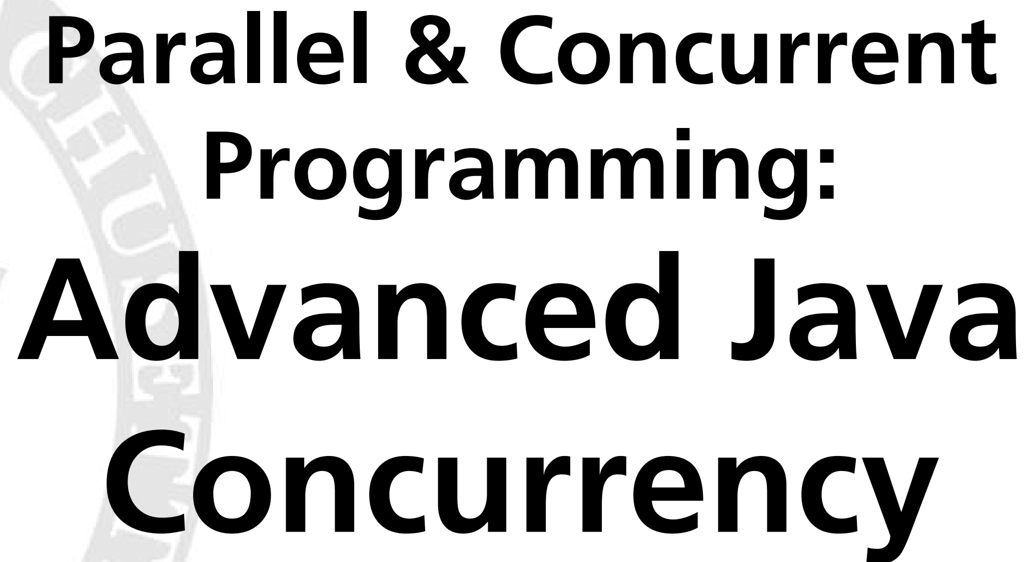

Parallel & Concurrent Programming:

Advanced Java Concurrency

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CMPSCI 691W - Spring 2006

Outline

- Last time:
  - Built-in Java concurrency
    - **`Thread`, `synchronized`, `wait()`, `notify()`…**
  - New in **`java.util.concurrent`**
    - Semaphores
    - Blocking queues, barriers, futures
- Today:
  - Lock "improvements"
  - **Non-blocking** operations
  - **`java.nio`** library

Problems with Locks

- No way to
  - *Try* to acquire lock
  - Give up after timeout
  - Use reader/writer locking
- Locks always reentrant
- Access control:
  - Any method can call **`synchronized(obj)`**
- Only block-structured locking
- Locks may *block*

New Lock classes

- `java.util.concurrent.locks`
  - Familiar Lock interface
    - `lock(), unlock()`
    - `tryLock()`
    - `tryLock(time, unit)`
  - `ReentrantLock`
  - `ReentrantReadWriteLock`
- Support for rolling your own
  - `Condition`

Locks & Conditions

```
class BoundedBuffer {
  final Lock lock =
   new ReentrantLock();
  final Condition notFull =
   lock.newCondition();
  final Condition notEmpty =
   lock.newCondition();

 public void put (Object x)
  throws InterruptedException {
   lock.lock();
   try {
     while (count == items.length)
       notFull.await();
     items[putptr] = x;
     if (++putptr == items.length)
       putptr = 0;
     ++count;
     notEmpty.signal();
  } finally { lock.unlock(); }
}
```

```
public Object take()
 throws InterruptedException {
  lock.lock();
  try {
    while (count == 0)
      notEmpty.await();
    Object x = items[takeptr];
    if (++takeptr == items.length)
      takeptr = 0;
    --count;
    notFull.signal();
    return x;
  } finally { lock.unlock(); } }
}
```

Non-blocking Atomics

- Locks can *block* ⇒
  - Priority inversion
  - Can wait unbounded time till success
  - Deadlock, relatively slow, **convoying**
- **`java.util.concurrent.atomic`**
  - Provides access to hardware-level *atomic operations*
  - Building blocks for **non-blocking** data structures

Non-blocking Atomics

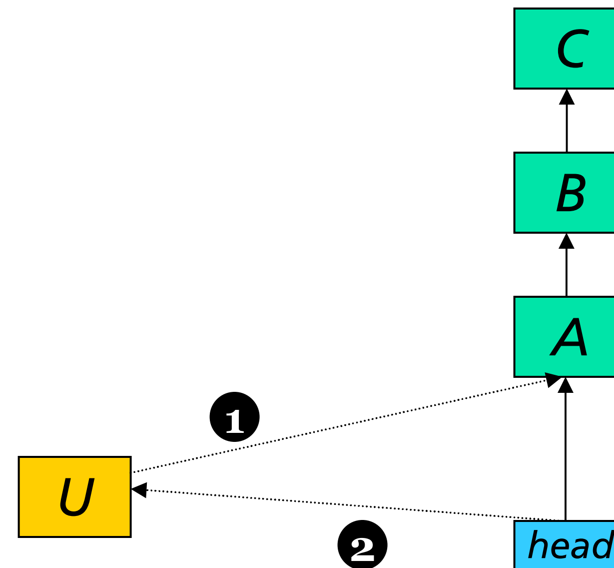
- **`AtomicInteger`**
  - **`set(int)`**
  - **`get()`**
  - **`addAndGet(int), incrementAndGet()`**
  - **`getAndAdd(int), getAndIncrement()`**
  - **`compareAndSet(expected,update)`**
    - Atomically sets value to updated value iff current value == expected value
    - True iff successful
- No locks used on most platforms

Non-blocking Atomics

- `AtomicReference<V>`
  - `set(V newValue)`
  - `get()`
  - `compareAndSet(expected,update)`
  - `getAndSet(newValue)`
    - Returns old value

Non-blocking stack

- push (N)
  - h = Head; N->next = h
  - Repeat until
    CAS(Head, h, N)
- pop:
  - h = Head;
    next = h->next
  - Repeat until
    CAS(head, h, next)
  - Return h
- But: **ABA problem**



Non-blocking stack

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C

B

A

next *h* *head*

Non-blocking stack

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  - h = Head; N->next = h
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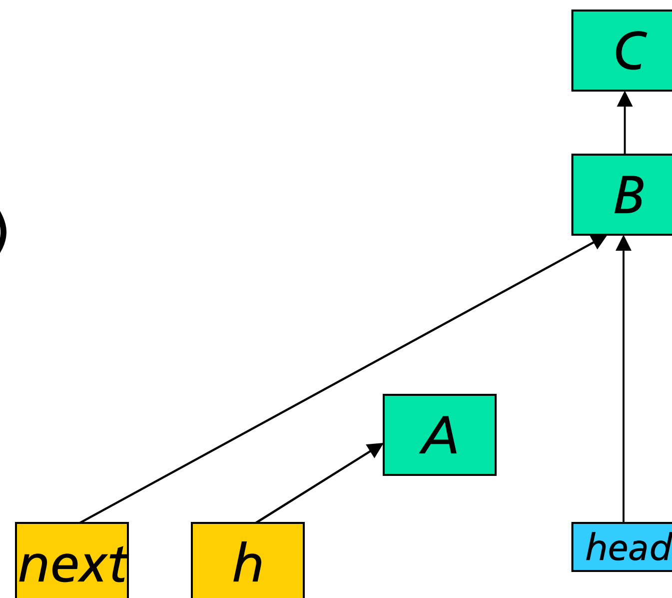

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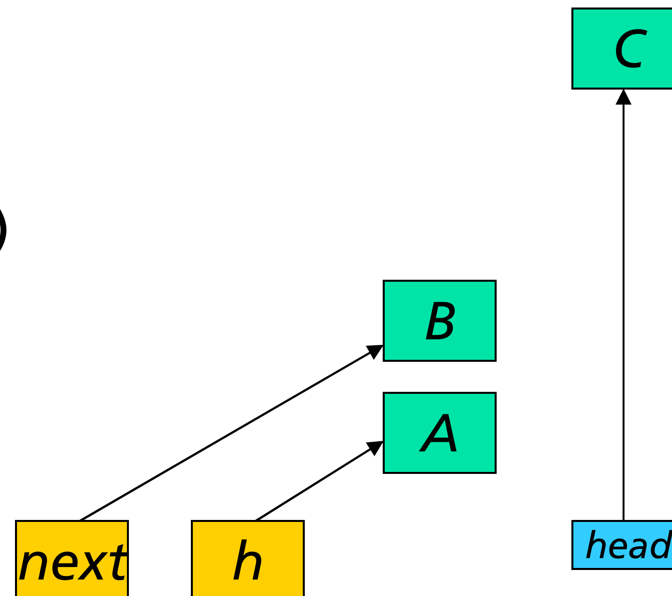

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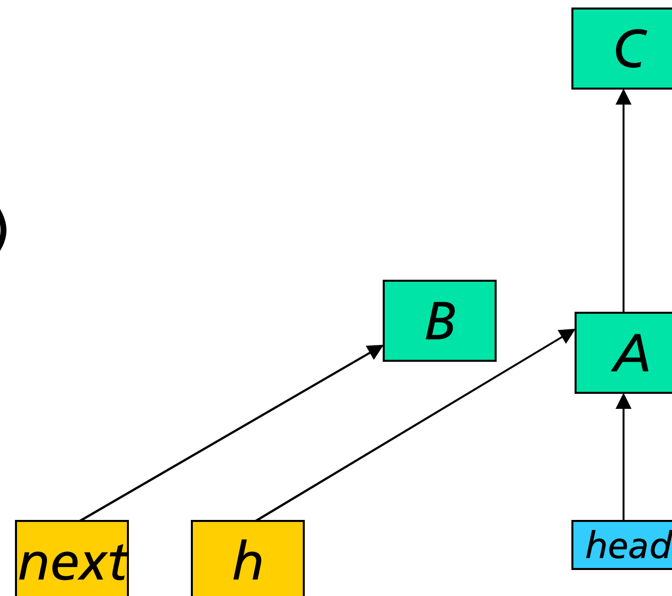
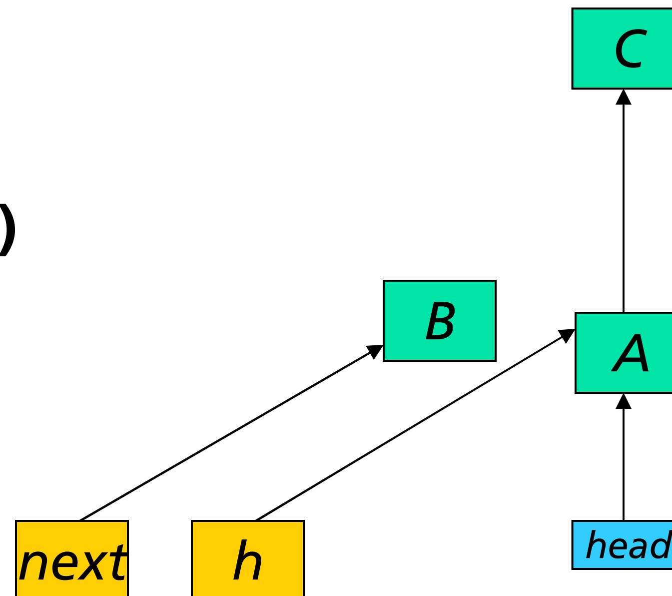


Non-blocking stack

- push (N)
  - h = Head; N->next = h
  - Repeat until CAS(Head, h, N)
- pop:
  - h = Head; next = h->next
  - Repeat until **CAS(head, h, next)**
  - Return h
- But: **ABA problem**



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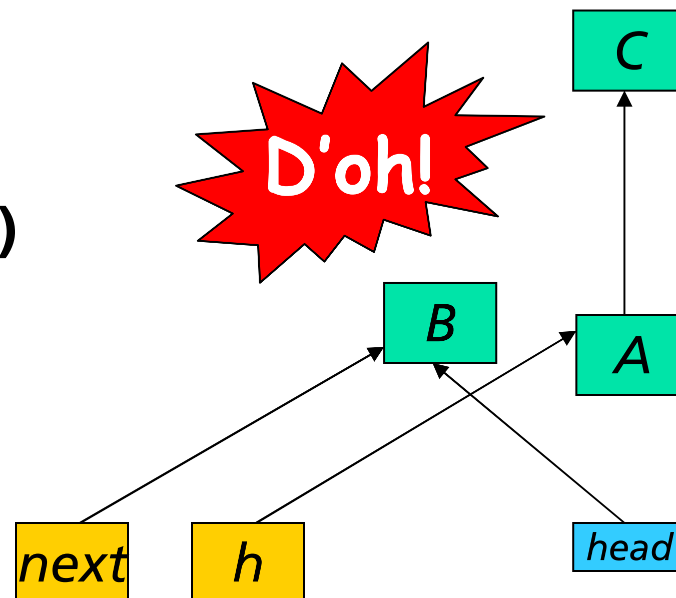
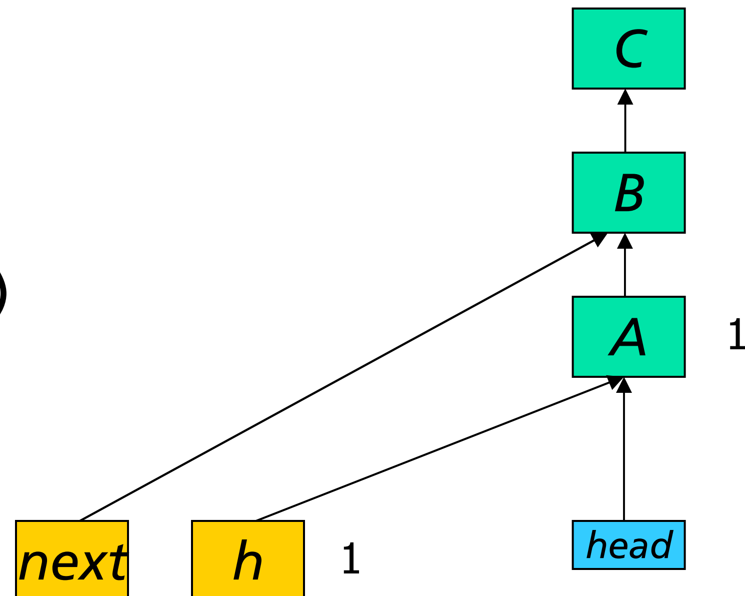


Versioning

- One solution – use **tags**
  - Associate **version number** with refs
- **`AtomicStampedReference<V>`**
  - **`set(V newReference, int newStamp)`**
  - **`get(stampHolder)`**
  - **`compareAndSet(expectedRef, newRef, expectedStamp, newStamp)`**
- Non-blocking only on supporting architectures
  - x86, but not 64-bit

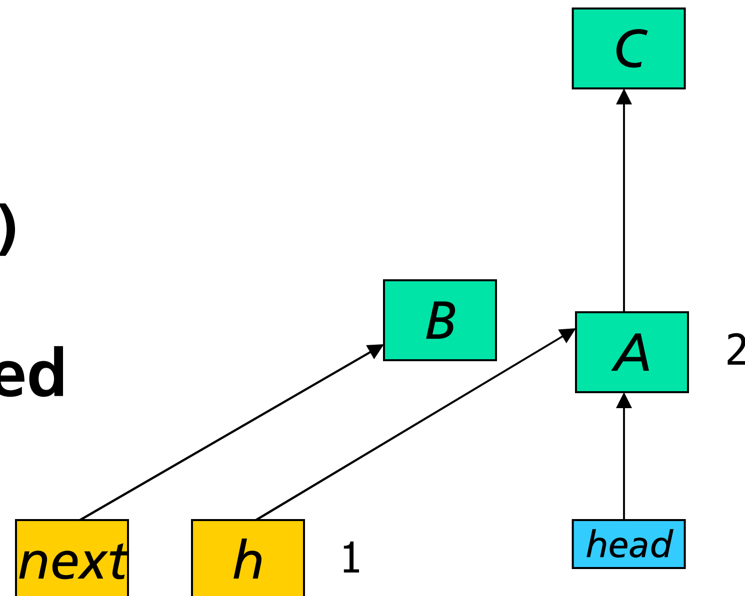
Non-blocking stack

- push (N)
  - h = Head; N->next = h
  - Repeat until CAS(Head, h, N)
- pop:
  - **h = Head; next = h->next**
  - Repeat until CAS(head, h, next)
  - Return h



Non-blocking stack

- push (N)
  - h = Head; N->next = h
  - Repeat until CAS(Head, h, N)
- pop:
  - h = Head; next = h->next
  - Repeat until **CAS(head, h, next)**
  - Return h
- **ABA problem solved**



java.nio

- Java (as of 1.4) supports **non-blocking I/O** and other low-level I/O
  - Memory mapped byte buffers
  - Channels
  - Pipes
  - Selectors

java.nio

- **Memory-mapped buffers**
  - Array mapped to file on disk
    - Uses virtual memory operations
  - Access to buffer in memory = file operation
- *Much* faster than direct calls to file I/O
  - Why?

java.nio

- **Selector**
  - Essentially same notion as **`select()`**
  - Add any channels of interest and start I/O operations
    - Must have configured as non-blocking: **`sc.configureBlocking (false)`**
  - Returns iterator to channels ready for I/O operations

The End

- **No class next week**
- Homework due Feb 27
- Next time(s):
  server architectures, SEDA, Flux
  - Read SEDA & Flux papers