Department of Computer Science
UNIVERSITY OF COLORADO BOULDER

Design and Analysis of Operating Systems CSCI 3753

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These slides adapted from materials provided by the textbook authors.


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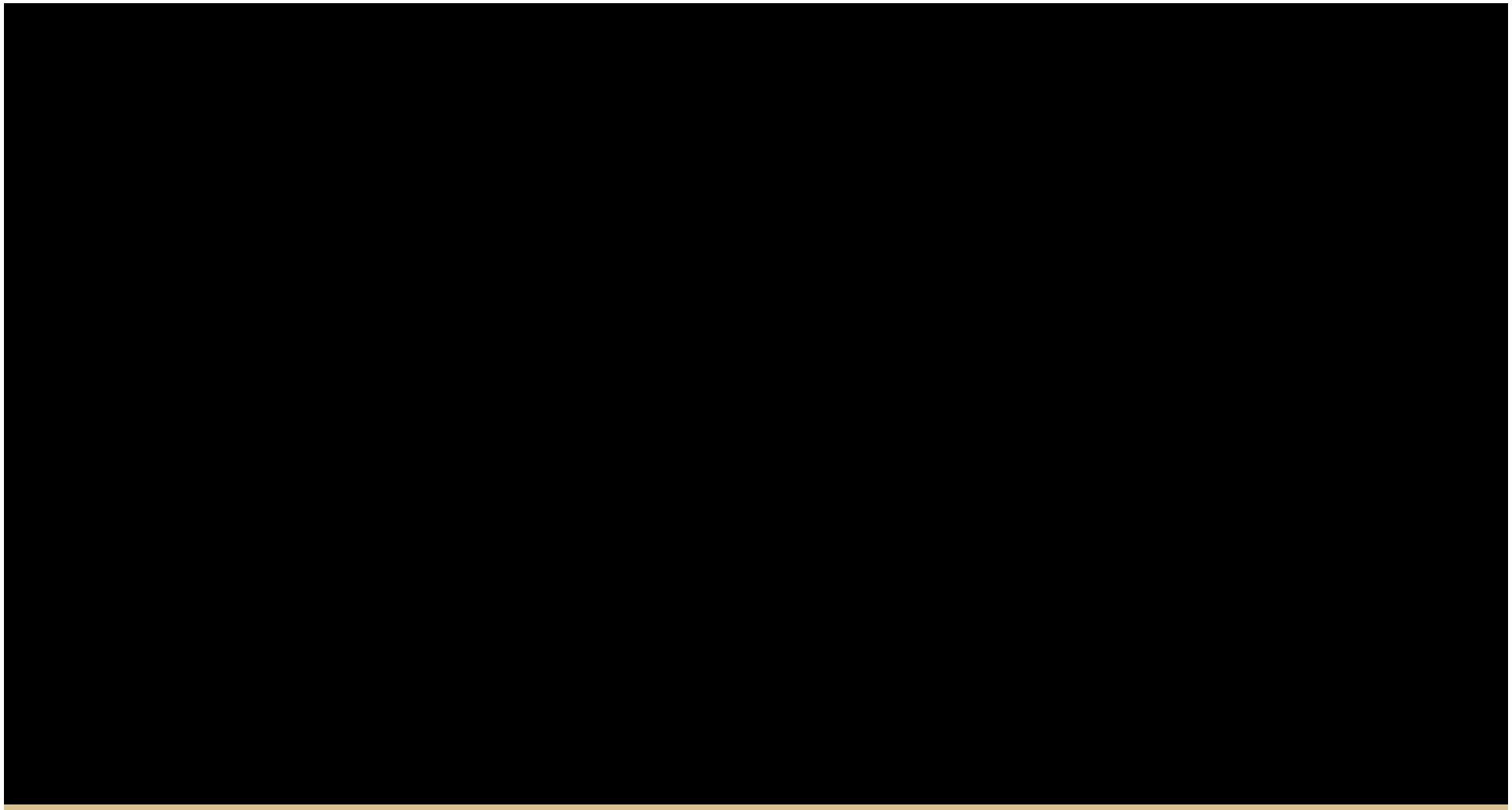
Classical Problems of Synchronization

- Bounded-Buffer Problem
- Readers and Writers Problem
- Dining-Philosophers Problem



Reader/Writer Problem

- *N* tasks want to write to a shared file
- *M* different tasks want to read from same shared file
- Must synchronize access
- Condition 1: a writer must have exclusive access
- Condition 2: Readers can share access with other readers

Reader/Writer problem is similar, but different, to Bounded Buffer problem

	Reader / Writer	Bounded Buffer
# tasks	*M* readers *N* writers	1 or more producers, 1 or more consumers
Amount of data	One shared data object	*D* data objects stored in a shared buffer
Exclusion	A writer must exclude all other writer and readers A reader allows other readers, but excludes writers	Any producer excludes all other tasks Any consumer excludes all other tasks

Modified Conditions

- Condition 1: a writer must have exclusive access
- Condition 2: Readers can share access with other readers
  - No reader is denied access unless a writer has control
  - A writer cannot be kept waiting indefinitely by readers arriving after the writer

- **Problem**:
  first reader grabs lock, preventing other readers & writers
- Solution:
  only the first reader will grab the lock, and the last reader will release the lock
- **Problem**:
  readcount++ and *readcount–* lead to race conditions
- Solution:
  surround access to *readcount* with a mutex

- **Problem**:

  This solution could starve pending writers

Current solution gives precedence to readers

- new readers can keep arriving while any one reader holds the write lock, the writer can starve waiting until the last reader is finished

Add another mutex and counter

- Instead, allow a pending writer to block future reads
- Once first writer grabs readBlock,
  - any number of writers can come through while the first reader is blocked on readBlock
  - and subsequent readers are blocked on writePending
  - So, behavior is that a writer can block not just new readers, but also some earlier readers
  - Note now that readers can be starved!

```
int readCount = 0, writeCount = 0;
semaphore mutex = 1, mutex2 = 1;
semaphore readBlock = 1, writeBlock =
1,
          writePending = 1;

writer() {
  while(TRUE) {

    P(mutex2);
      writeCount++;
      if(writeCount == 1)
        P(readBlock);
    V(mutex2);

    P(writeBlock);
      // writing
    V(writeBlock);

    P(mutex2)
      writeCount--;
      if(writeCount == 0)
        V(readBlock);
    V(mutex2);
  }
}
```

```
reader() {
  while(TRUE) {

    P(writePending);
      P(readBlock);
        P(mutex1);
          readCount++;
          if(readCount == 1)
            P(writeBlock);
        V(mutex1);
      V(readBlock);
    V(writePending);

     // reading

    P(mutex1);
      readCount--;
      if(readCount == 0)
        V(writeBlock);
    V(mutex1);
  }
}
```

- We can simplify the algorithm
- This is starvation-free solution

Modified Conditions

- Condition 1: a writer must have exclusive access
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  - A writer cannot be kept waiting indefinitely by readers arriving after the writer

Starvation free solution

```
Semaphore writeblock=1, mutex=1, readblock=1
int readcount = 0
```

Writer:

```
while(1) {
  wait(readblock)
    wait(writeblock);
      // writing
    signal(writeblock);
  signal(readblock)
}
```

Reader:

```
while(1) {
    wait(readblock)
      wait(mutex)
      readcount++;
      if (readcount==1)
         wait(writeblock);
      signal(mutex)
    signal(readblock)

       // reading

    wait(mutex)
    readcount--;
    if (readcount==0)
       signal(writeblock);
    signal(mutex)
}
```

Modified Conditions

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