TE WHARE WĀNANGA O TE ŪPOKO O TE IKA A MĀUI

VICTORIA
UNIVERSITY OF WELLINGTON

FINAL TEST – 2021

TRIMESTER 1

NWEN 439
SPECIAL TOPIC: PROTOCOLS AND ARCHITECTURES FOR THE INTERNET OF THINGS

Time Allowed: TWO HOURS

CLOSED BOOK

Permitted materials: Only silent non-programmable calculators or silent programmable calculators with their memories cleared are permitted in this examination.

No electronic dictionaries are allowed.

Paper foreign to English language dictionaries are allowed.

ONE A4 sheet, written on ONE side only.

No other material is permitted.

Instructions: Attempt ALL FOUR (4) questions:

1. IoT Architecture. [20 marks]
2. Short-Range Wireless Technologies. [40 marks]
3. Long Range Wide Area Networks. [25 marks]
4. Routing in Low-Power and Lossy Networks. [35 marks]

The test consists of 120 marks in total.

1. IoT Architecture **(20 marks)**

   (a) Traditional information technology (IT) systems are primarily concerned with reliable and continuous support of business applications such as databases, web, and electronic mail, among others. Whereas, one key concern in IoT is how to manage massive volumes of data generated by sensors and IoT devices, which can cause network bottlenecks and slow analytics in the cloud. What change is needed to the current network architecture to cope with this challenge? Explain how this change will address network bottlenecks and slow analytics in the cloud. **(6 marks)**

   (b) IoT networks are envisaged to support massive scale of IoT endpoints far beyond that of typical IT networks. Explain one limitation of IPv4 that makes it hard to support massive scale deployment and how IPv6 can resolve this issue at the network layer. **(6 marks)**

(c) Explain how latency can be lower when the applications and analytics are deployed closer to the edge. **(8 marks)**

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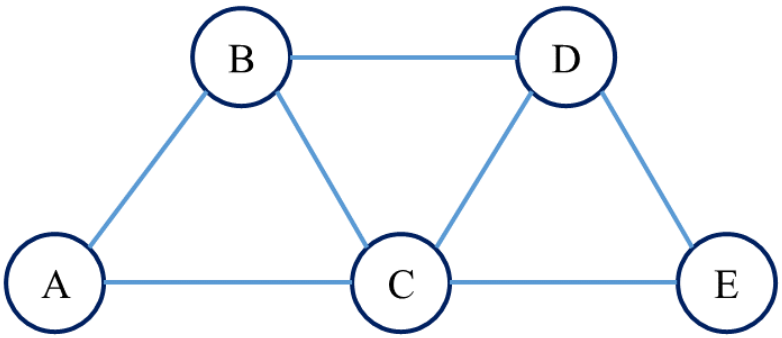
Specify the question number for work that you do want marked.

2. Short-Range Wireless Technologies **(40 marks)**

(a) Discuss the motivation behind the development of IEEE 802.15.4. Specifically, talk about two node constraints and how IEEE 802.15.4 addresses those constraints. **(8 marks)**

(b) Zigbee uses the routing protocol called Ad hoc On Demand Distance Vector (AODV). A node using AODV does not maintain routes, instead it performs a process known as *route discovery* when it needs to send data to another node and it has no route to that node. Explain how the route discovery process (node A searches a route to node E) would work in the given network. Which path is eventually used from A to E? **(10 marks)**



You can draw diagrams to aid your explanation.

(c) In the recent COVID-19 pandemic, Bluetooth Low Energy (BLE) has been considered as a possible technology solution for enabling efficient contact tracing. The key assumption is that a majority of the general population would be carrying mobile devices with BLE interface enabled. The general idea is to use BLE to detect and log "encounters" between individuals. When two individuals come into contact by virtue of them being within close proximity of each other, BLE is used to automatically exchange contact information.

i. You are asked to design a mobile app that uses BLE to log encounters between individuals. For simplicity, define an encounter as a duration in time when the individuals are within BLE range of each other. Using flowcharts, sequence diagrams, or any suitable diagram of your choice, provide a design showing how two user devices will discover each other and exchange contact information. You must clearly show how the user devices will switch between BLE roles to enable discovery and contact information exchange. Provide clear and sufficient explanations about your diagram. You may use either broadcasts or connections, but you will need to justify your choice. Your design must support BLE 4.1 devices (i.e., a device cannot be peripheral and central simultaneously.) **(14 marks)**

ii. Discuss two potential issues (one non-security related and one security related) with your mobile app design that is due to the use of BLE. Explain a possible solution or workaround to each of the identified issues. **(8 marks)**

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3. Long Range Wide Area Networks **(25 marks)**

   (a) In the legacy IEEE 802.11, a station (STA) operates in two modes: *active* and *power saving* (PS). Briefly describe the operation of a STA in these two modes. **(5 marks)**

   (b) How does an access point (AP) send data packets to stations in power saving mode? **(5 marks)**

(c) IEEE 802.11ah defines two classes of power saving STAs: TIM (like legacy 802.11) and non-TIM (*new*).

(i) Compared to TIM STAs, how are non-TIM STAs different?

(ii) Briefly explain how the new *Targeted Wake Time* (TWT) feature of non-TIM STAs work.

(6 marks)

(d) For TIM stations, the IEEE 802.11ah standard adds a new concept called *Restricted Access Window* (RAW). With the help of diagram(s), briefly explain how the RAW mechanism works and is able to ensure that selected STAs have contention-free access to the channel. **(9 marks)**

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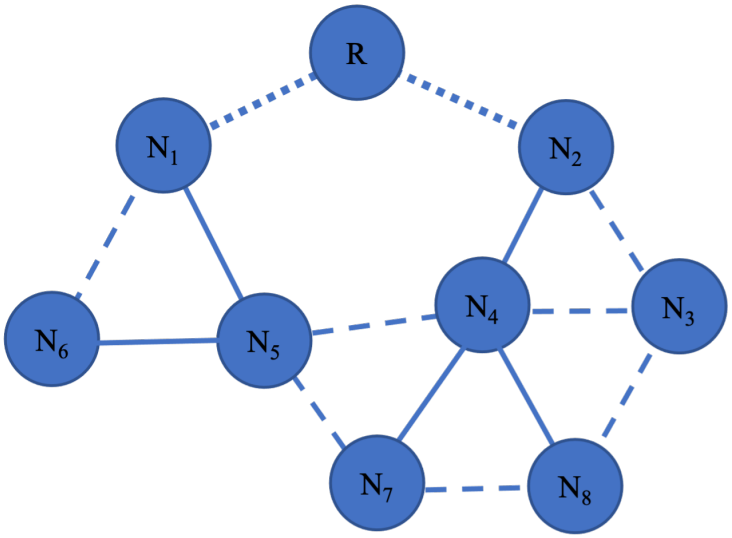
4. Routing in Low-Power and Lossy Networks **(35 marks)**



Link Types	ETX
———	1
·····	2
- - - -	3

In the network shown above, node R is the root node. The network is connected by links of different quality (ETX) as shown in the table.

(a) Briefly explain, with the help of diagram(s), how the Destination-Oriented Directed Acyclic Graph (DODAG) is constructed by clearly showing the exchange of DODAG Information objects (DIOs) and how the reverse paths are established in sequence. Assume that each node broadcasts the DIOs in the order of their node numbers, i.e. node R broadcasts first, followed N_1, then N_2, and so forth. **(20 marks)**

(b) When N_3 sends a packet to N_7, briefly discuss the advantages and disadvantages of using the storing mode vs non-storing mode for downward routing in terms of (i) memory requirements, (ii) control overheads, and (iii) latency. **(15 marks)**

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