Fiji Priority Rollback Protocol

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Communication between mixed-criticality partitions

Situational Awareness

Flight System

Communication between mixed-criticality partitions

Situational Awareness

Middleware

Flight System

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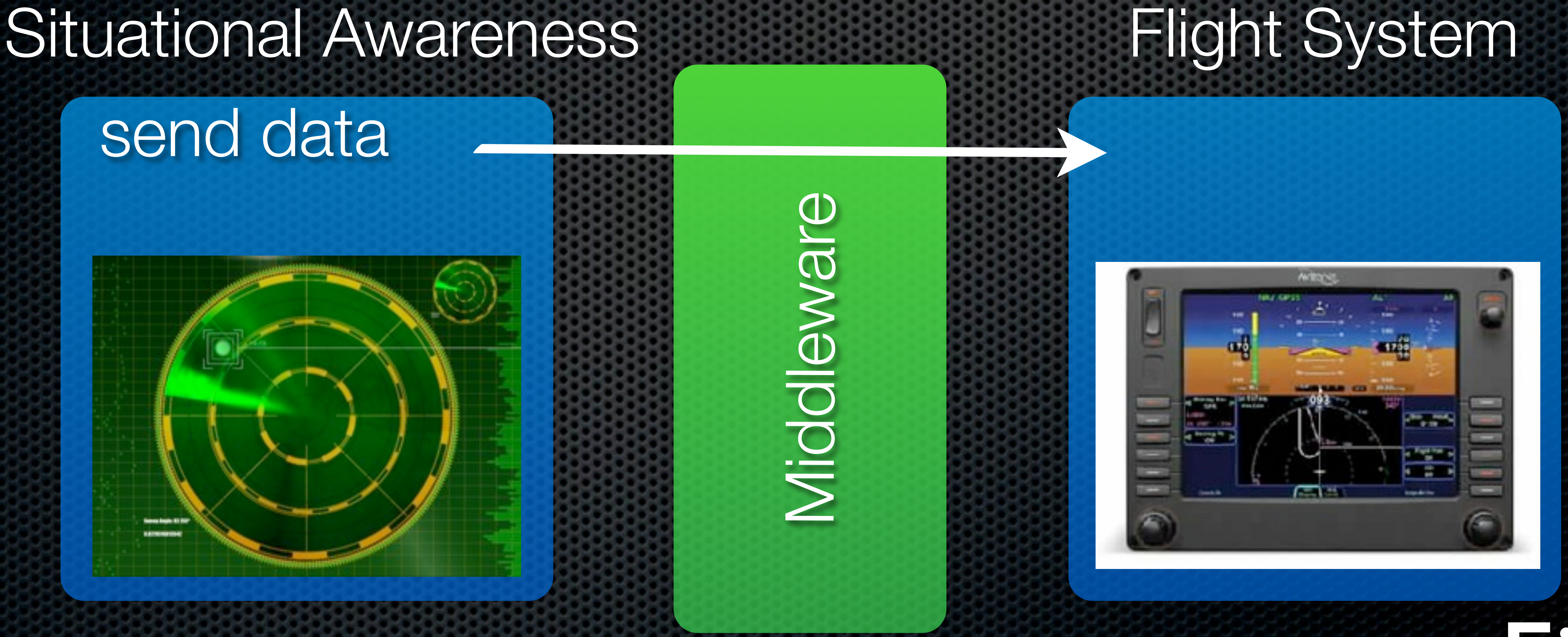
Communication between mixed-criticality partitions

Situational Awareness package data

Middleware

Flight System

Communication between mixed-criticality partitions



Situational Awareness

send data

Middleware

Flight System

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Communication between mixed-criticality partitions

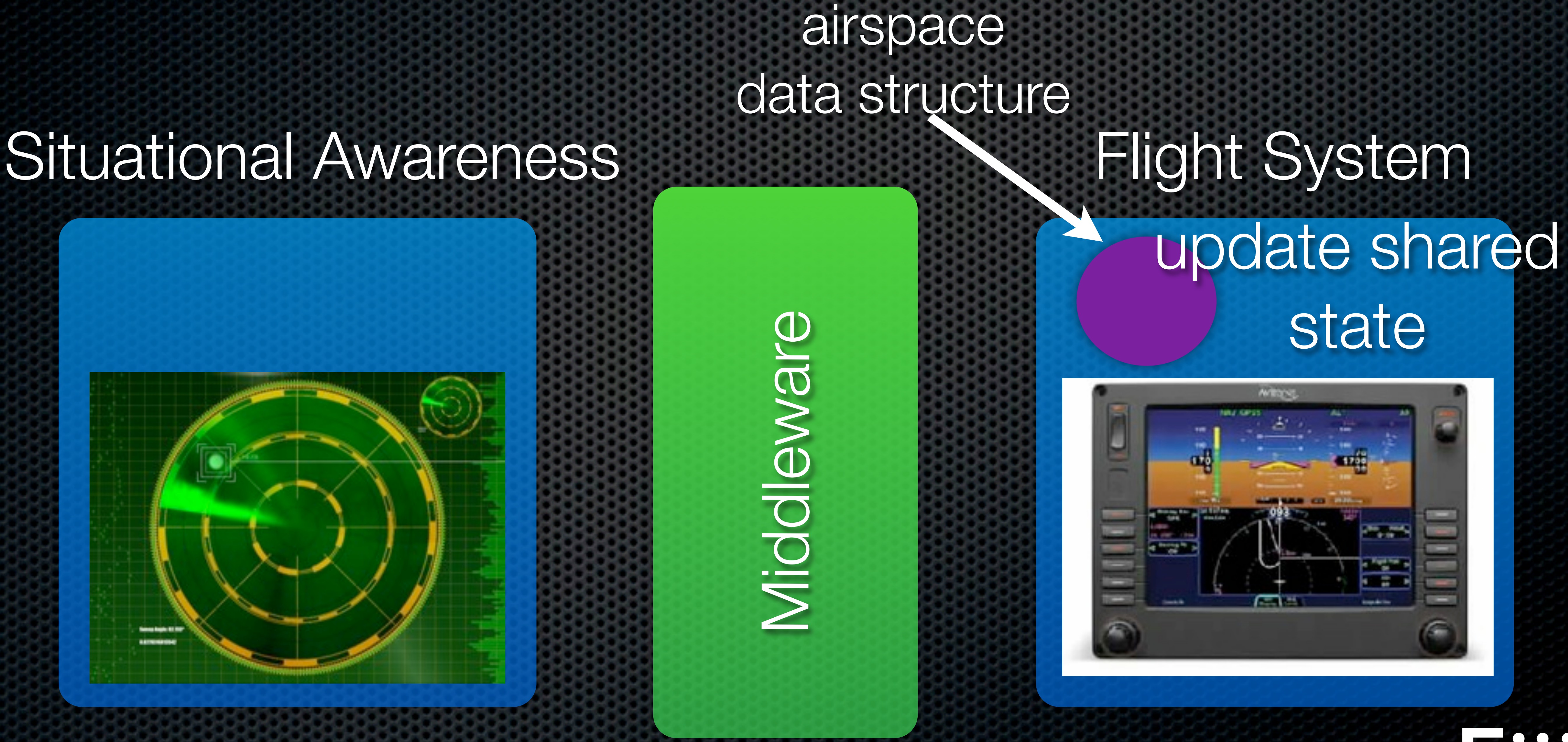
Situational Awareness

Middleware

Flight System

unpack data

Communication between mixed-criticality partitions



airspace
data structure

Situational Awareness

Middleware

Flight System

update shared
state

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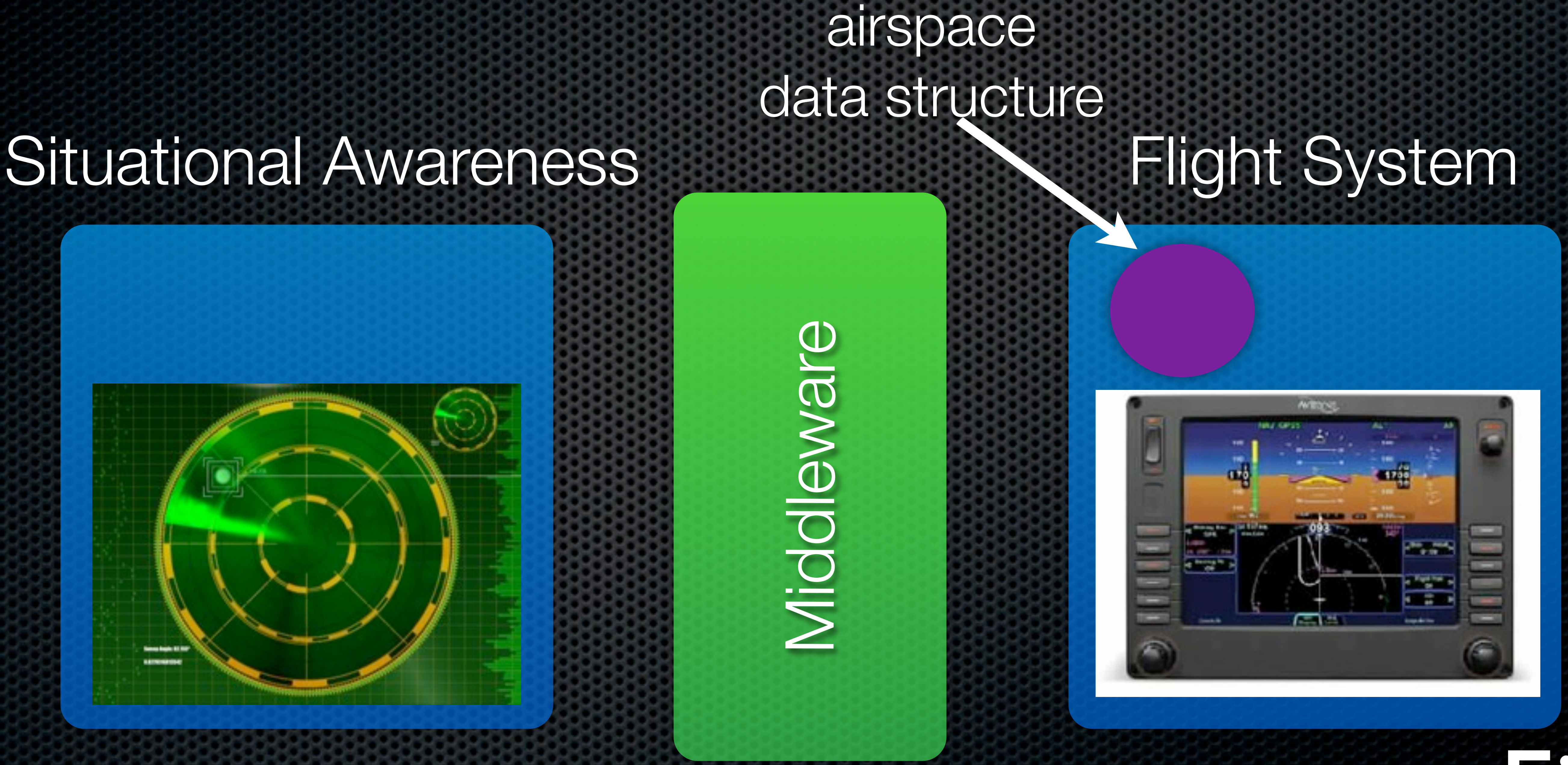
Communication between mixed-criticality partitions



airspace
data structure

Situational Awareness

Middleware

Flight System

typically a communication protocol

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Communication between mixed-criticality partitions

Situational Awareness

Flight System

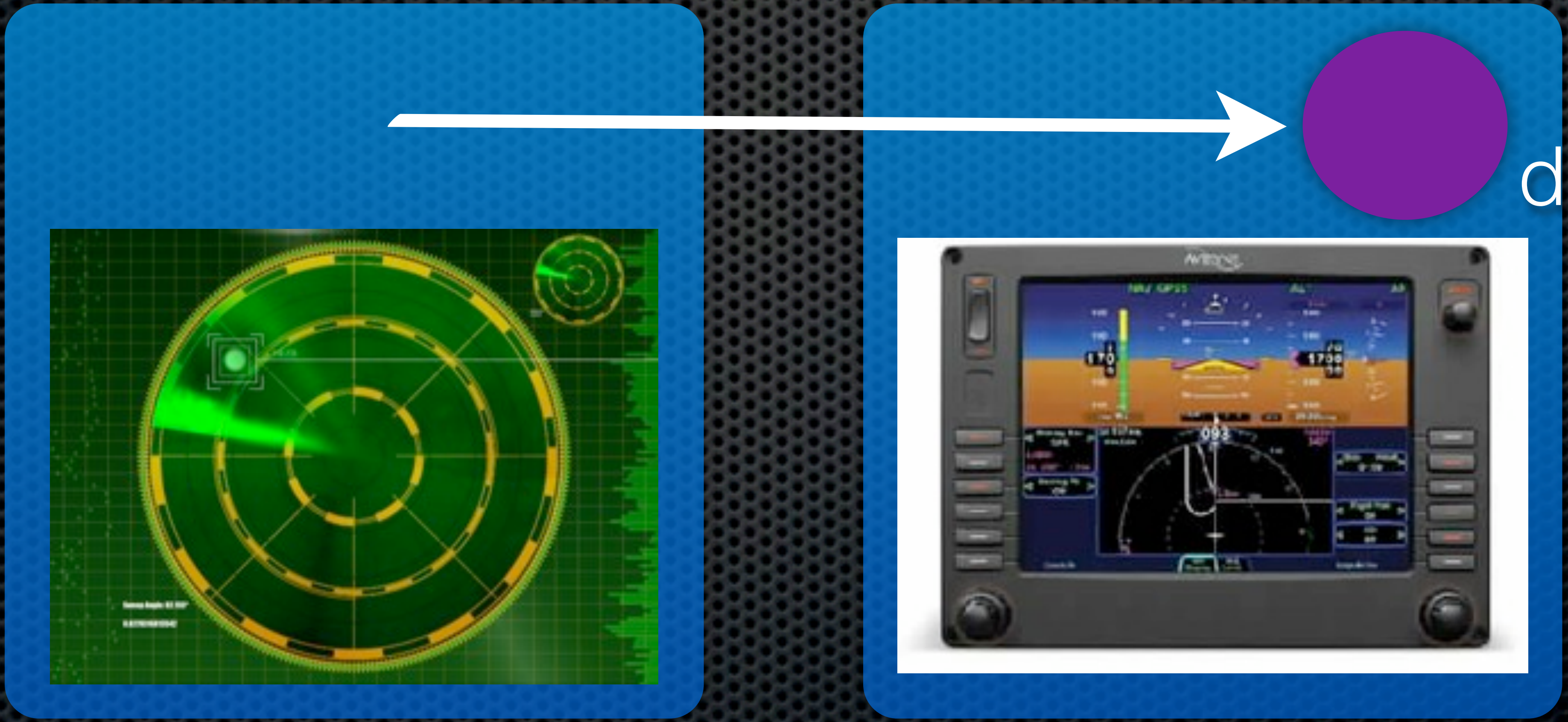
airspace data structure

Communication between mixed-criticality partitions

can we allow direct access?

Situational Awareness

Flight System



airspace data structure

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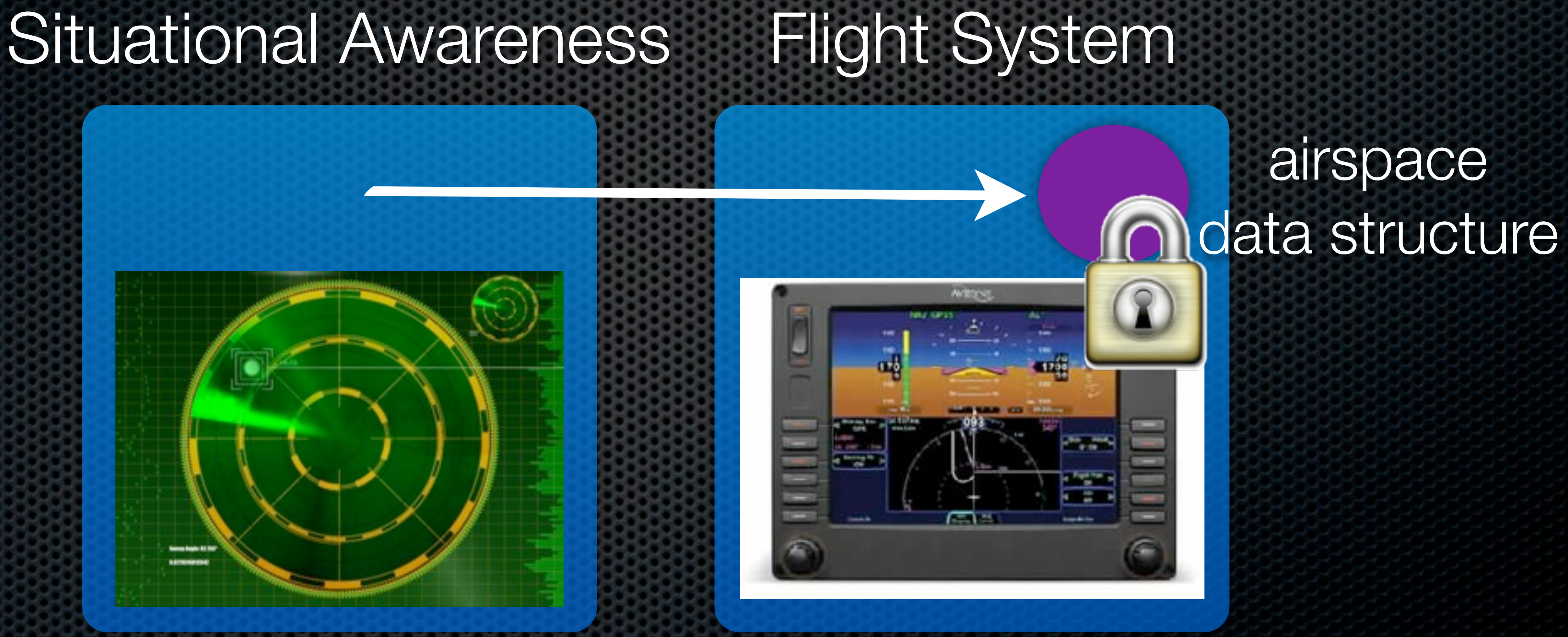
Communication between mixed-criticality partitions

mediate access via a lock



Situational Awareness

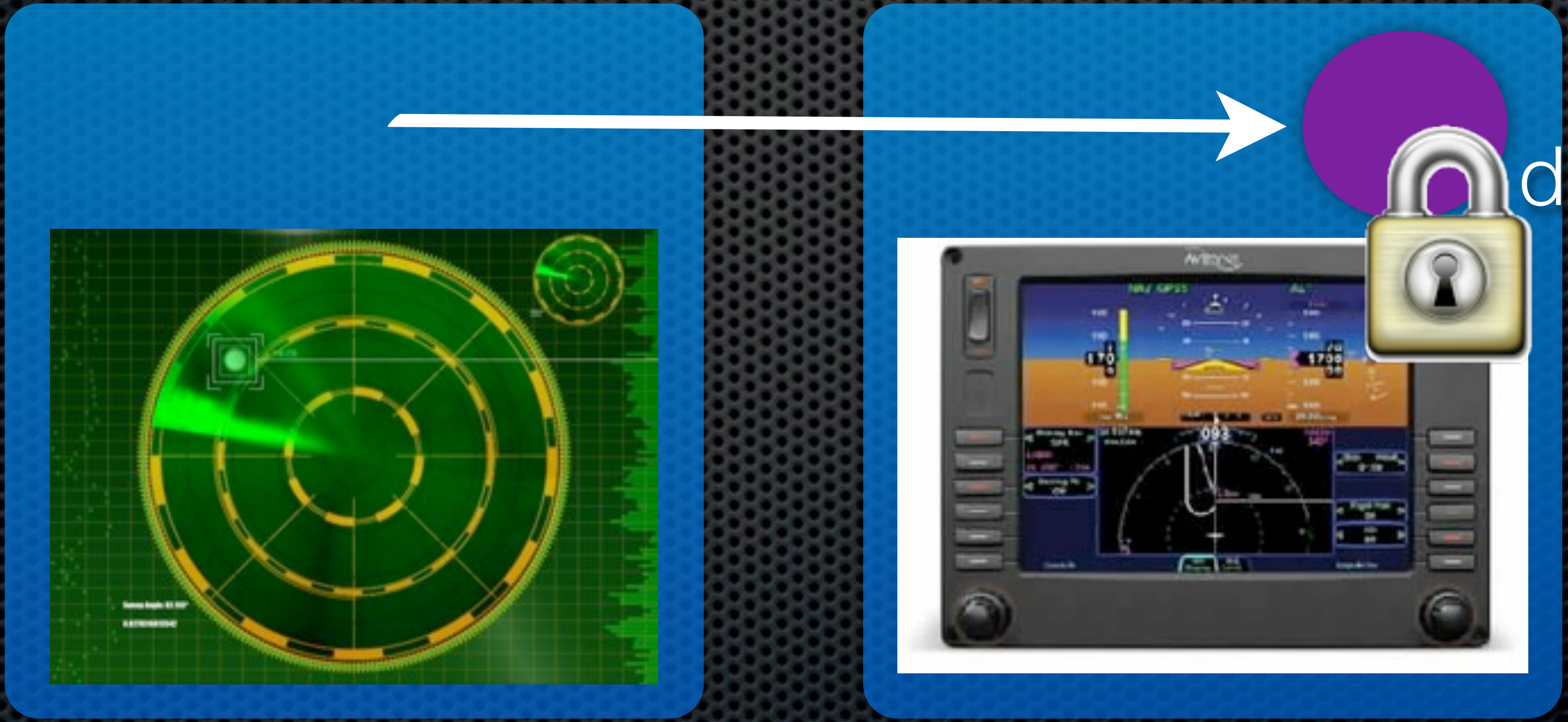
Flight System

airspace data structure

Communication between mixed-criticality partitions

Situational Awareness

Flight System



airspace data structure

how do we guarantee responsiveness of higher criticality partitions?

Communication between mixed-criticality partitions

Situational Awareness

Flight System

airspace data structure

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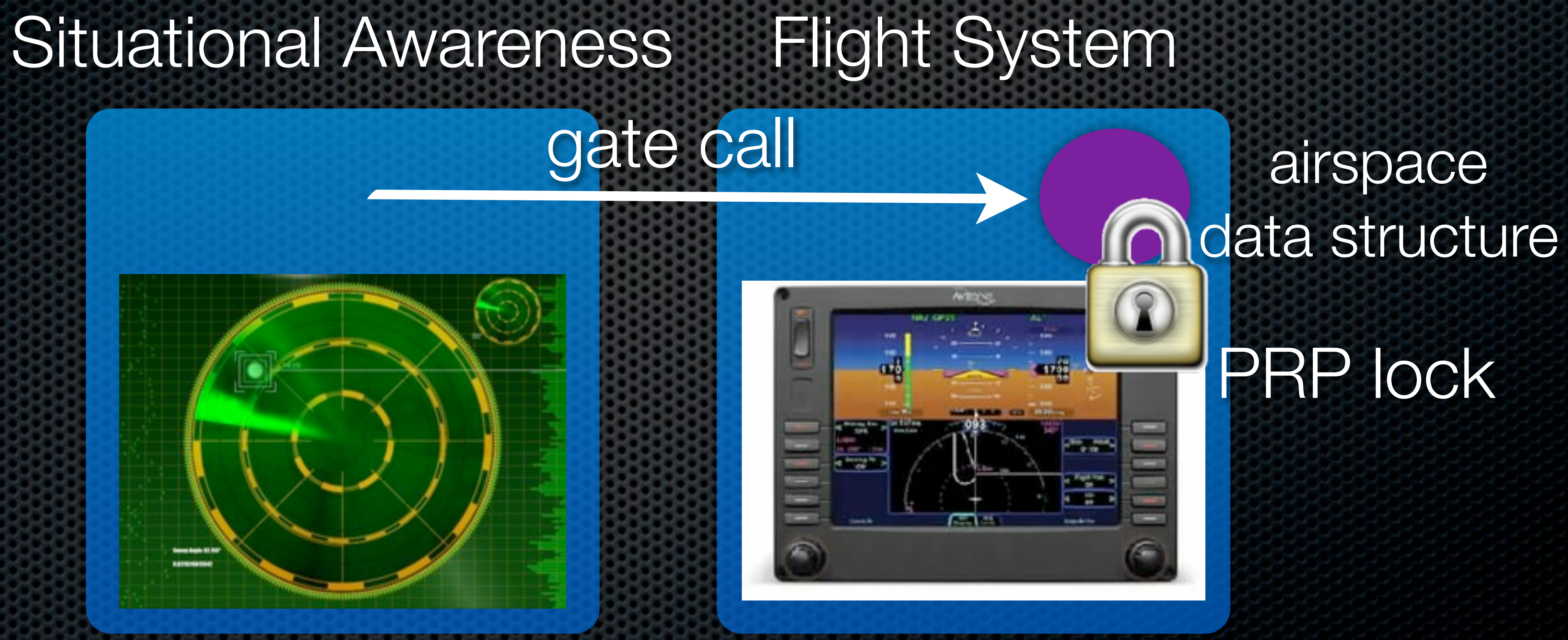
Communication between mixed-criticality partitions



Situational Awareness

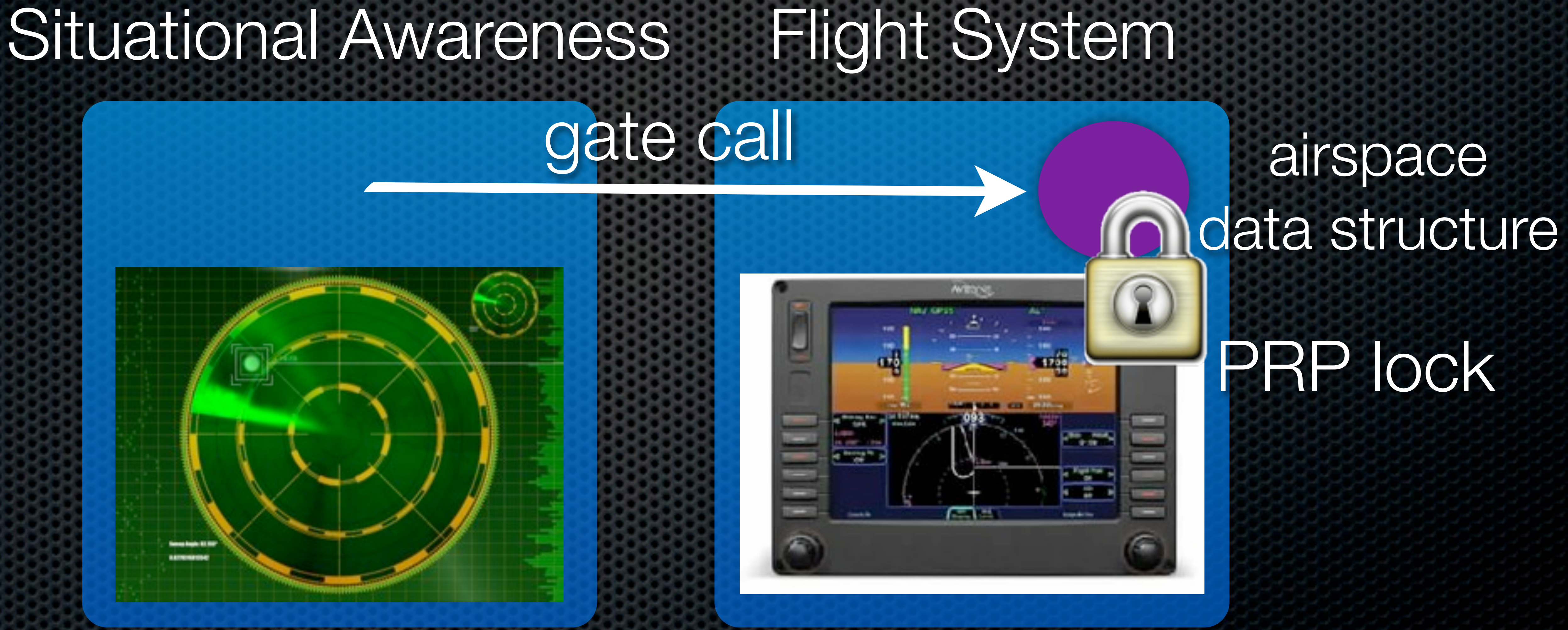
Flight System

gate call

airspace data structure

PRP lock

Communication between mixed-criticality partitions



Situational Awareness

Flight System

gate call

airspace data structure

PRP lock

PRP allows for priority aware, criticality aware, safe, reliable, shared memory between partitions

PRP Locks

- Flight System’s partition is guaranteed fast
- Bound on preemption based on data structure size
- Situational awareness' partition access is slightly slower but is still bounded in time

Inspiration from Transactions

- Atomic replacement for locks
- Automatic serializability detection
- Runtime monitoring
- Aborts - ability to rollback

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Inspiration from Transactions

- Atomic rep✗cement for locks
- Automatic serializability detection
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New programming model

Inspiration from Transactions

- ~~Atomic replacement for locks~~
- ~~Automatic serializability detection~~
- Runtime monitoring
- Aborts - ability to rollback

New programming model

Unpredictable

Inspiration from Transactions

- Atomic replacement for locks ✗
- Automatic serializability detection ✗
- Runtime monitoring ✓
- Aborts - ability to rollback

New programming model

Unpredictable

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Inspiration from Transactions

- Atomic replacement for locks ✗
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- Aborts - ability to rollback ✓

New programming model

Unpredictable

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PRP: Two Options

- Write Buffering
  - All updates buffered : memory is always consistent
- Write Logging
  - Updates to shared memory : undo log allows reversion to consistent state of memory

Write Buffering

```
synchronized(lock){
    foo.a = x;
    foo.b = y;
    foo.c = z;
    foo.a = w;
    if(foo.b+4 > foo.a)
        ...
}
```

Write Buffering

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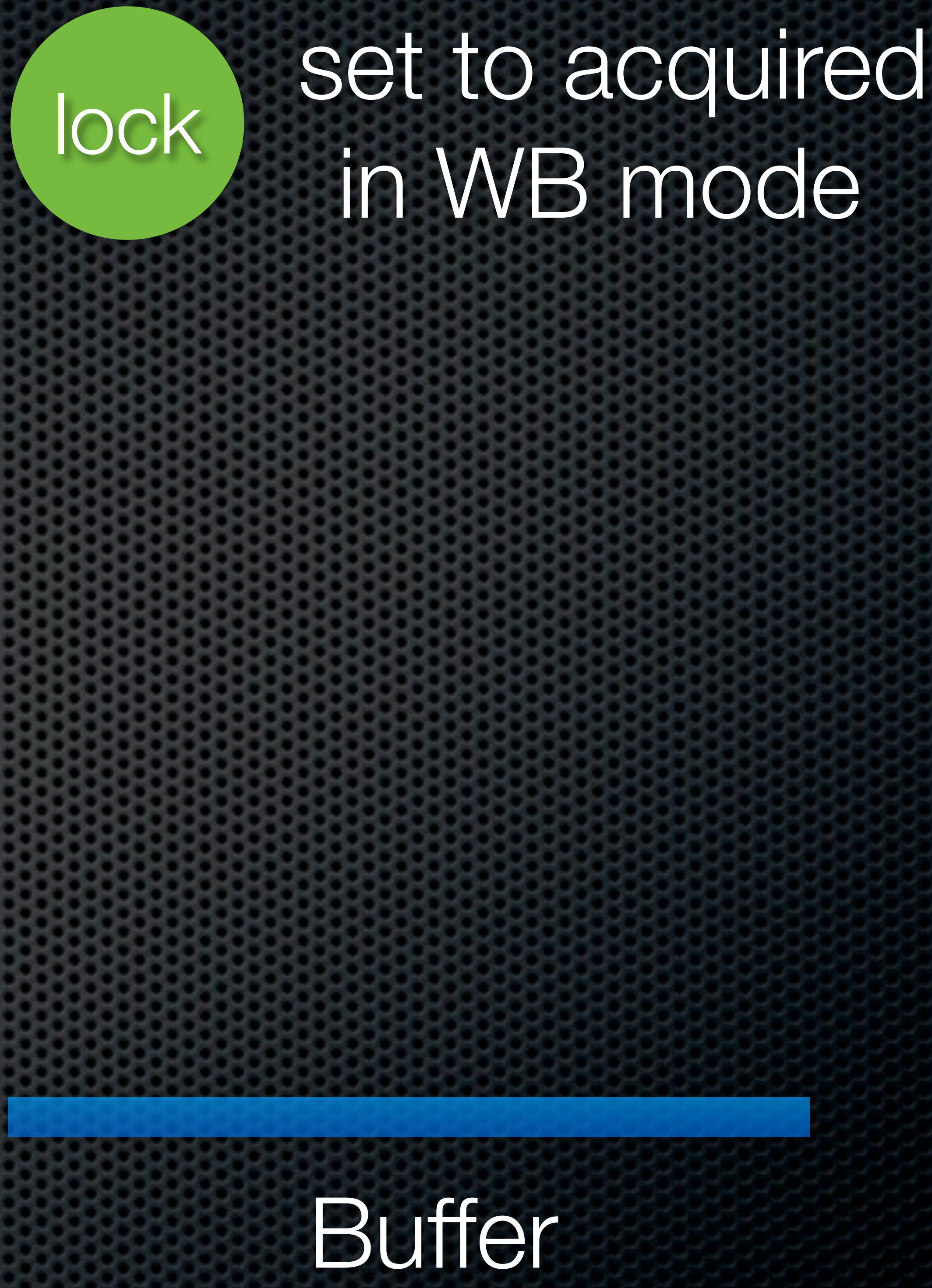

Write Buffering

lock

set to acquired
in WB mode

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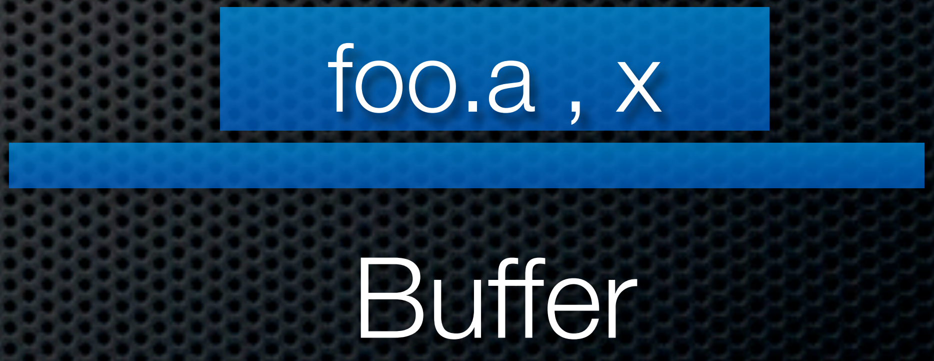

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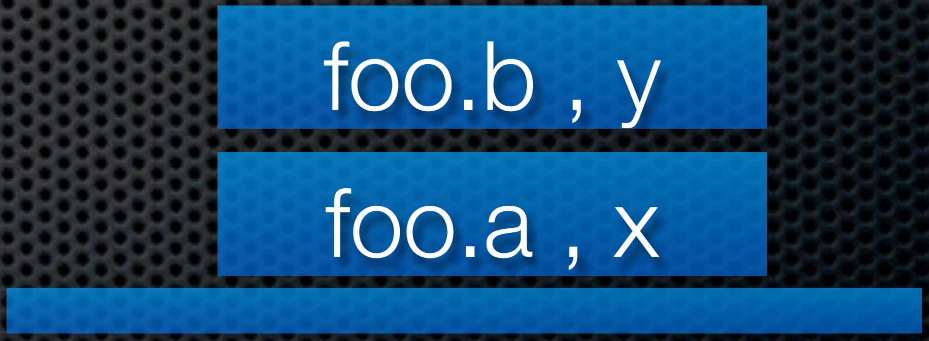

foo.b , y

foo.a , x

Buffer

Write Buffering

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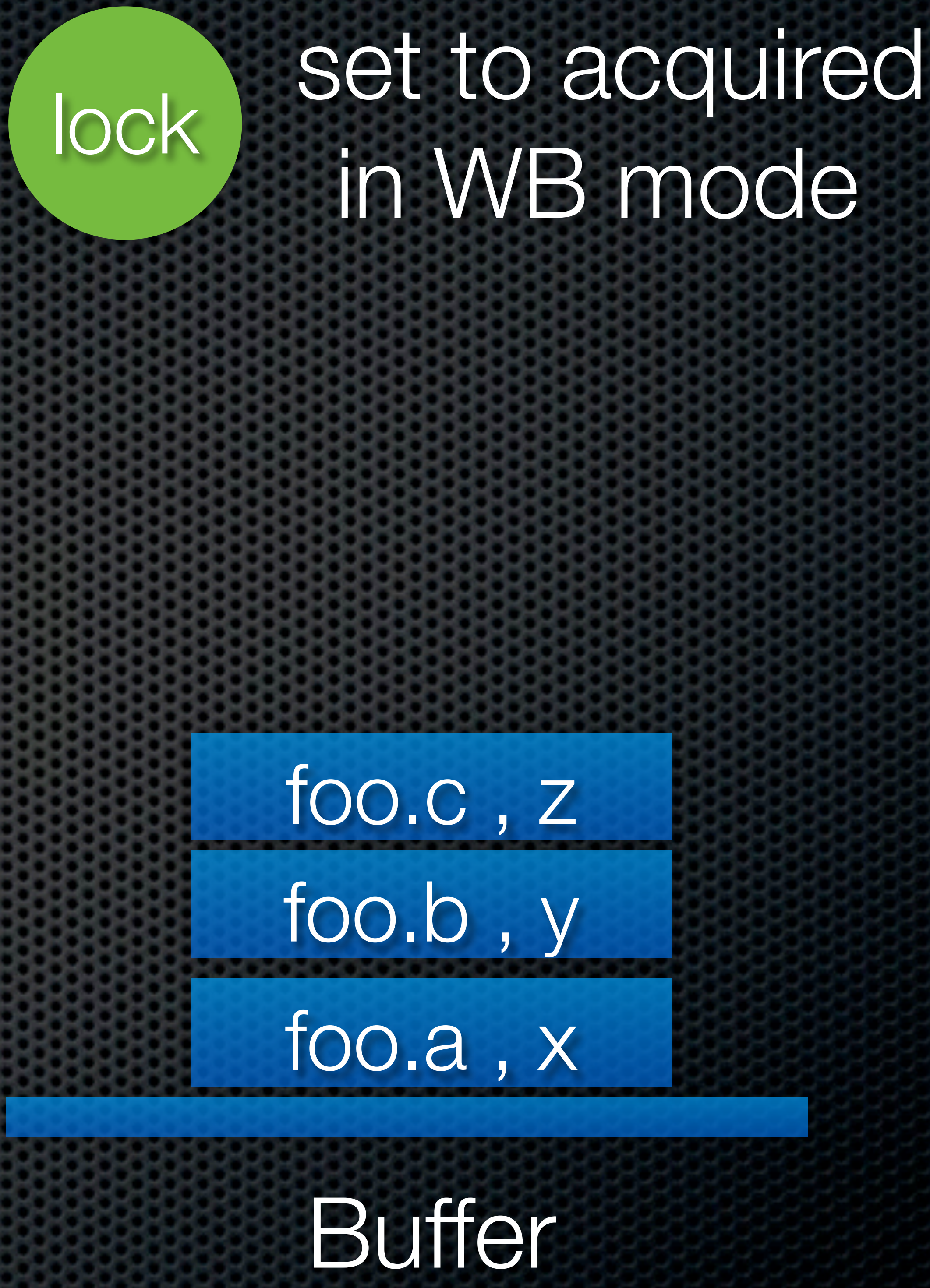

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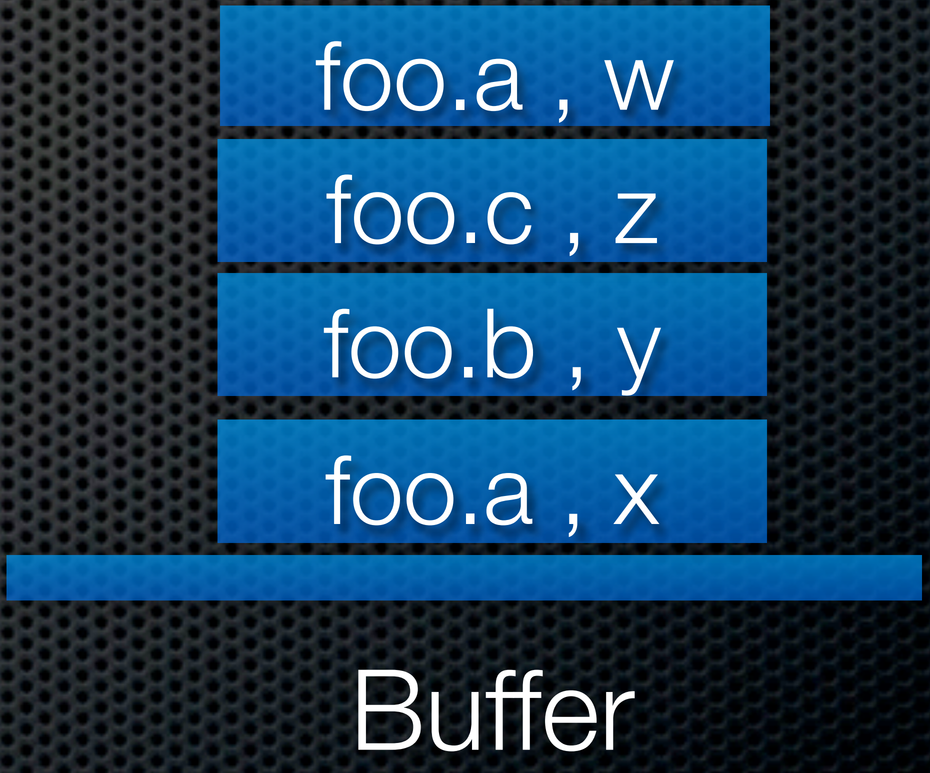

Write Buffering

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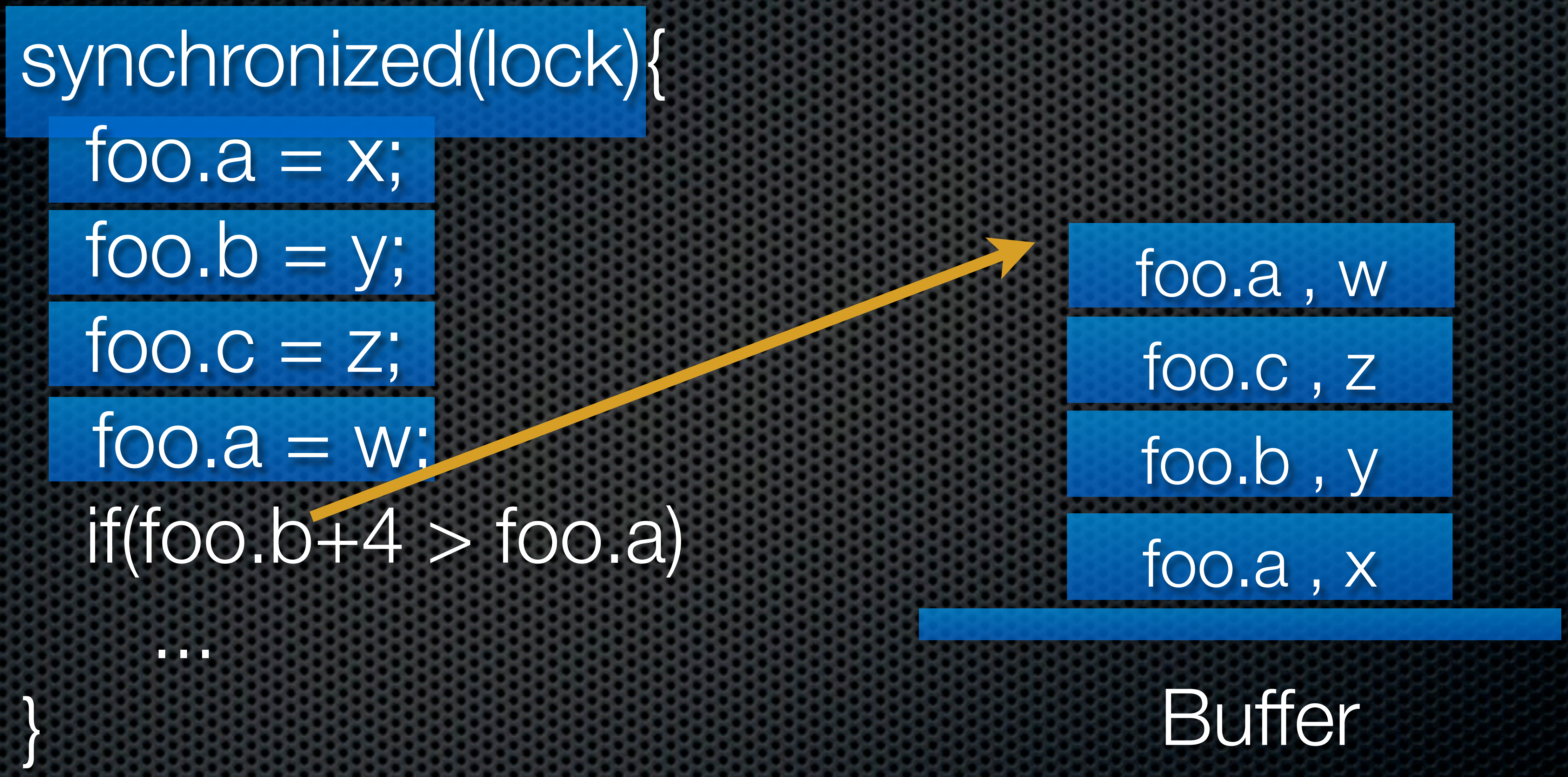

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}
```

foo.a , w
foo.c , z
foo.b , y
foo.a , x

Buffer

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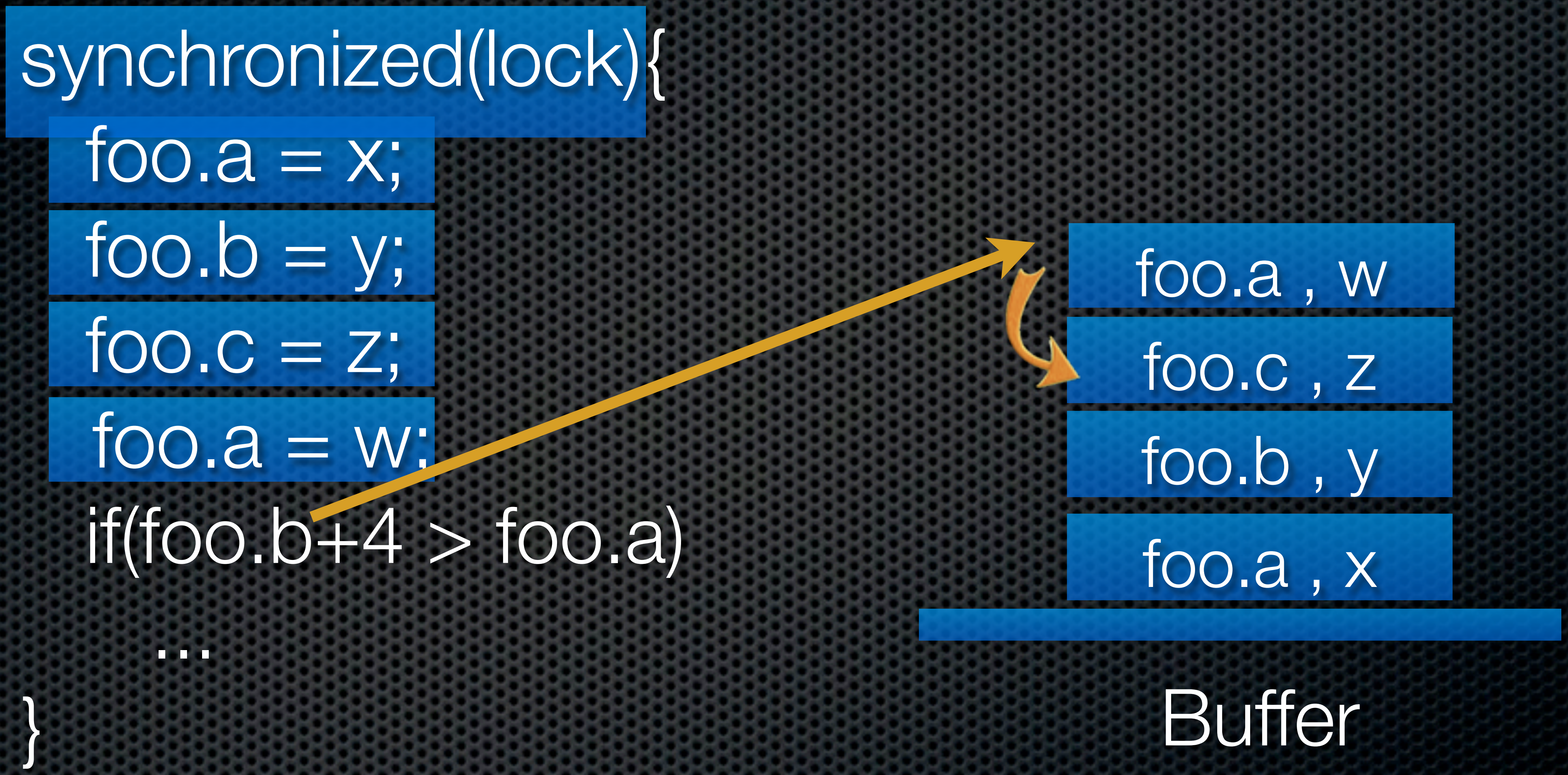
Write Buffering

lock

set to acquired
in WB mode



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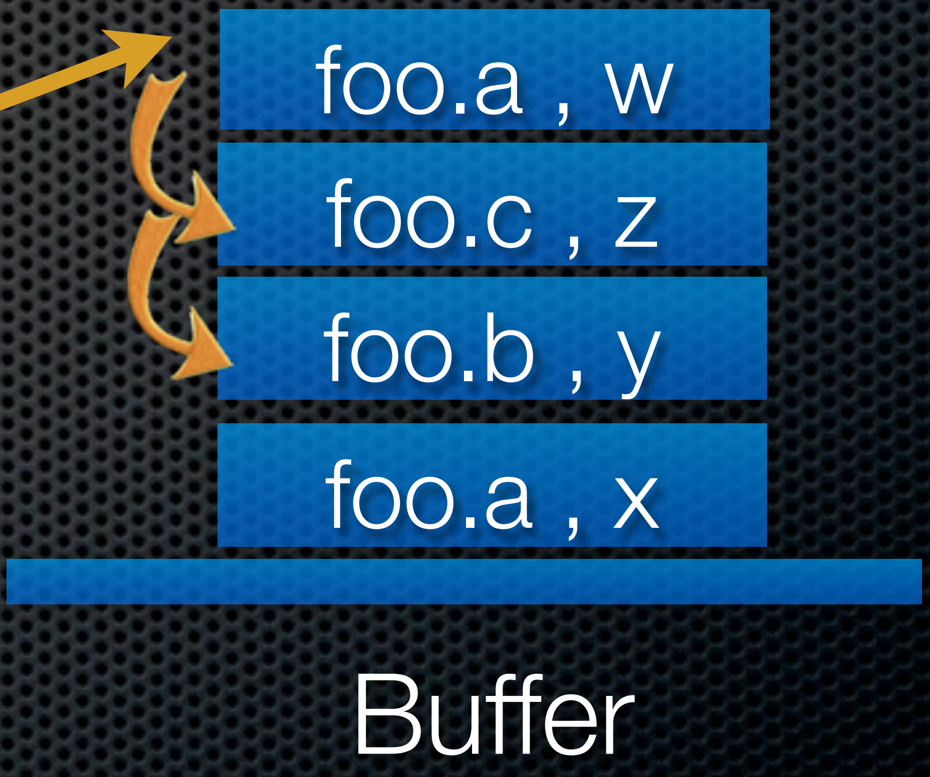

foo.a , w

foo.c , z

foo.b , y

foo.a , x

Buffer

Write Buffering

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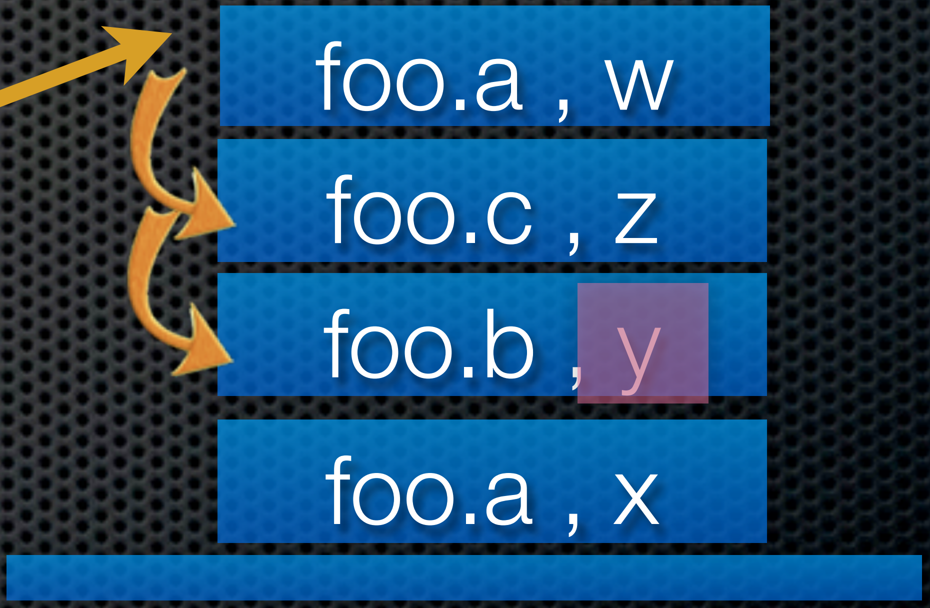

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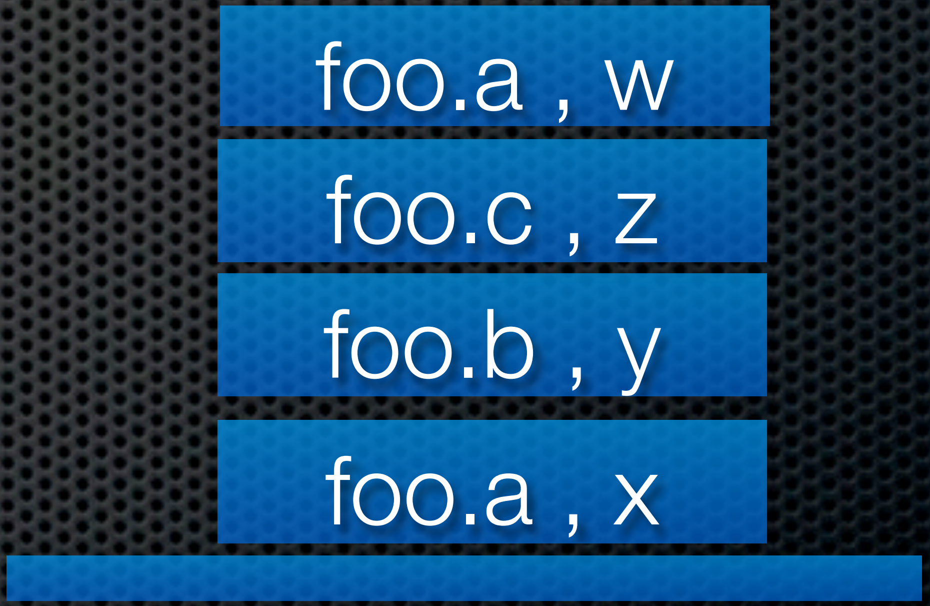

foo.a , w

foo.c , z

foo.b , y

foo.a , x

Buffer

Write Buffering

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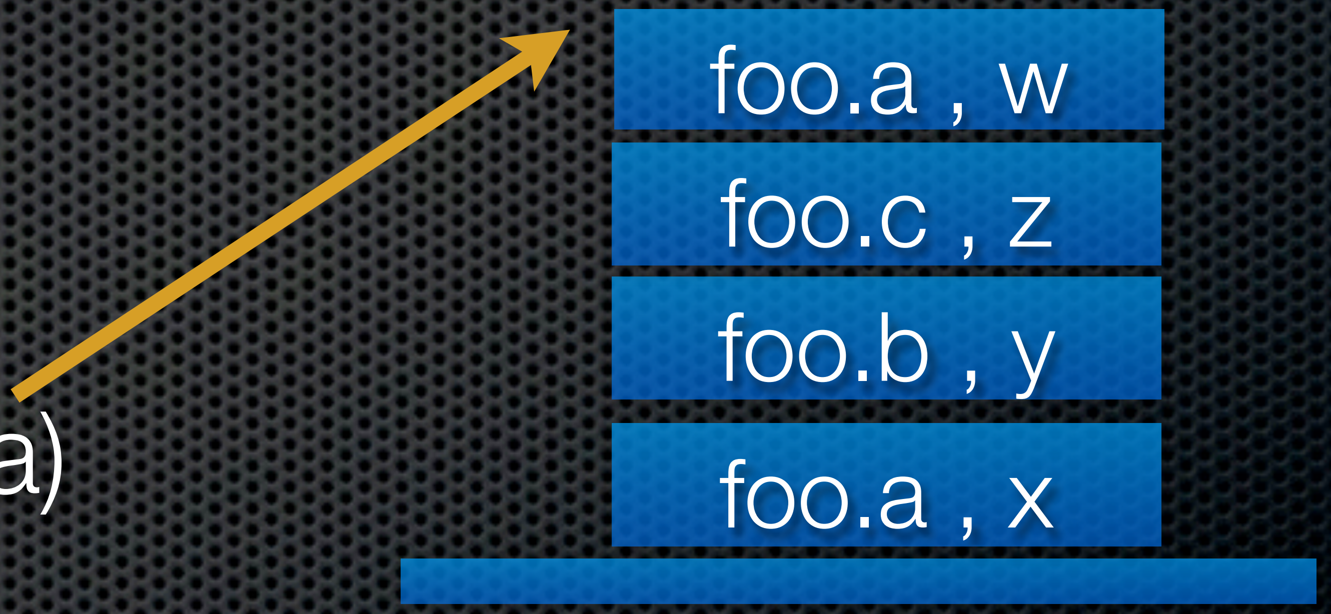

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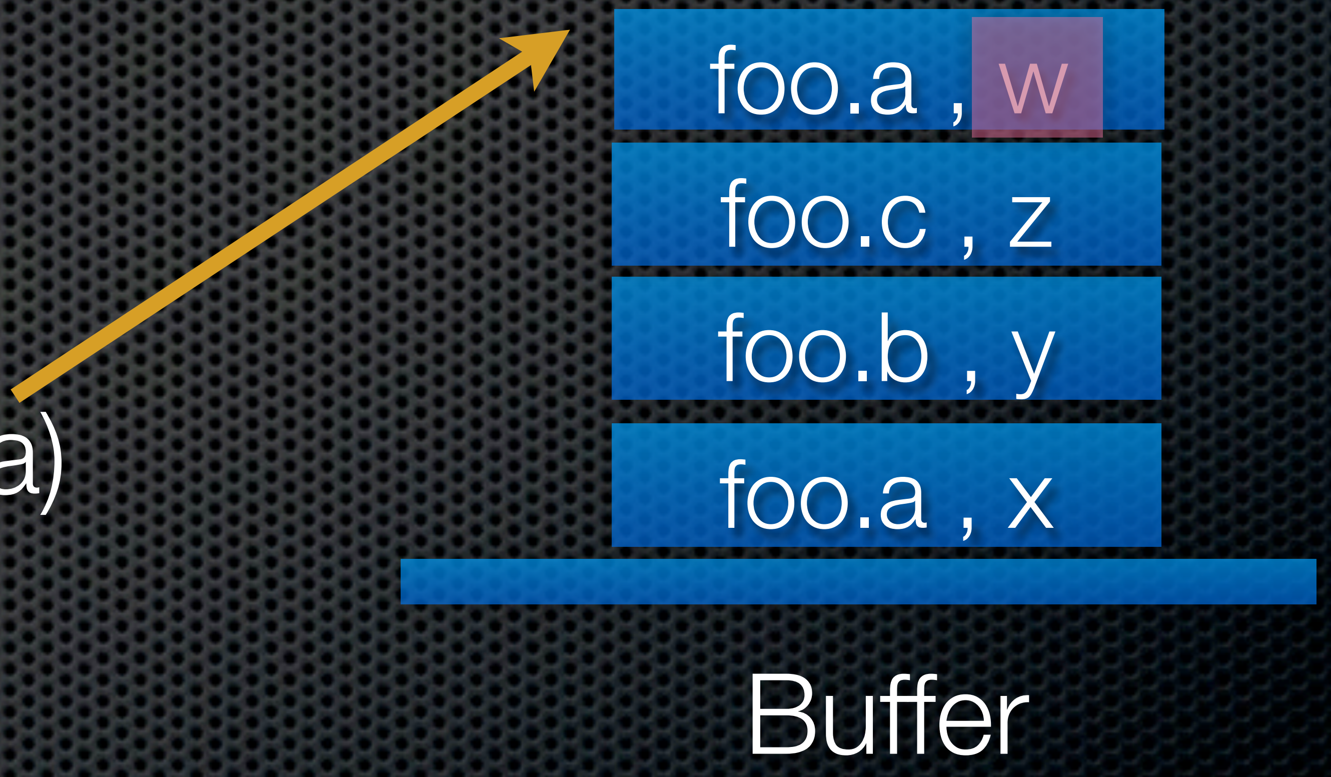

foo.a , w

foo.c , z

foo.b , y

foo.a , x

Buffer

Write Buffering

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set to acquired
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```

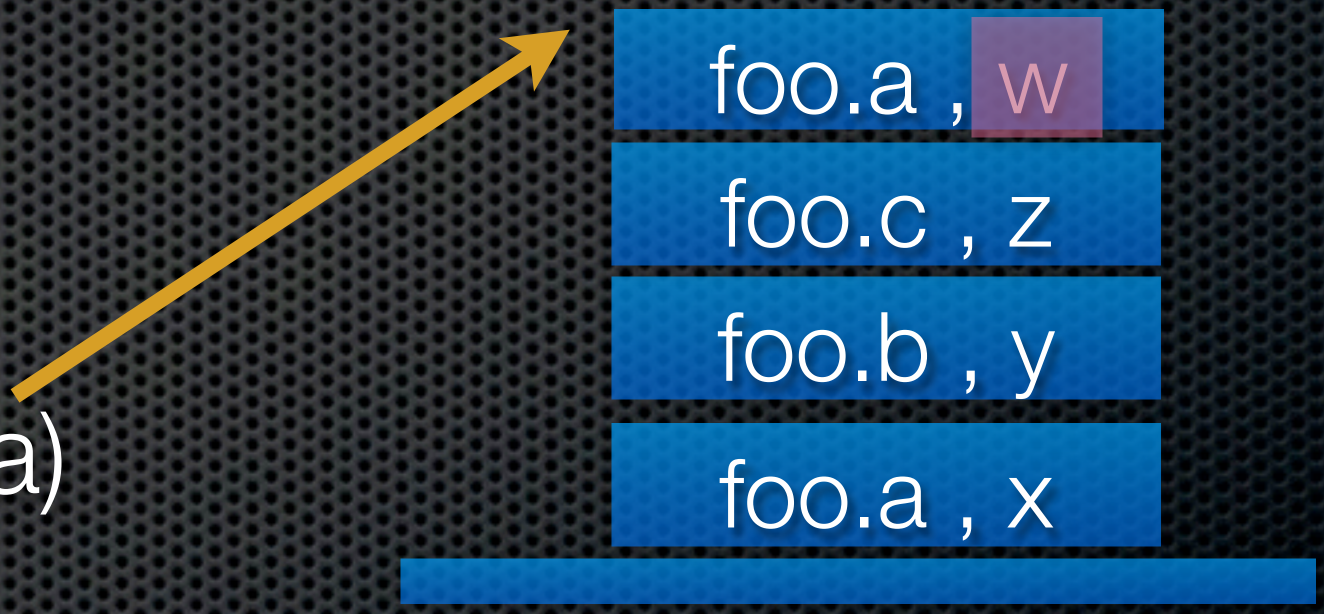

foo.a , w
foo.c , z
foo.b , y
foo.a , x

Buffer

Write Buffering

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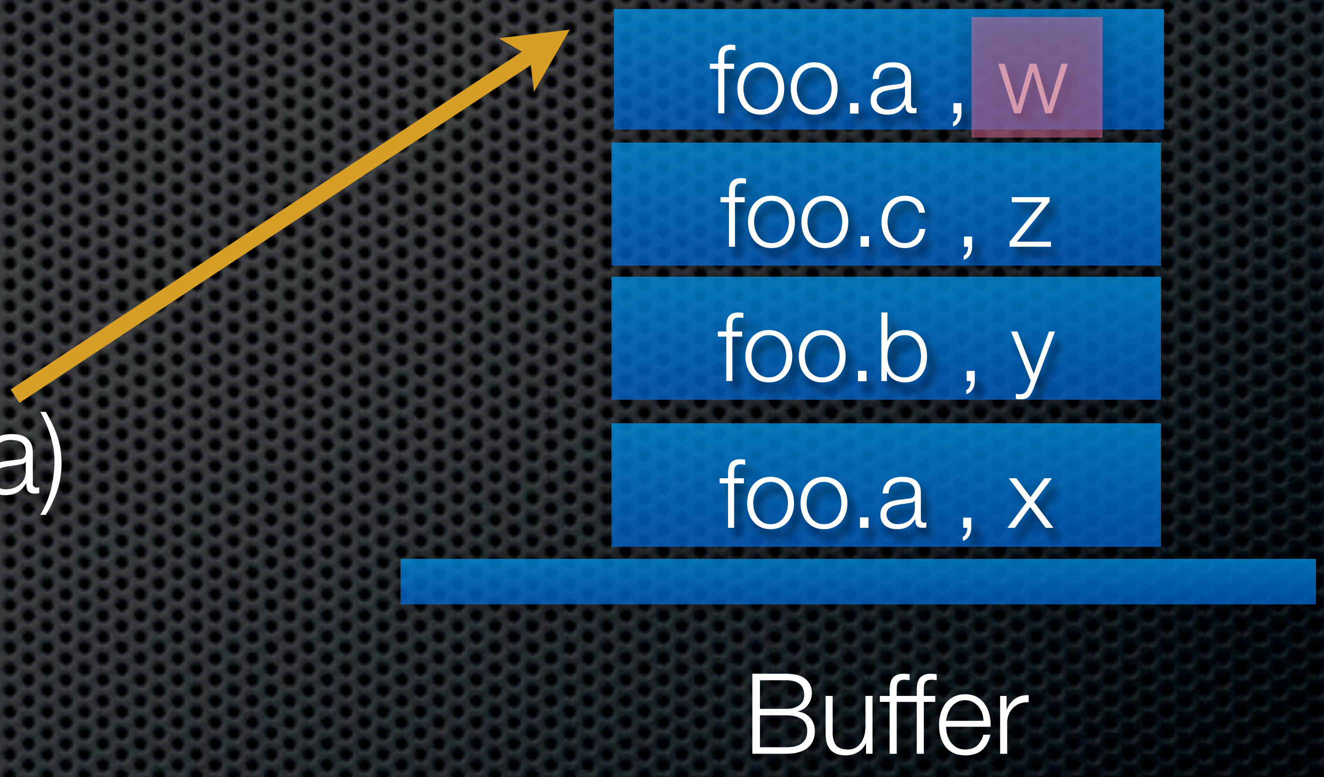
foo.a , w
foo.c , z
foo.b , y
foo.a , x
Buffer

Set lock mode to commit

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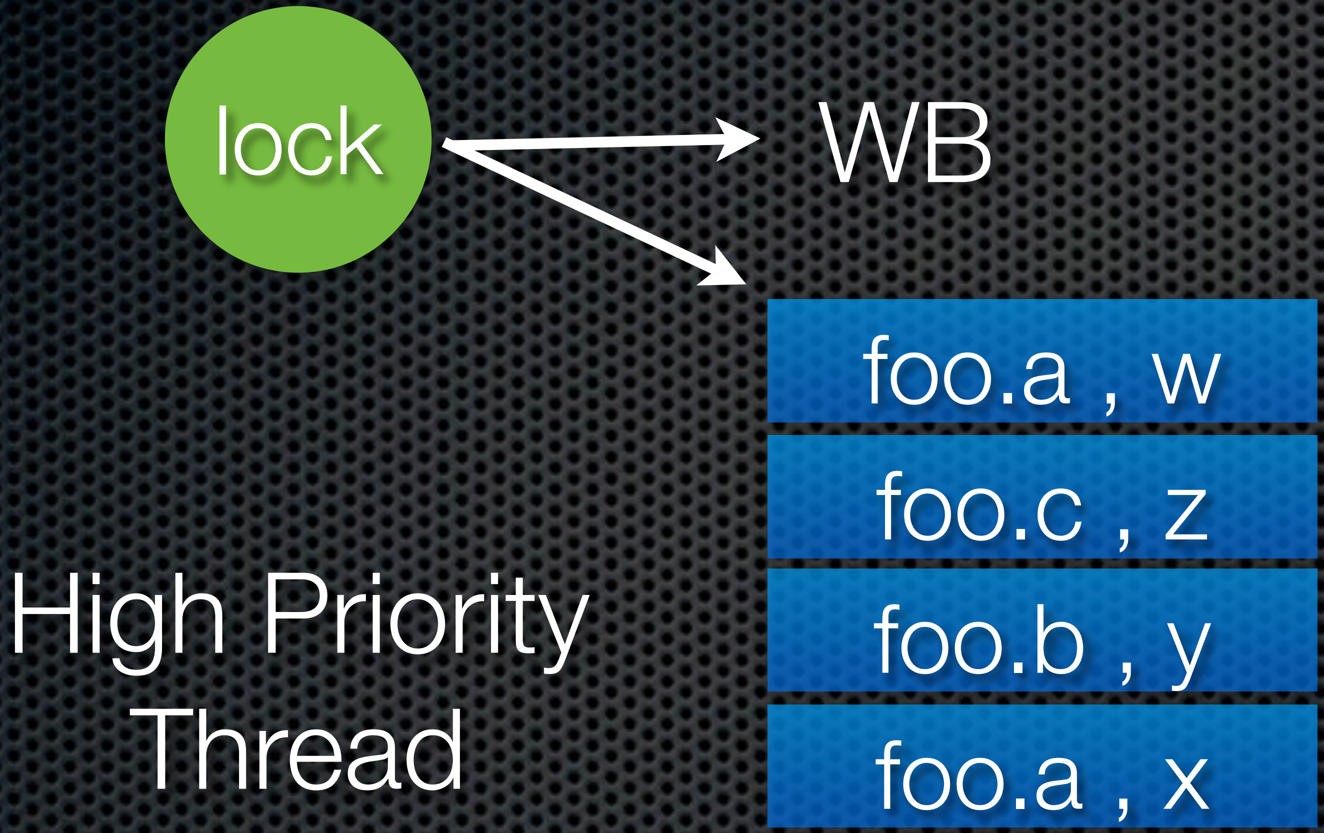
Acquisition by higher priority thread



lock

WB

foo.a , w

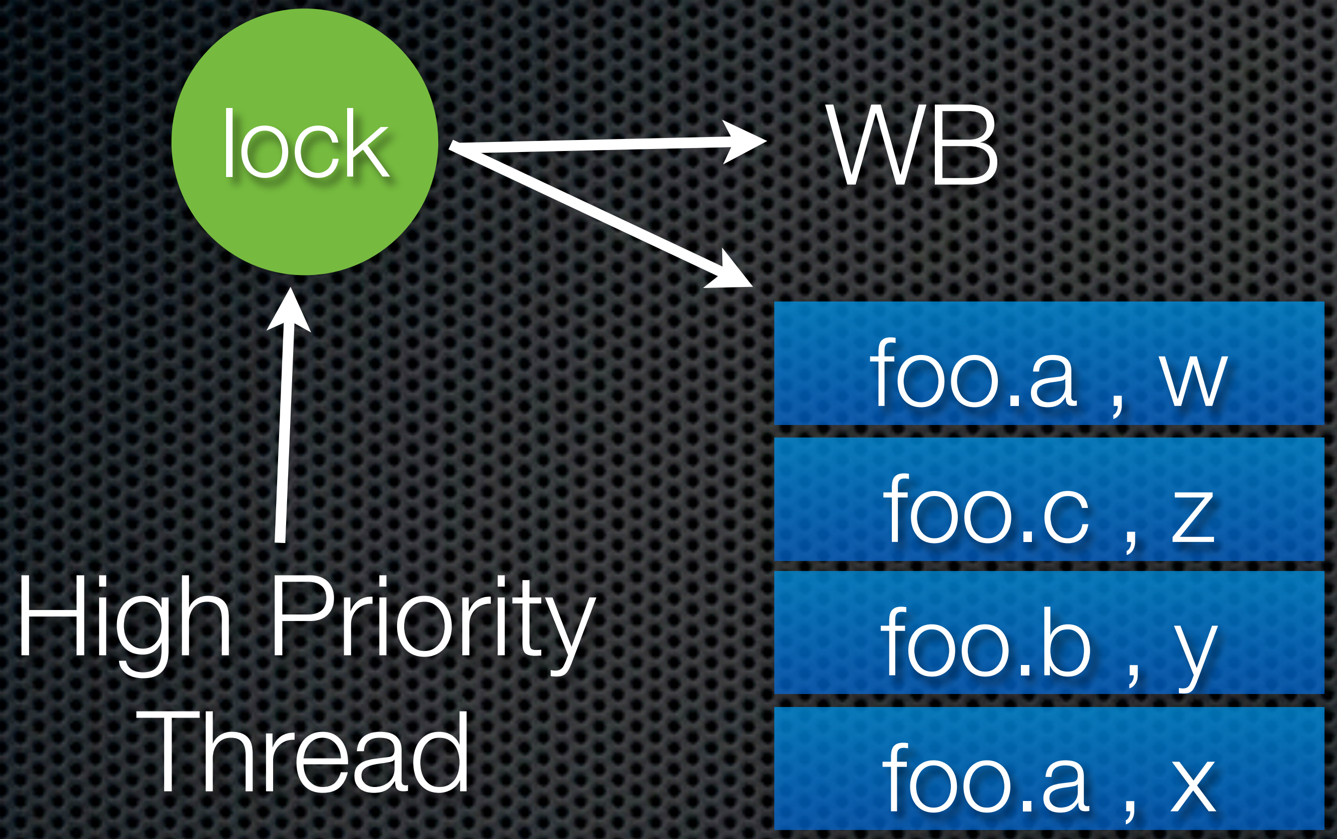
foo.c , z

foo.b , y

foo.a , x

High Priority Thread

Acquisition by higher priority thread



lock

WB

foo.a , w

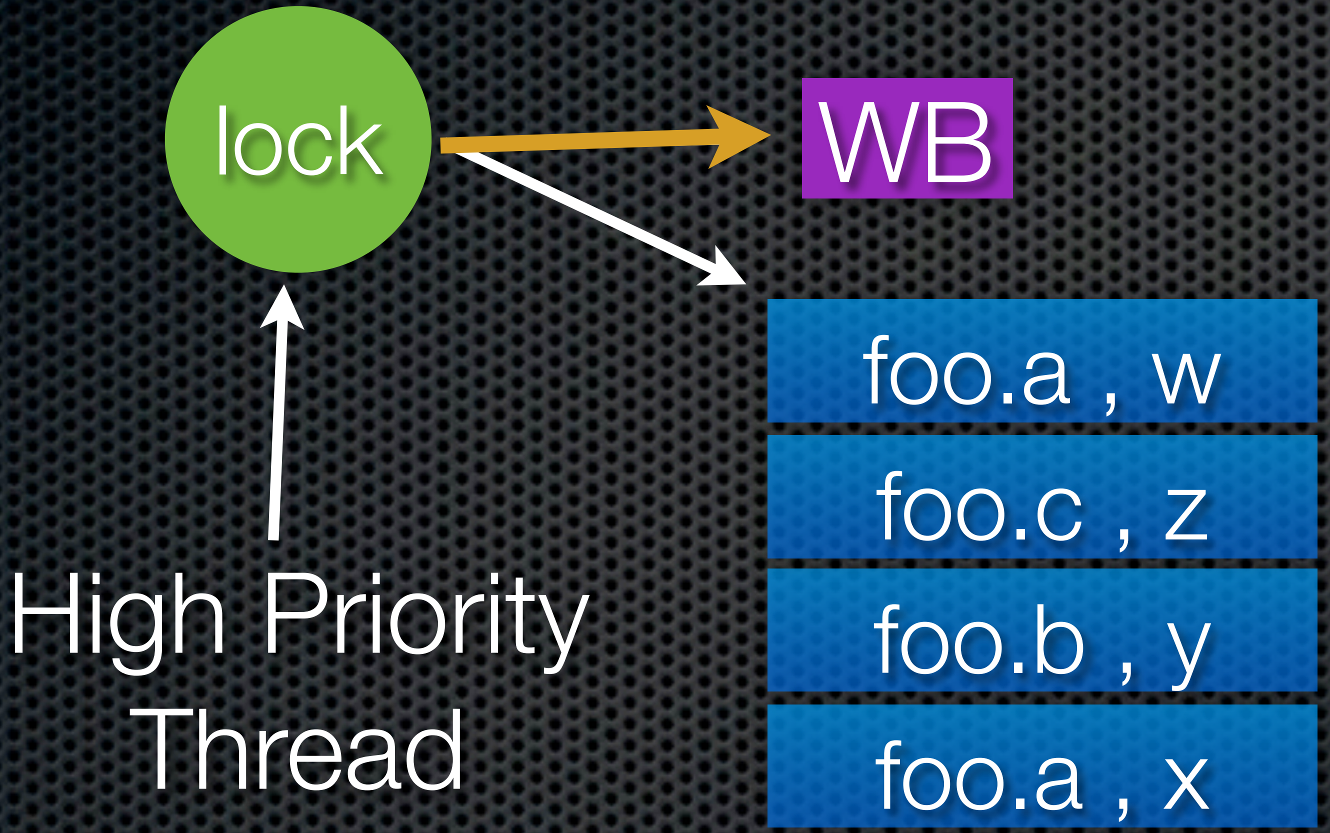
foo.c , z

foo.b , y

foo.a , x

High Priority Thread

Acquisition by higher priority thread



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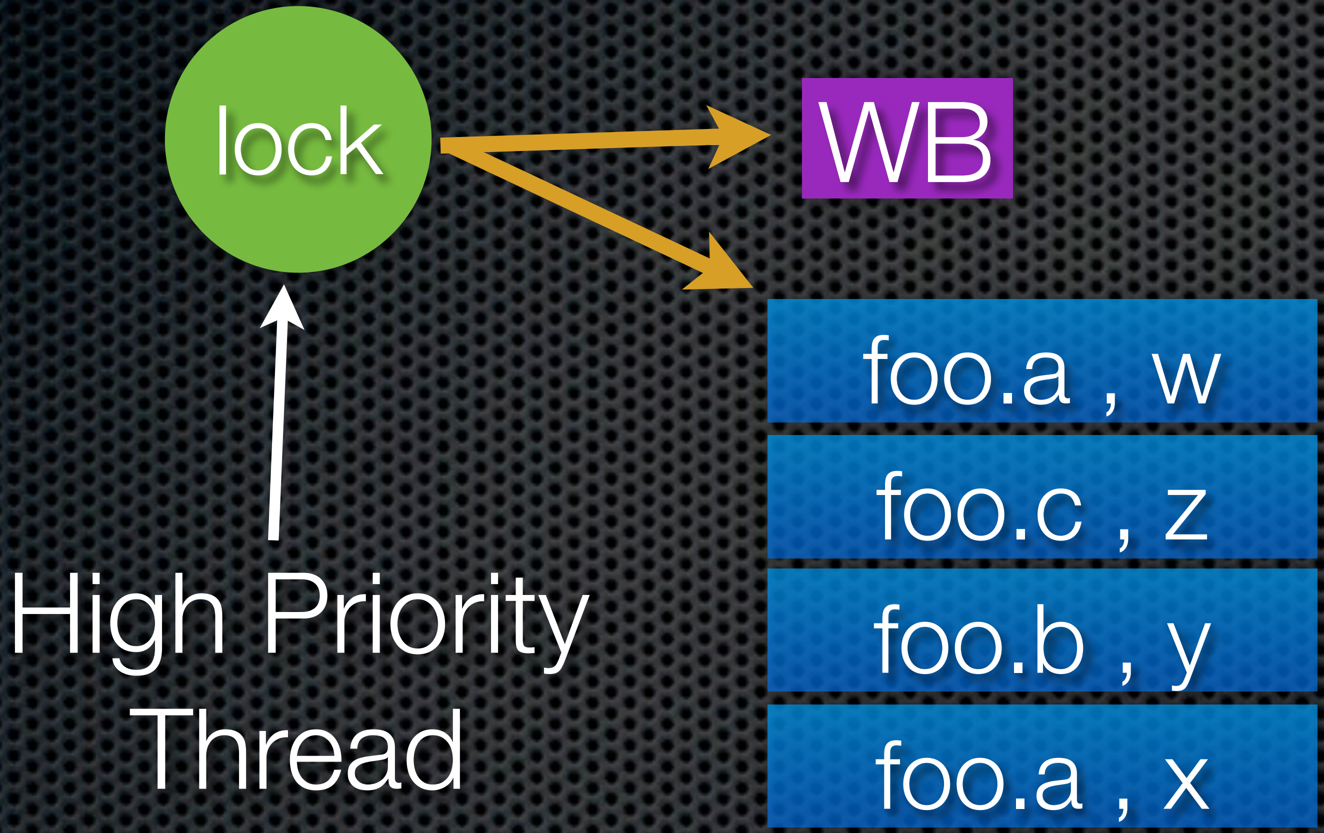
Acquisition by higher priority thread



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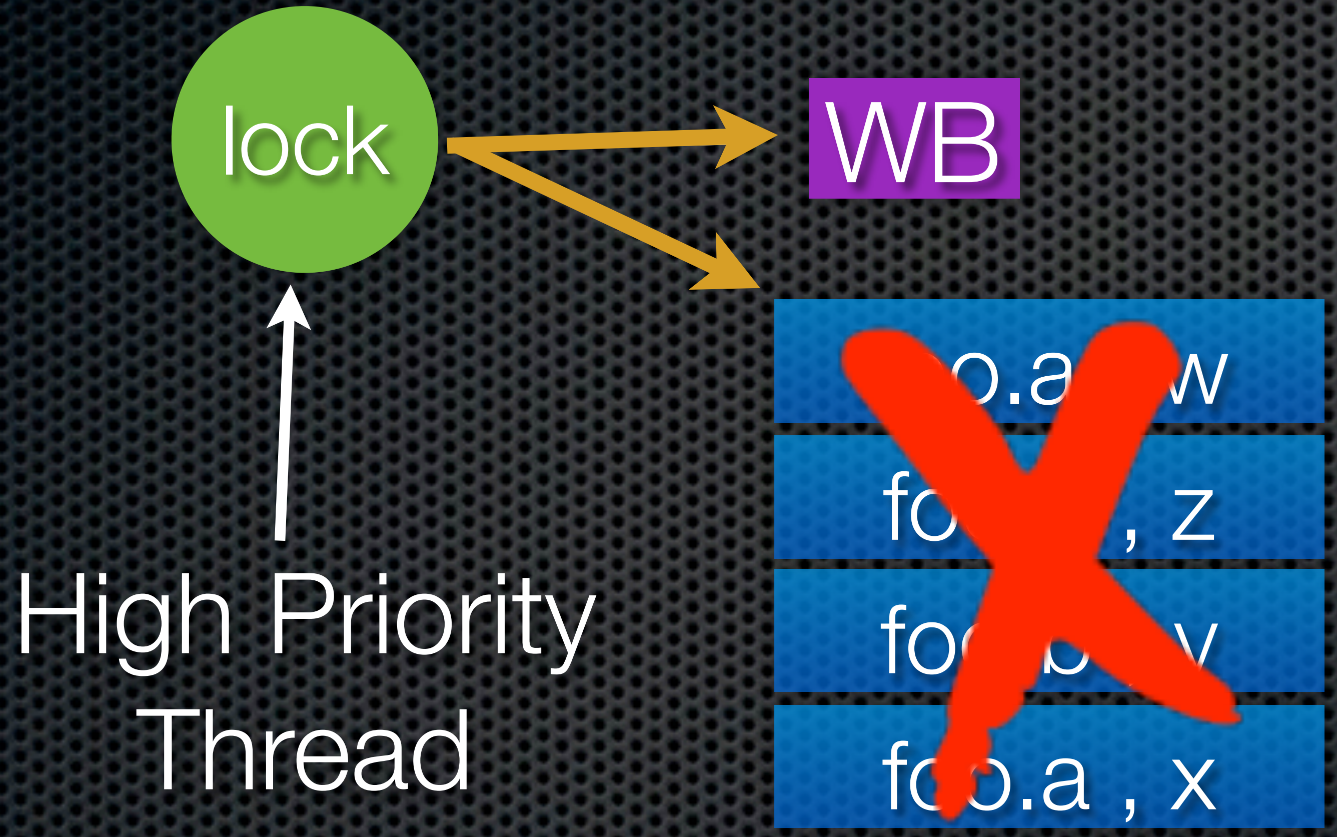
Acquisition by higher priority thread



lock

WB

o.a w

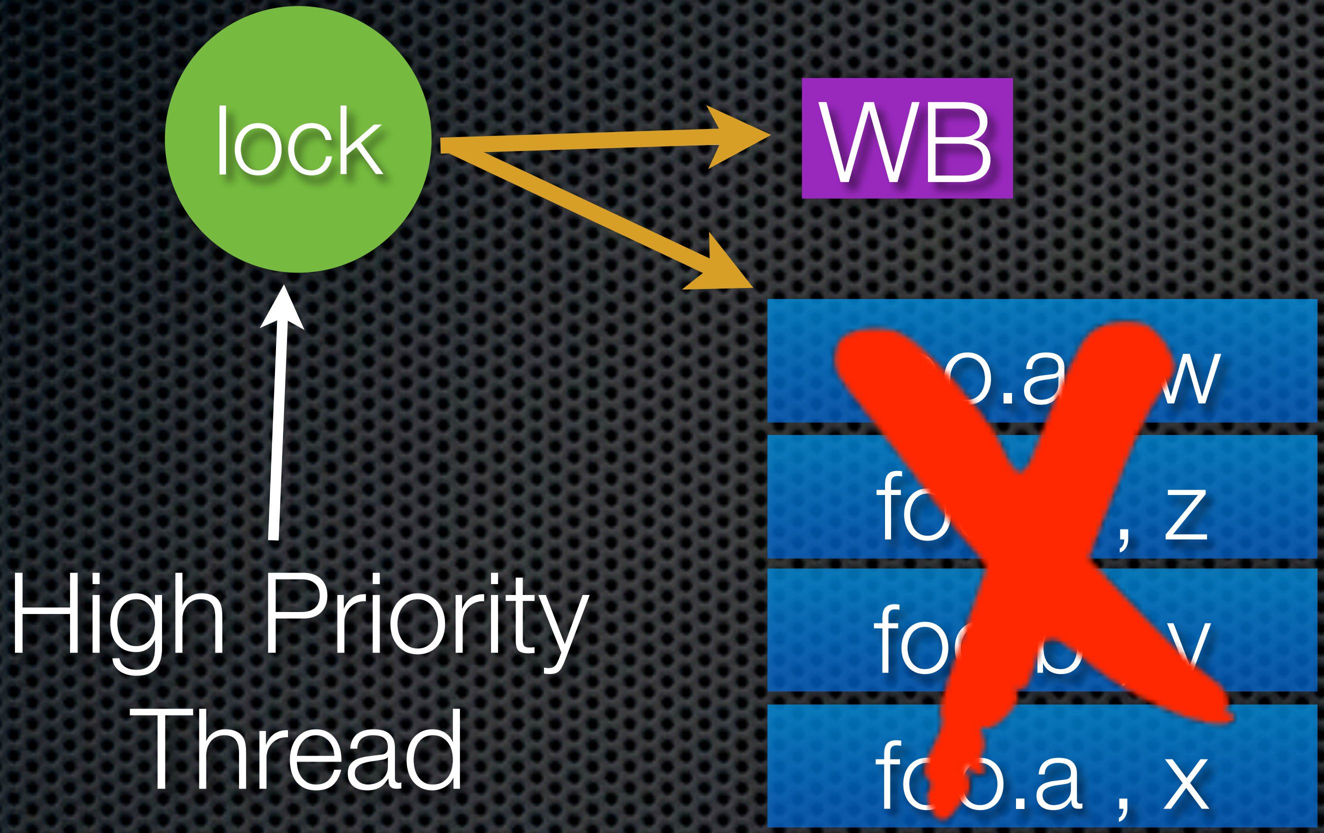
fo , z

fo b y

fo o.a , x

High Priority Thread

Acquisition by higher priority thread



No priority boosting!

High Priority Thread Acquires Lock

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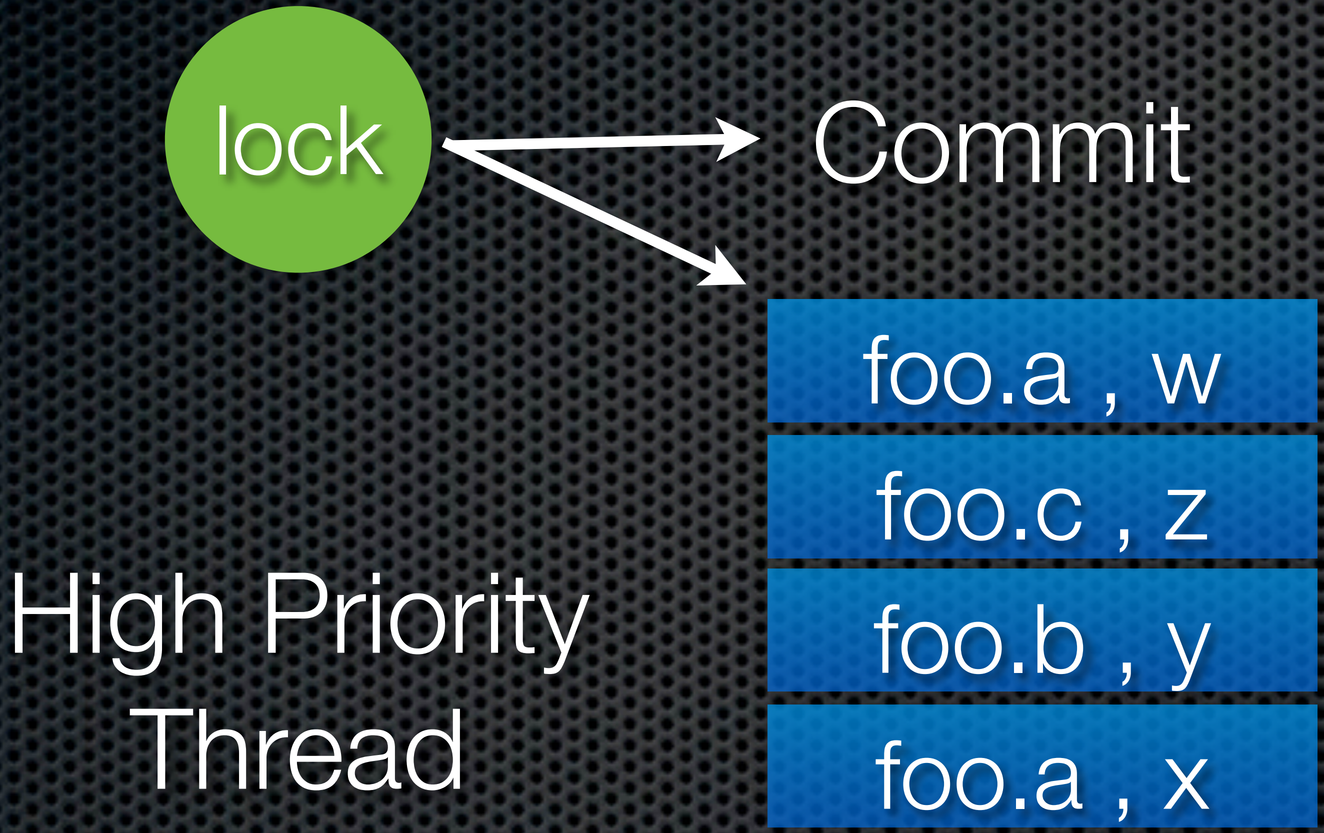
Acquisition by higher priority thread

Main Memory



lock

Commit

foo.a , w

foo.c , z

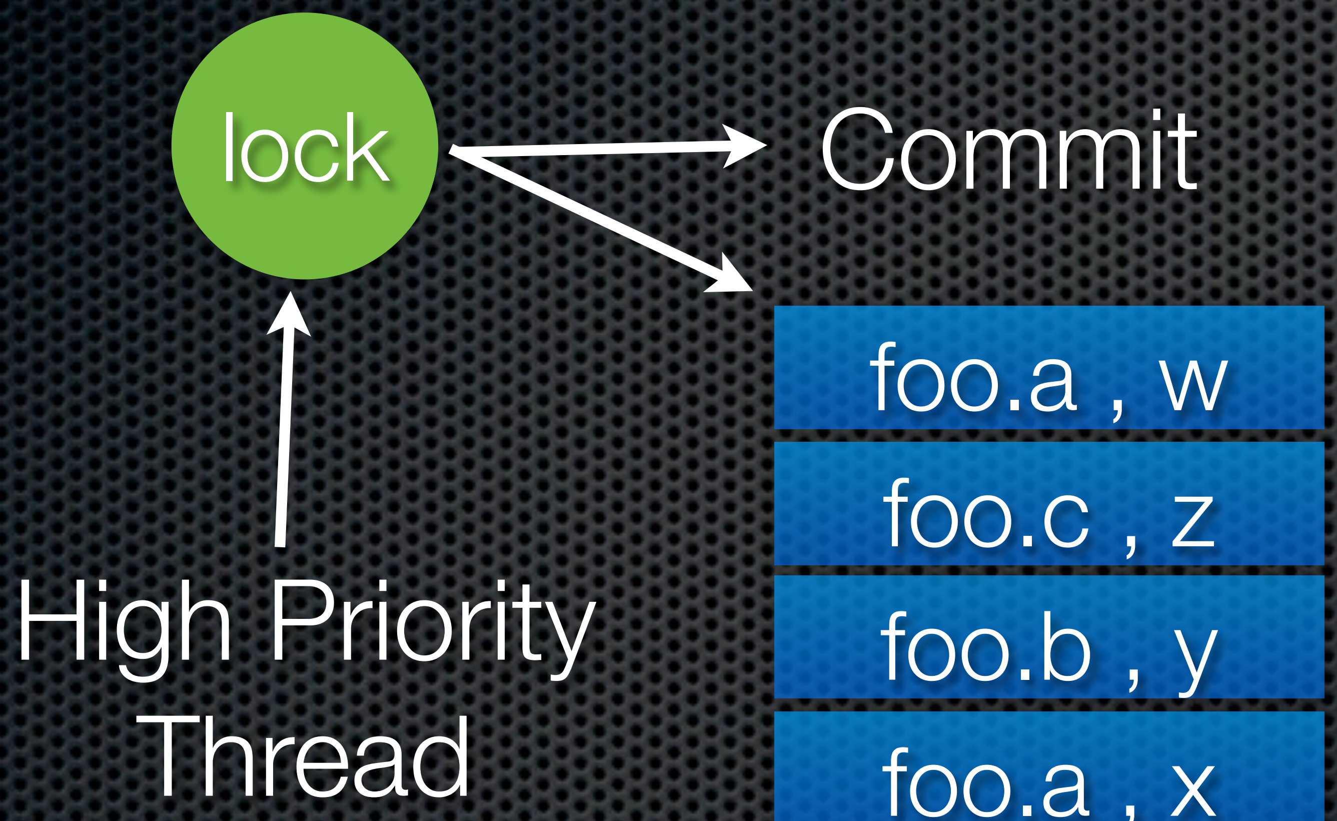
foo.b , y

foo.a , x

High Priority Thread

Acquisition by higher priority thread

Main Memory



lock

Commit

foo.a , w

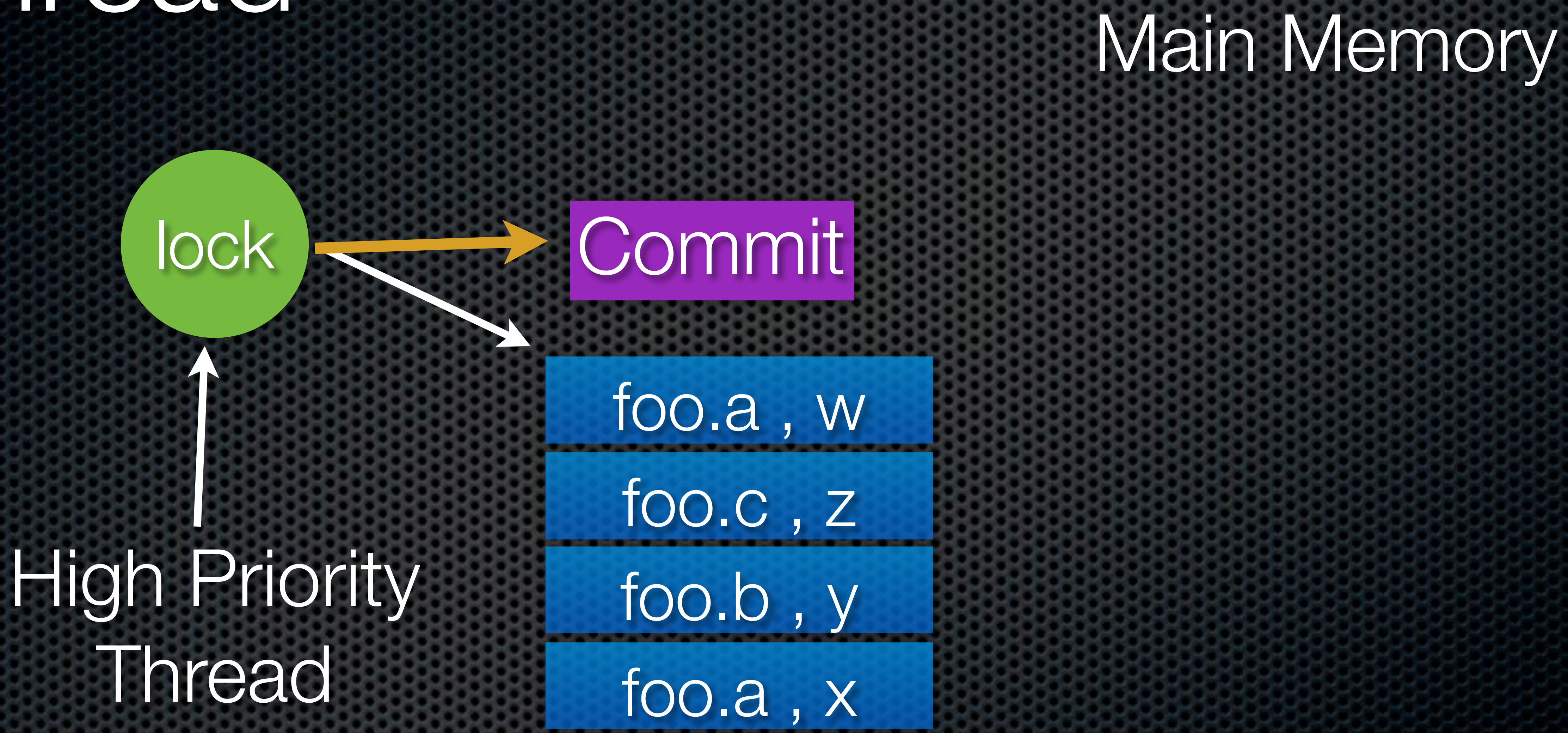
foo.c , z

foo.b , y

foo.a , x

High Priority Thread

Acquisition by higher priority thread



Main Memory

lock

Commit

foo.a , w

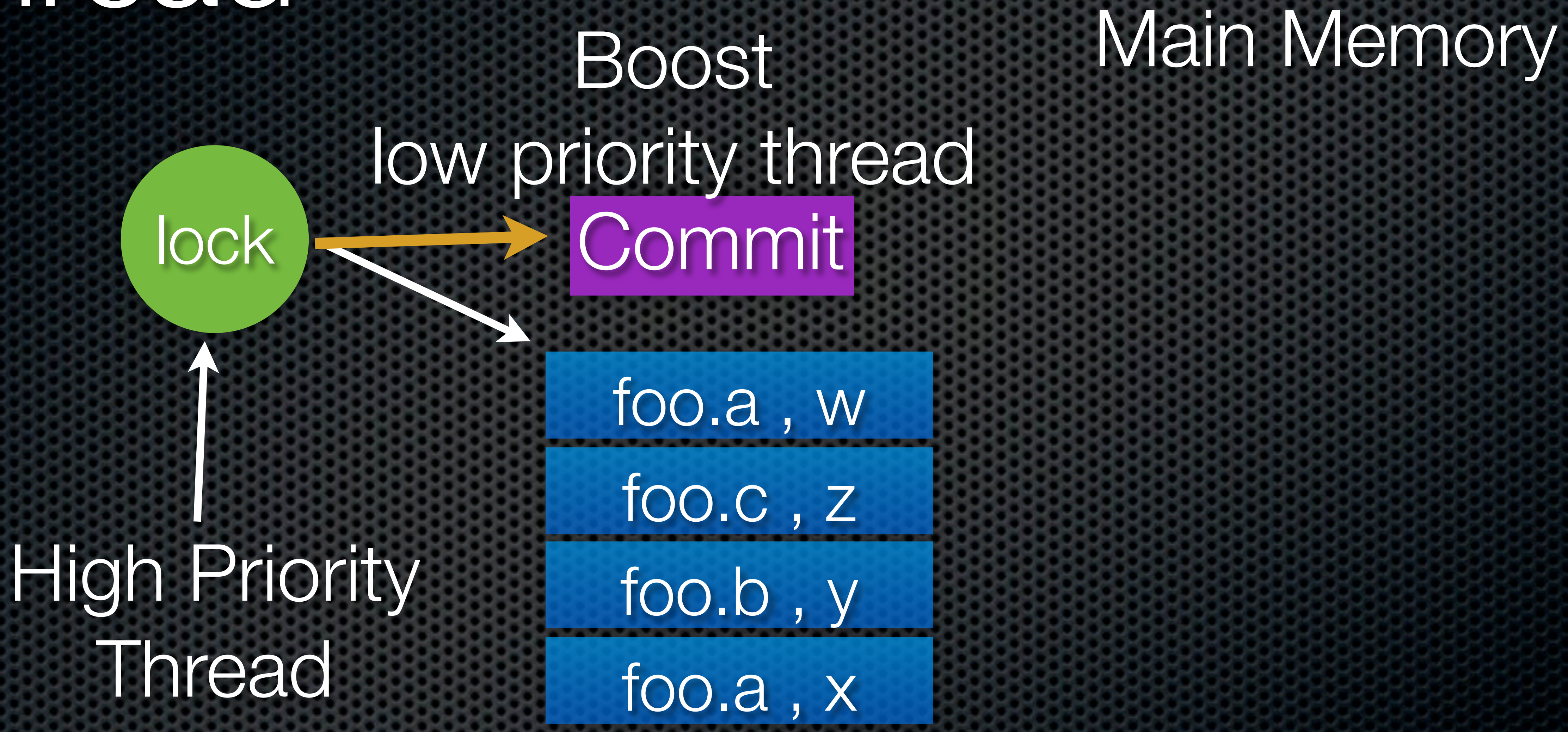
foo.c , z

foo.b , y

foo.a , x

High Priority Thread

Acquisition by higher priority thread



Boost

low priority thread

Main Memory

lock

Commit

foo.a , w

foo.c , z

foo.b , y

foo.a , x

High Priority Thread

Fiji

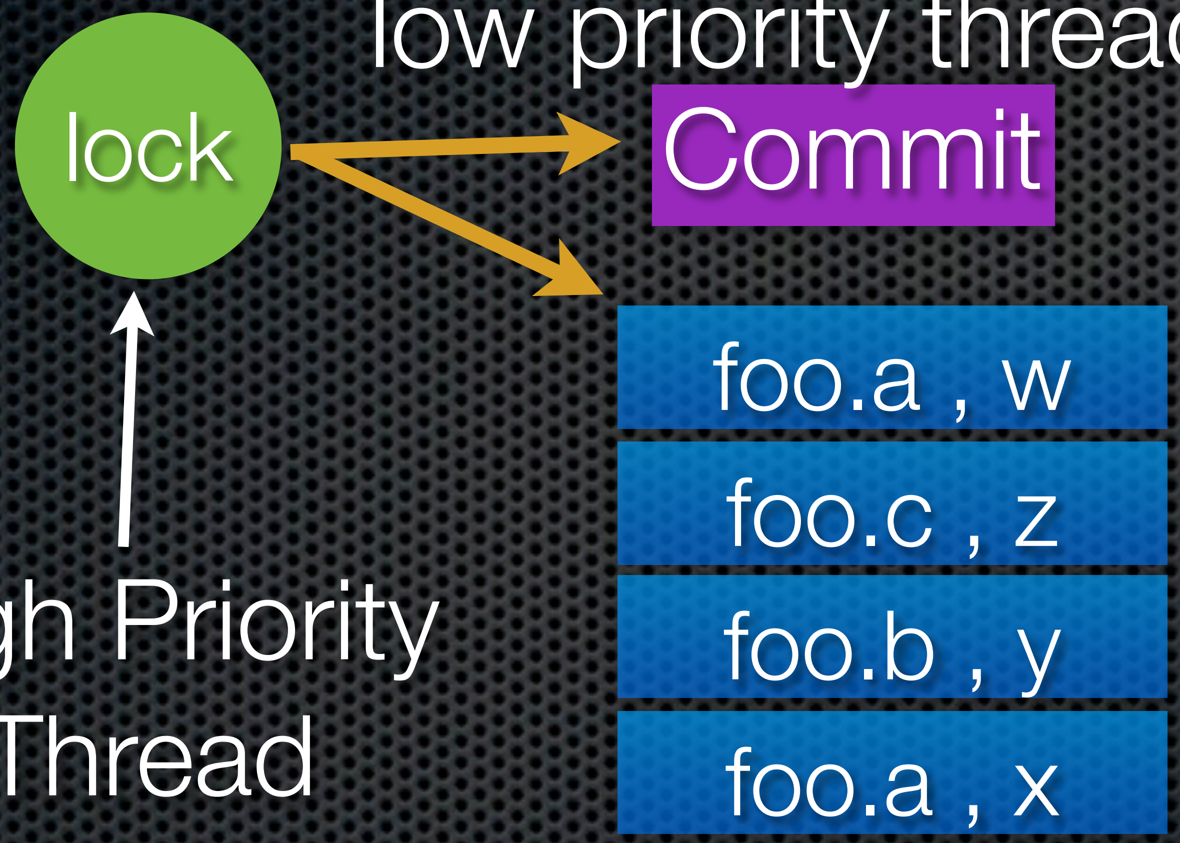
Systems LLC

Acquisition by higher priority thread

Main Memory

Boost

low priority thread



lock

Commit

foo.a , w

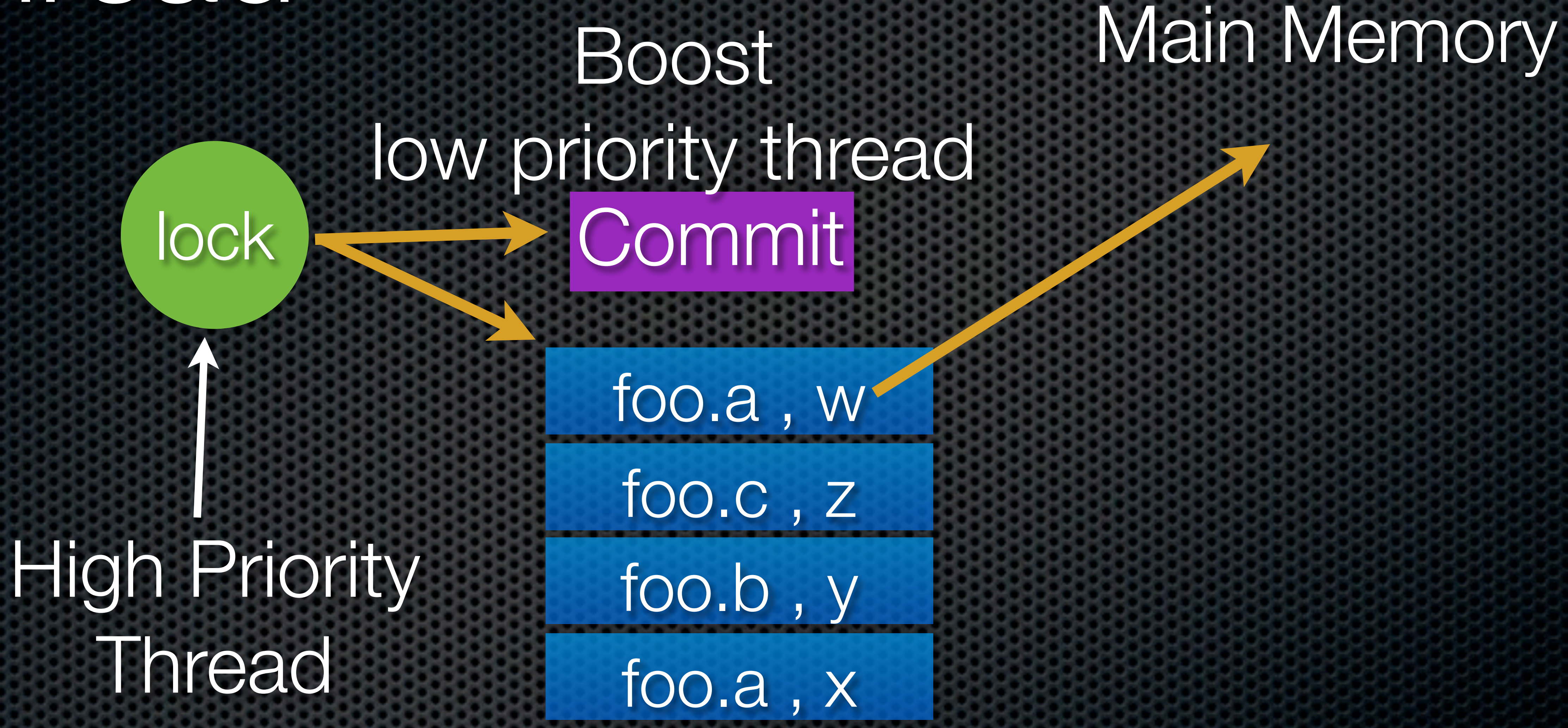
foo.c , z

foo.b , y

foo.a , x

High Priority Thread

Acquisition by higher priority thread



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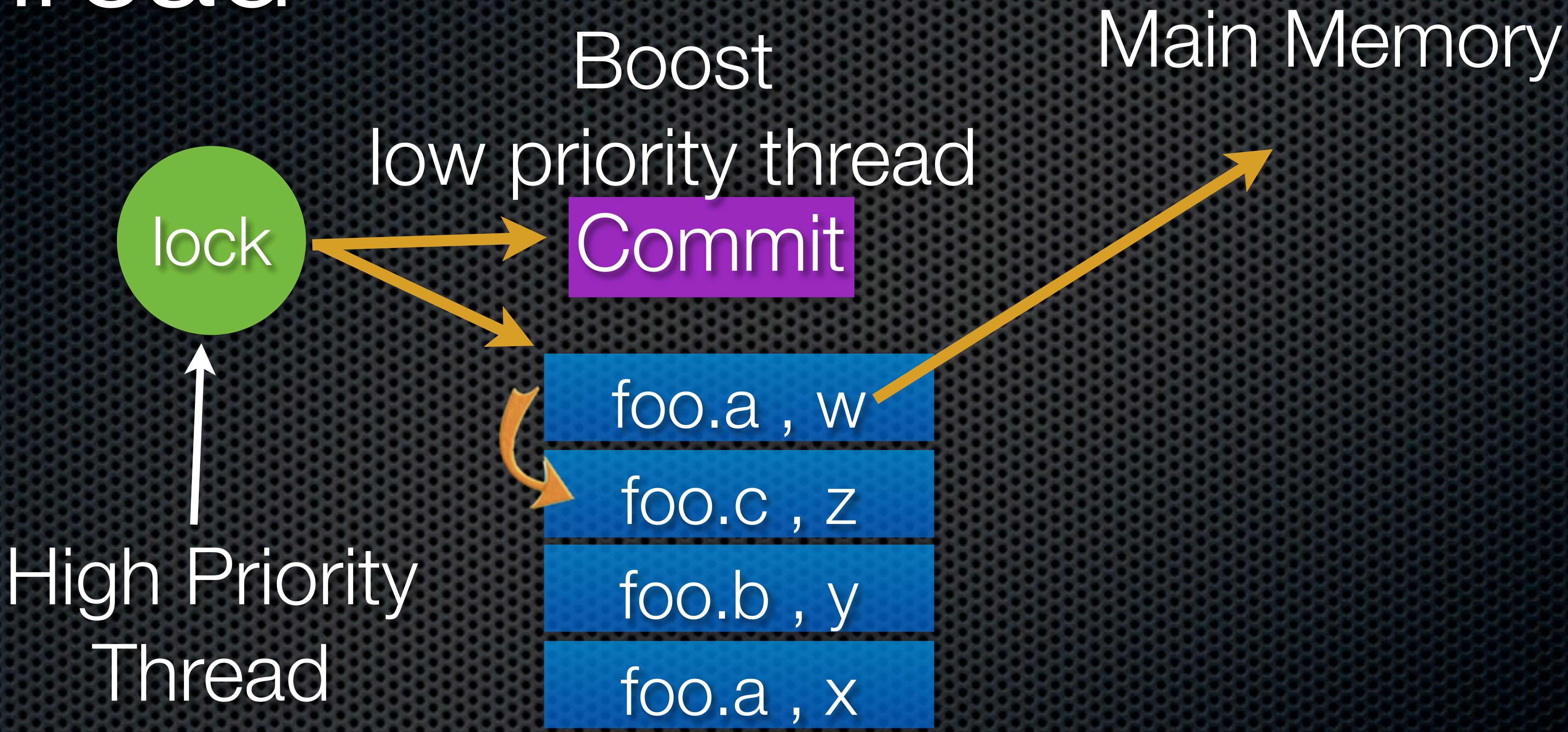

Boost

low priority thread

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lock

Commit

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foo.c , z

foo.b , y

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High Priority Thread

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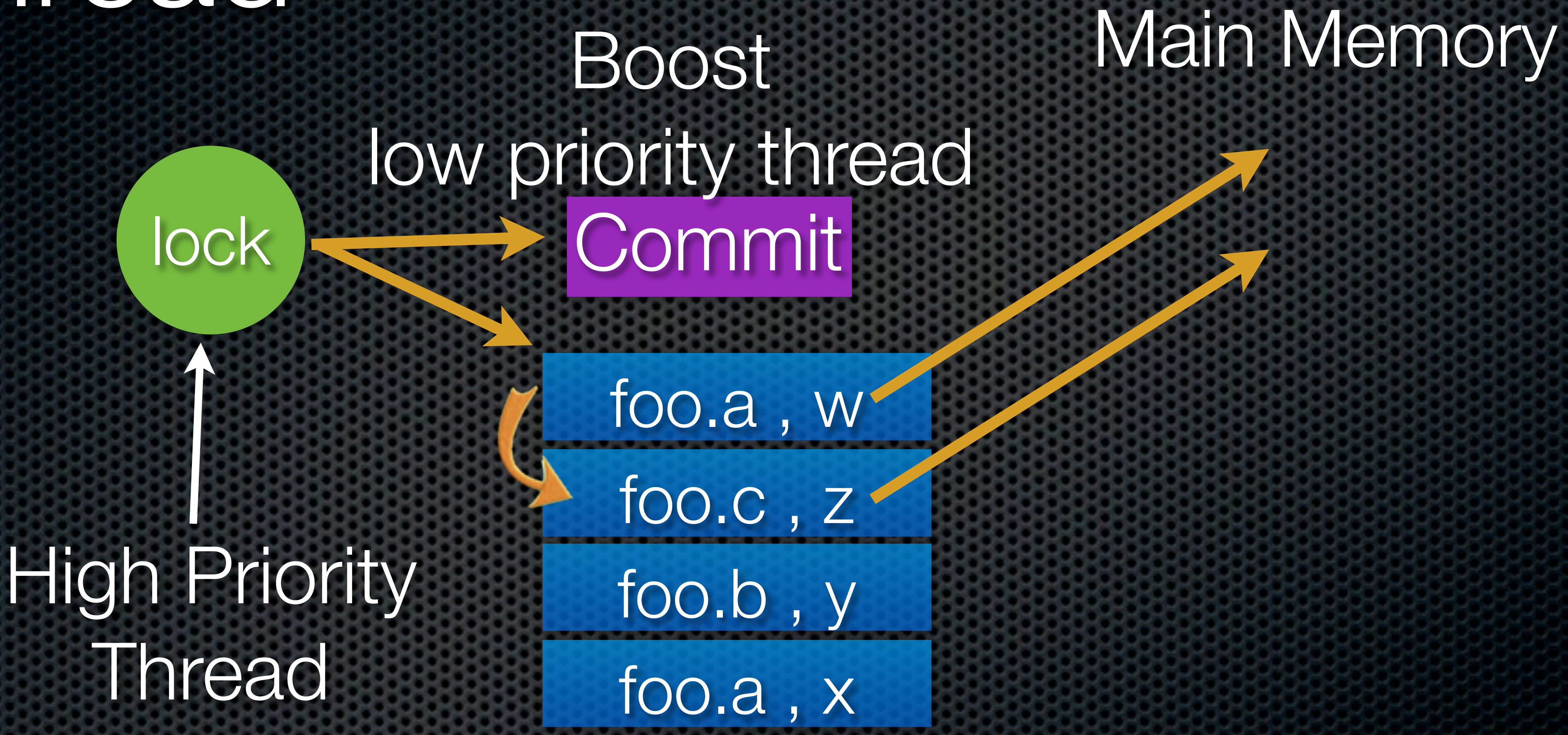

Boost

low priority thread

Main Memory

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High Priority Thread

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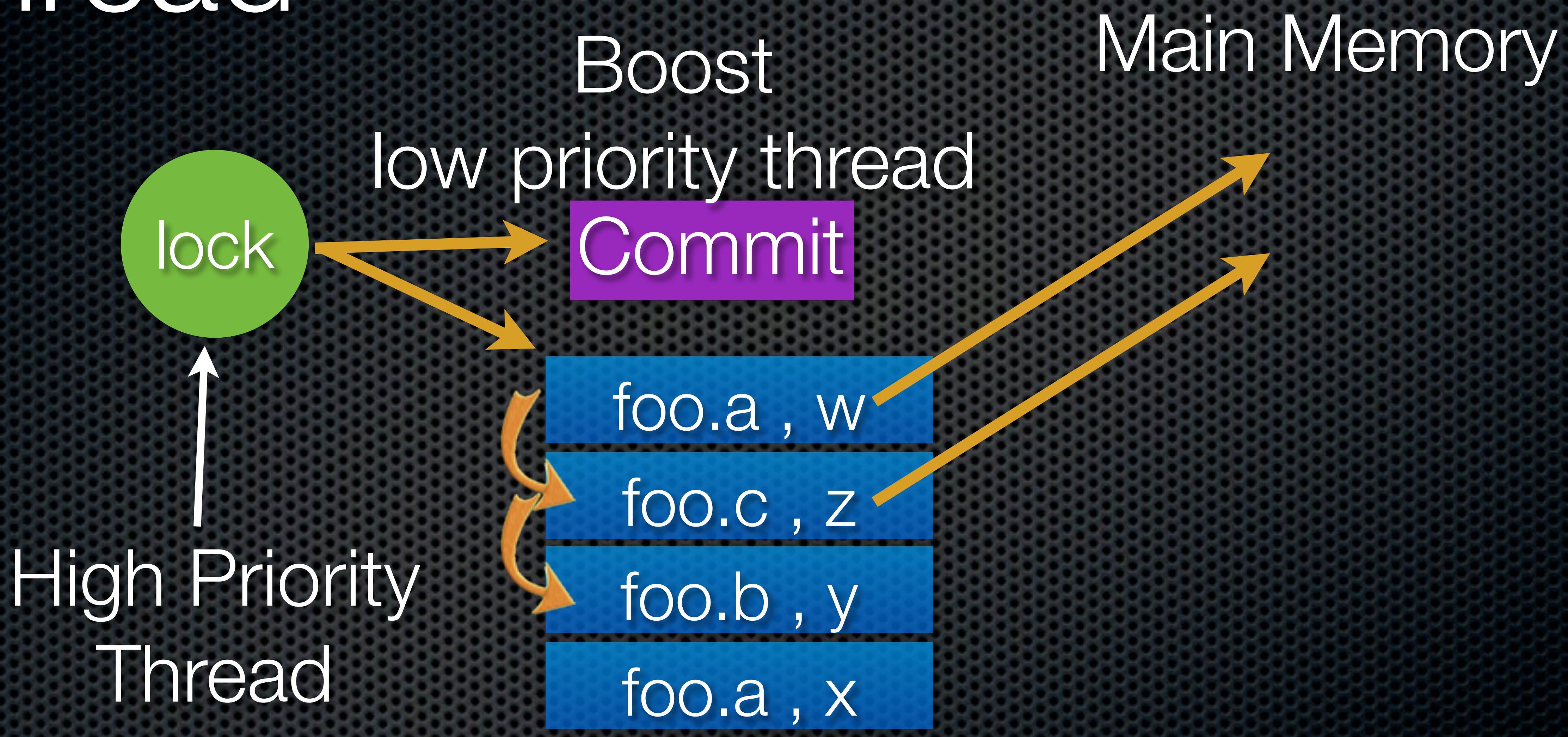

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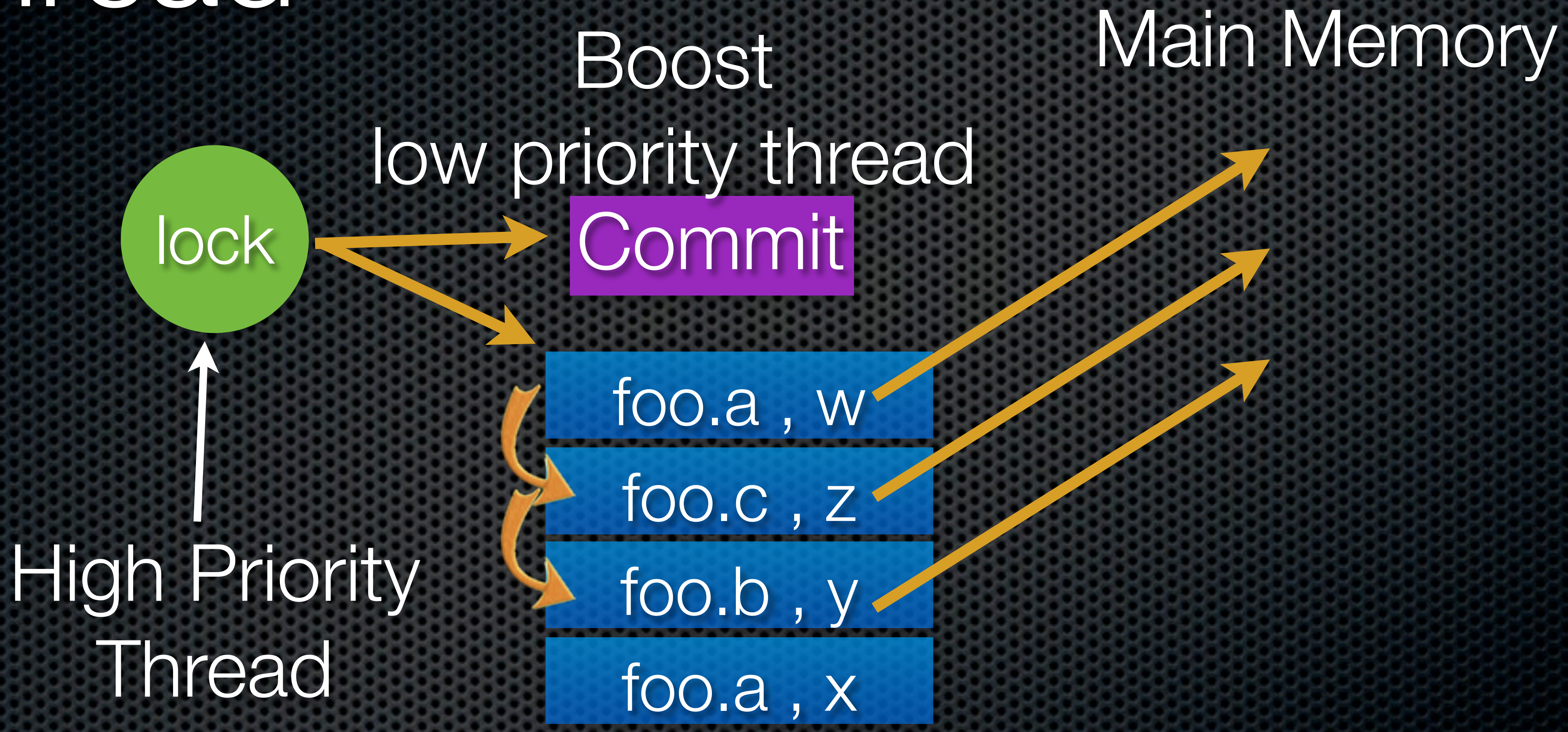

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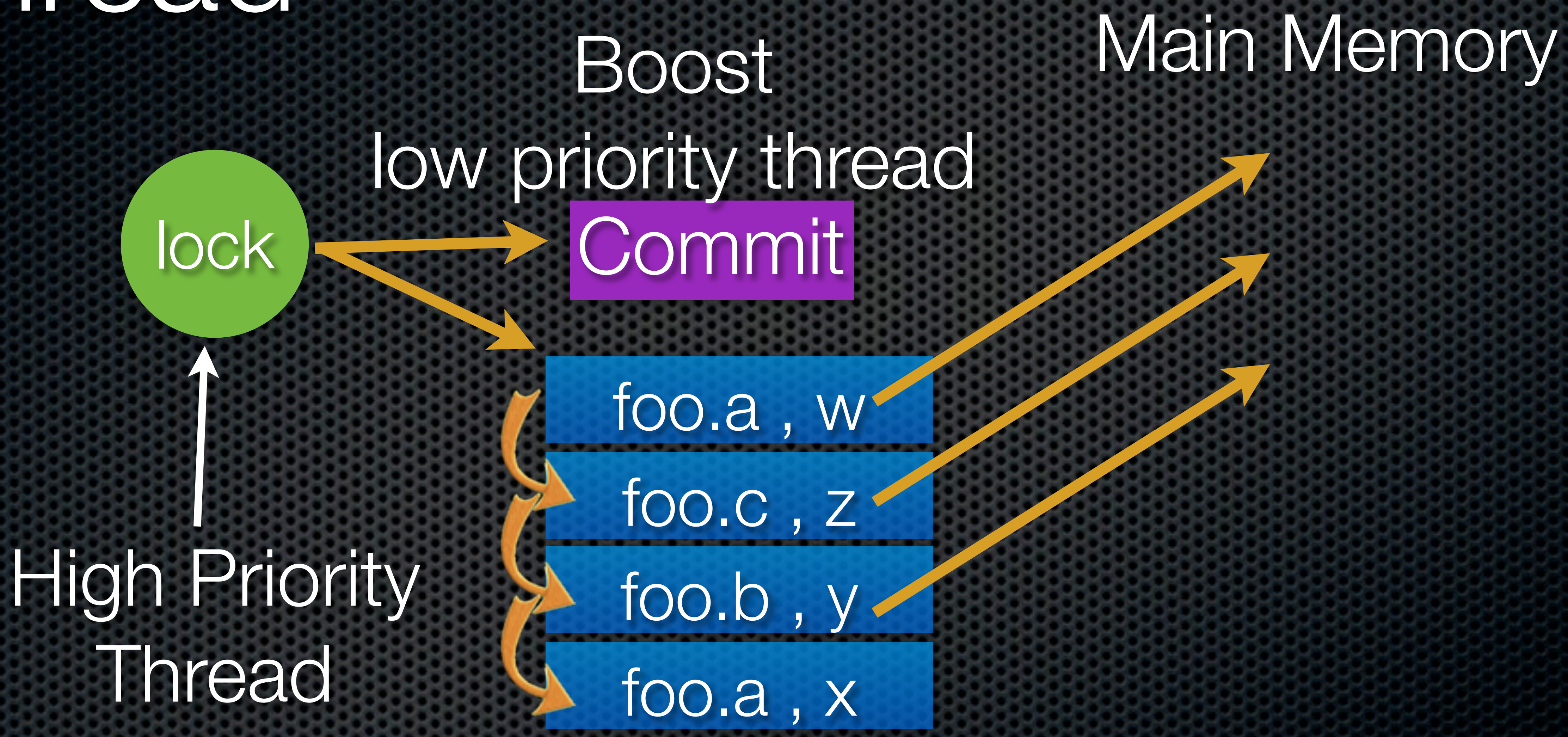

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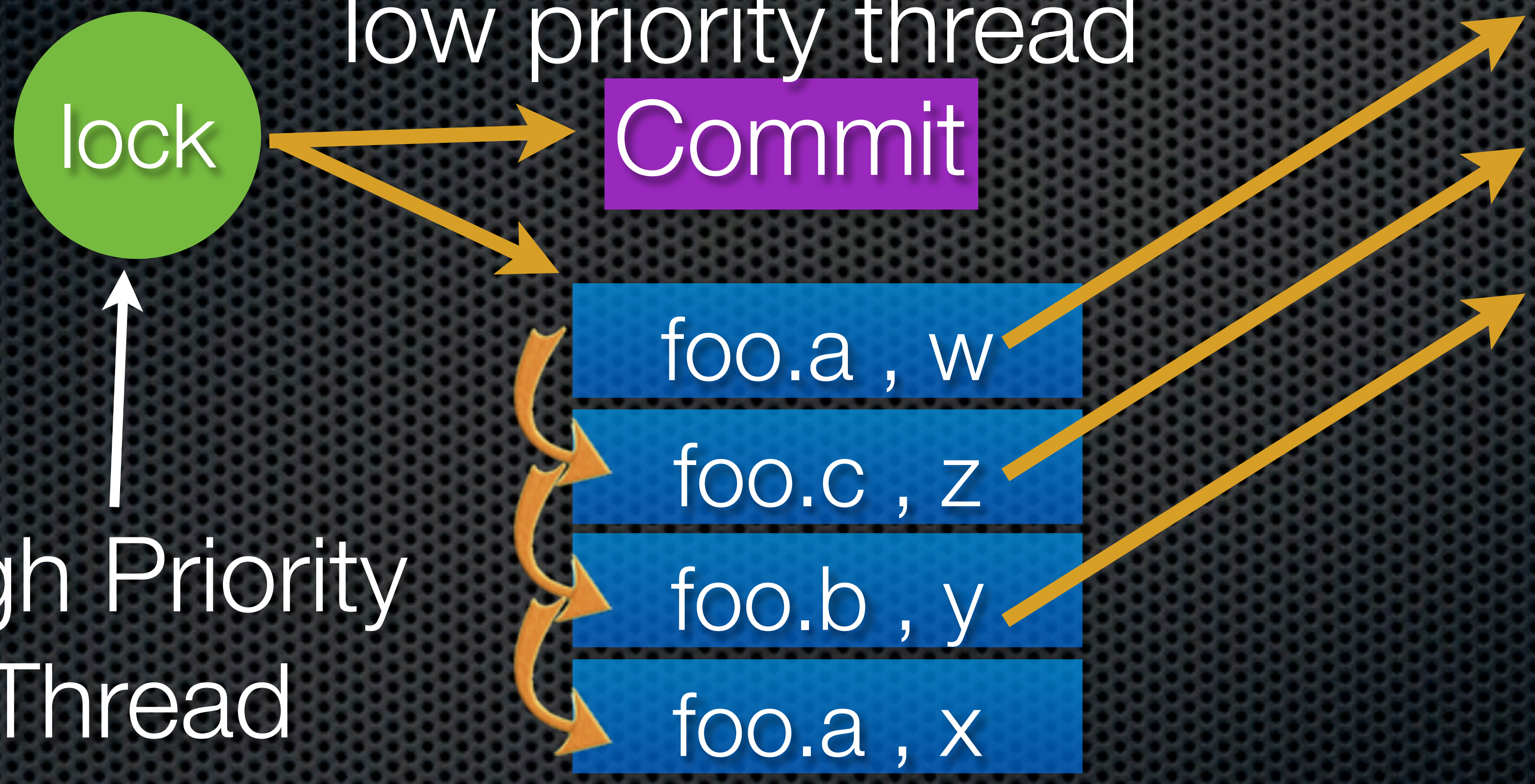

Main Memory

Boost

low priority thread

lock

Commit

foo.a , w

foo.c , z

foo.b , y

foo.a , x

High Priority Thread

High Priority Thread Acquires Lock

Complexity Costs - Write Buffering Low Priority Thread

- Reads: log(size of buffer) --- use RB tree
- Writes: log(size of buffer)
- Commit: size of buffer -- nested commit: n log(n)
- Acquisition: constant if thread not flushing buffer, size of buffer + context switches otherwise
- Memory: size of buffer

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Write Logging

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synchronized(lock){
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  foo.c = z;
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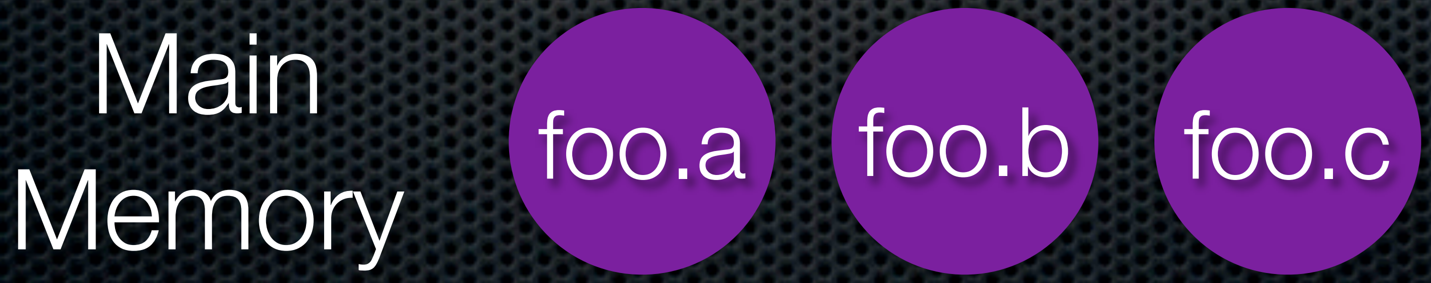
    ...
}
```



Write Logging

lock

set to acquired
in WL mode

```
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    foo.a = x;
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}
```

Log

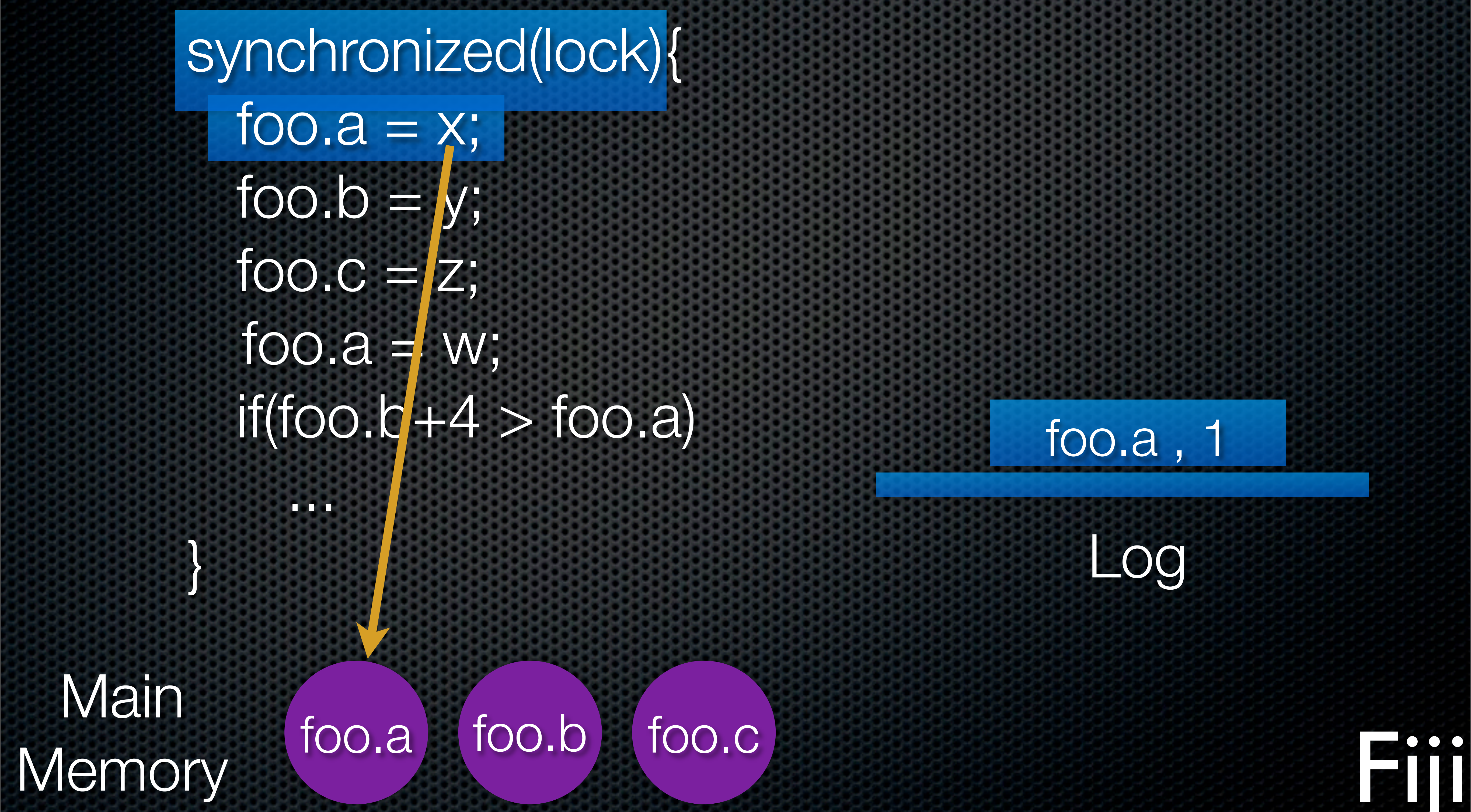
Main
Memory

foo.a foo.b foo.c

Write Logging

lock

set to acquired
in WL mode



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Write Logging

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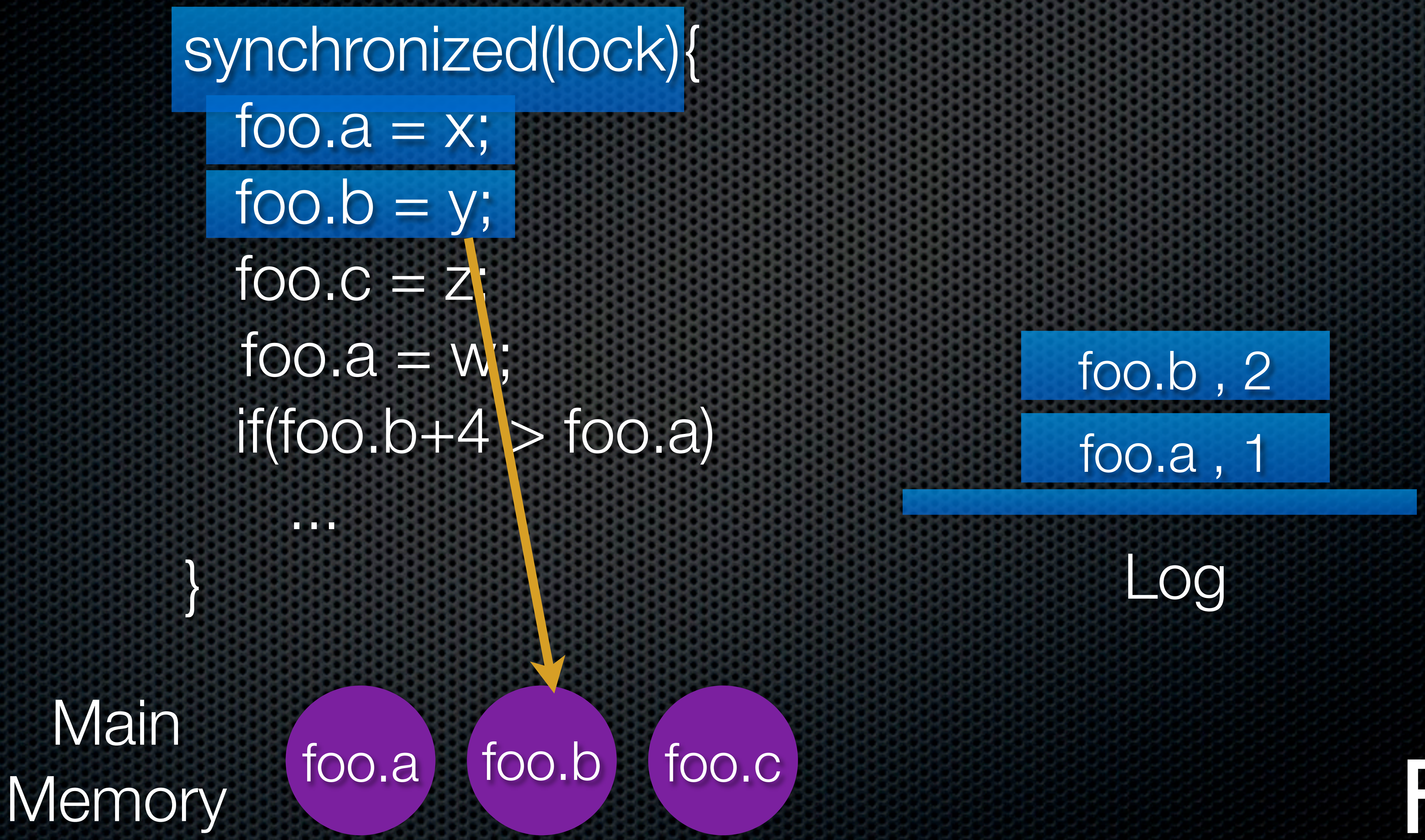

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   foo.c = z;
   foo.a = w;
   if(foo.b+4 > foo.a)
      ...
}
```
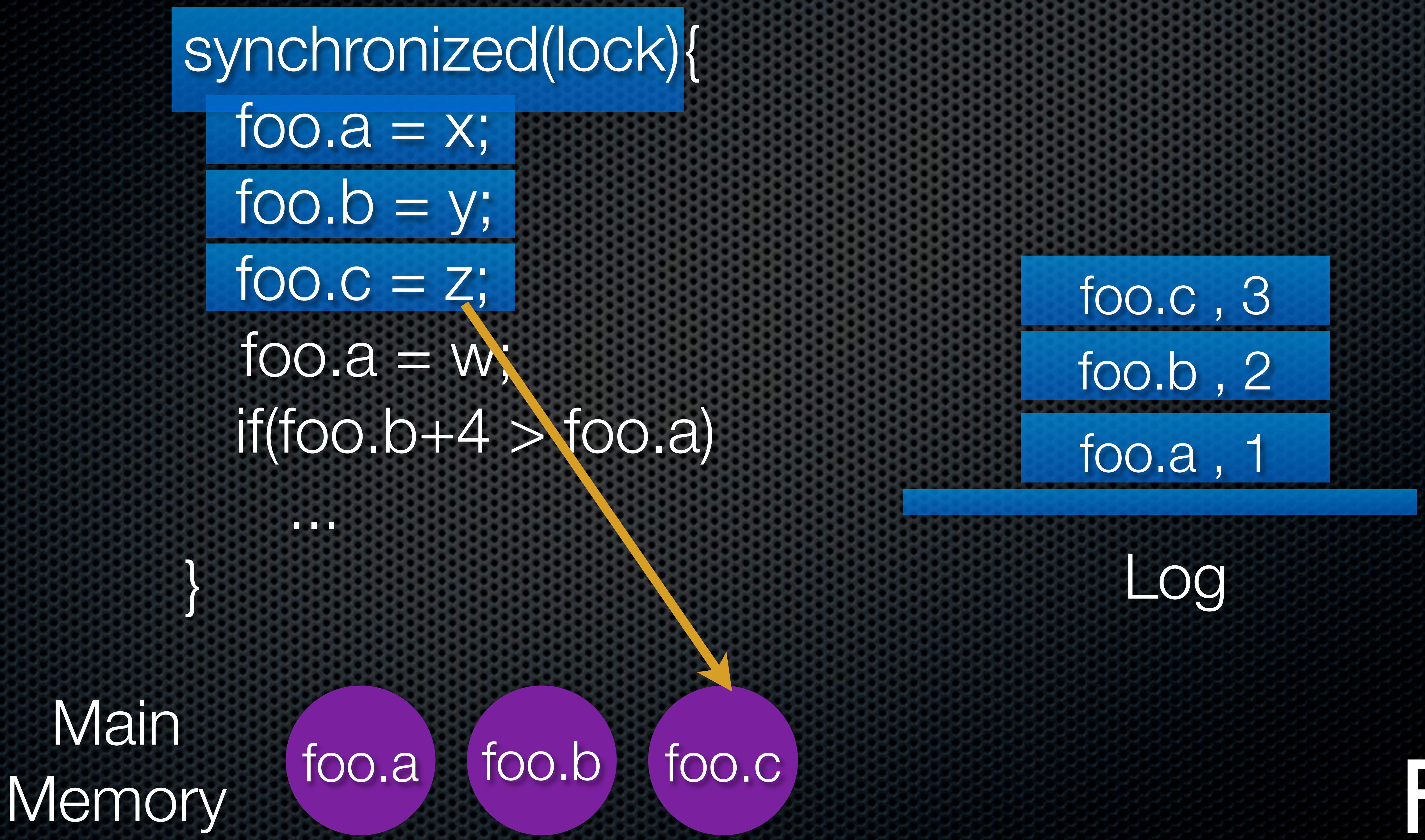

Fiji Systems LLC

Write Logging

lock

set to acquired
in WL mode



```
synchronized(lock){
  foo.a = x;
  foo.b = y;
  foo.c = z;
  foo.a = w;
  if(foo.b+4 > foo.a)
     ...
}
```

foo.c , 3

foo.b , 2

foo.a , 1

Log

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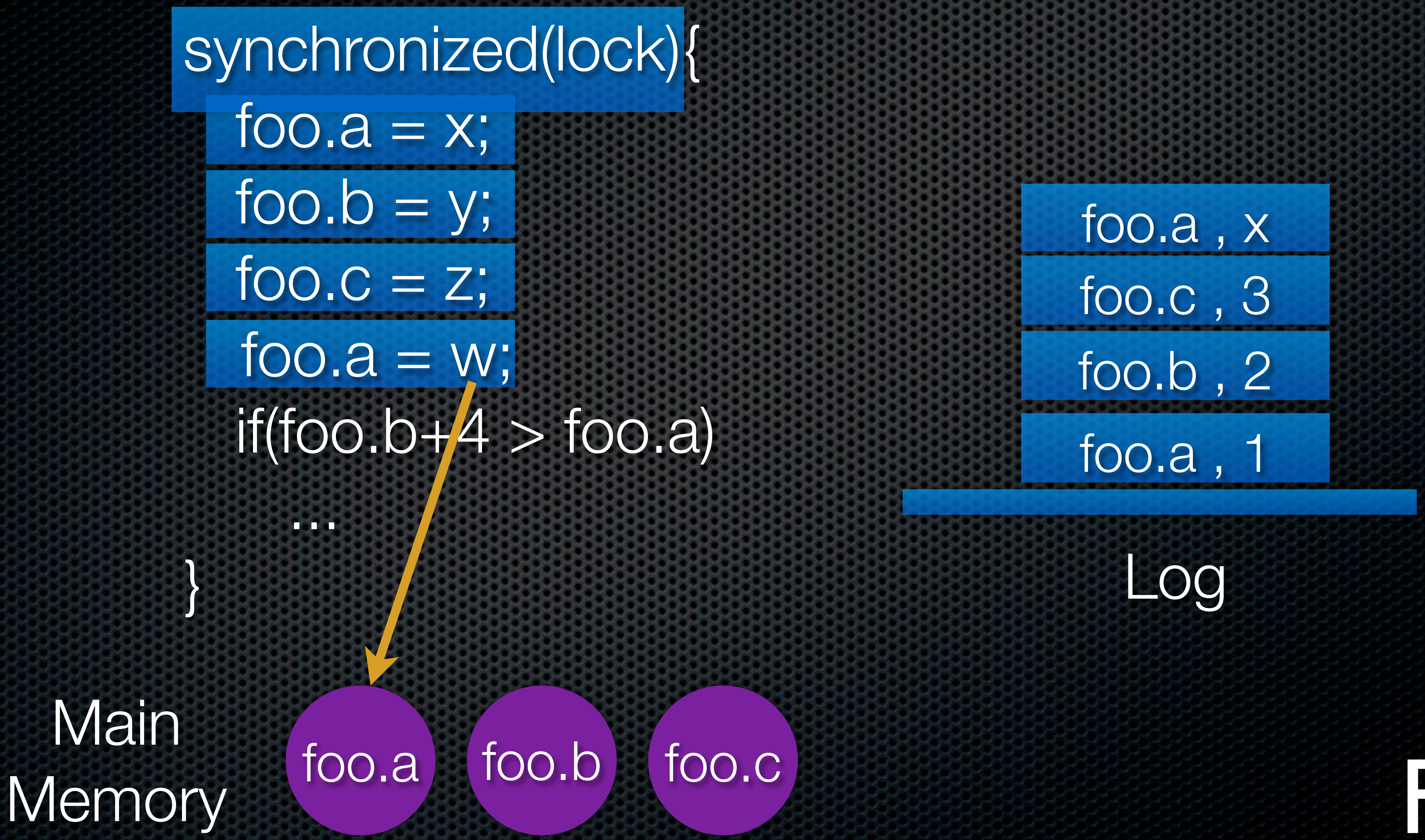
Write Logging

lock

set to acquired in WL mode

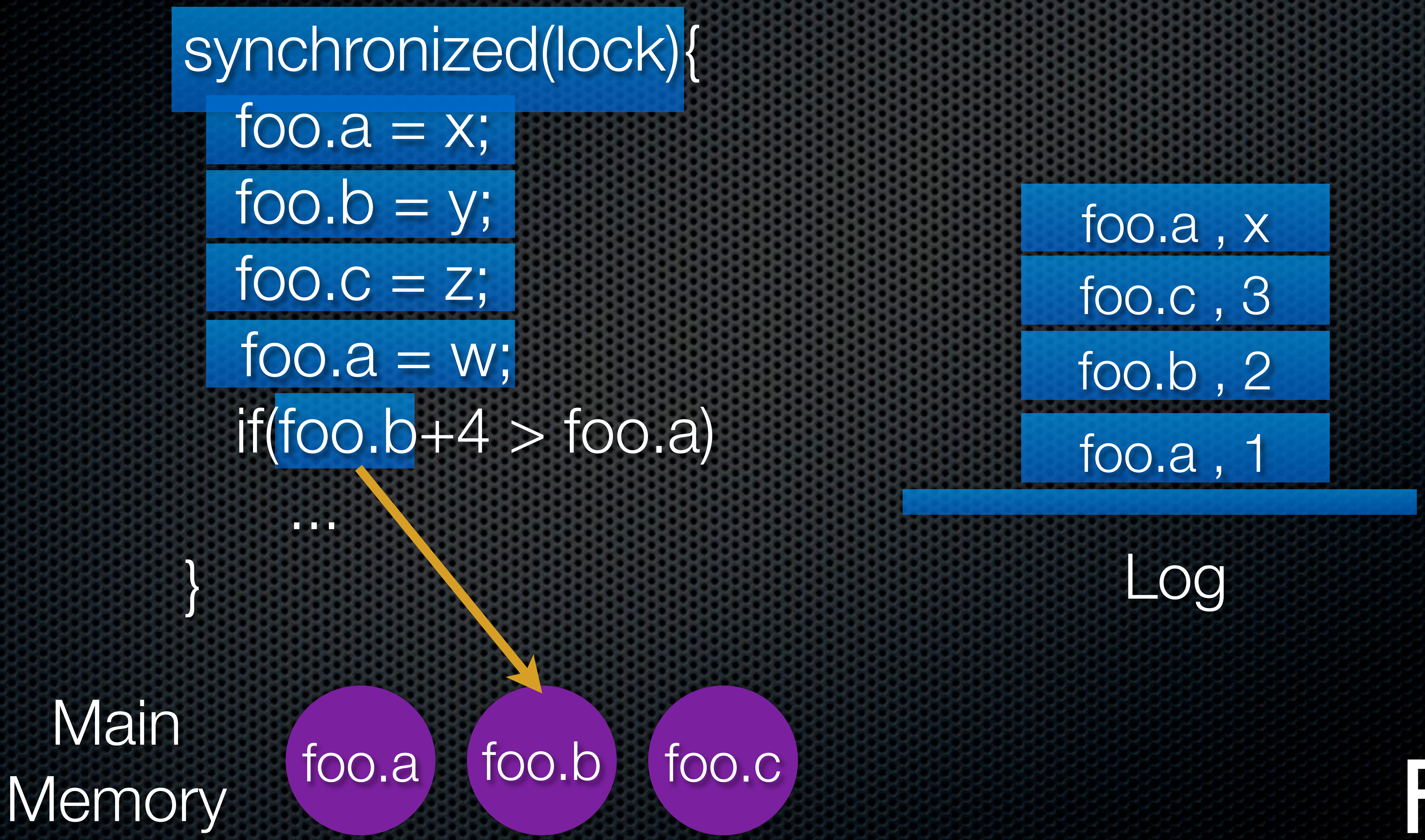


```
synchronized(lock){
   foo.a = x;
   foo.b = y;
   foo.c = z;
   foo.a = w;
   if(foo.b+4 > foo.a)
      ...
}
```

Write Logging

lock

set to acquired in WL mode



```
synchronized(lock){
  foo.a = x;
  foo.b = y;
  foo.c = z;
  foo.a = w;
  if(foo.b+4 > foo.a)
    ...
}
```

foo.a , x

foo.c , 3

foo.b , 2

foo.a , 1

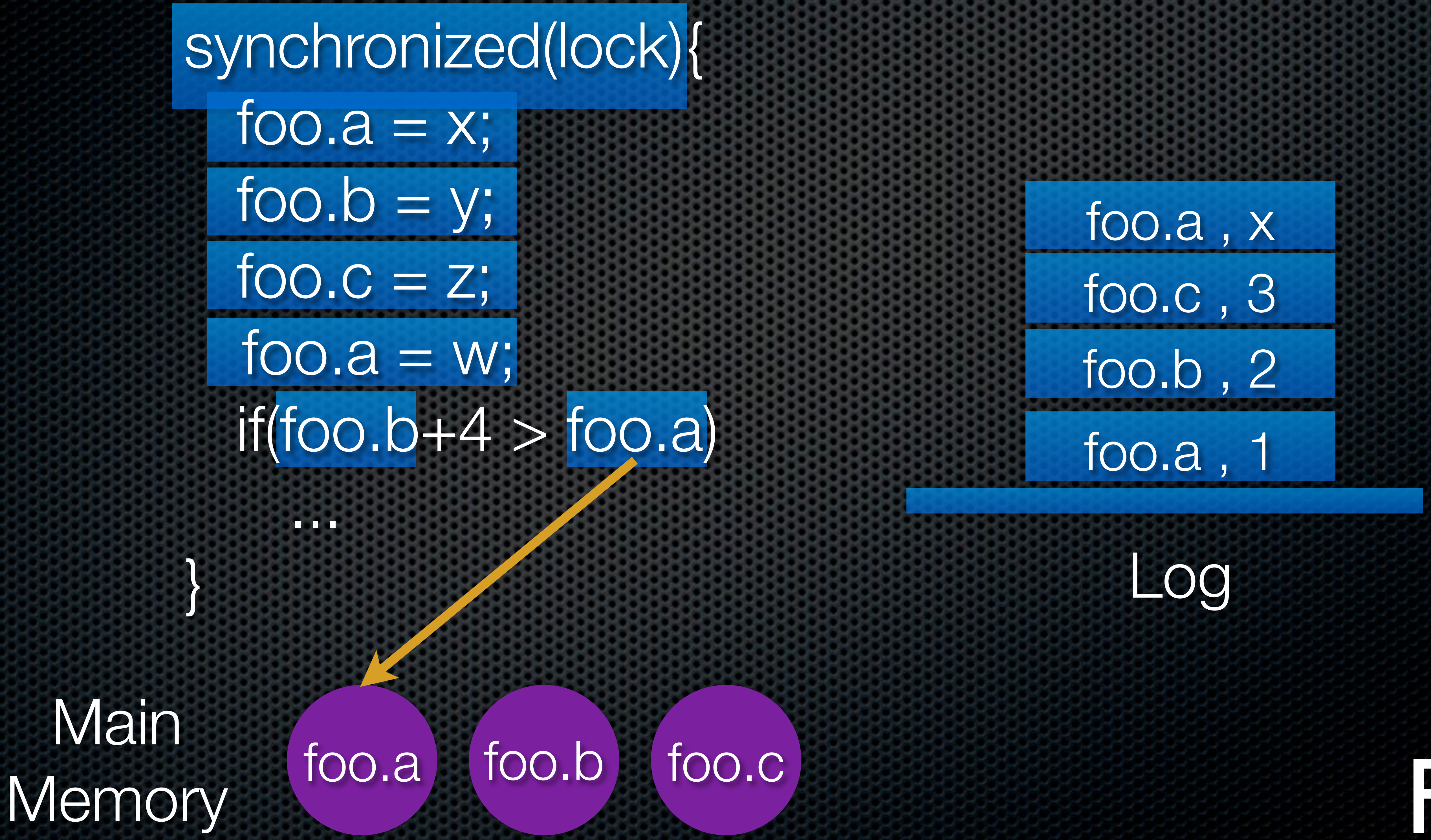
Log

Main Memory

Write Logging

lock

set to acquired
in WL mode



```
synchronized(lock){
   foo.a = x;
   foo.b = y;
   foo.c = z;
   foo.a = w;
   if(foo.b+4 > foo.a)
      ...
}
```

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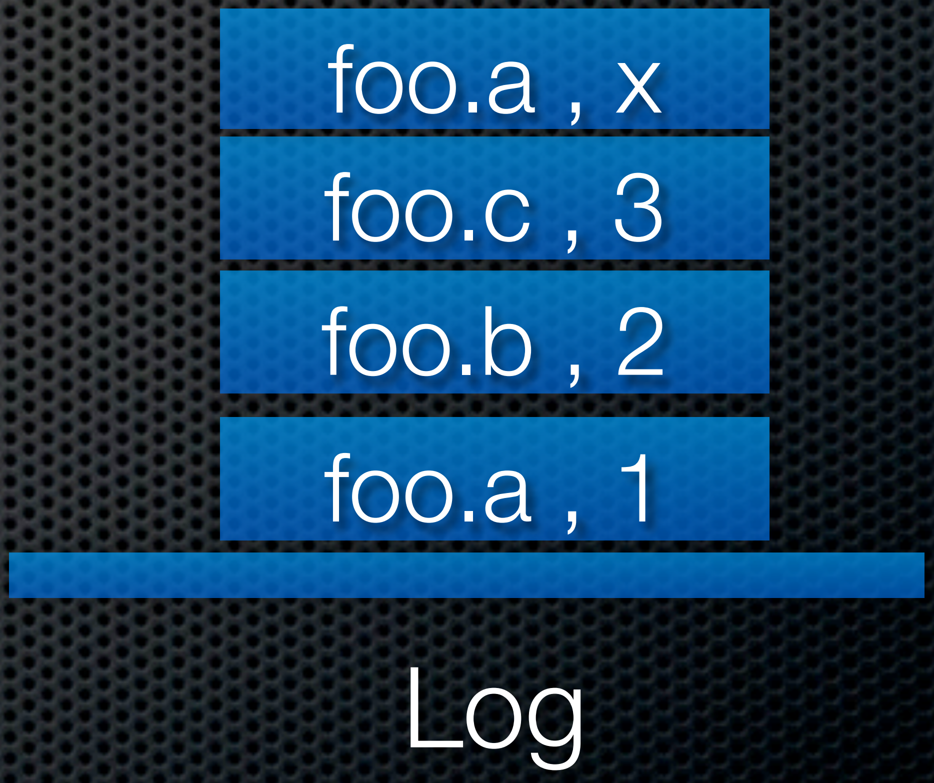
Write Logging

lock — set to acquired in WL mode

```
synchronized(lock){
   foo.a = x;
   foo.b = y;
   foo.c = z;
   foo.a = w;
   if(foo.b+4 > foo.a)
      ...
}  Commit
```



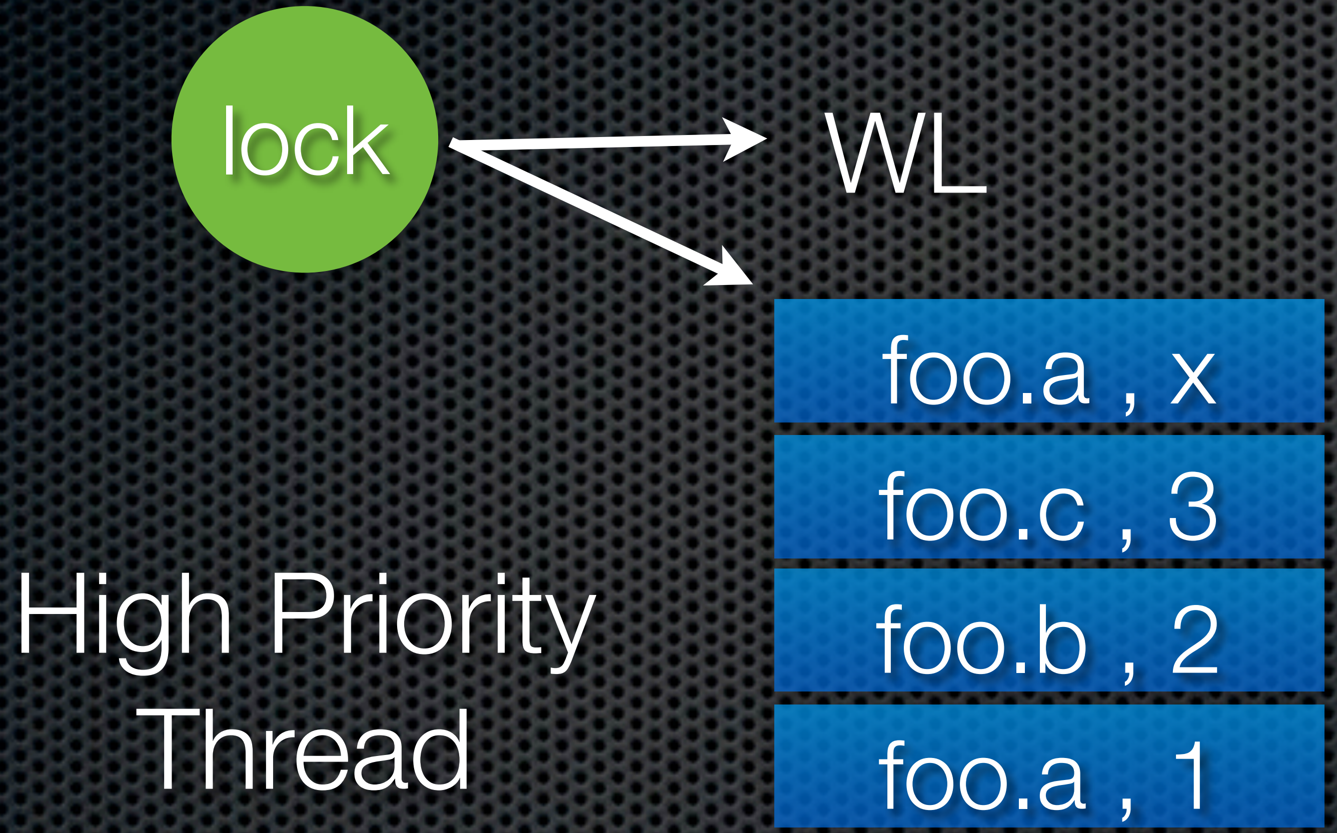
foo.a , x
foo.c , 3
foo.b , 2
foo.a , 1

Log

Main Memory
foo.a
foo.b
foo.c

Acquisition by higher priority thread

Main Memory



lock

WL

foo.a , x

foo.c , 3

foo.b , 2

foo.a , 1

High Priority Thread

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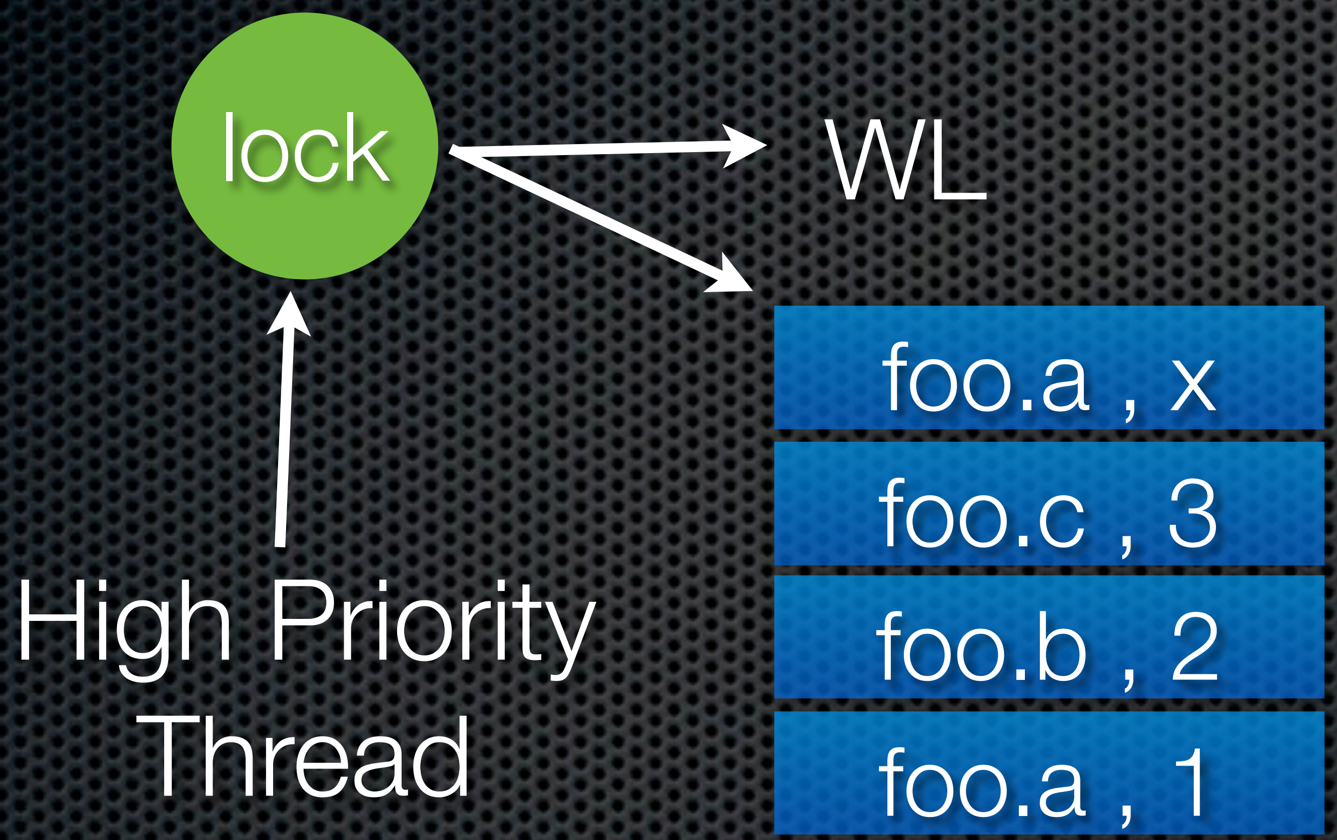
Acquisition by higher priority thread

Main Memory



lock

WL

High Priority Thread

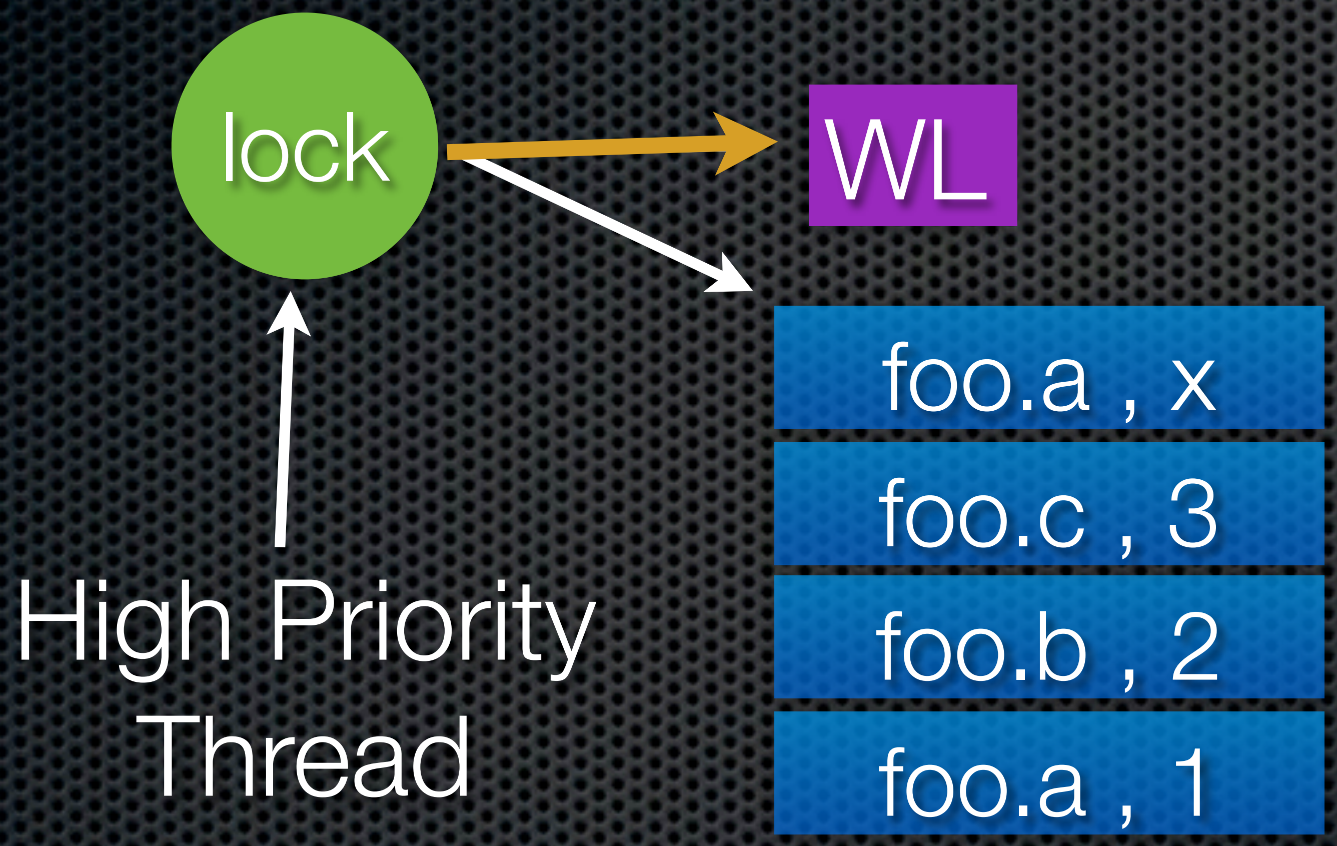
foo.a , x

foo.c , 3

foo.b , 2

foo.a , 1

Acquisition by higher priority thread



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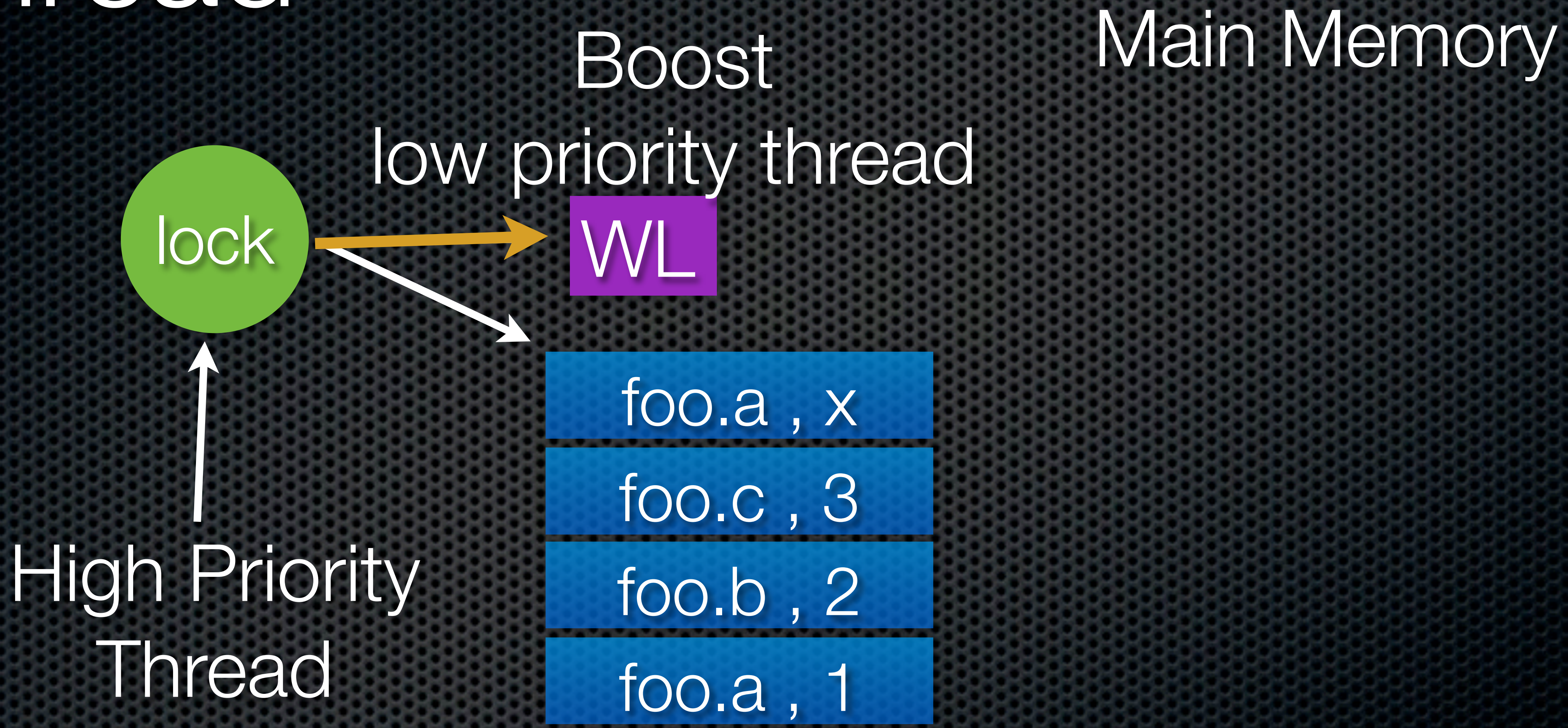
Acquisition by higher priority thread



Boost

low priority thread

Main Memory

lock

WL

foo.a , x

foo.c , 3

foo.b , 2

foo.a , 1

High Priority Thread

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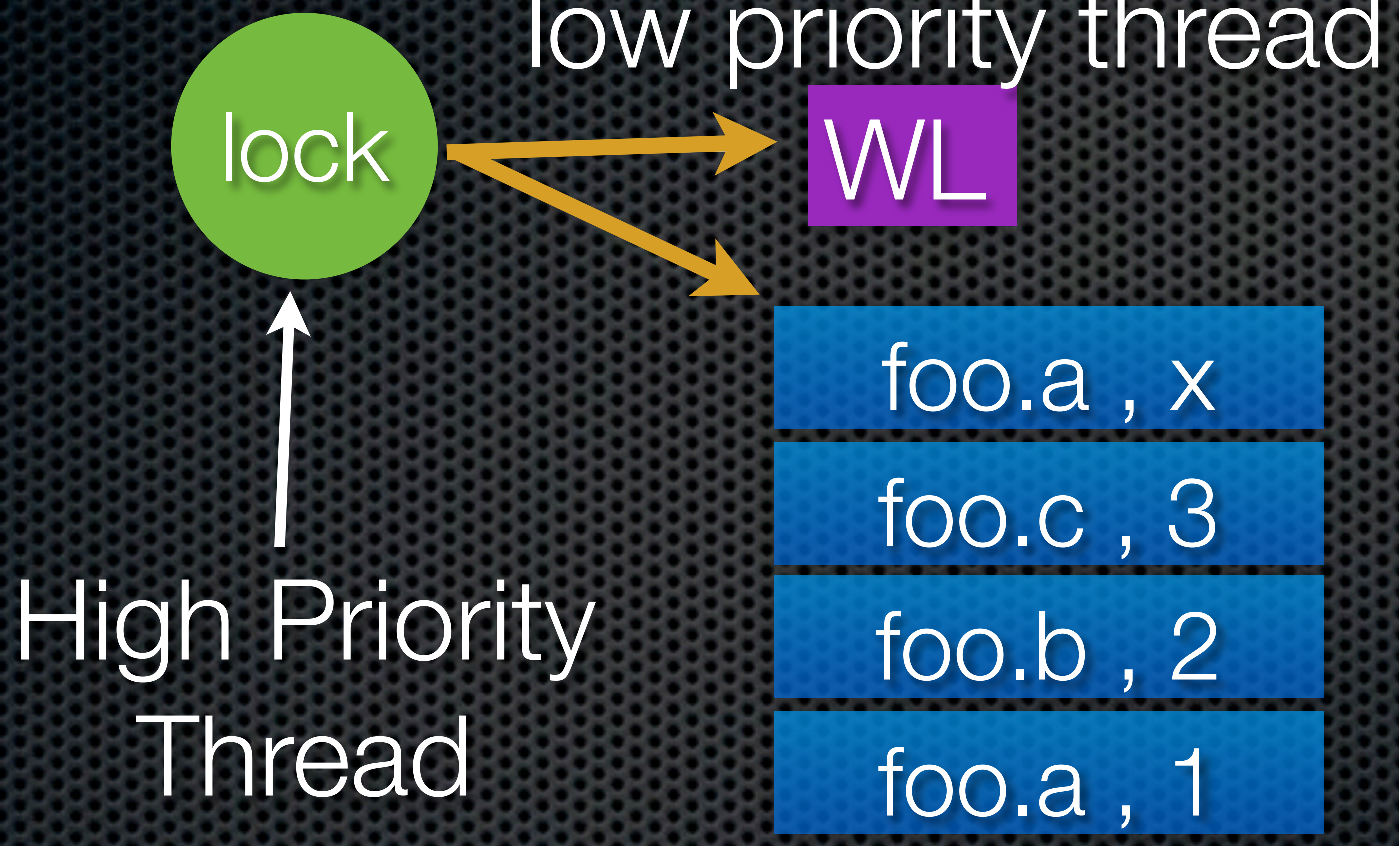
Acquisition by higher priority thread

Main Memory

Boost
low priority thread



lock

WL

foo.a , x

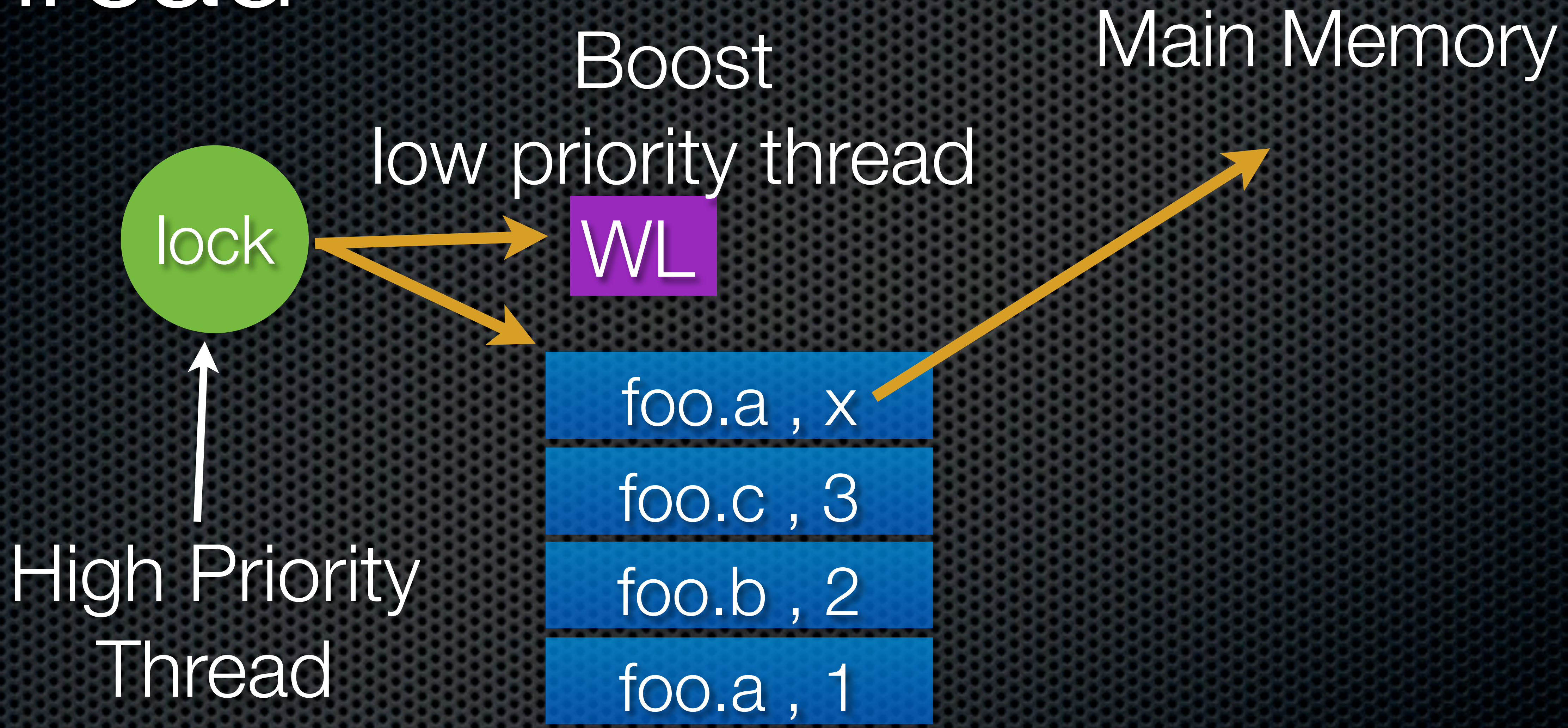
foo.c , 3

foo.b , 2

foo.a , 1

High Priority Thread

Acquisition by higher priority thread



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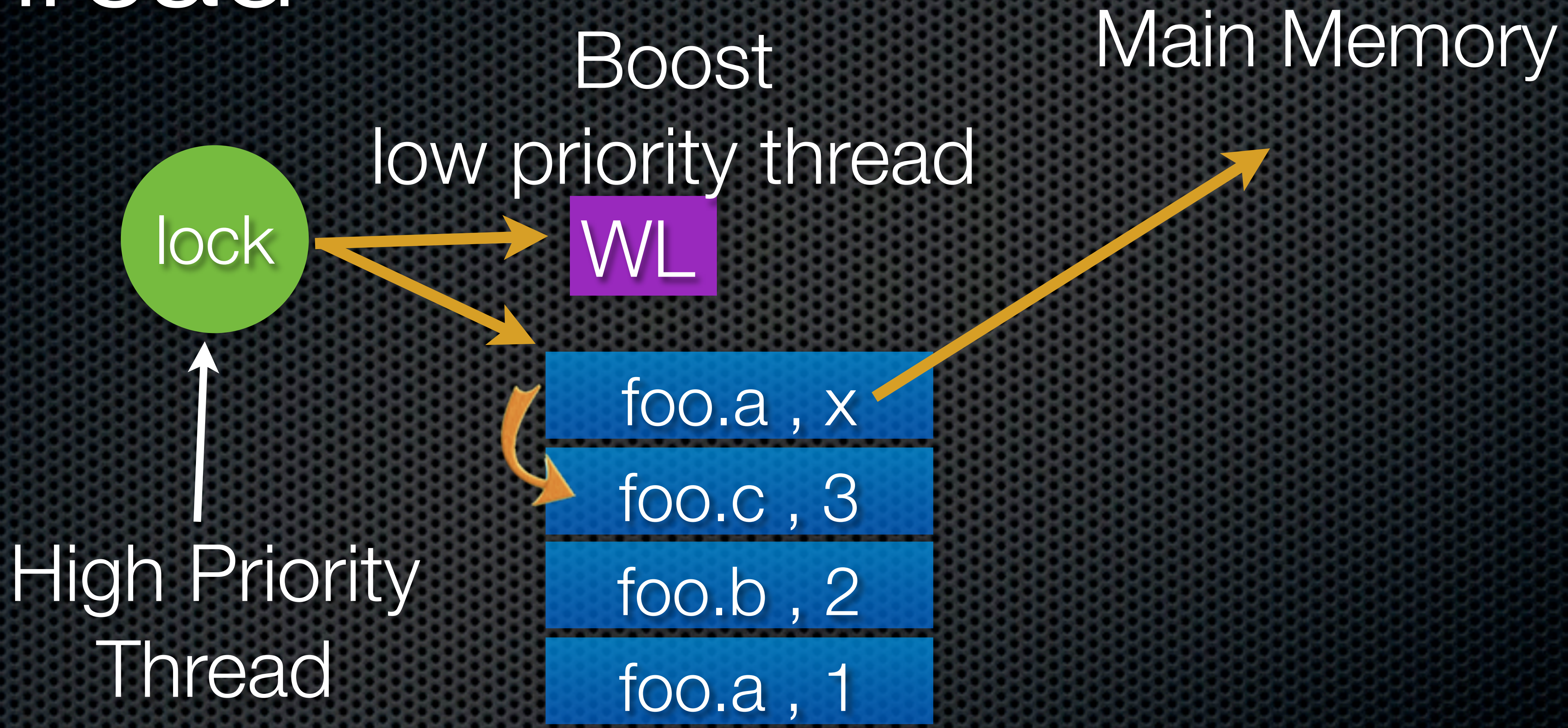
Acquisition by higher priority thread



Boost

low priority thread

Main Memory

lock

WL

foo.a , x

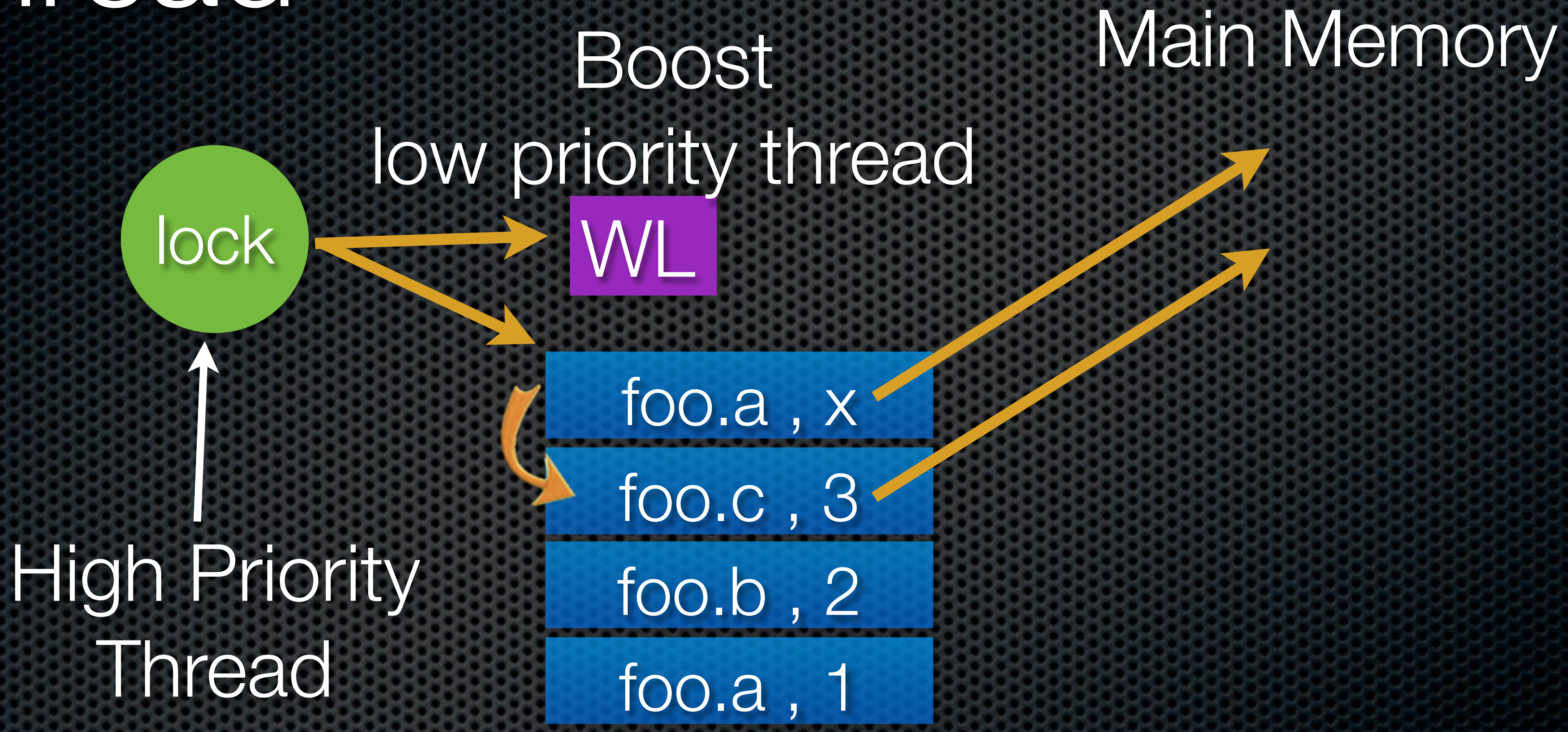
foo.c , 3

foo.b , 2

foo.a , 1

High Priority Thread

Acquisition by higher priority thread



Boost
low priority thread

Main Memory

lock

WL

foo.a , x

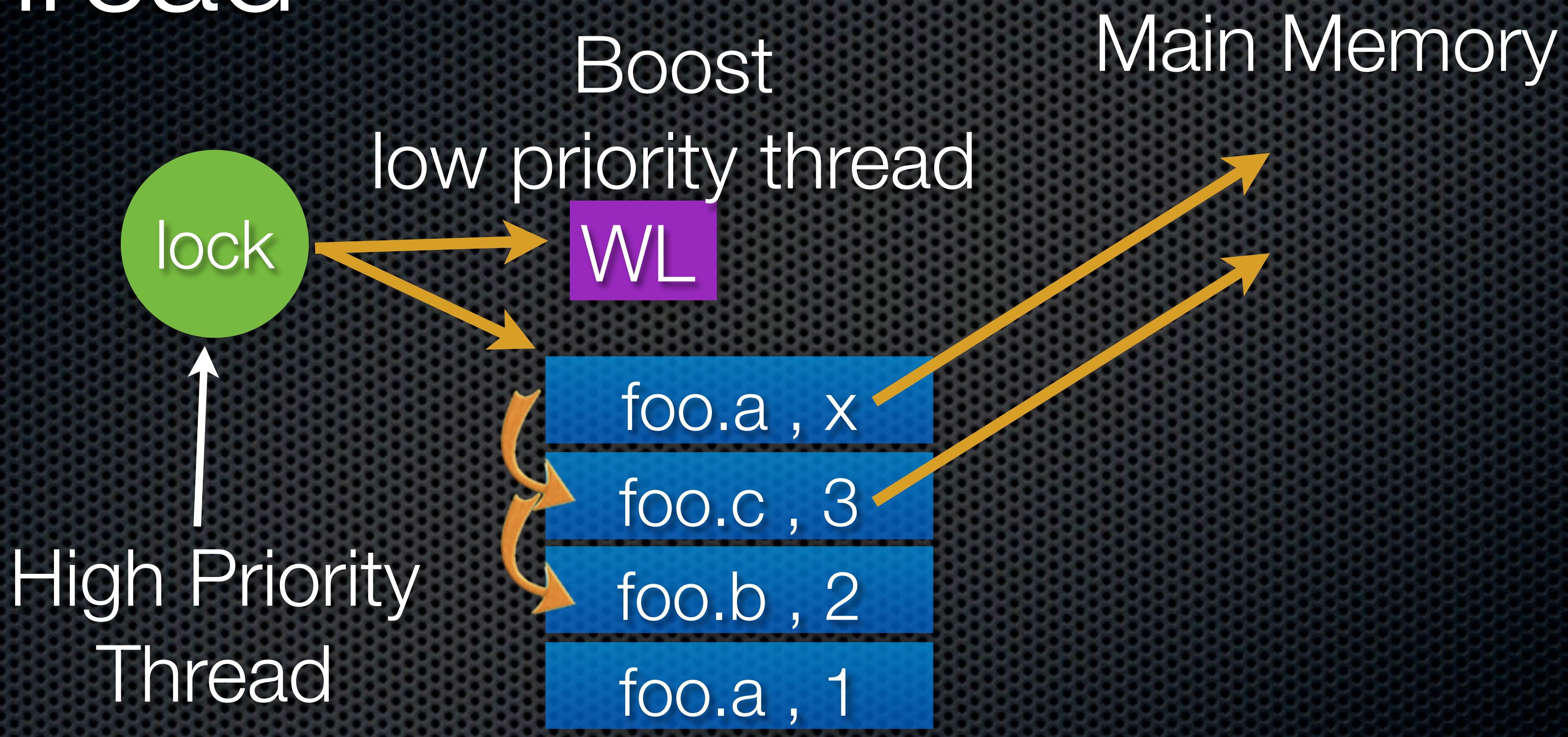
foo.c , 3

foo.b , 2

foo.a , 1

High Priority
Thread

Acquisition by higher priority thread



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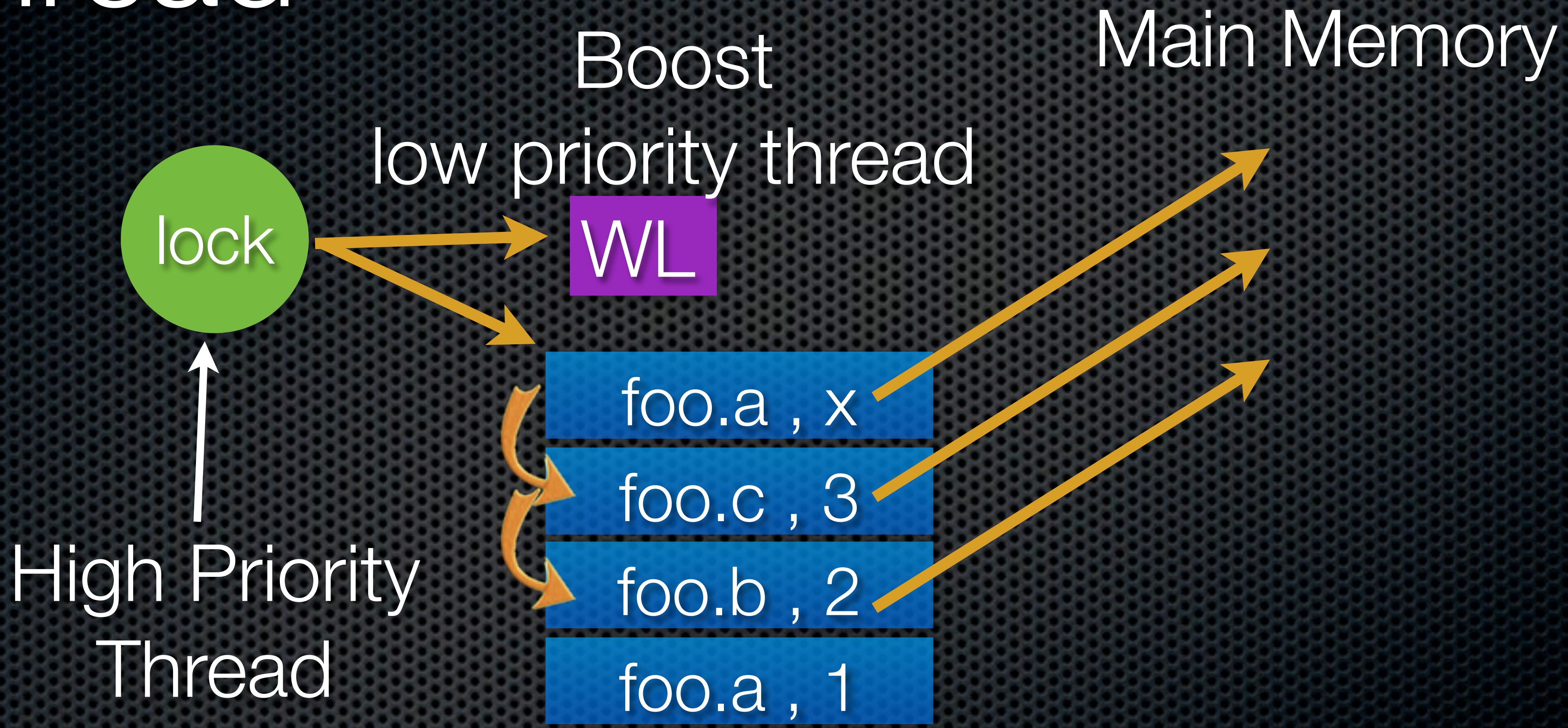
Acquisition by higher priority thread



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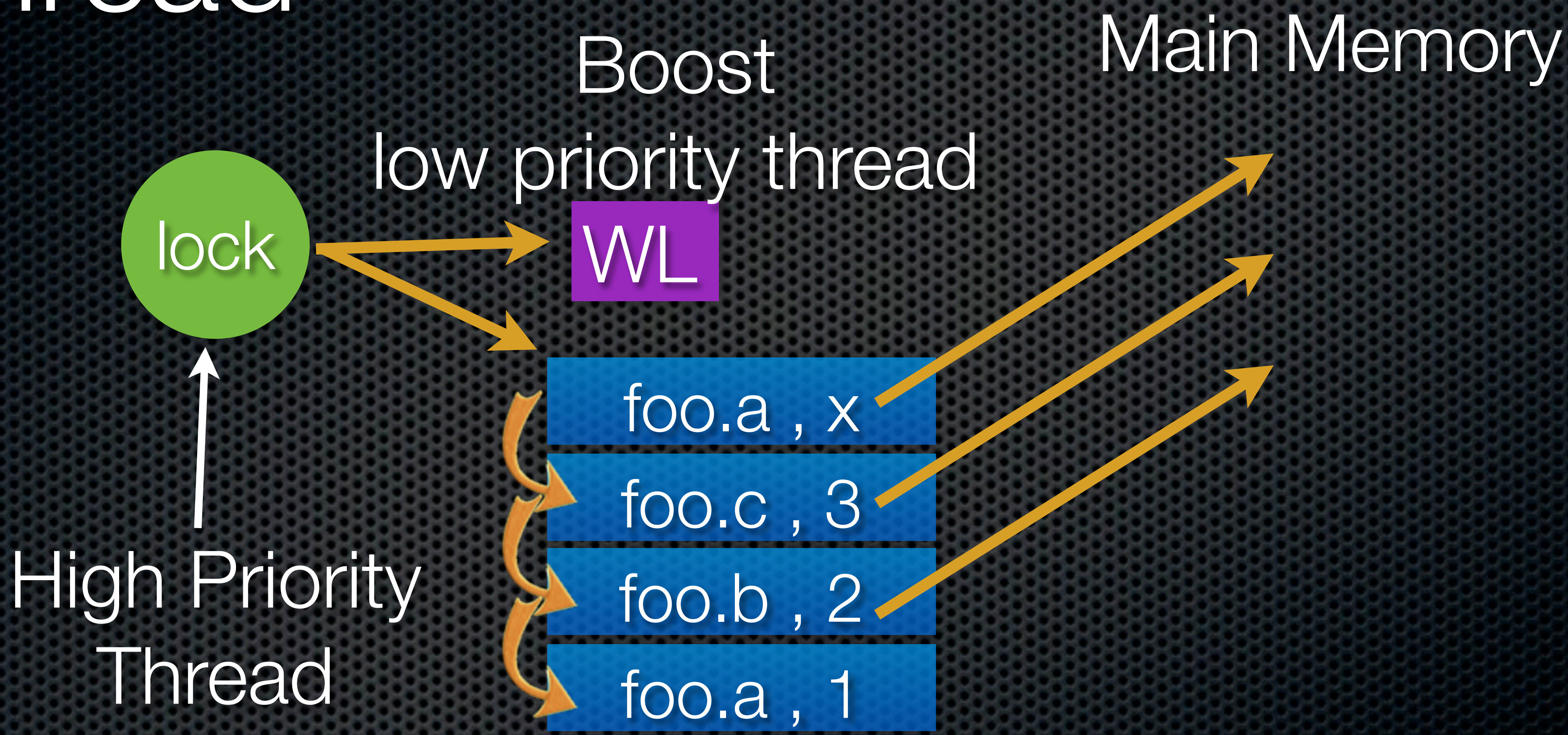
Acquisition by higher priority thread



Boost

low priority thread

Main Memory

lock

WL

foo.a , x

foo.c , 3

foo.b , 2

foo.a , 1

High Priority Thread

Fiji

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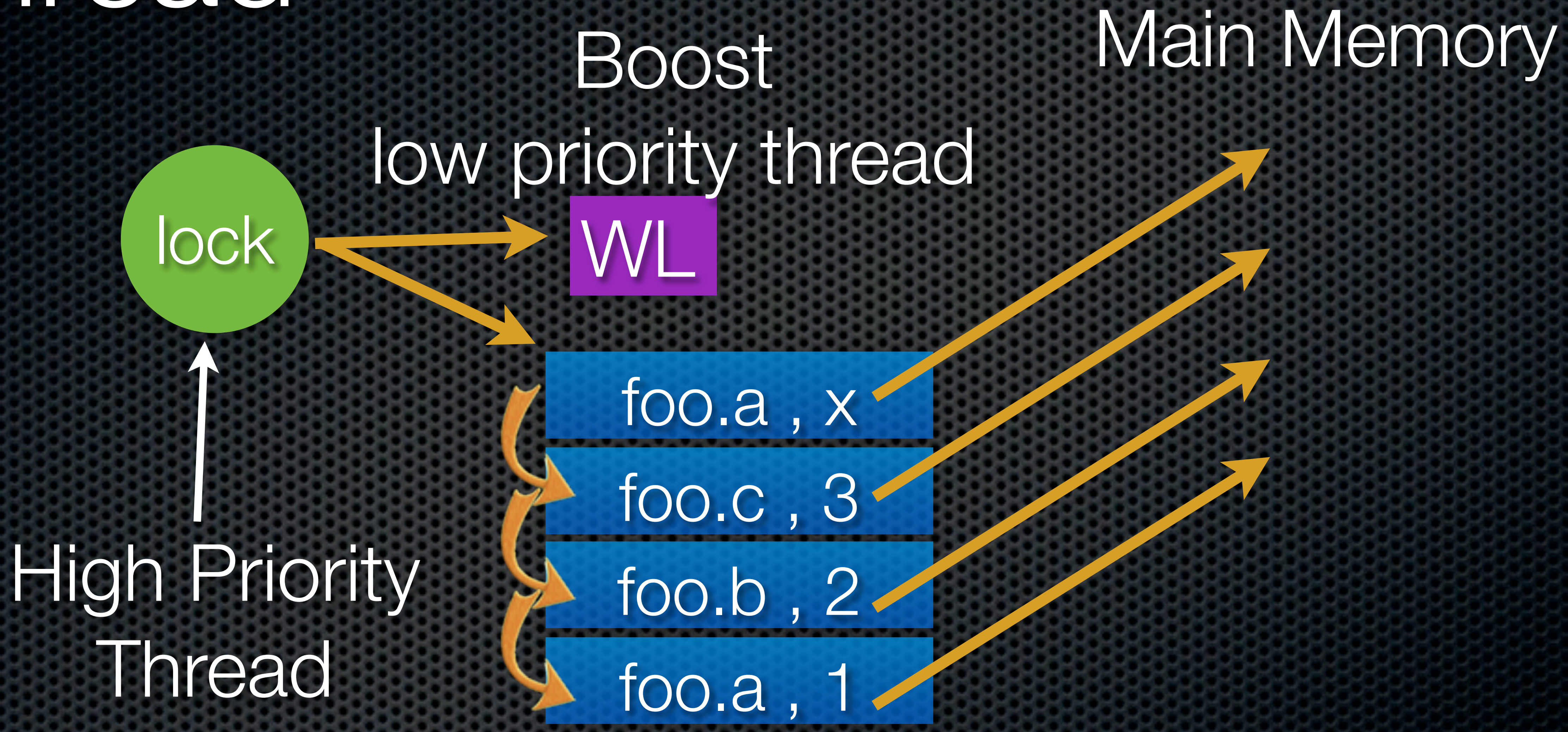
Acquisition by higher priority thread



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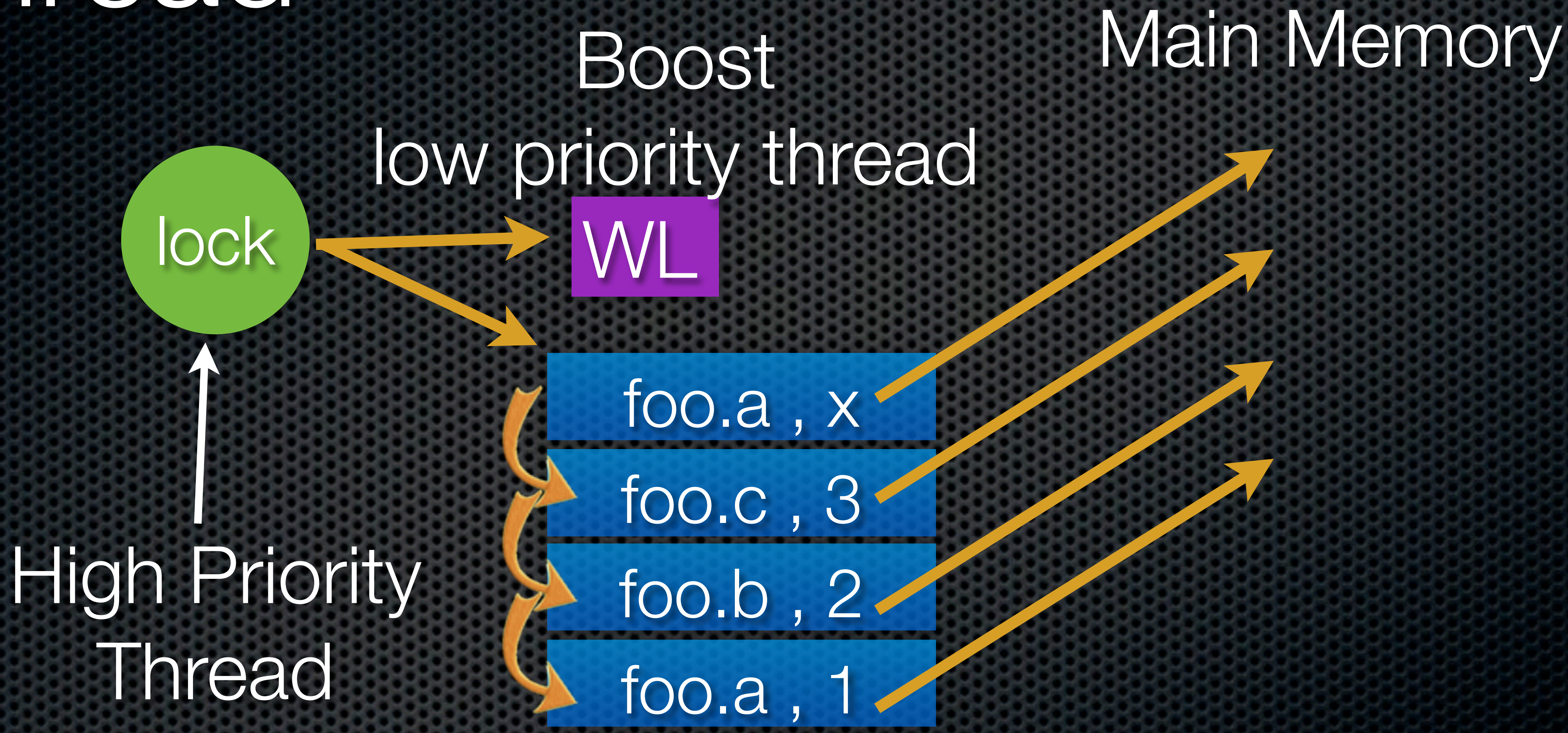
Wednesday, August 18, 2010

Acquisition by higher priority thread



Boost

low priority thread

Main Memory

lock

WL

foo.a , x

foo.c , 3

foo.b , 2

foo.a , 1

High Priority Thread

High Priority Thread Acquires Lock

Complexity Costs - Write Logging Low Priority Thread

- Reads: constant
- Writes: read + log(size of write log)
- Commit: constant
- Acquisition: size of write log + context switches
- Memory: size of write log

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Questions?

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