Exam 25 Feb 2022

Duration: 80 mins (with support of slides and notes; not electronic equipment)

Student Name: ____

Number:________________

TCP/IP & Sockets

Consider the TCP/IP reference model for the Internet protocol stack and the assignment in which you used sockets. You have learned that the TCP/IP protocol stack is composed of 5 layers: Application (Appl.); Transport (Transp.); Network (Netw.); Data Link and Physical (Phys.) (sometimes the last two are called jointly Access layer).

Consider that, over a network of TCP/IP-enabled devices, you wish to send 1 packet from device A (the source) to device B (the destination) over an Ethernet network. Device A is connected to a switch device S1 (a device that implements up to Layer 2), which in turn is connected to switch device S2. Lastly, switch device S2 is connected to device B. Describe the sequence of (device, layer) pairs that the packets experience when moving from the source to the destination. We will provide the first two steps of the sequence: (Dev A, Appl. layer) => (Dev A, Transp. layer) => …

(15%)

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1) Find below the skeleton for the server application of the TCP/IP socket assignment you did. Suppose you wish to communicate with the server at IP address 192.168.1.125 that is listening at port 12000. The function ‘bind()’, although not mandatory at the client side, can be used to specify the local (client’s) port that you wish the client application to use. In turn, your client application should use the port 24000.

   (15%)

```
1.   #include ...
2.   #define BUF_LEN 10
3.
4.   main () {
5.       int sock, len;
6.       struct sockaddr_in a, b;
7.       socklen_t addlen = sizeof(a);
8.       char buf[BUF_LEN];
9.       sock = socket (PF_INET, SOCK_STREAM, 0);
10.
11.      a.sin_family = AF_INET;
12.      a.sin_port = htons(_______);
13.      inet_aton("127.0.0.1", &a.sin_addr);
14.
15.      b.sin_family = AF_INET;
16.      b.sin_port = htons(_______);
17.      inet_aton("_______", &b.sin_addr);
18.
19.      bind(sock, (struct sockaddr *) &a, addlen);
20.      connect(sock, (struct sockaddr *) &b, addlen);
21.
22.      scanf("%s", buf);
23.      len = send (sock, buf, strlen(buf)+1,0);
24.  }
```

   a) Indicate the line at which you must write the IP address of the server.

   b) Indicate the line at which you must write the port number of the server application.

   c) Indicate the line at which you must write the port number of the client application.

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Time-Critical MACs

2) Consider a *switch* with 4 ports, each connecting to a different computing device (CD). The ports are full-duplex, thus allowing simultaneous communication CD ↔ switch. Each port of the switch has 2 FIFOs of "unlimited" capacity: one *input* and one *output* FIFO. The links between CDs and the switch have the speed of 0.5 Mbps (both ways). Each CD has an output FIFO for messages to be sent to the other CDs via the switch. All messages in the network have 0.6Kbit of length. In the switch, the input FIFOs are served in a *round-robin* (…, 1, 2, 3, 4, 1, 2 …) fashion. Consider also that implicitly there are priorities associated to the switch ports: in each cycle of the round-robin the maximum number of messages served is 1, 2, 3 and 4 messages, for the switch ports 1, 2, 3 and 4, respectively. The switching time (time for the switch to move a message from an input FIFO to an output FIFO is C = 2ms. The traffic generated by CD2 (connected to port 2 of the switch) is not known. However, it is known that CD3 and CD4 (connected to port 3 of the switch and port 4 of the switch, respectively) generate, each, a message every 400ms. Consider that 4 messages are placed in the output FIFO of CD1 (that FIFO was empty before) at time instant t_0. Consider also that at t_0 the input FIFO of the port 1 of the switch was empty. Determine the maximum elapsed time (since t_0) until all 4 messages generated in CD1 are *switched*. Detail your answer. **(20%)**

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3) Consider a generic network of the type producer/distributor/consumer, has illustrated in the theoretical classes (Module 2B). Determine the parameters (table and microcycle value) to schedule the distribution of the following periodic objects. **(15%)**

Object	T (distribution period)	C (transaction time)
A	6	2.5
B	15	2.5
C	18	2.5
D	24	2
E	30	2

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WSN & IoT Aspects

4) When discussing Low-Power Wide Area Network (LPWAN) and Wireless Sensor Network (WSN) technologies, you have learned that any wireless signal is attenuated as it passes through obstacles (such as tree trunks or walls). LPWAN technologies, by offering larger link budgets, enable their wireless signals to sustain more attenuation (i.e., travel farther or across more obstacles), but require the existence of a base-station with powerful transmit/receive capabilities. In turn, despite the short-range communication capabilities of WSNs, there are routing protocols that explore paths over multiple links (multi-hop) to allow data to flow from any node to centralized locations (i.e., gateway) over medium-to-large distances.

   The success of the strategy of WSNs is dependent on the density of nodes that are deployed in the target scenario. If insufficient, some WSN nodes may experience limited or null connectivity to other nodes. Adding more nodes to enable more connectivity is a possible solution, but the costs of deployment may become too large.

   Consider the following use-cases and scenarios from the perspective of deploying a network of sensing devices (WSN or LPWAN). Indicate: (i) if the density of WSN nodes that must be deployed to ensure existence of paths to most nodes is 'high' or 'low', and explain why; and (ii) if it would be more cost-effective to deploy a WSN or a LPWAN, and explain why.

   (15%).

   a) Smart water metering over a large urban area with only a single collection point available.

   b) Ground-level precision agriculture in low-density crops, with no pre-existing infrastructure of any kind (power supply, communications, etc).

   c) Humidity monitoring over a large forest area, at canopy level (i.e., level of the leaves, above the trunks).

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5) Consider the following code for a Raspberry Pi using C:

```
1.   1.    #include <stdio.h>
2.   #include <stdlib.h>
3.   #include <string.h>
4.   #include "mosquitto.h"
5.   void my_connect_callback(
6.            struct mosquitto *mosq, void *obj, int rc
7.            ) {
8.               mosquitto_subscribe(mosq, NULL, "hello", 2))
9.            }
10.  }
11.  void my_message_callback(
12.           struct mosquitto *mosq, void *obj,
13.           const struct mosquitto_message *msg
14.           ){
15.           printf("%s : %s\n",
16.                    (char *)msg->topic,
17.                    (char *)msg->payload
18.           );
19.  }
20.  void main()
21.  {
22.           struct mosquitto *mosq;
23.           // CODE
24.  }
```

(20%)

a) What is the minimum code needed to insert in line 23, to enable the MQTT functionality?

b) What changes would be needed so that a LED connected to pin 11 (GPIO 17) will turn on when the MQTT server is connected, and pin 12 (GPIO18) will turn on when the MQTT Broker topic “home/led” is “on” and off when topic “home/led” is “off”.

c) Suppose that you are writing code that presents in the console the updates on topic “home/temperature” on a specific MQTT broker. What do you have to do, in order to enable multiple machines to run this code?