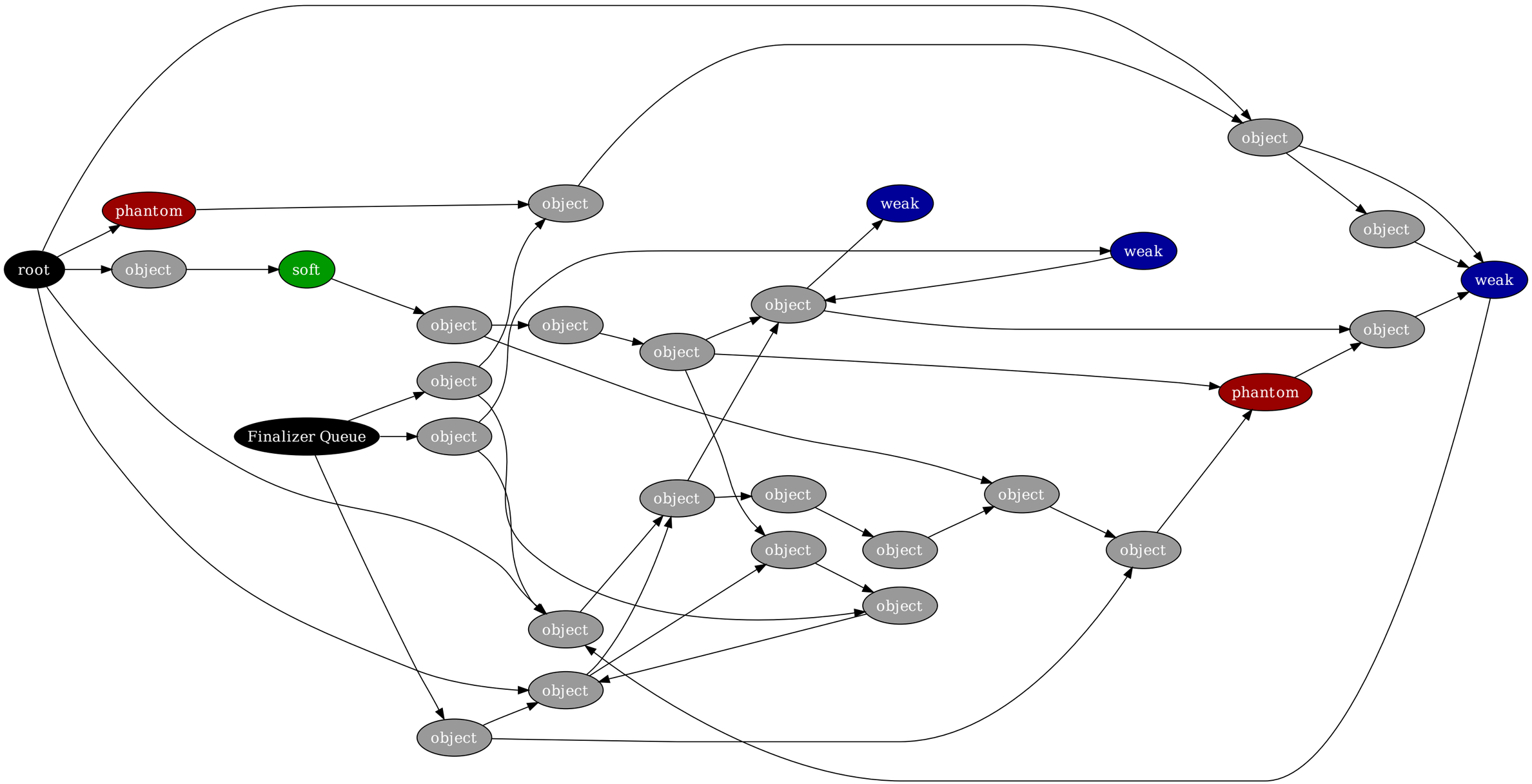
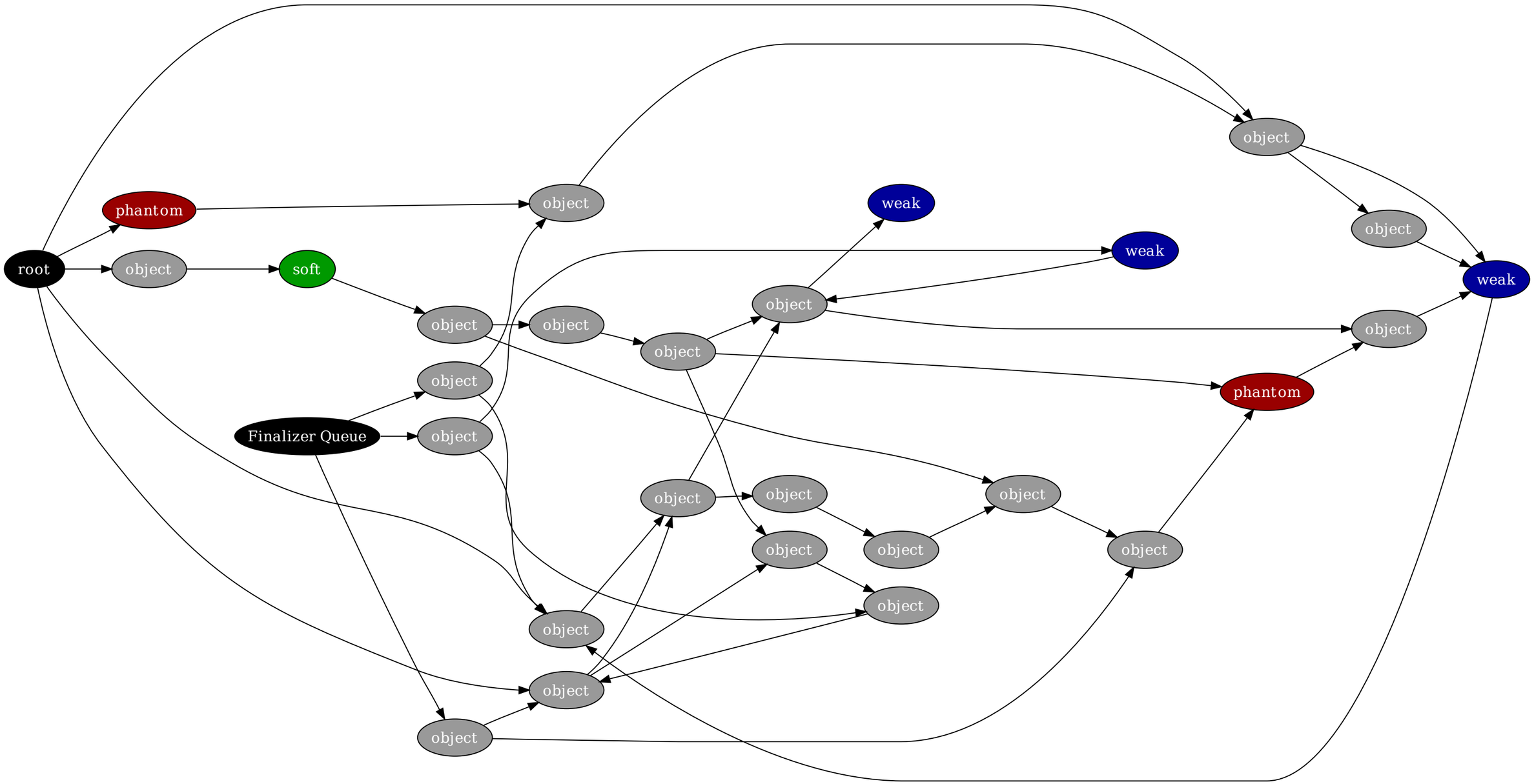
8. Trace phantom references.



9. The remaining objects are dead.



9. The remaining objects are dead.



10. Go to step 1.