[ENG17]

UNIVERSITY OF BOLTON

SCHOOL OF ENGINEERING

MSc ENGINEERING (Various Pathways)

SEMESTER 1 EXAM 2022/2023

SMART ENGINEERING SYSTEMS

MODULE NO: MSE 7003

Date: Tuesday 10th January 2023 **Time: 14:00 – 16:30**

INSTRUCTIONS TO CANDIDATES:

There are FIVE questions.

Answer any FOUR questions.

All questions carry equal marks.

Marks for parts of questions are shown in brackets.

This examination paper carries a total of 100 marks.

Formulae sheet is attached at the end of the paper.

All working must be shown. A numerical solution to a question obtained by programming an electronic calculator will not be accepted.

School of Engineering
MSc Engineering (Various Pathways)
Semester 1 Exam 2022/23
Smart Engineering Systems
Module No. MSE7003

Question 1

a) Explain how the role of wireless communications affect the development of IoT. **[5 marks]**

b) How would the assignment of internet addresses impact on the expansion of IoT devices? **[8 marks]**

c) Compare with the aid of a table, the difference between CoAP and HTTP protocol. **[5 marks]**

d) What are the key privacy issues related to IoT? **[7 marks]**

Total 25 marks

Question 2:

a) What is big stream and how does it differ from big data? **[6 marks]**

b) What are the advantages of providing IoT security at the IP layer? **[4 marks]**

c) Compare the key differences between Symmetric-Key LWC Algorithms and Tiny Encryption Algorithm. **[10 marks]**

d) Describe the timings process of a listener-based cloud architecture. **[5 marks]**

Total 25 marks

Question 3

(a) What does a generic UML use case diagram show?

[3 Marks]

(b) Considering the six general principles of Design for Reliability: Element/component selection, De-Rating, Environment, Minimum complexity, Redundancy and Diversity. Give an example of a system which should be designed using Redundancy, and explain how Redundancy could be designed into this system. **[6 Marks]**

(c) The BS ISO-IEC-IEEE 15288 standard for "Systems and Software engineering – System life cycle processes" includes consideration of enabling systems. Give two examples of enabling systems, and for each explain briefly why it is an enabling system. **[8 Marks]**

(d) For the purposes of the SPE+ framework, a system can be either an S-System, a P-System, or an E-System. Please provide two instances of E-Systems and a brief description of what makes each one an E-System. **[8 Marks]**

Total 25 marks

Please turn the page….

School of Engineering
MSc Engineering (Various Pathways)
Semester 1 Exam 2022/23
Smart Engineering Systems
Module No. MSE7003

Question 4

(a) Draw a UML Use Case Diagram for the Car Park Access Control Software System described in Figure Q4. **[12 marks]**

(b) Draw a UML Class Diagram for the Car Park Access Control Software System described in Figure Q4. Show classes, and relationships between classes on your diagram. Show attributes and methods in the classes. Show multiplicity if you feel it is appropriate. **[13 marks]**

Software controls access to a car park using ticket machines, entry and exit barriers and sensor modules. A sensor module is a set of ultrasonic sensors which can detect the presence of a car. A car driver must take a ticket from a machine before entering the car park, and must present a validated ticket in order to exit the car park. The paths through the entry and exit barriers each contain a sensor module which detects the presence of a car. The car park has 500 spaces. Each car parking space contains a sensor module which detects whether the space is occupied; if a car were parked across *n* spaces, all *n* spaces would be shown as occupied. Information from the sensor modules is communicated to the access control software using a wireless communication system. The access control software controls the raising and lowering of the entry and exit barriers.

Entering the car park To enter the car park, the car moves to the entry ticket machine just before the entry barrier. The driver must take a ticket from the ticket machine, after which the entry barrier is raised, and the car may enter the car park. Once the car is clear of the entry barrier, the entry barrier is lowered. If the car park has no available spaces, a ticket will not be issued and the entry barrier will not be raised.

Tickets Drivers must pay for parking before returning to their cars. To do this, a driver must take the ticket to a pay station (of which there are two); once the driver has paid the required amount the pay station will return the validated ticket to the driver. Using the validated ticket the driver will be able to exit the car park. The software in the pay station is not part of the software which controls access to the car park, however the pay station must be functional in order for the access control software to function, because the access control software relies on validated tickets being issued.

Exiting the car park To exit the car park, the car moves to the exit ticket machine just before the exit barrier. The driver must insert a validated ticket into the exit ticket machine. After a validated ticket is read by the exit ticket machine, the exit barrier is raised. Once the car is clear of the exit barrier, the exit barrier is lowered. If a validated ticket is not inserted into the exit ticket machine, the exit barrier will not be raised.

Figure Q4

Total 25 marks

Please turn the page….

Question 5

A step-index fibre with a normalized frequency of 70 and a numerical aperture of 0.2. The optical fibre cable is to be used at an optimum wavelength of 820 *nm*. If it has been decided that the core refractive index will be 1.458, determine:

(a) (i) The required core radius;

(ii) The cladding Refractive Index. **[10 marks]**

(b) The mean optical power launched into an optical fibre link is $1.5mW$ and the fibre has an attenuation of $0.5dB/km$. Determine the maximum possible link length without repeaters (assuming lossless communication) when the minimum mean optical power level required at the detector is $2\mu W$.

[10 marks]

(c) A fibre has a coupled power –8*dBm* and attenuation of 6*dBm/km,* and a length 2*km.* Calculate the output power**.** **[5 marks]**

Total 25 marks

Formulae List

Snell's law: $\dfrac{\sin\theta_i}{\sin\theta_r} = \dfrac{n_2}{n_1} = n = \text{constant}$

Numerical Aperture, $NA = n_0 \sin\theta_a = \left(n^2{}_1 - n_2{}^2\right)^{\frac{1}{2}}$

The relative refractive index difference, $\Delta = \dfrac{n_1^2 - n_2^2}{2n_1^2} \approx \dfrac{n_1 - n_2}{n_1} \quad for\ \Delta \ll 1$

$NA = n_1\left(2\Delta\right)^{\frac{1}{2}}$

The Rayleigh scattering coefficient:

$$\gamma_R = \frac{8\pi^3 n^8 p^2 \beta_c K\, T_F}{3\lambda^4}$$

where:

$\beta_c -$ the isothermal compressibility

$K -$ Boltzmann's constant $= 1.381\times10^{-23}\ J/K$

$p -$ the average photoelastic coefficient

$T_F -$ fictive temperature.

Transmission loss factor, $\mathscr{L}_{km} = \exp\left(-\gamma_R L\right)$

The attenuation due to Rayleigh scattering *in dB/km*, $Attenuation = 10\log_{10}(1/\ \mathscr{L}_{km})$

The optical power generated internally by the LED, $P_{\text{int}} = \eta_{\text{int}}\dfrac{hic}{\lambda e}$

where:$-$

$h -$ Planck's const $= 6.625\times10^{-34}\ Js$

$c = 3\times10^8\ m/s$

$e -$ the charge on an electron $= 1.602\times10^{-19}\ coulomb$

The total recombination lifetime, $\tau = \dfrac{\tau_r \times \tau_{nr}}{\tau_r + \tau_{nr}}$

The internal quantum efficiency, $\eta_{\text{int}} = \dfrac{\tau}{\tau_r}$

The external power efficiency, $\eta_{ep} = \dfrac{P_e}{P}\times100\%$

$P -$ power provided in device

The optical power emitted externally, $P_e = \dfrac{P_{\text{int}} F\, n^2}{4n_x^2}$

END OF PAPER