Concurrency and Processes of Pthreads

Pthreads

- Pthreads is a POSIX standard for describing a thread model, it specifies the API and the semantics of the calls.
  - POSIX: Portable Operating System Interface of UNIX
- Model popular – nowadays practically all major thread libraries on Unix systems are Pthreads-compatible
  - Solaris, FreeBSD, Linux
  - Pthreads-win32

Preliminaries

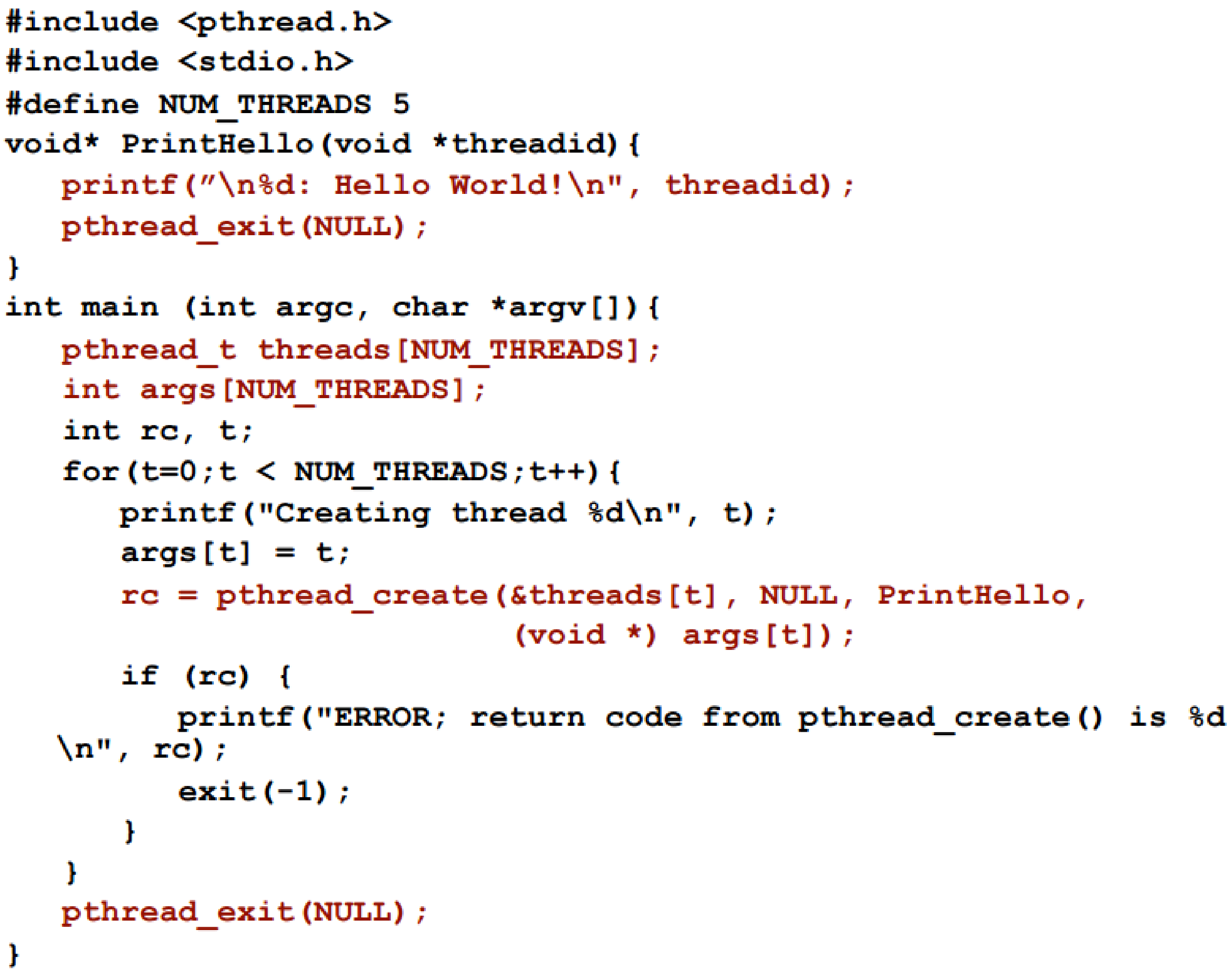
- Include `pthread.h` in the main file
- Compile program with `–lpthread`
  - `gcc -pthread -o test test.c`
  - may not report compilation errors otherwise but calls will fail
- Good idea to check return values on common functions

Thread basic API

- Types: `pthread_t` – type of a thread
- Some calls:

```
int pthread_create(pthread_t *thread,
                      const pthread_attr_t *attr,
                      void * (*start_routine)(void *),
                      void *arg);
int pthread_join(pthread_t thread, void **status);
int pthread_detach();
void pthread_exit();
```

  - No explicit parent/child model, except main thread holds process info
  - Call `pthread_exit` in main, don’t just fall through;
  - Most likely you wouldn’t need `pthread_join`
    - `status` = exit value returned by joinable thread
  - Detached threads are those which cannot be joined (can also set this at creation)



```
#include <pthread.h>
#include <stdio.h>
#define NUM_THREADS 5
void* PrintHello(void *threadid){
   printf(”\n%d: Hello World!\n", threadid);
   pthread_exit(NULL);
}
int main (int argc, char *argv[]){
   pthread_t threads[NUM_THREADS];
   int args[NUM_THREADS];
   int rc, t;
   for(t=0;t < NUM_THREADS;t++){
      printf("Creating thread %d\n", t);
      args[t] = t;
      rc = pthread_create(&threads[t], NULL, PrintHello,
                     (void *) args[t]);
      if (rc) {
         printf("ERROR; return code from pthread_create() is %d
   \n", rc);
         exit(-1);
      }
   }
   pthread_exit(NULL);
}
```

Attributes

- Type: `pthread_attr_t` (see `pthread_create`)
- Attributes define the state of the new thread
- Attributes: system scope, joinable, stack size, inheritance… you can use default behaviors with `NULL` in `pthread_create()`

```
 int pthread_attr_init(pthread_attr_t *attr);
 int pthread_attr_destroy(pthread_attr_t *attr);
 pthread_attr_{set/get}{attribute}
```

- Example:

```
pthread_attr_t attr;
pthread_attr_init(&attr); // Needed!!!
pthread_setdetachstate(&attr, PTHREAD_CREATE_DETACHED);
pthread_attr_setscope(&attr, PTHREAD_SCOPE_SYSTEM);
pthread_create(NULL, &attr, foo, NULL);
```

Pthread Mutexes

- Type: `pthread_mutex_t`

```
int pthread_mutex_init(pthread_mutex_t *mutex,
                       const pthread_mutexattr_t *attr);
int pthread_mutex_destroy(pthread_mutex_t *mutex);
int pthread_mutex_lock(pthread_mutex_t *mutex);
int pthread_mutex_unlock(pthread_mutex_t *mutex);
int pthread_mutex_trylock(pthread_mutex_t *mutex);
```

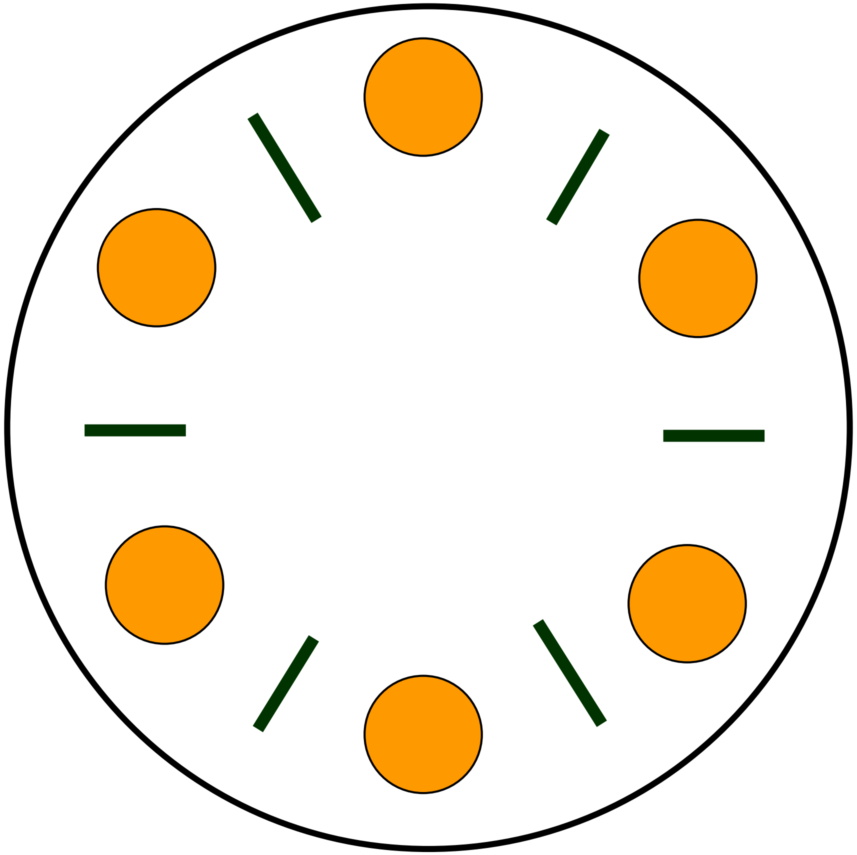
- Attributes: for shared mutexes/condition vars among processes, for priority inheritance, etc.
  - use defaults
- Important: Mutex scope must be visible to all threads!

Pthread semaphore

- int sem_init(sem_t *sem, int pshared, unsigned int value);
- int sem_wait(sem_t *sem);
- int sem_post(sem_t *sem);

The Dining Philosophers Problem

- Philosophers
  - think
  - take forks (one at a time)
  - eat
  - put forks (one at a time)
- Eating requires 2 forks
- Pick one fork at a time
- How to prevent deadlock?
- What about starvation?
- What about concurrency?



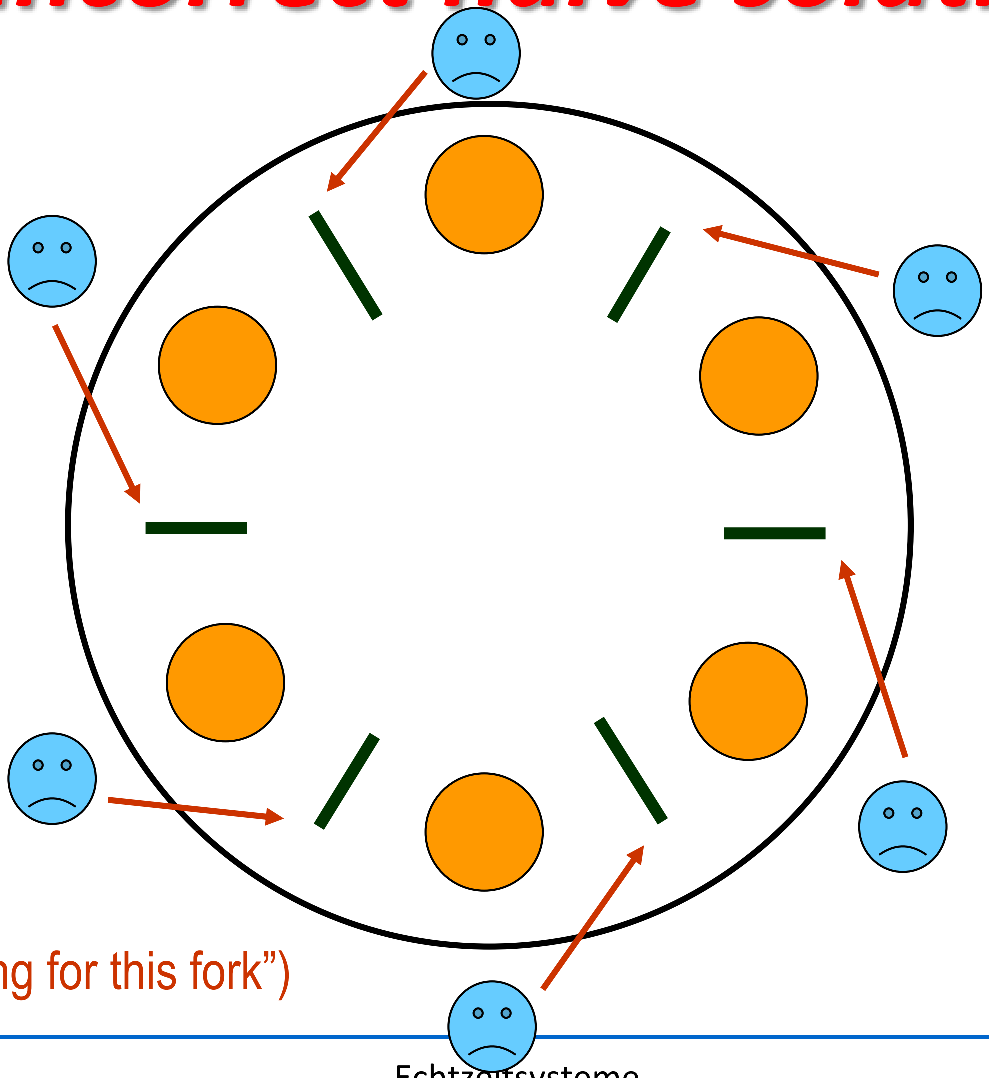
Slide taken from a presentation by Gadi Taubenfeld, IDC

Dining philosophers: definition

- Each process needs two resources
- Every pair of processes compete for a specific resource
- *A process may proceed only if it is assigned both resources*
- Every process that is waiting for a resource should sleep (be blocked)
- Every process that releases its two resources must wake-up the two competing processes for these resources, if they are interested

Dining Philosophers Problem

An incorrect naïve solution



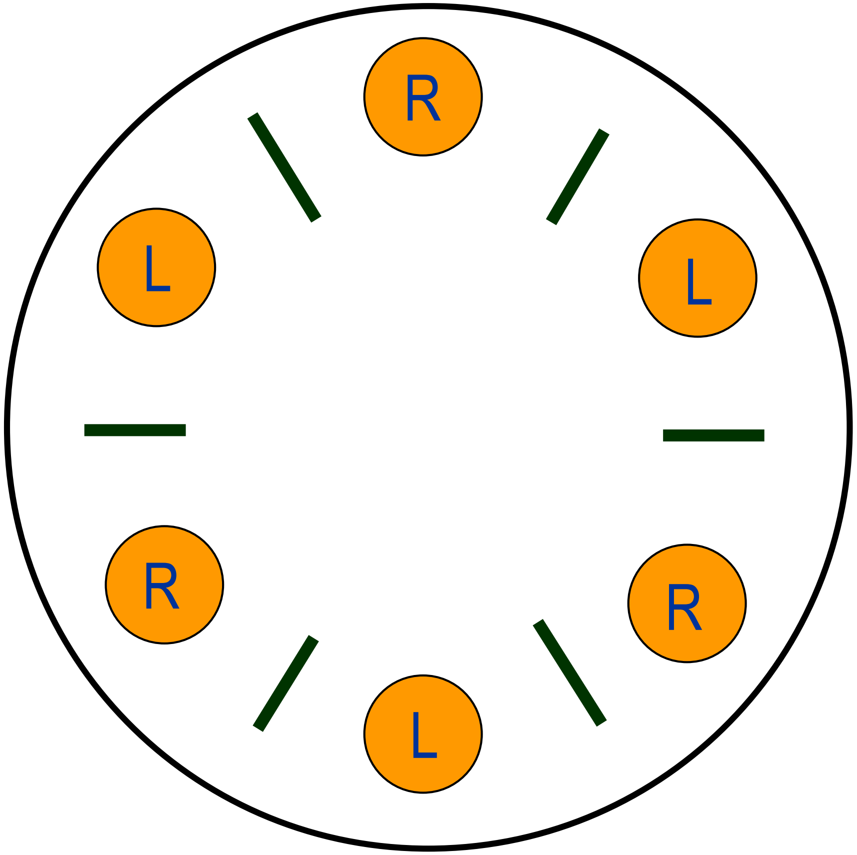
(→ means “waiting for this fork”)

The LR Solution

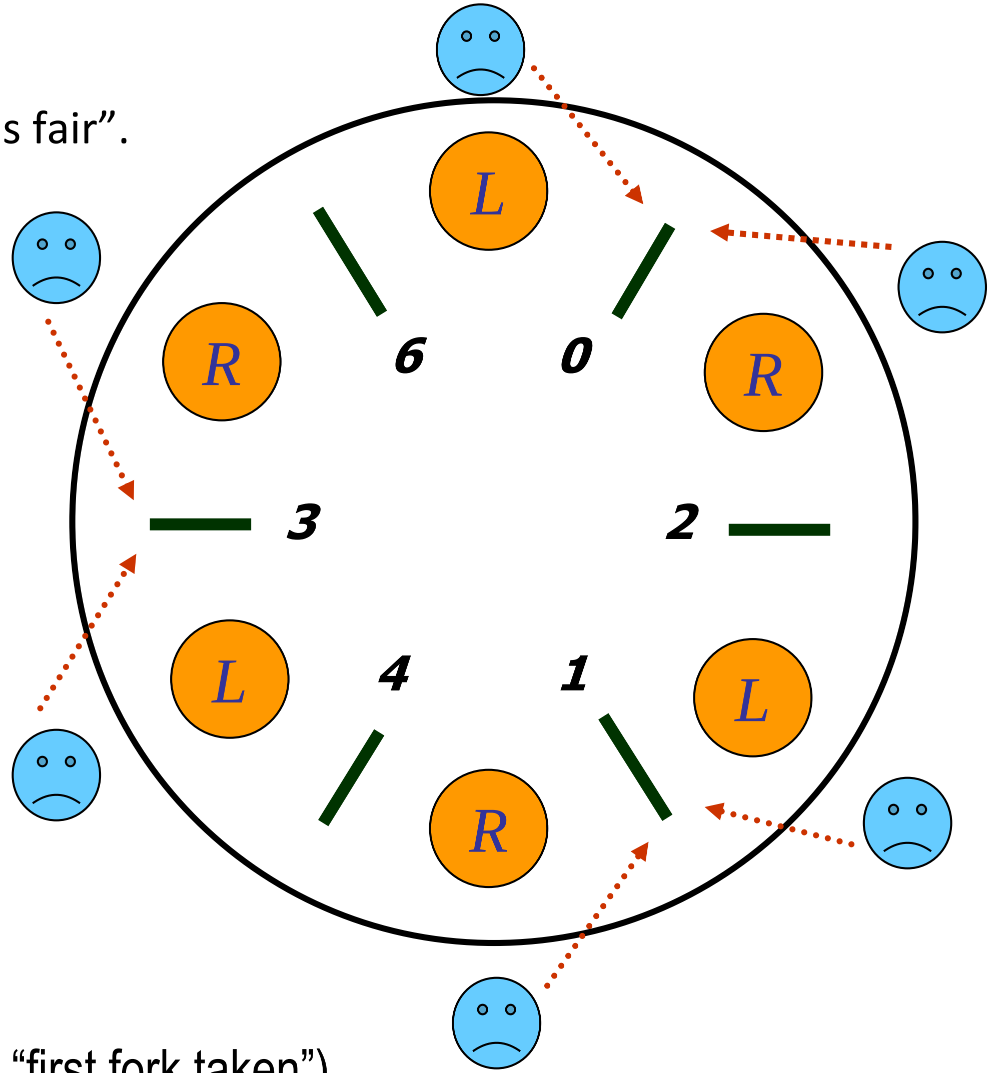
- If the philosopher acquires one fork and the other fork is not immediately available, she holds the acquired fork until the other fork is free.

- Two types of philosophers:
  - L -- The philosopher first obtains its left fork and then its right fork.
  - R -- The philosopher first obtains its right fork and then its left fork.

- The LR solution: the philosophers are assigned acquisition strategies as follows: philosopher *i* is R-type if *i* is even, L-type if i is odd.



Assumption: “the fork is fair”.



(······➤ means “first fork taken”)

Thank you!

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