Recitation 14: Proxy Lab Part 2

Instructor: TA(s)
Outline

- Proxylab
- Threading
- Threads and Synchronization
ProxyLab

- **ProxyLab is due in 1 week.**
  - No grace days
  - Make sure to submit well in advance of the deadline in case there are errors in your submission.
  - Build errors are a common source of failure

- **A proxy is a server process**
  - It is expected to be long-lived
  - To not leak resources
  - To be robust against user input
Proxies and Threads

- **Network connections can be handled concurrently**
  - Three approaches were discussed in lecture for doing so
  - Your proxy should (eventually) use threads
  - Threaded echo server is a good example of how to do this

- **Multi-threaded cache design**
  - Need to have multiple readers or one writer
  - Be careful how you use mutexes – you do not want to serialize your readers
  - Be careful how you maintain your object age

- **Tools**
  - Use Firefox’s Network Monitor (Developer > Network) to see if all requests have been fulfilled
Join / Detach

Does the following code terminate? Why or why not?

```c
int main(int argc, char** argv)
{
    ...
    pthread_create(&tid, NULL, work, NULL);
    if (pthread_join(tid, NULL) != 0) printf("Done.\n");
    ...
    void* work(void* a)
    {
        pthread_detach(pthread_self());
        while(1);
    }
```
Join / Detach cont.

Does the following code terminate now? Why or why not?

```c
int main(int argc, char** argv)
{
    ...
    pthread_create(&tid, NULL, work, NULL); sleep(1);
    if (pthread_join(tid, NULL) != 0) printf("Done.\n");
    ...
    void* work(void* a)
    {
        pthread_detach(pthread_self());
        while(1);
    }
}```
When should threads detach?

- In general, pthreads will wait to be reaped via pthread_join.

- When should this behavior be overridden?
  - When termination status does not matter.
    - pthread_join provides a return value
  - When result of thread is not needed.
    - When other threads do not depend on this thread having completed
Threads

- What is the range of value(s) that main will print?
- A programmer proposes removing j from thread and just directly accessing count. Does the answer change?

```c
volatile int count = 0;

int main(int argc, char** argv)
{
    pthread_t tid[2];
    for(int i = 0; i < 2; i++)
    {
        pthread_create(&tid[i], NULL,
            thread, NULL);
        for (int i = 0; i < 2; i++)
        {
            pthread_join(tid[i]);
            printf("%d\n", count);
        }
        return 0;
    }
}

void* thread(void* v)
{
    int j = count;
    j = j + 1;
    count = j;
}
```
Synchronization

- **Is not cheap**
  - 100s of cycles just to acquire without waiting

- **Is also not that expensive**
  - Recall your malloc target of 15000kops => ~100 cycles

- **May be necessary**
  - Correctness is always more important than performance
Which synchronization should I use?

- **Counting a shared resource, such as shared buffers**
  - Semaphore

- **Exclusive access to one or more variables**
  - Mutex

- **Most operations are reading, rarely writing / modifying**
  - RWLock
Threads Revisited

- Which lock type should be used?
- Where should it be acquired / released?

```c
volatile int count = 0;

void* thread(void* v)
{
    int j = count;
    j = j + 1;
    count = j;
}

int main(int argc, char** argv)
{
    pthread_t tid[2];
    for(int i = 0; i < 2; i++)
    {
        pthread_create(&tid[i], NULL,
                        thread, NULL);
        for (int i = 0; i < 2; i++)
        {
            pthread_join(tid[i]);
            printf("%d\n", count);
        }
    }
    return 0;
}
```
Associating locks with data

- **Given the following key-value store**
  - Key and value have separate RWLocks: klock and vlock
  - When an entry is replaced, both locks are acquired.

- **Describe why the `printf` may not be accurate.**

```c
typedef struct _data_t {
    int key;
    size_t value;
} data_t;

#define SIZE 10
data_t space[SIZE];
int search(int k)
{
    for(int j = 0; j < SIZE; j++)
        if (space[j].key == k) return j;
    return -1;
}

pthread_rwlock_rdlock(klock);
match = search(k);
pthread_rwlock_unlock(klock);
if (match != -1)
{
    pthread_rwlock_rdlock(vlock);
    printf("%zd\n", space[match]);
    pthread_rwlock_unlock(vlock);
}
```
Locks gone wrong

1. RWLocks are particularly susceptible to which issue:
   a. Starvation  b. Livelock  c. Deadlock

2. If some code acquires rwlocks as readers: LockA then LockB, while other readers go LockB then LockA. What, if any, order can a writer acquire both LockA and LockB?
   No order is possible without a potential deadlock.

3. Design an approach to acquiring two semaphores that avoids deadlock and livelock, while allowing progress to other threads needing only one semaphore.
Client-to-Client Communication

- **Clients don’t have to fetch content from servers**
  - Clients can communicate with each other
  - In a chat system, a server acts as a facilitator between clients
  - Clients could also send messages directly to each other, but this is more complicated (peer-to-peer networking)

- **Running the chat server**
  - `./chatserver <port>`

- **Running the client**
  - `telnet <hostname> <port>`

- **What race conditions could arise from having communication between multiple clients?**
Proxylab Reminders

- **Plan out your implementation**
  - “Weeks of programming can save you hours of planning”
  - – Anonymous
  - Arbitrarily using mutexes will not fix race conditions

- **Read the writeup**

- **Submit your code (days) early**
  - Test that the submission will build and run on Autolab

- **Final exam is only a few weeks away!**
Appendix

- Calling exit() will terminate all threads

- Calling pthread_join on a detached thread is technically undefined behavior. Was defined as returning an error.