Exam 11 Feb 2022

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

Student Name: ____

Number:________________

TCP/IP & Sockets

1) An application in a TCP/IP-enabled device that wishes to send data through the network starts by delivering its data to a socket, where it will be processed through the layers of the TCP/IP stack. At each layer, a header, identified by 'H<number of layer>' (and in some cases a tail, identified by 'T<number of layer'>) is added until it arrives to the Physical layer. Therefore, the packet that is effectively transmitted through the physical medium is a collection of the initial application data and the concatenated headers/tails.

   Consider that, over a network of TCP/IP-enabled devices, you wish to send 1 packet from device A (the source) in an IP network to device B (the destination) in another IP network. The two networks are connected via a router device R (a device that implements up to Layer 3) and that both devices are connected directly to the router.

   Describe the various structures that the packet takes, in terms of application data and concatenated headers/tails, as it transits from the application layer of Device A to the application layer of Device B. Note that: the Physical layer does not add any headers (it is concerned solely with modulating logical 1's and 0's into a physical quantity); and that the Data Link layer adds not only a header but also a tail to the packet.

   We will provide the first three steps of the sequence: (Appl. data) => (Appl. data, H4) => (Appl. data, H4, H3) =>

   (15%)

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2) Find below the skeleton for the server application of the TCP/IP socket assignment you did. You have learned that multiple clients can connect to a server port to request connections, and that the value of this port must be known a priori by the clients. On the server side, it is first necessary that the server application, when starting, 'reserves' this port number so that no other server application can use it. Once client requests start arriving, these are stored in a First-In-First-Out (FIFO) queue which the server application processes at its capacity. As the request of each client is handled, a new socket is created individually for each client to continue the data exchange with the server (in the assignment you carried out, there is code to handle only one request -- your client's).

(15%)

```
1. #include ...
2. #define BUF_LEN 10
3.
4. main() {
5.     int so, sd, len;
6.     struct sockaddr_in loc, rem;
7.     socklen_t addlen = sizeof(loc);
8.     char buf[BUF_LEN];
9.
10.          so = socket (PF_INET, SOCK_STREAM, 0);
11.
12.          loc.sin_family = AF_INET;
13.          loc.sin_port = htons(12000);
14.          inet_aton("127.0.0.1",&loc.sin_addr);
15.          bind(so, (struct sockaddr *) &loc, addlen);
16.          listen (so, 10);
17.
18.          sd=accept (so, (struct sockaddr *) &rem, &addlen);
19.
20.          len= recv (sd, buf, BUF_LEN, 0);
21.          ...
22.    }
```

a) Indicate the line at which the server application 'reserves' the port number that will be used by the clients to request connections, and the value of that port.

b) Indicate the line at which the server application requests the FIFO queue to hold unhandled client requests, and the value of the queue size that is requested.

c) Indicate the line at which the new socket was produced for your client's connection request, and the name of the variable that identifies that new socket.

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Time-Critical MACs

3) 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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4) 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

5) You have learned that there are different technologies to be used whether you opt for Wireless Sensor Networks (WSN) or Low-Power Wide Area Network (LPWAN). WSNs use mainly IEEE 802.15.4-based radios, whereas for LPWANs there are more competing technologies, such as NB-IoT, SigFox and LoRa. Compare the following technologies in the indicated dimensions **(15%).**

   a) LoRa and NB-IoT, in terms of the bandwidth of the transmitted signal.

   b) SigFox and IEEE 802.15.4, in terms of communication capacity (bit rate, number of messages, etc.).

   c) SigFox and IEEE 802.15.4, in terms of link budget (i.e., the difference between the transmit power and receiver sensitivity).

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

```
#include <stdio.h>
#include <wiringPi.h>
const int myPin1 = 23;
const int myPin2 = 17;
int main(void)
{
      wiringPiSetupGpio();
      pinMode(myPin1, OUTPUT);
      pinMode(myPin2, INPUT);
      while(1)
      {
            if (digitalRead(myPin1))
            {
                  digitalWrite(myPin2, LOW);
            }
      else
            {
                  digitalWrite(myPin2, HIGH);
                  delay(75);
                  digitalWrite(myPin2, LOW);
                  delay(75);
            }
      }
      return 0;
}
```

(20%)

a) What is wrong with this code?

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b) What changes would be needed in the corrected code so that the updated "state" would be sent to an MQTT broker at Iocalhost port 8808 in topic "home/status" with values "on" and "off". Use the minimum code possible, ignoring any MQTT error processing.

c) MQTT supports authentication and encryption. State, with a brief justification, one scenario where the MQTT authentication can be useful, and two drawbacks of the usage of MQTT encryption.