Exam paper

# Question 1

1. A gateway performs protocol translation between local and wide area networks, provides bridging between the two, and is responsible for end-to-end packet routing. The gateway can also implement local storage and aggregation of measurements, as well as security features (encryption, access control, etc.). It further allows incremental addition of new technology. The main limitation of fog computing is scalability – as the number of devices deployed at the edge grows, more gateways need to be deployed, which becomes expensive.

1. The time required to send the entire payload is: 250\*8 B / 1 Mbps = 2,000 μs

The duration of the preamble and header is: 122 b / 1Mbps = 122 μs

The duration of a Bluetooth slot is: 625 μs

A transmissions can occupy 1, 3, or 5 slots, i.e. 625, 1,250, or 1,875 μs . Therefore,

* the first transmission will span 5 slots (1,875 μs) and will contain (1,875 - 122 - 16)/1 Mbps = 1,737 bits of information (note that 16 bits are needed for CRC);
* the second transmission will comprise 2,000-1,737 = 263 bits and will take 122 +263 + 16 = 401 μs

Each frame will be transmitted in odd slots and even slots are occupied by a transmission of the master. Hence, the total duration of the transactions is

T= 1,875 + 625 + 401 = 2,901 μs

1. – Virtual Machines: multiple instances of potentially different OSes running on the same physical machine (Infrastructure as a Service – IaaS)

– Containers: different applications running on a virtualised OS within partitions. Execution safe to the kernel even if apps may have security issues (Platform as a Service – PaaS). Fast to instantiate, can be destroyed as needed, no need for a hypervisor, OS libraries can be shared

– Functions (serverless): Applications broken up into functions, each of these hosted by a cloud provider (Function as a Service – FaaS). No specific machine assigned to a function. Faster to deploy even than containers, highly scalable. Charging based on the amount of time each function runs.

1. The logic is as follows:

L0 = 0xFFCCBF0D, R0 = 0xFEBB001C

At the first round:

L1 = R0 = 0xFEBB001C;

R1 = L0 XOR (R0 << 4) XOR K0 = 0xFFCCBF0D XOR 0xEBB001CF XOR 0x01010101 = 0x157DBFC3

At the second round

L2 = R1 = 0x157DBFC3

R2 = L1 XOR (R1 << 4) XOR K1 = 0xFEBB001C XOR 0x57DBFC31 XOR 0xCB2ECF45 = 0x624E3368

The resulting ciphertext is 0x157DBFC3624E3368

# Question 2

1. Firmware sent over a wireless connection and either (i) an on-chip bootloader implements the functionality required for firmware updates, or (ii) a dedicated off-chip programmer implements the FW update protocol, completely separate from the actual applications

Advantage: rapid prototyping and testing before and after deployment.

The drawback of the first approach is that if the update fails, and the bootloader becomes corrupt, the device is bricked. The drawback of the second approach is that it increases device size, complexity and cost.

1. Bit rate:

R = CR • SF • BW/2SF = 4/5 • 7 • 250/128 = 10.973 kb/s

The duration of a single transmission is:

t = (25 B • 8 b + 190 B • 8 b) / 10.973 kb/s = 157ms

With a 1% duty cycle, the node transmits one packet every 15.7s.

1,900 bytes of information require 10 packets. **The total duration required of sending these is 157s.**

During 20 minutes, it is possible to transmit

N = 20\*60/15.7 = 76 packets

If 10% of these are corrupted, then 68 will be delivered successfully. **The total amount of information is hence 68 \* 190 B = 12.92 kB.**

1. A retained message is a normal MQTT message with the retained flag set to true. The broker will store the last retained message and the corresponding QoS for that topic. Each client that subscribes to a topic pattern, which matches the topic of the retained message, will receive the message immediately after subscribing. For each topic, only one retained message will be stored by the broker. A retained message makes sense when newly connected subscribers should receive messages immediately and should not have to wait until a publishing client sends the next message.
2. The total power budget of the device with the given battery is P = 22 Ah • 5 = 110 Wh. Throughout the duration of its operation, t, the microcontroller will consume

t • (0.05 • 0.25 W + 0.95 • 0.001 W) = P. Hence,

t = 110/(0.05 • 0.5 W + 0.95 • 0.001 W) = 8,178.44 h