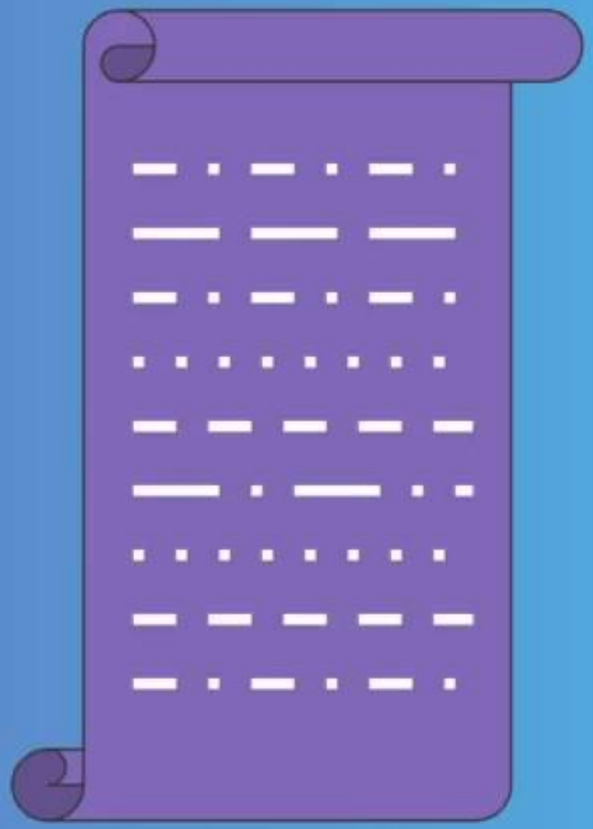
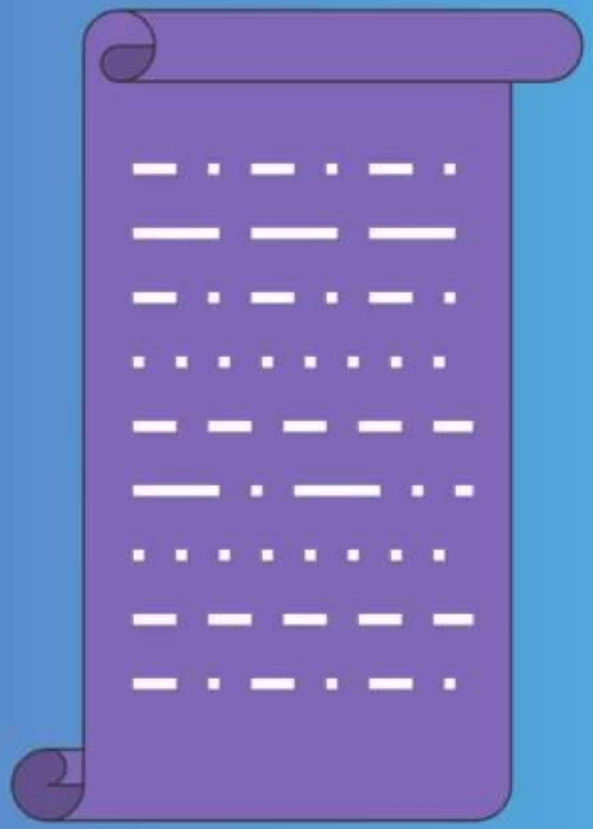
Java Memory Model



Java Memory Model



Out of order execution

Performance driven changes

done by

Compiler, JVM or CPU

Out of order execution

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```
a = 3;
b = 2;
a = a + 1;
```

Instructions

- → Load a
- → Set to 3
- → Store a

- → Load b
- → Set to 2
- → Store b

- → Load a
- → Set to 4
- → Store a

Consider this code

```
a = 3;
a = a + 1;

b = 2;
```

Instructions

- → Load a
- → Set to 3
- → Set to 4
- → Store a

- → Load b
- → Set to 2
- → Store b

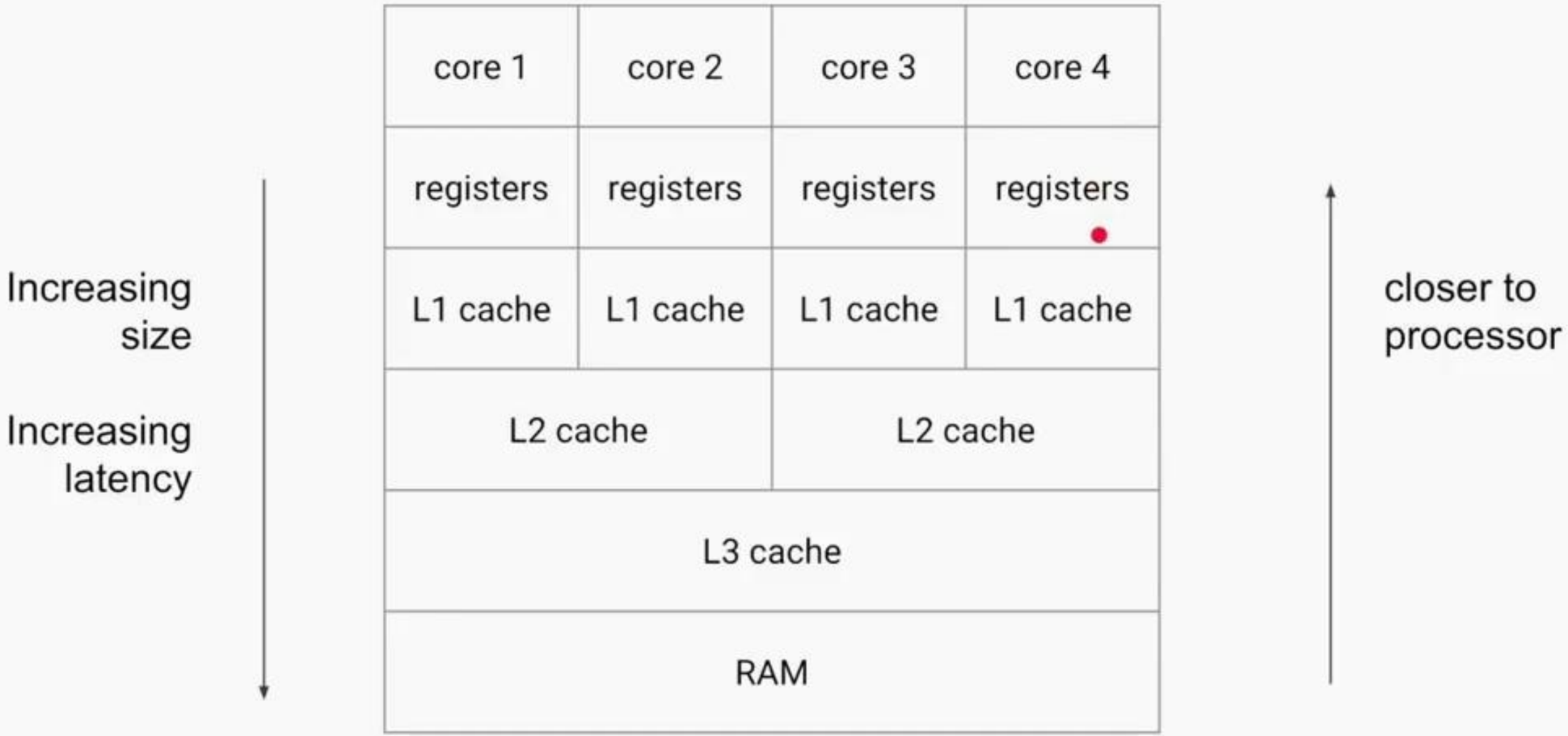
Reordered instructions

Field Visibility

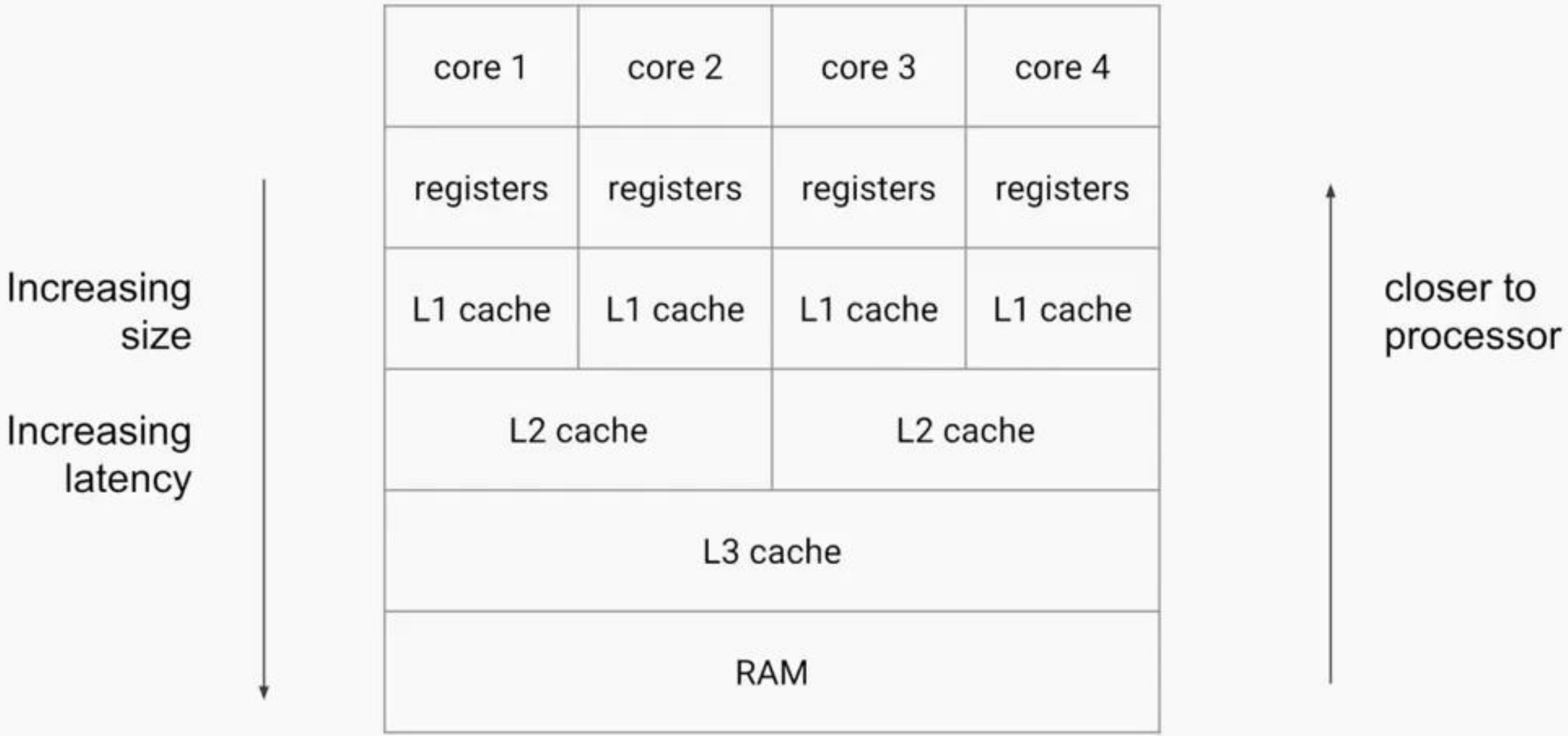
In presence of multiple threads

a.k.a

Concurrency



CPU caches (multi-core processor)



CPU caches (multi-core processor)

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public class FieldVisibility {

    int x = 0;

    public void writerThread() {
        x = 1;
    }

    public void readerThread() {
        int r2 = x;
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}
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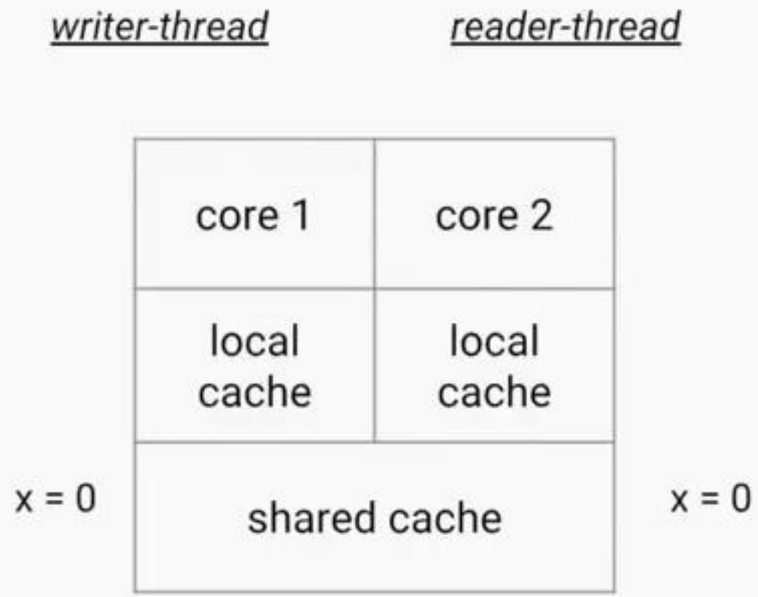

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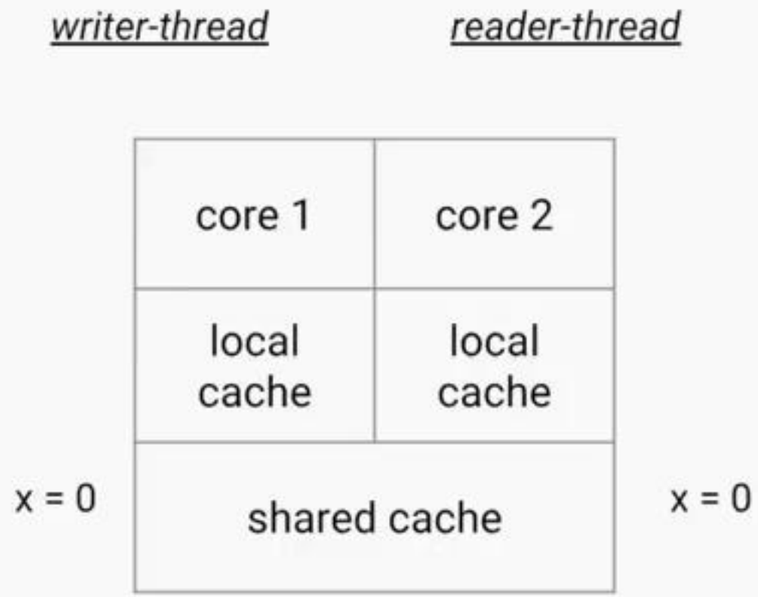

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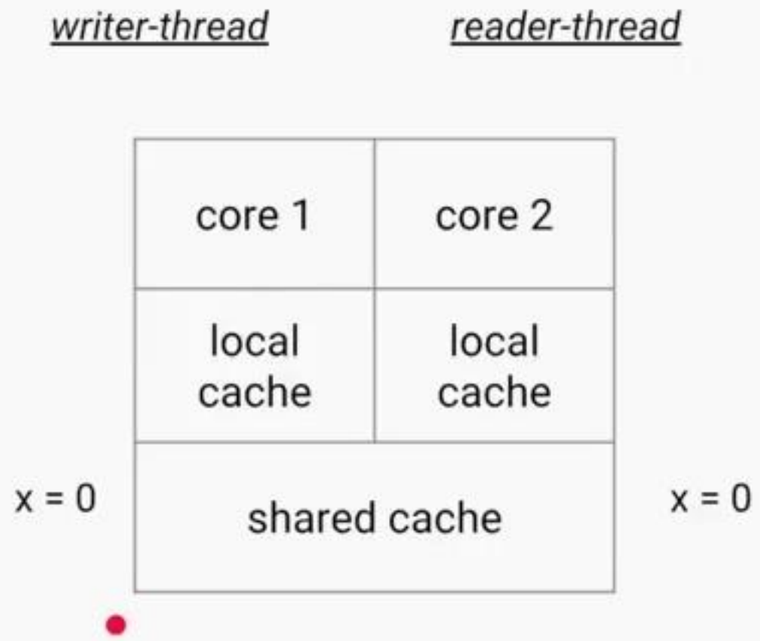

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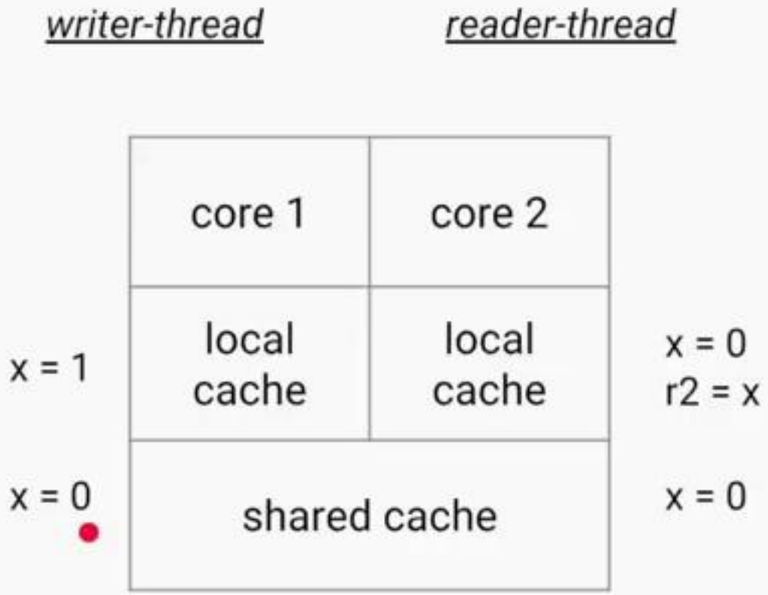

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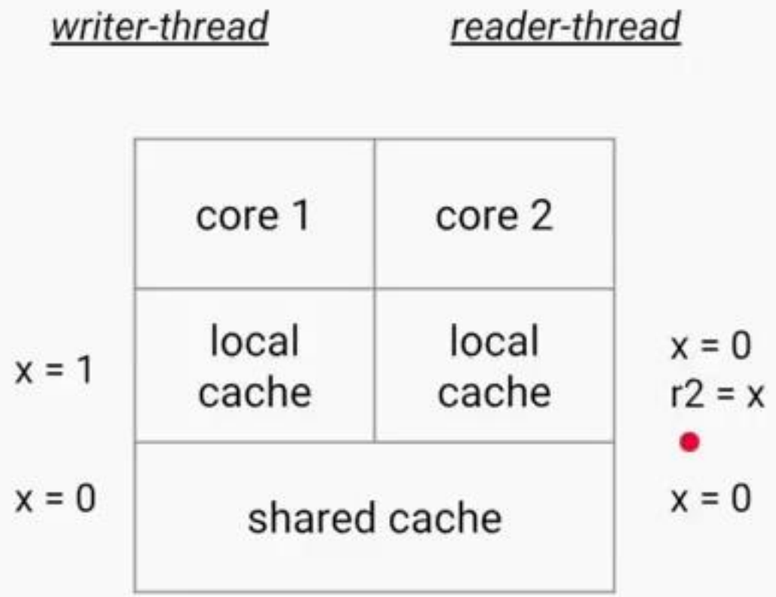
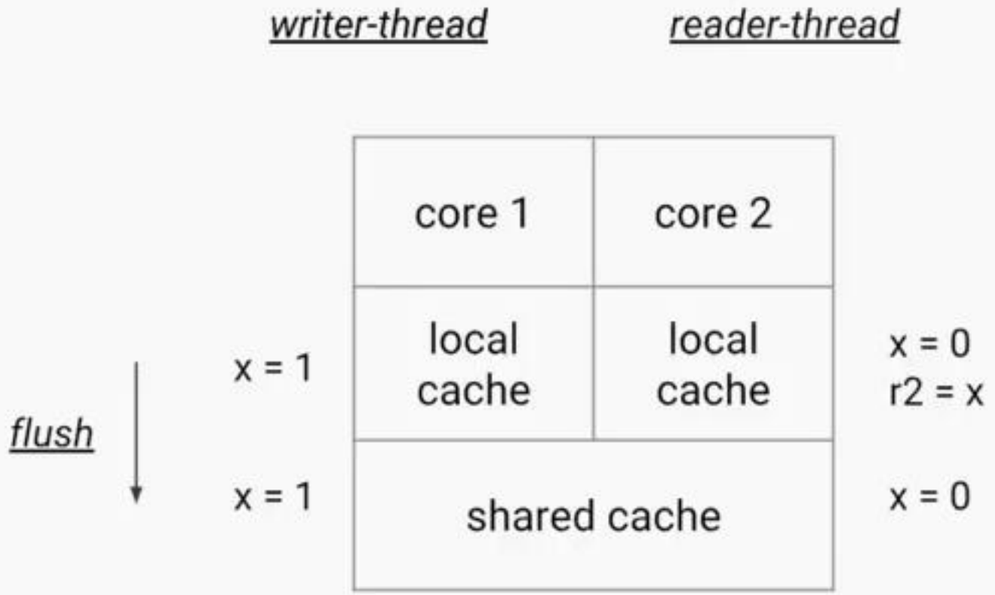


```java
public class VolatileVisibility {

    volatile int x = 0;

    public void writerThread() {
        x = 1;
    }

    public void readerThread() {
        int r2 = x;
    }
}
```



Field visibility sample with volatile

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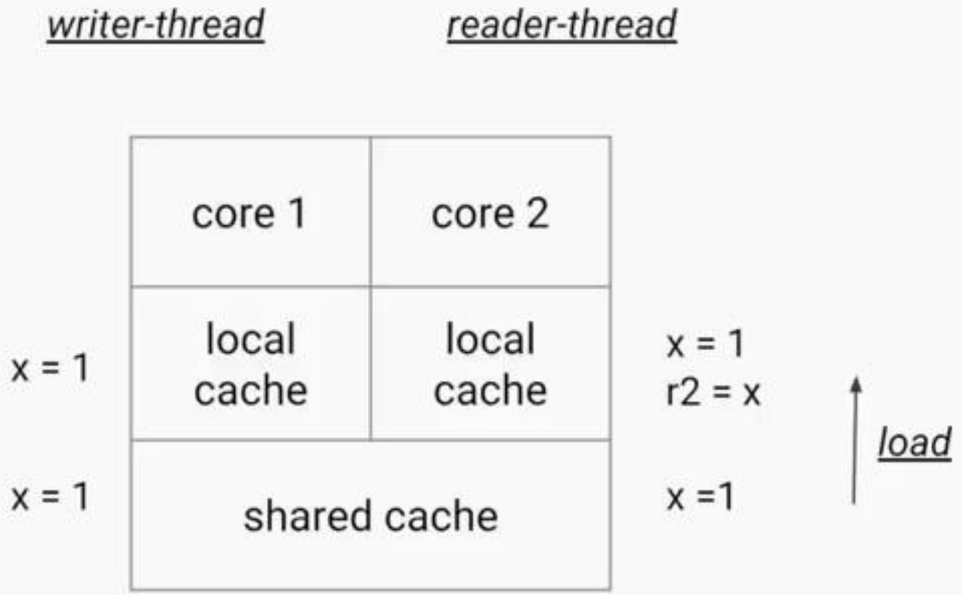

Field visibility sample with volatile

What is Java Memory Model?

JMM is a specification which guarantees visibility of fields (aka happens before) amidst reordering of instructions.

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```java
public class VolatileFieldsVisibility {

    int a = 0, b = 0, c = 0;
    volatile int x = 0;

    public void writerThread() {

        a = 1;
        b = 1;
        c = 1;

        x = 1;  // write of x
    }

    public void readerThread() {

        int r2 = x;   // read of x

        int d1 = a;
        int d2 = b;
        int d3 = c;
    }
}
```

“Happens-before” relationship for volatile

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    int a = 0, b = 0, c = 0;
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```

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        int d2 = b;
        int d3 = c;
    }
}
```

"Happens-before" relationship for volatile

Not only volatile

Also

1. Synchronized
2. Locks
3. Concurrent collections
4. Thread operations (join,start)

final fields (special behavior)

```java
public class SynchronizedFieldsVisibility {

    int a = 0, b = 0, c = 0;
    volatile int x = 0;

    public void writerThread() {
        a = 1;
        b = 1;
        c = 1;

        synchronized (this) {
            x = 1;
        }
    }

    public void readerThread() {

        synchronized (this) {
            int r2 = x;
        }

        int d1 = a;
        int d2 = b;
        int d3 = c;
    }
}
```

Same behavior with synchronized blocks. V.Imp: Has to be synchronized on same object!!

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    int a = 0, b = 0, c = 0;
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        synchronized (this) {
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        }
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            int r2 = x;
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            int d2 = b;
            int d3 = c;
        }
    }
}
```

Better to be more clear though!

```java
public class LockVisibility {

    int a = 0, b = 0, c = 0, x = 0;
    Lock lock = new ReentrantLock();

    public void writerThread() {

        lock.lock();
        a = 1;
        b = 1;
        c = 1;
        x = 1;
        lock.unlock();
    }

    public void readerThread() {

        lock.lock();
        int r2 = x;
        int d1 = a;
        int d2 = b;
        int d3 = c;
        lock.unlock();
    }
}
```

Same behavior with Locks.

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        x = 1;
        lock.unlock();
    }

    public void readerThread() {

        lock.lock();
        int r2 = x;
        int d1 = a;
        int d2 = b;
        int d3 = c;
        lock.unlock();
    }
}
```

```java
public class VolatileVisibility {

    boolean flag = true;

    public void writerThread() {
        flag = false;
    }

    public void readerThread() {
        while (flag) {
            // do some operations
        }
    }
}
```

wrong

```java
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    volatile boolean flag = true;

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right

Code on the left can have reader thread keep running. Fixed with volatile flag.

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