

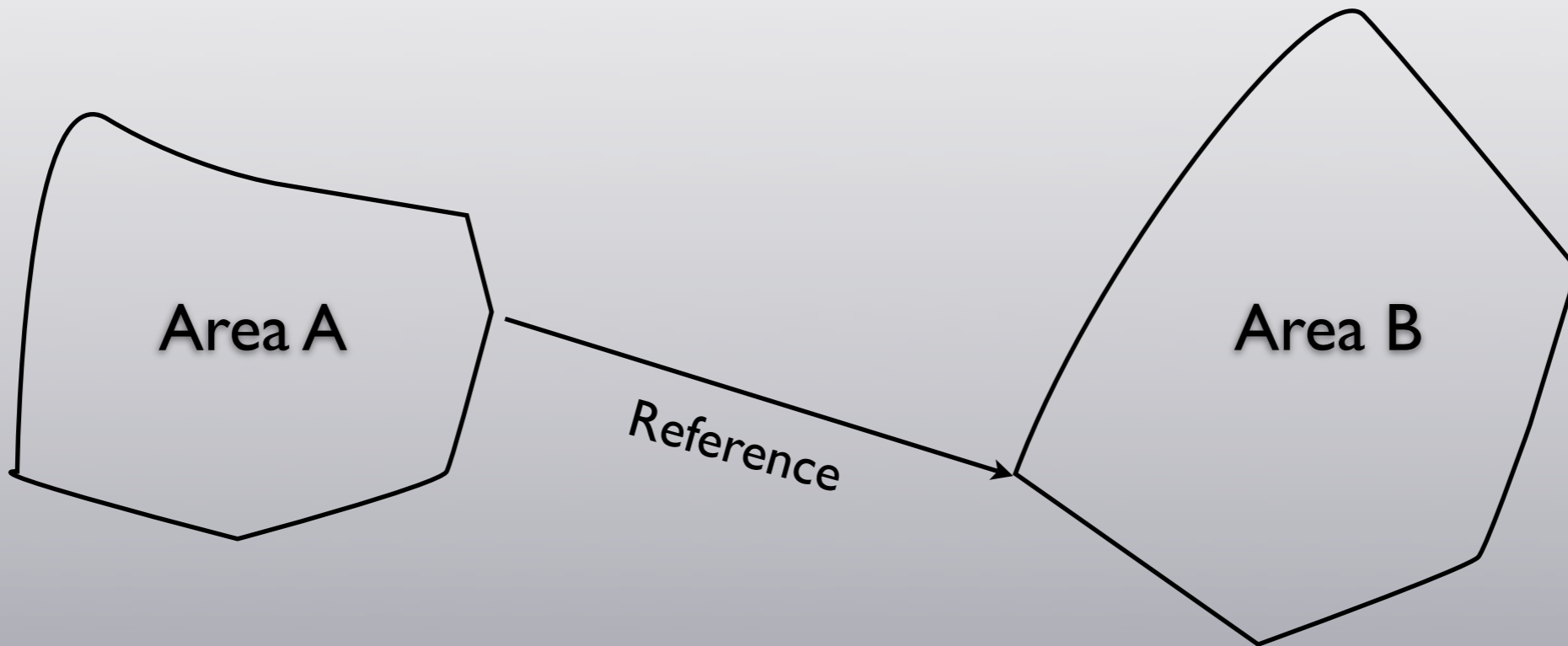
# System Enforced Transitive Read-Only Objects in KeyKOS-like Systems

This talk is about system-level assurance of an isolation property.

Being a walk along one  
path through the design  
space.

There may be better paths. Go find them.

# The Problem



We want objects in A to be able to get data from objects in B without being able to influence anything in B in any way.

# The Problem

```
Class Foo {  
    private Object a;  
    void setA(Object x) { a = x; }  
    void getA(void) { return a; }  
}
```

# The Problem

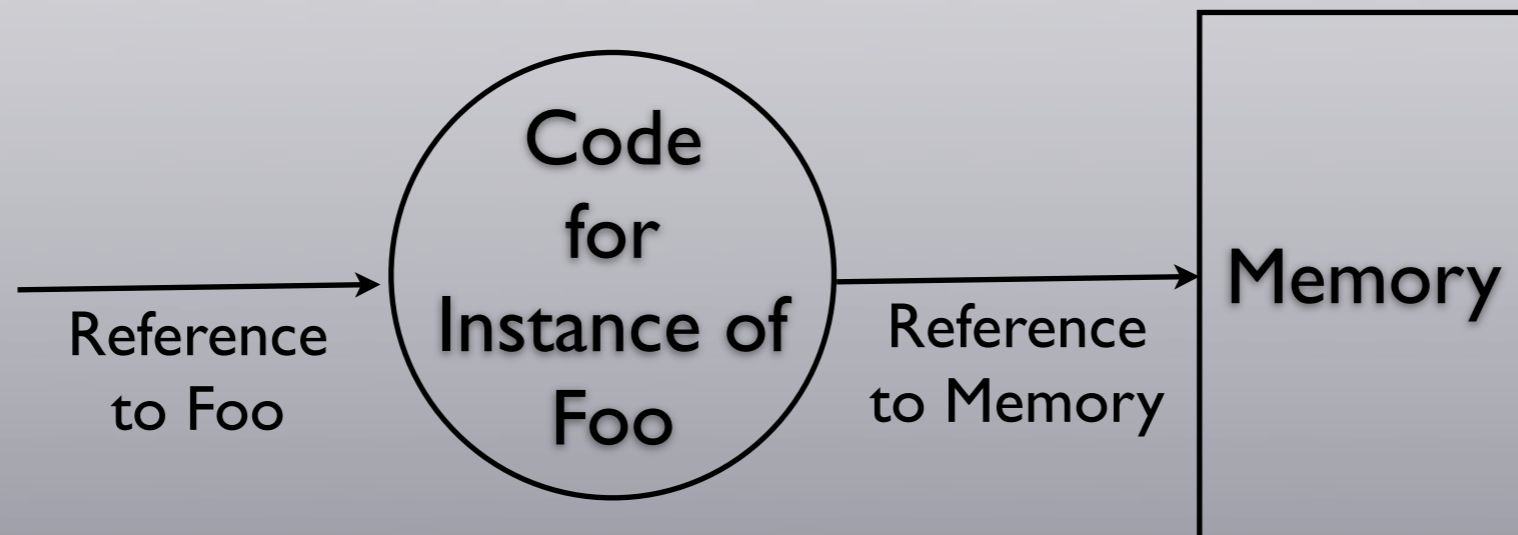
We need two types of reference to a Foo:

A strong reference which can use any method.

A “no-influence” reference where:

- (1) setA() can't be used
- (2) any object returned by getA() is transitively read-only,
- (3) these restrictions are enforced by “the system”.





# The (Simplified) Object



# Existing: The Factory

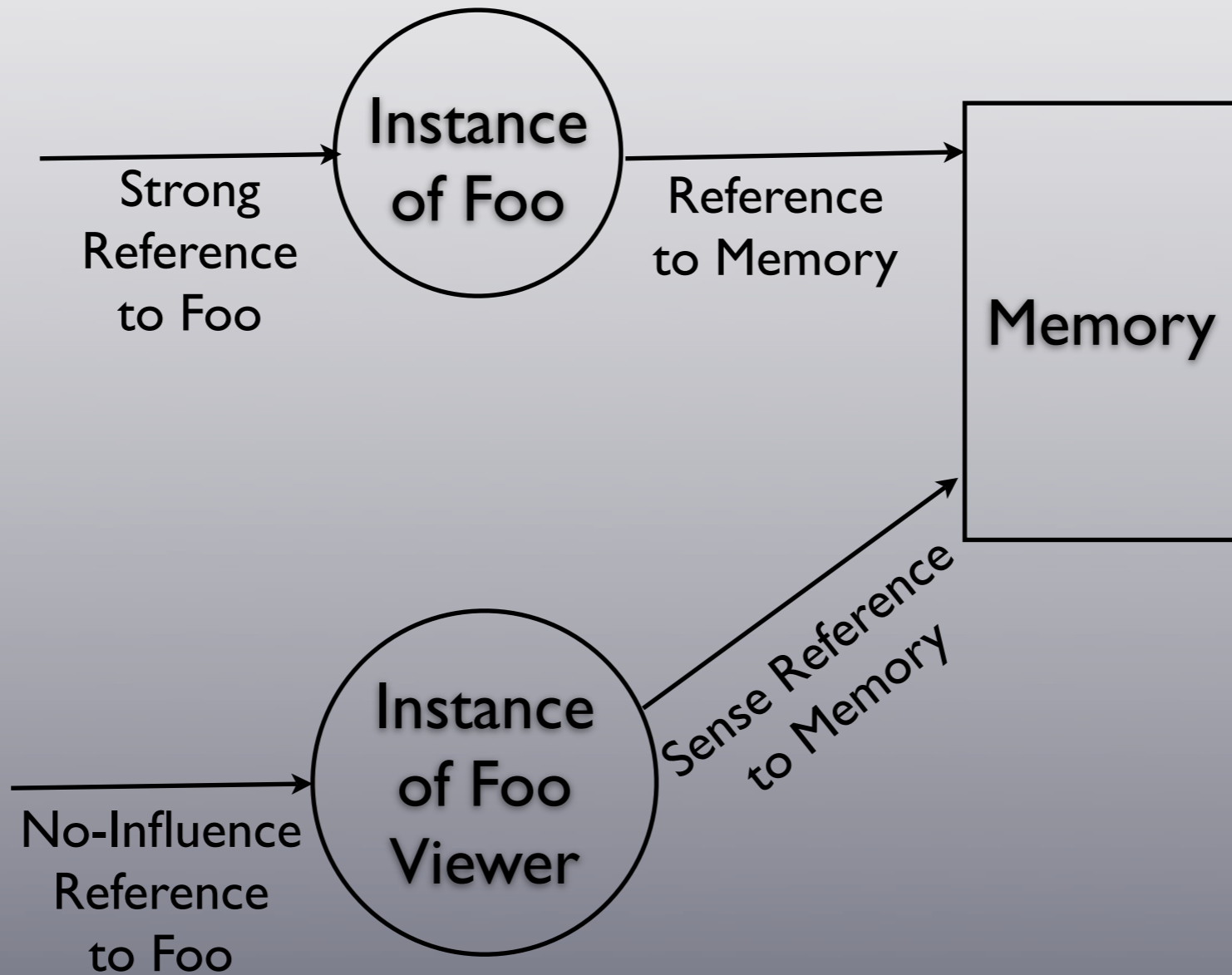
- Standard object creation tool
- Allows auditing the communication paths new objects have when they are “born”
- Allows debug access with permission of both the type’s “owner”, and the instance’s “owner”

# Existing: The Sense Reference

- Allows transitive read/only access to memory 
- Allows reference to a (very) few other objects 
- Sets general object references to null 
- Is known by the Factory 



# Today, We Can:



# What It Does Right

- Provides both strong and no-influence accesses.
- Provides system assurance of transitive read/only.

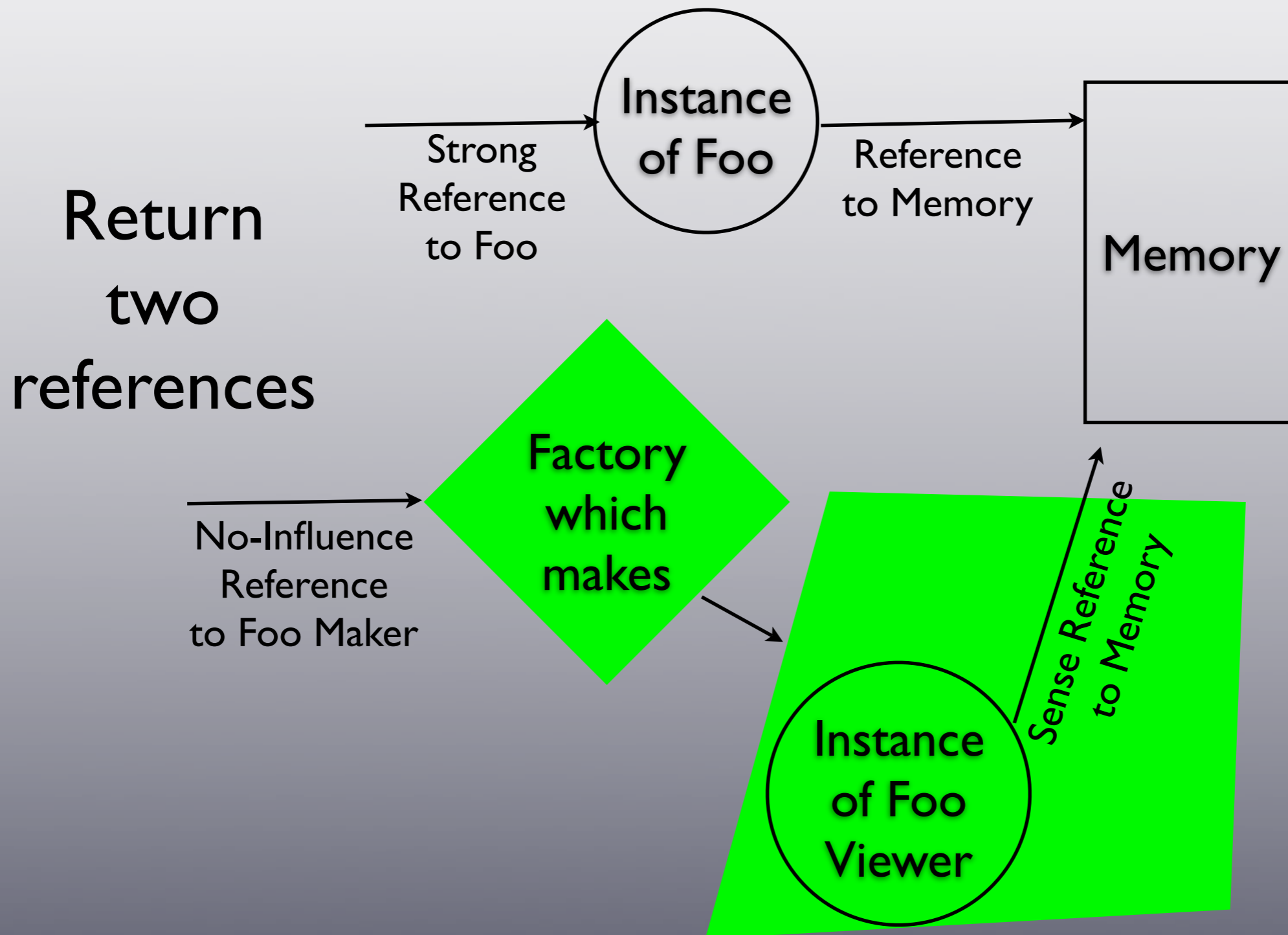
# What It Doesn't Do

- Provide for verifying the no-influence reference is indeed no-influence.
- Provide for calling sub-objects. i.e. It doesn't compose
- Handle race conditions for memory access

# Features

- Instance of Foo Viewer can have its own state from call to call, perhaps making an Instance of Foo Viewer Instance Viewer desirable.
- We're glossing over the question of how the viewer's stack and heap addresses are allocated. Having an Instance of Foo Viewer Instance Viewer makes the answer more complex.

# Verifiability Today



Since instead of getting a no influence reference, we get a reference to a factory which will create a no influence reference, we can use the standard factory mechanism <http://www.cis.upenn.edu/~KeyKOS/agorics/KeyKos/Gnosis/72.html#discr> to verify that the reference we get is indeed “no influence”.

# Verifiability Today

## Viewer Factory Components:

- (1) Sense reference to instance of Foo's memory
- (2) Read/Only reference to Instance of Foo Viewer code

This is a “no hole” factory

Hole: <http://www.cis.upenn.edu/~KeyKOS/agorics/KeyKos/Gnosis/73.html#hole> is a reference that factory can't say doesn't pass data. The factory knows about both read-only memory references and sense references.

# New Sense References

- Provide sensory access to an object
- Have “discretion” for use by the factory
- Pass factories at least as discreet as it is

# New Sense Function

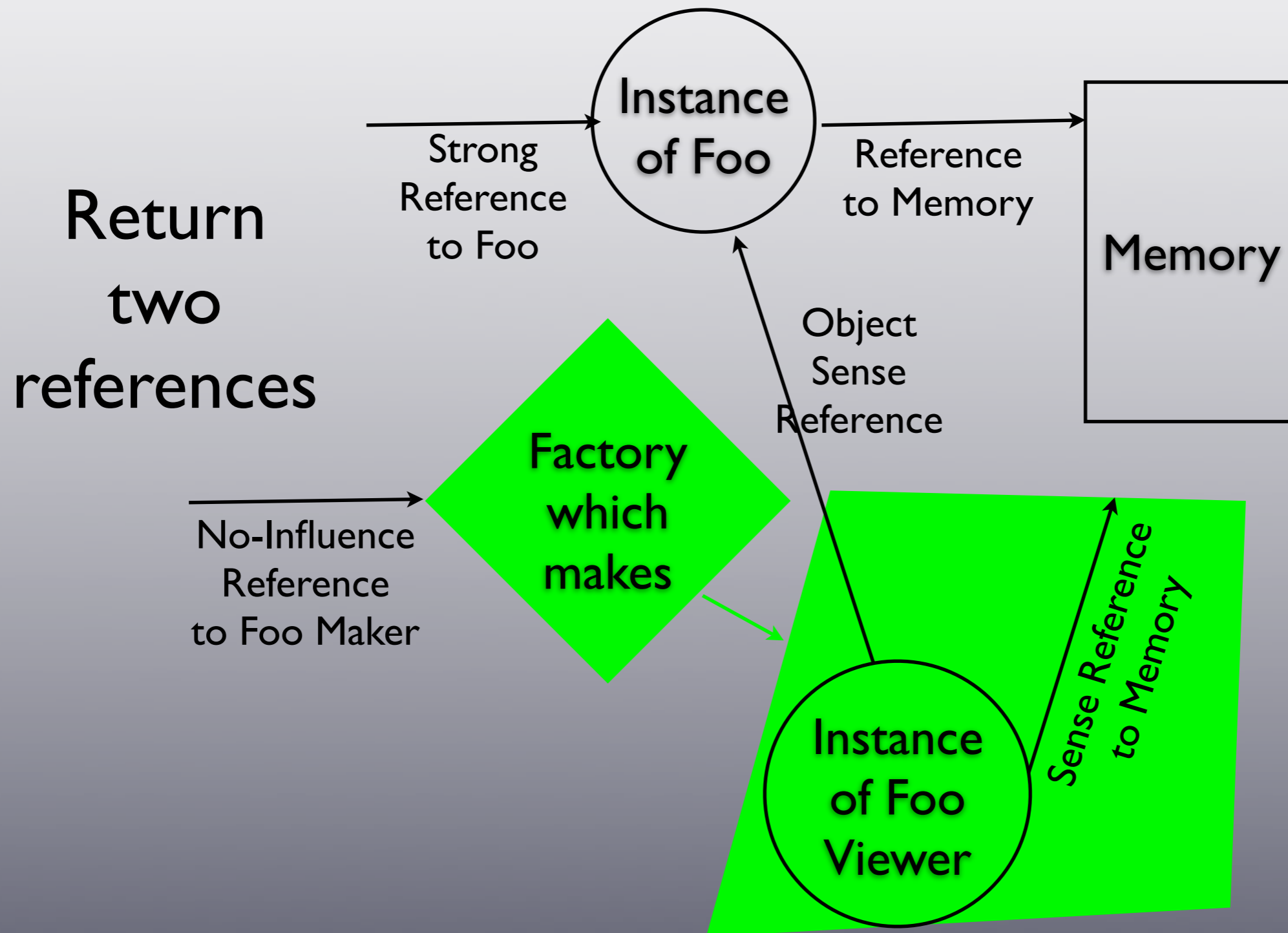
- References to nodes become sensory references to the same node
- Factories must be at least as discreet as the sense reference or they become null
- Discrim, sensory references, etc. are passed unchanged
- All other references become null



# Object Sense Reference

- Allows sensory access to an object's reference registers
- Allows sensory access to an object's address space
- Allows sensory access to an object's extra slots, C10 and C11
- Allows access to an object's data registers

# New Sense References



The “object sense reference” allows the viewer to fetch sensory versions of any references that Foo holds.

# How Do We Get No-Influence References to Sub-Objects?

- If our object uses other objects, we can use the sensory reference to fetch from its reference registers to access them.
- But we don't have a way of getting their no-influence factories.

But typically Foo will not be using sensory references to its sub-objects. But the viewer can only fetch sensory references.

# Two ways to get References to Sub- Objects

- A new kernel function which gets it from the R/W object
- By cooperation between the R/W object and the R/O viewer

# The Get No-Influence Factory Tool

- Define an object register which holds the No-Influence Factory (NIF) reference
- No such reference: this register holds Null
- Get NIF Tool takes an object reference and returns the object's NIF register contents
- Tool is used by the Object sense reference

# New Sense Function

- References to nodes become sensory references to the same node
- Object references use the NIF Tool
- Factories must be at least as discreet as the sense reference or they become null
- Discrim, sensory references, etc: unchanged
- All other references become null

# Cooperative Option

- Factories return both the R/W reference and the NIF reference
- When a sub-object is built, the builder saves the NIF reference for use by its NIF during construction of a viewer
- Requires more complex reference structures for complex object graphs
- Get NIF Tool is an optimization

# Issues and Annoyances

- Need a new factory for each object instance
- An object can execute concurrently with its viewers

Potentially lots of factories, with one for each R/W object instance.  
Race conditions accessing memory.



# Need A Factory For Each Object instance

- Factory can be one node with a debugging reference to object + other data for factory with factory code as “keeper”
- A new object reference type which, with conventions, eliminates the need for a node

# Concurrent Execution

- Wall banging is an issue with most solutions
- All solutions have significant issues

# Concurrent Execution Approaches

- Meter manipulation
- One object w/separate references
- “Canned” front end that vectors requests
- Virtual copy memory for stability
- Object entry + exit counts

# Meter manipulation

- Meter keeper ensures either R/W object's meter is on or the viewer's meters are on
- Trap on no objects running under a meter has never been implemented
- Timing tests can notice viewers running

# One object with separate references

- Change references for object or for each viewer
- Major kernel changes
- Not clear how to handle mutually suspicious viewer objects
- Natural for a Vat oriented system

# “Canned” front end that vectors requests

- Timing busy state allows view use to be detected by R/W object’s users
- Limits flexibility of object interface
- Vectoring object needs to be trusted
- Adds additional gate jumps to the path

# Virtual copy memory for stability

- Cost of virtual copy for each change in object
- Doesn't provide synchronization with sub-objects

# Entry + exit counts

- Object increments a counter on entry and another on exit
- Viewers repeat their methods until both counters are unchanged
- Viewers not assured of termination
- Good from a wall banging point of view
- Transient invalid states cause viewers to trap