Advanced concurrent programming in Java
Shared objects

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To see(m) or not to see(m)...

There is more to synchronization than just atomicity or critical sessions.

Memory visibility... Updates by one thread to a shared objects state must be visible to the others.

Without proper synchronization, reordering can mess up the view.

- Stale data: out-of-date value

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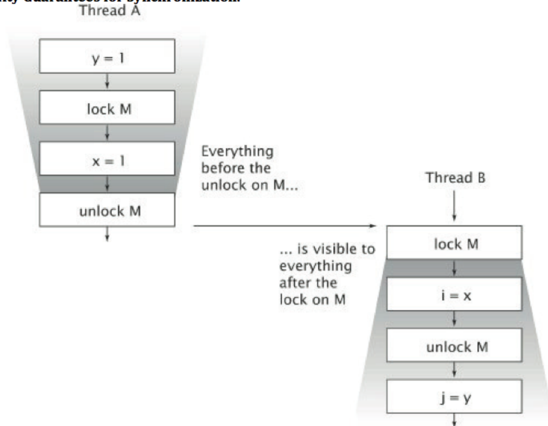
Figure 3.1. Visibility Guarantees for Synchronization.



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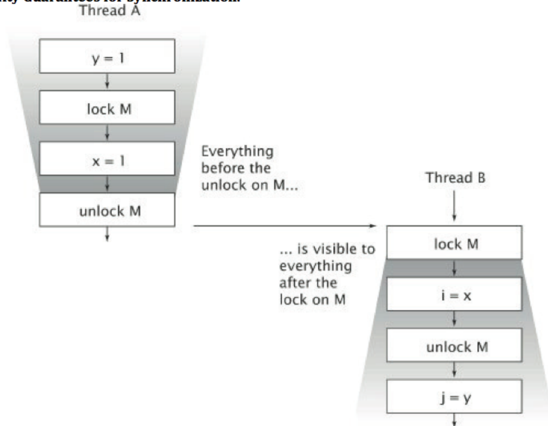

...acts like a barrier.

`volatile`

- Weaker form of synch.
- To compiler and runtime: "Do not reorder with other memory ops!"
- "...a read of a volatile variable always returns the most recent write by any thread."
- No locking → lighter than `synchronized`
- Does not guarantee atomicity!

Use only when:

- writes don't depend on the current value or only a single thread ever updates.
- the variable does not participate in invariants with other state vars.
- locking is not required for any other reason

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Definitions

Making an object available out of its current scope is called **publishing** it. Examples of publication:

- `public`
- any objects referred to as non-private fields of a published object
- an object passed to an *alien method* i.e. a method whose behavior is not fully specified by the respective object (includes its overrideable methods as well).

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Escape under construction/Safe construction

An object is in a consistent state only after its constructor returns. Publication before that is hazardous.

Some examples that would lead `this` reference to escape:

- starting a thread in the constructor
- calling an overrideable instance method in the constructor that is neither private nor final

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To share or not to share... - No publication

When an object is confined to a thread, safety is guaranteed. Even if the object itself is not thread-safe. Programmer is responsible to ensure that the confined objects do not escape from the thread.

- Ad-hoc - no language feature is used. Often used for implementing a single-threaded subsystem.
- Stack - confine objects as local variables
- `ThreadLocal` - every thread gets its own value-holding object, not shared with others.

No mutable, no cry

State cannot be changed after construction = **immutable**
Always thread-safe. No worries about publishing.
Two more conditions for an object to be immutable:

- all fields are `final`
- properly constructed (no escape under construction)

Safe vs. improper publication

- A publication is **safe** when the published object is correctly visible at publication time - regards initialization of the object.
- Both the reference of the object and the object's state must be published at the same time.
- Even if the object itself is thread-safe, if the reference to it is published without sufficient synch., this will cause visibility problems thus, **improper** publication.
- JavaMemory Model guarantees *initialization safety* for immutables.

How to publish a properly constructed object

Properly constructed - no escape in constructor
Some safe publication methods:

- Init the reference from a `static` initializer - safety guaranteed by JVM
- Store a reference into a `volatile` field or `AtomicReference`
- Store a reference to it in a `final` field of another properly constructed object
- Store a reference to it in a field that is guarded by a lock

Sharing objects safely

Safe publication ensures only the visibility of the as-published state $\rightarrow$ synch. is necessary for every access to shared mutable objects.

"Rules of engagement": when publishing an object, document how it can be accessed-regarding mutability, synch. methods, etc.

Some common policies for sharing objects:

- Thread-confined: no thread interaction for the respective object
- Shared read-only: immutable and effectively immutable objects
- Shared thread-safe: object itself is responsible
- Guarded: can be accessed only with a specific lock held

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Exercise 1

```
//QUESTION 1: Is the class still immutable? If not, why?
//QUESTION 2: Assuming that we don't want to publish any fields of ThreeStooges,
//            is there an escape we should be worried about?
public final class ThreeStooges {
    private final Set<String> stooges;

    public ThreeStooges() {
        stooges = new HashSet<String>();
        stooges.add("Moe");
        stooges.add("Larry");
        stooges.add("Curly");
    }

    public ThreeStooges(String first, String second, String third, HashSet<String> set){
        set.add(first);
        set.add(second);
        set.add(third);
        this.stooges = set;
    }


    public boolean isStooge(String name) {
        return stooges.contains(name);
    }

}
```

Exercise 2

```
//QUESTION : Is it possible to make this class thread safe
//           using the immutable holder class scheme
//           used in section 3.4.2 in the book?
public final class HungryThreeStooges {
    private final String[] stooges = {"Moe", "Larry", "Curly"};
    private int numberOfSteaks=10;
    private int turn=0;
    static HungryThreeStooges instance = new HungryThreeStooges();
    public String feedStooge(){
        if (numberOfSteaks<1)
            return "Damn stooges ate everything!";
        else{
            String stooge = stooges[turn % stooges.length];
            turn++;
            numberOfSteaks--;
            return stooge;
        }
    }
}
```

Thanks for the attention!