Semaphores

- Learning Objectives
  - Explain the pt61_sem implementation.
  - Solve synchronization problems using semaphores.

Primitives of Primitives

- It turns out that once you have a good synchronization primitive, you can often build other primitives out of them.
- Example:
  - Processors give you a few atomic instructions and you build a collection of primitives on top of those instructions.
  - Pthreads gives us condition variables and mutexes (and read-write locks), but no semaphores, so today we're going to build them!
  - We could build read/write locks ourselves too if we wanted to.

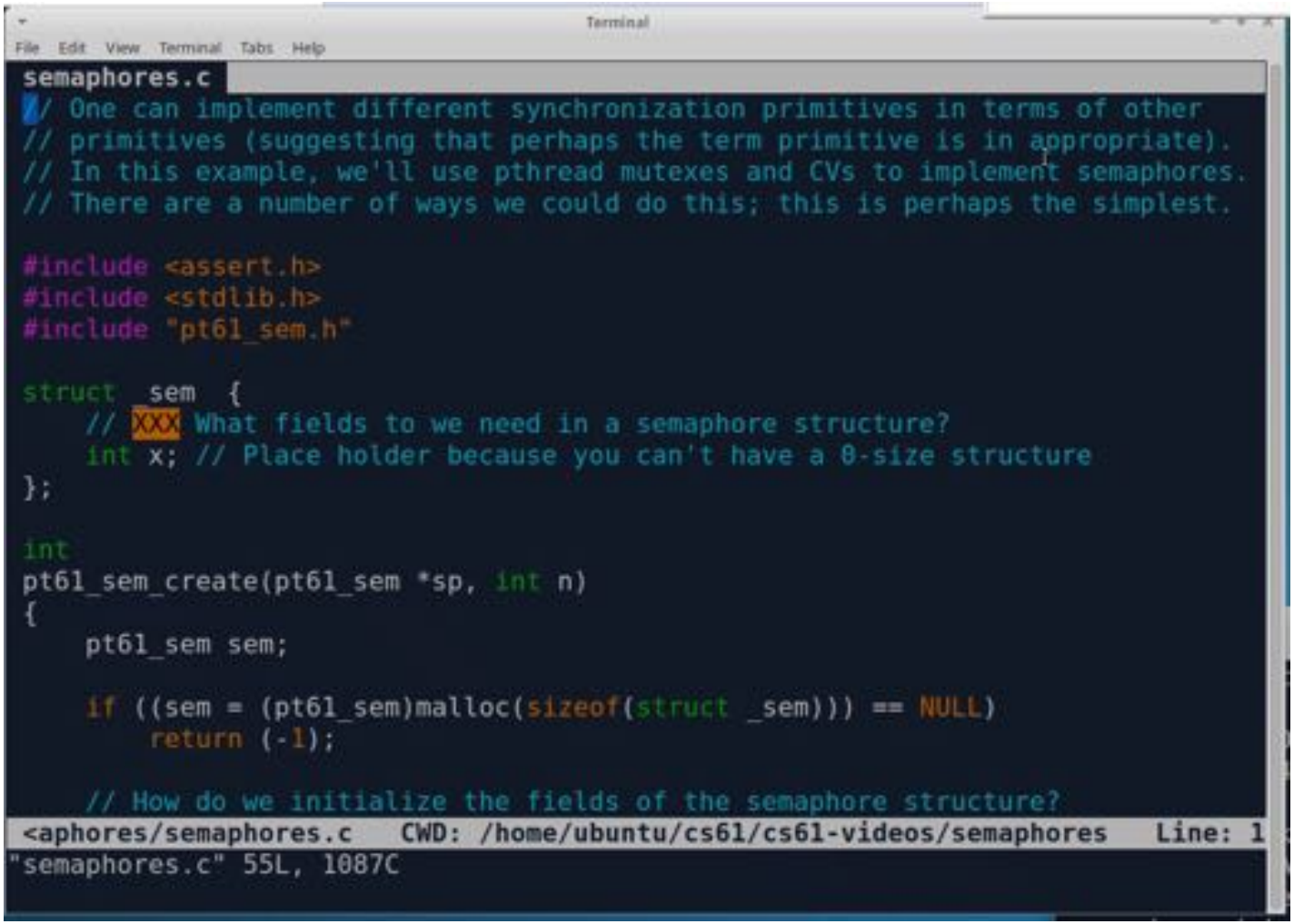
Semaphore API

- We'll define a new set of routines (pthread + cs61 semaphores):
- Declarations are in `pt61_sem.h`:

```
typedef struct _sem *pt61_sem;

int pt61_sem_create(pt61_sem *, int);
void pt61_sem_destroy(pt61_sem);

void pt61_sem_P(pt61_sem);
void pt61_sem_V(pt61_sem);
```


Terminal
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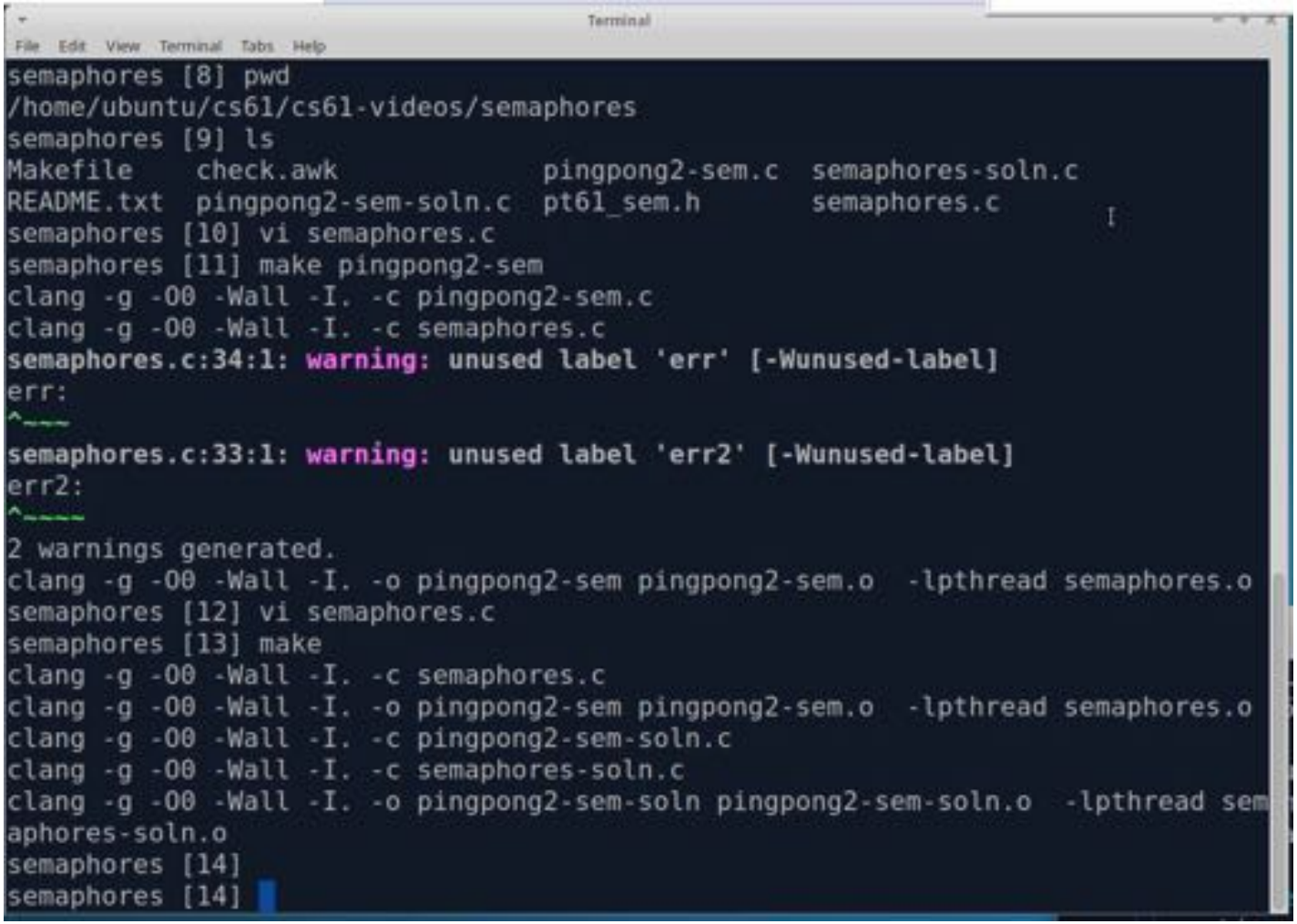
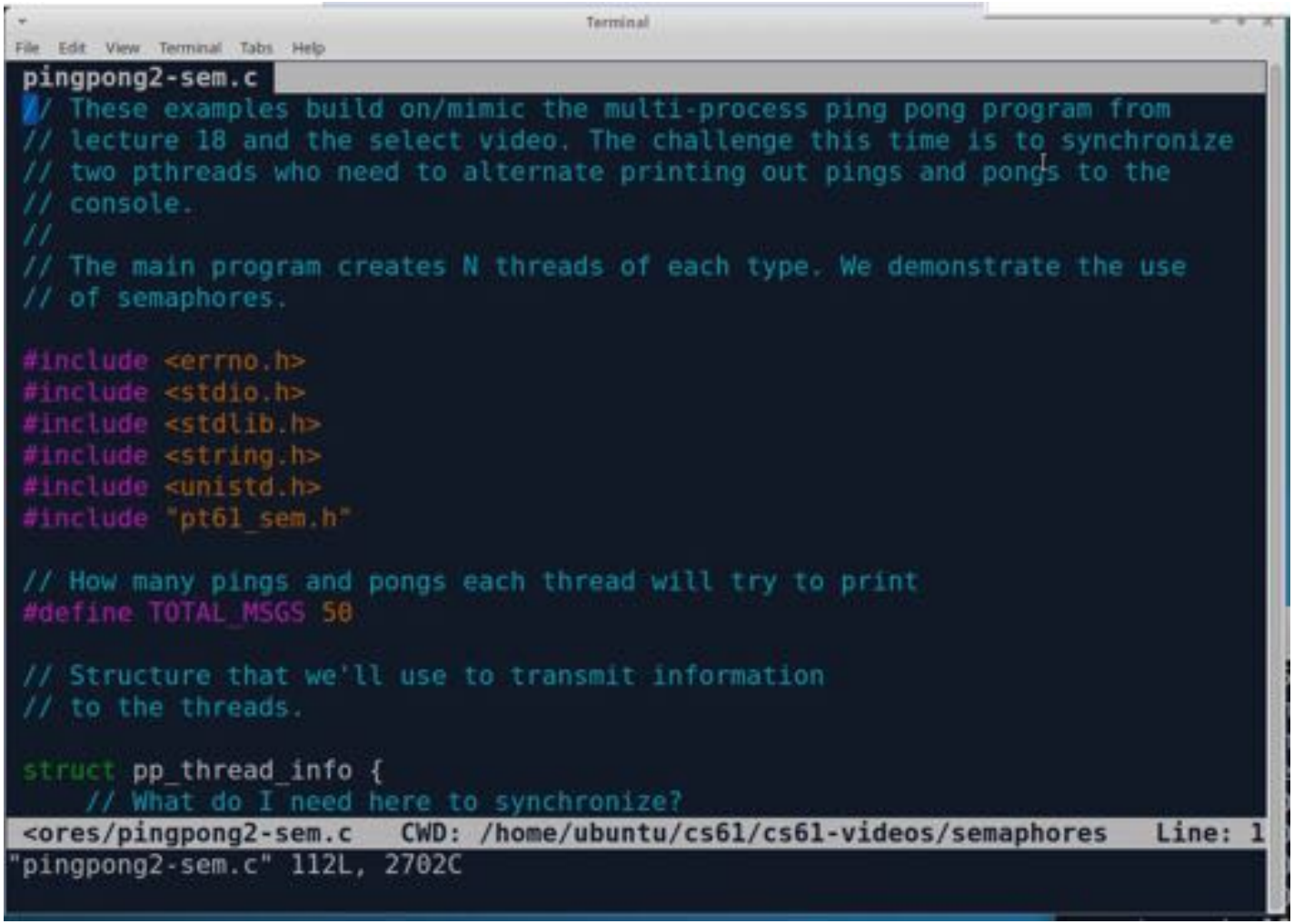
semaphores.c
// One can implement different synchronization primitives in terms of other
// primitives (suggesting that perhaps the term primitive is in appropriate).
// In this example, we'll use pthread mutexes and CVs to implement semaphores.
// There are a number of ways we could do this; this is perhaps the simplest.
#include <assert.h>
#include <stdlib.h>
#include "pt61_sem.h"
struct _sem {
// XXX What fields to we need in a semaphore structure?
int x; // Place holder because you can't have a 0-size structure
};
int
pt61_sem_create(pt61_sem *sp, int n)
{
pt61_sem sem;
if ((sem = (pt61_sem)malloc(sizeof(struct _sem))) == NULL)
return (-1);
// How do we initialize the fields of the semaphore structure?
<aphores/semaphores.c CWD: /home/ubuntu/cs61/cs61-videos/semaphores Line: 1
"semaphores.c" 55L, 1087C


Terminal
File Edit View Terminal Tabs Help
semaphores [8] pwd
/home/ubuntu/cs61/cs61-videos/semaphores
semaphores [9] ls
Makefile check.awk pingpong2-sem.c semaphores-soln.c
README.txt pingpong2-sem-soln.c pt61_sem.h semaphores.c
semaphores [10] vi semaphores.c
semaphores [11] make pingpong2-sem
clang -g -O0 -Wall -I. -c pingpong2-sem.c
clang -g -O0 -Wall -I. -c semaphores.c
semaphores.c:34:1: warning: unused label 'err' [-Wunused-label]
err:
^~~
semaphores.c:33:1: warning: unused label 'err2' [-Wunused-label]
err2:
^~~~
2 warnings generated.
clang -g -O0 -Wall -I. -o pingpong2-sem pingpong2-sem.o -lpthread semaphores.o
semaphores [12] vi semaphores.c
semaphores [13] make
clang -g -O0 -Wall -I. -c semaphores.c
clang -g -O0 -Wall -I. -o pingpong2-sem pingpong2-sem.o -lpthread semaphores.o
clang -g -O0 -Wall -I. -c pingpong2-sem-soln.c
clang -g -O0 -Wall -I. -c semaphores-soln.c
clang -g -O0 -Wall -I. -o pingpong2-sem-soln pingpong2-sem-soln.o -lpthread sem
aphores-soln.o
semaphores [14]
semaphores [14]

Ping Pong Returns

- We've solved the pingpong problem using:
  - Pipes
  - Locks
  - Condition Variables
- Why not solve it using CVs?
  - We starting here with a slightly fancier version that takes a value N and spawns that many pings and that many pongs.
  - All the infrastructure is set up for you.
  - All we need to do is:
    - Define the structure we pass to the threads
    - Write the code to initialize those structures
    - Write the thread function!


Terminal
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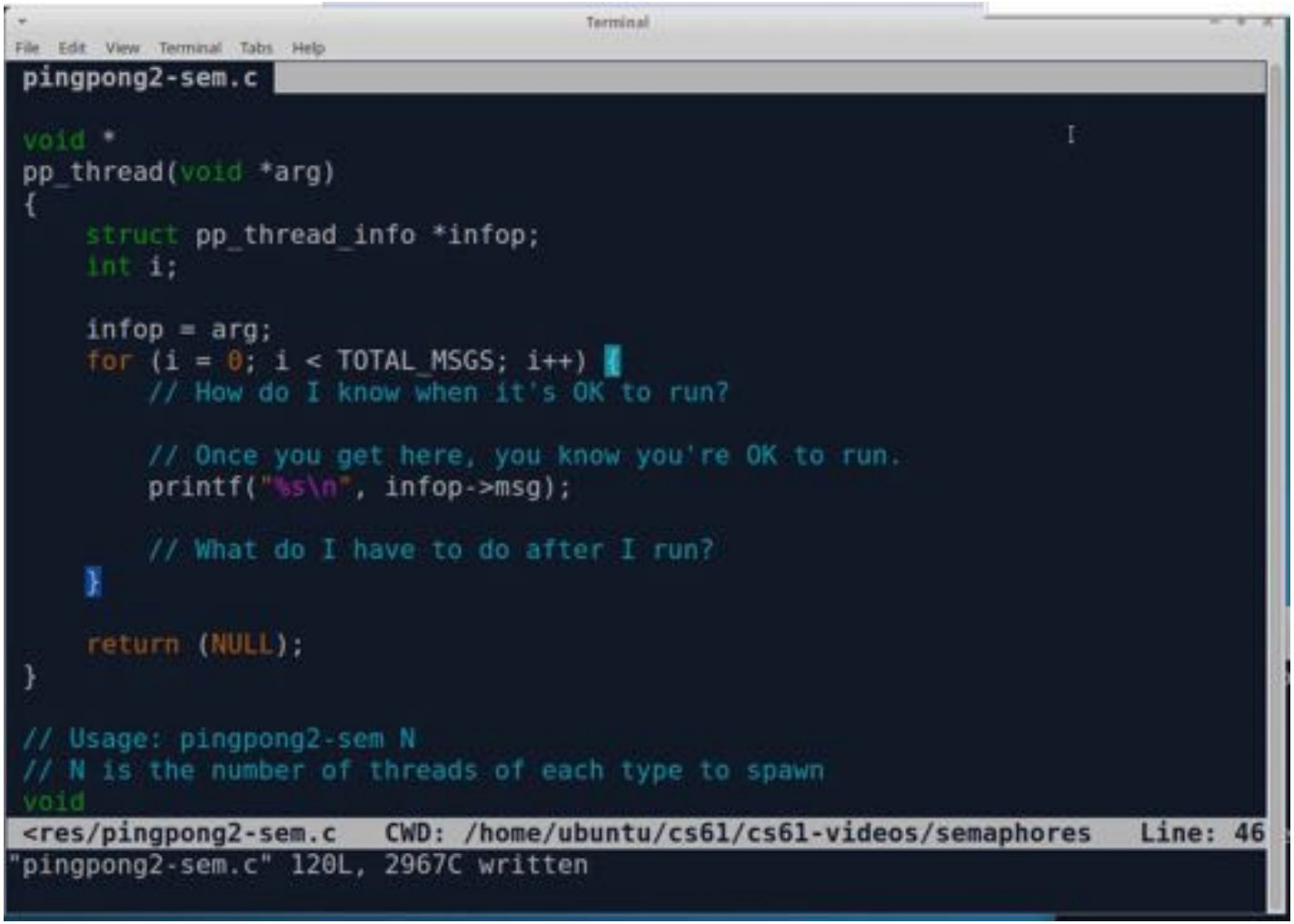
pingpong2-sem.c
// These examples build on/mimic the multi-process ping pong program from
// lecture 18 and the select video. The challenge this time is to synchronize
// two pthreads who need to alternate printing out pings and pongs to the
// console.
//
// The main program creates N threads of each type. We demonstrate the use
// of semaphores.
#include <errno.h>
#include <stdio.h>
#include <stdlib.h>
#include <string.h>
#include <unistd.h>
#include "pt61_sem.h"
// How many pings and pongs each thread will try to print
#define TOTAL_MSGS 50
// Structure that we'll use to transmit information
// to the threads.
struct pp_thread_info {
// What do I need here to synchronize?
<ores/pingpong2-sem.c CWD: /home/ubuntu/cs61/cs61-videos/semaphores Line: 1
"pingpong2-sem.c" 112L, 2702C


Terminal
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pingpong2-sem.c
void *
pp_thread(void *arg)
{
struct pp_thread_info *infop;
int i;
infop = arg;
for (i = 0; i < TOTAL_MSGS; i++) {
// How do I know when it's OK to run?
// Once you get here, you know you're OK to run.
printf("%s\n", infop->msg);
// What do I have to do after I run?
}
return (NULL);
}
// Usage: pingpong2-sem N
// N is the number of threads of each type to spawn
void
<res/pingpong2-sem.c CWD: /home/ubuntu/cs61/cs61-videos/semaphores Line: 46
"pingpong2-sem.c" 120L, 2967C written

Wrapping Up

- You can implement one synchronization primitive in terms of another.
- Writing properly synchronized code requires two pieces:
  - Think carefully about what you're trying to accomplish.
  - Pick the right primitive.