Problem Sheet for B16, Operating Systems, Wood, Trinity 2013

1.) Write a TCP/IP-based client server application that runs *nix text commands on a remote host and streams the response back to the client. The client command should have an interface like "client <ipaddr> <textofcmd>" where ipaddr is the ip address of a machine, something like "nslookup engs-station60.eng.ox.ac.uk" -> 163.1.140.60 and <textofcmd> is the command to run on the server, e.g. "/usr/bin/uptime." Write the server side such that there is a single thread that accepts connections and creates a thread to service each request. This thread should create a pipe, fork, close stdout and stderr, use dup to redirect stdout and stderr to the correct end of the pipe, and in the parent (of the forked thread) read the output from execl'ing the command using a buffer to intermediate between the pipe and the socket connection back to the client. Note that you can use gcc and any of the linux software laboratory machines, e.g. engs-station60.eng.ox.ac.uk to as the server in this task. Note that ports 8889 and above are good ports to use as they have user bind permissions.

2.) Recursion can be used to compute the nth Fibonacci number in the following way:

```
int fib(int n) {
   if(n==0)
      return 0;
   if(n==1)
     return 1;
   return fib(n-1) + fib(n-2);
}
```

a) What is the largest value of n that could be computed on a machine with 1MB memory if the OS pushes, including function parameters, 32 bytes to the stack for every function call?

b) What could be done to increase the largest computable value?

3.) Describe the various mechanisms OS's provide to support interprocess communication. (*)

4.) Suppose a, b and c are three arrays of integers in a C program. Why, when N is large, might

```
for (j = 0; j < N; j++)
   for (i = 0; i < N; i++)
        c[i][j] = a[i][j] + b[i][j];
```

take a thousand times longer than

```
for (i = 0; i < N; i++)
   for (j = 0; j < N; j++)
        c[i][j] = a[i][j] + b[i][j];
```

on the same machine? (*)

5.) Use semaphores to solve the producer consumer problem. Assume the existence of a single reader, single writer, a character array buffer, and two semaphores; one labeled empty, the other labeled occupied. Other variables may be instantiated as needed.

6.) On the slide titled "Blocking Lock," currently page 62, a subtle thread synchronization problem can happen. What is it?

7.) A multithreaded server processes web requests and streams audio data to 100 clients simultaneously.

a) Assuming a 100Mb/sec network interface card what is the maximum achievable audio stream rate to each client assuming a 3% packet header network overhead and perfect sharing of the network and CPU?

b) Describe using diagrams and text the data flow, scheduling, interrupt, and switching behavior of a straight threads OS running on a single core CPU required to serve each of these clients.

c) Note in particular the OS services required and used. Also, compute the order of magnitude of the minimum CPU clock speed required to saturate the network if memory reads and writes take two CPU clock ticks, device I/O is PIO-style, and saving context including register state takes five CPU clock ticks.

8.) Assume 8-Kb pages, how big is a page table for a 64-bit architecture? What are some strategies for dealing with this problem? (*)