CMPS 455

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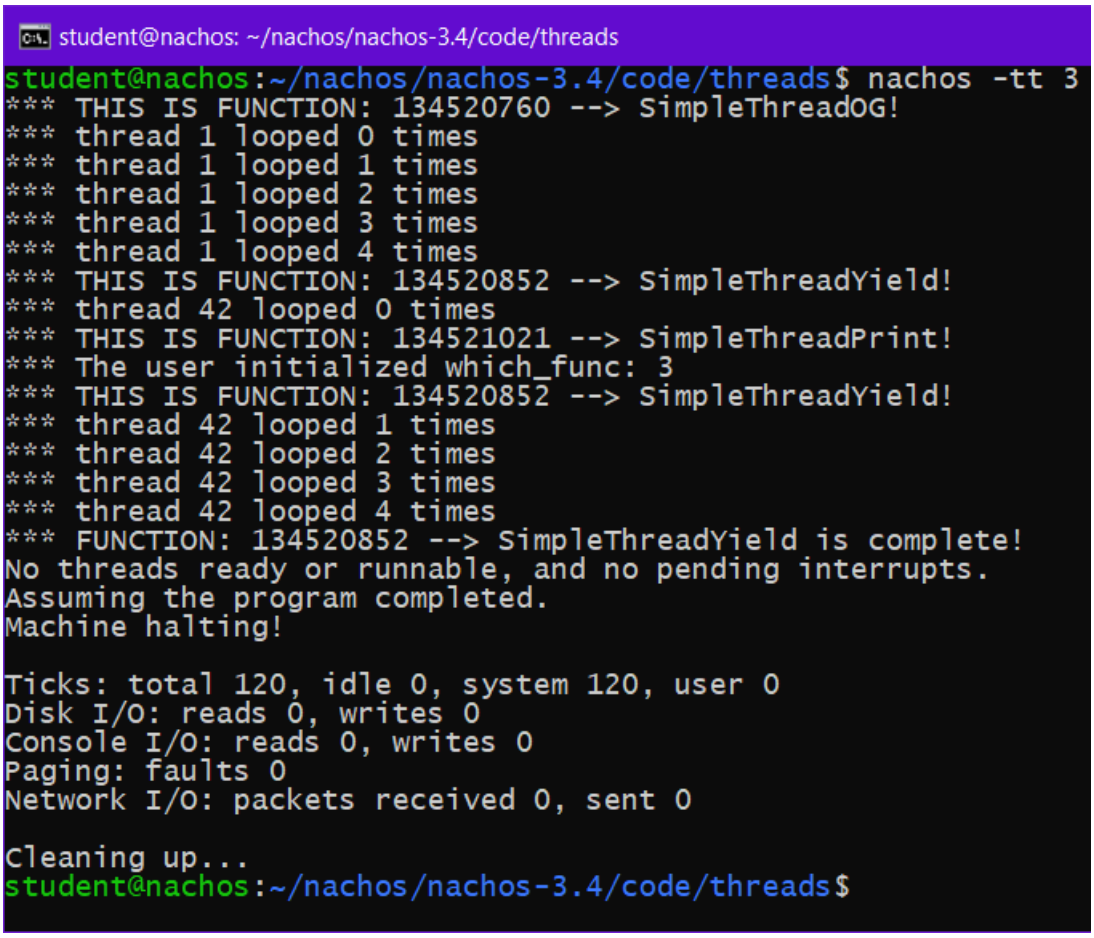
Homework 1

1

1.1 Modify the threadtest.cc file such that three new threads are created and each thread executes a different function. Upload your updated threadtest.cc file along with a snapshot of your Nachos run (you can copy-paste these in the same document that you are answering the other questions).



```
// threadtest.cc
//      Simple test case for the threads assignment.
//
//      Create two threads, and have them context switch
//      back and forth between themselves by calling Thread::Yield,
//      to illustratethe inner workings of the thread system.
//
// Copyright (c) 1992-1993,2021 The Regents of the University of California.
// All rights reserved.  See copyright.h for copyright notice and limitation
// of liability and disclaimer of warranty provisions.

#include "copyright.h"
#include "system.h"

//----------------------------------------------------------------------
// SimpleThread
//      Loop 5 times, yielding the CPU to another ready thread
//      each iteration.
//
//      "which" is simply a number identifying the thread, for debugging
//      purposes.
//----------------------------------------------------------------------

// void SimpleThread(int which)
// {
//     int num;
//
//     for (num = 0; num < 5; num++)    // HOMEWORK 1
//     {
//         printf("*** thread %d looped %d times\n", which, num);
//         currentThread->Yield();
//     }
// }
// HOMEWORK 1
void SimpleThreadOG(int which)
{
    printf("*** THIS IS FUNCTION: %d -> %s\n", (int) SimpleThreadOG, "
        SimpleThreadOG!");
    int start = 0;
    int num;
    int limit = 5;

    for (num = start; num < limit; num++)    // HOMEWORK 1
    {
        printf("*** thread %d looped %d times\n", which, num);
    }
}
// HOMEWORK 1
void SimpleThreadYield(int which)
{
    printf("*** THIS IS FUNCTION: %d -> %s\n", (int) SimpleThreadYield, "
        SimpleThreadYield!");
    int start = 0;
    int num;
    int limit = 5;

    for (num = start; num < limit; num++)    // HOMEWORK 1
    {
        printf("*** thread %d looped %d times\n", which, num);
        currentThread->Yield();
        if (num==0) {
```

```
            printf("*** THIS IS FUNCTION: %d --> %s\n", (int) SimpleThreadYield
                , "SimpleThreadYield!");
        }
    }
    printf("*** FUNCTION: %d --> %s\n", (int) SimpleThreadYield, "
        SimpleThreadYield is complete!");
}
// HOMEWORK 1
void SimpleThreadPrint(int which)
{
    printf("*** THIS IS FUNCTION: %d --> %s\n", (int) SimpleThreadPrint, "
        SimpleThreadPrint!");
    printf("*** The user initialized which_func: %d\n", which_func);
}

//----------------------------------------------------------------------
// ThreadTest
//      Invoke a test routine.
//----------------------------------------------------------------------

void ThreadTest()
{
    DEBUG('t', "Entering ThreadTest");

    Thread *t1 = new Thread("forked thread T1");
    Thread *t2 = new Thread("forked thread T2");  // HOMEWORK 1
    Thread *t3 = new Thread("forked thread T3");  // HOMEWORK 1

    t1->Fork(SimpleThreadOG, 1);
    t2->Fork(SimpleThreadYield, 42);  // HOMEWORK 1
    t3->Fork(SimpleThreadPrint, 3);  // HOMEWORK 1
    // SimpleThread(0);
    // printf("which_func: %d\n", which_func);  // HOMEWORK 1
}
```

2 Please provide a summary of the two videos

2.1

Codes contains 8 folders of which **Threads** is the most important for our upcoming project. Threads is responsible for kernel/startup, synchronization of threads, switching and the scheduler. Machine simulates a MIPS architecture. **Userprog** is for running user programs. Use *./nachos* in the Threads folder to run the looping program. This program starts in **main.cc** which contains **Initialize()** (which is defined in **system.cc**). **#ifdef THREADS** declares

> if in the folder named THREADS, then run.

main.cc takes *args* and then **DebugInit, Statistics, Interrupt, Scheduler, randomYield** (which randomly yields threads), **ThreadTest** (which is exposed through *extern void **ThreadTest()*** and forks thread invoking **SimpleThread()**) are all declared in system.cc and eventually called through the processes of **Initialize()**. Once *currentThread* points to **Finish()** (which is a function of the Thread object), **Sleep()** is called (another Thread function) which checks for *currentThread* (active threads) and if not, then *interrupt* will point to **Idle()** (an **Interupt** function created in the Machine dir) which means the threads are waiting on I/O. If nothing then **Halt()** and **Cleanup()** are called (this stops the process and destroys the thread).

2.2

We begin in *thread.h* which contains kernel threads, status of threads, stack, registers, and runs functions such as **Fork(), Yield(),** and **Sleep()**. *UserProg* directory contains user state and address space.

When creating a thread:
Thread() and **Fork()** are invoked (of which the latter takes a thread running function) or we can **Yield()**.

When taking user input:
we can already run flags like **-d** (debug) at this point. *system.cc* contains the code which declares the flags. **include system.h** is in *threadtest.cc* which all starts in *main.cc*. Editing **ThreadTest()** and **SimpleThread()** in order to generate our own Thread Test. Jason then goes on to explain an example process of running threads which includes parallel and sequential threading. He also mentions thread 2 is sensitive to its counterpart thread 1, which we attempt to address with **Yield()** which places *currentThread* (Thread 1) in the back of the queue. He also mentions that you should not access global variables inside of a running thread for this would create a race condition where more than one thread is attempting to access the same address of memory.

4

4.1 Please read and summarize the main concepts from chapter/section 3.1, pages 106-110 in a few paragraphs

Older computer systems such as batch systems executed **jobs**. **Time-shared** systems ran **user programs; tasks**. **Single-user systems could run several programs**, although the operating system may need to support its own internal programmed activities (memory management). All of these are **processes; jobs**.

A process is the status of the current activity represented by the value of the **PC** and contents of the processor's registers. Memory layout is as follows:

- **text section** - executable (static)
- **data section** - global vars (static)
- **heap section** - dynamically allocated memory during program run time.
- **stack section** - temporary data storage when invoking functions (params, return addresses, local vars) (dyanmic)

Each function call pushes params, local vars, and return addresses onto the stack (**Activation Record**). When control is returned from a function the Activation Record is popped from the stack (this is true for heap memory as well). The stack and heap grow *towards* one another while the OS ensures they do not *overlap* one another. Considered an *active entity* in which the PC holds the next instruction to execute and set of associated resources. **State** refers to the current activity of processes which can be:

- New (create)
- Running (execute)
- Waiting (signal or I/O)
- Ready (idle)

- Terminated (finished)

Previously you could only run one process per core at one time. The **Process Control Block (PCB)** also known as the **Task Control Block** simply serves as the repository for all the data needed to start, or restart, a process, along with some accounting data. PCB contains information about specific processes such as:

- State
- PC
- CPU Registers (save state info for interrupts)
- CPU-scheduling info (priority queues)
- Memory-management information (value of base/limit of registers & page tables/segment tables)
- Accounting info (CPU & real time used, time limits, account numbers, process numbers)
- I/O status information (list of I/O devices allocated and open files)

A program is a *passive* entity; i.e. instructions stored on disk (**executable file**). Programs become processes when loaded into memory; i.e. double-click or command-line .out. Two processes can be associated to the same program, but considered two separate execution sequences; i.e. an execution environment (Java JVM).

4.2 Please read and summarize the main concepts from chapter/section 4.1, pages 160-162 in a few paragraphs

Threads control processes and PCB is expanded to include info on each thread in multi-thread systems. Most kernels are actually multithreaded. Share ID, PC, register set, stack, code data section, and files signals with threads of the same process.

Multicore processing, often called parallel processing, is more efficient because creating processes is costly. Benefits of multithreading include:

- **Responsiveness** (continue running if blocked useful for UI/UX)
- **Resource** sharing (shared memory message passing with several threads of activity in the same place)
- **Economy** (as stated before, costly to create process)
- **Scalability** (single-threaded can only run on one processor no matter how many cores may be available)