TUNKU ABDUL RAHMAN UNIVERSITY OF MANAGEMENT AND TECHNOLOGY

FACULTY OF COMPUTING AND INFORMATION TECHNOLOGY

ACADEMIC YEAR 2024/2025

JANUARY EXAMINATION

BAIT2123 INTERNET OF THINGS

TUESDAY, 7 JANUARY 2025 TIME: 9.00 AM – 11.00 AM (2 HOURS)

BACHELOR OF INFORMATION TECHNOLOGY (HONOURS) IN INTERNET TECHNOLOGY
BACHELOR OF INFORMATION TECHNOLOGY (HONOURS) IN SOFTWARE SYSTEMS DEVELOPMENT

BACHELOR IN DATA SCIENCE (HONOURS)

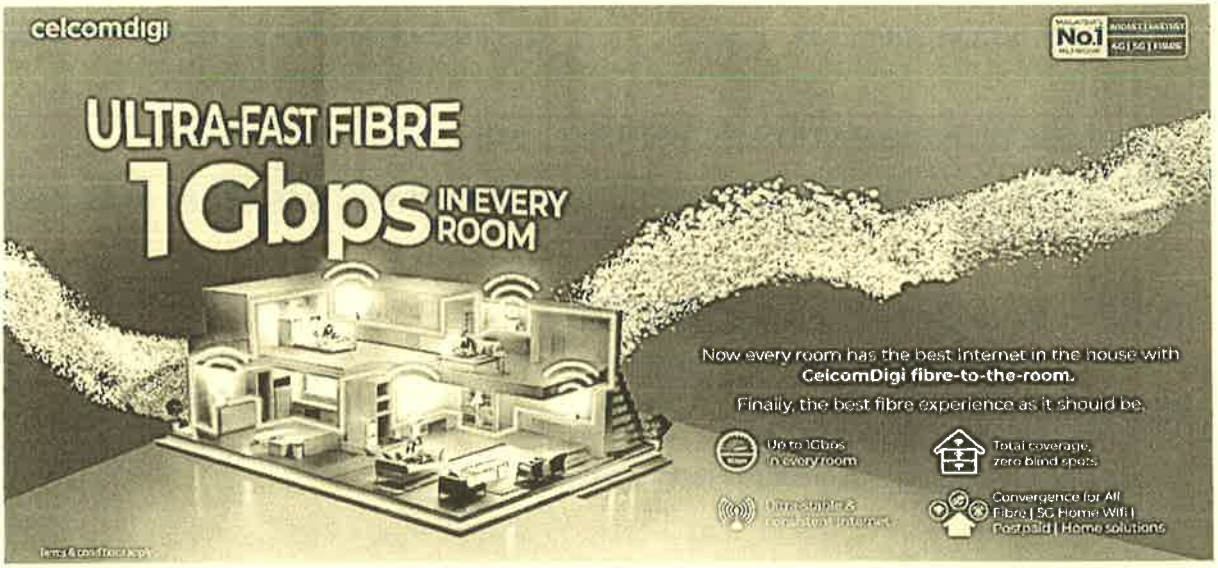
Instructions to Candidates:

Answer **ALL** questions. All questions carry equal marks.

BAIT2123 INTERNET OF THINGS

Question 1

The Internet of Things (IoT) is a network of interconnected devices that communicate and share data through the Internet. These smart devices, ranging from home appliances to security systems, work together to simplify everyday tasks and improve overall efficiency. By enabling seamless interaction between devices, IoT allows for automation and remote control, making it easier than ever to manage our homes and enhance our daily lives.



Incorporating IoT devices into our homes not only enhances convenience but also boosts security and energy efficiency, creating a seamless and connected living experience. As technology continues to evolve, these devices are becoming more accessible and user-friendly, making it easier than ever to embrace a smarter lifestyle. By investing in the right IoT solutions,i.e., ***smart security camera*** and ***smart lighting***, we can transform our home into a modern sanctuary that simplifies our daily tasks and improves our quality of life. The CelcomDigi Fibre plan can provide the full range of smart home devices available with and unlock even more savings on our connected home essentials!

Source: *Smart living: Top IoT device for our home*. Discover by CelcomDigi. (2024, October). https://discover.celcomdigi.com/blog/smart-living-top-iot-devices-for-your-home

a) Give examples of how the ***smart security camera*** (aka CCTV) can be an Internet of Things (IoT) device, based on the 3 elements that every IoT device should have. (6 marks)

b) Identify the communication model that is suitable for ***smart security camera*** solution and explain how does the model works. (1 + 3 marks)

c) Identify **TWO (2)** architectural components from the IoT platform architecture and describe how these components are utilised in the ***smart lighting*** solution. (2 + 4 marks)

d) Indicate and describe **TWO (2)** new resources or activities that are created by implementing IoT solutions in the ***smart lighting*** solution. (6 marks)

e) Relate **ONE (1)** process benefit in daily operation and describe it based on the ***smart lighting*** feature. (3 marks)

[Total: 25 marks]

Question 1

a) - Identity
   ↳ The smart security camera has its unique MAC address and IMEI number for being recognized, authenticated and addressed individually.

   - Intelligence
     ↳ The smart security camera uses AI algorithms to analyze the amount of people at surrounding to make decision on which action to be taken.

   - Communication
     ↳ The smart security camera can be remotely controlled by the user via mobile application with Wi-Fi or 4G/5G connection such as switching direction of the camera.

b) - Device-to-cloud communication model

   - The smart security camera can directly connect to the Internet cloud service via Wi-Fi connection without using intermediary application server.

   - The smart security camera will upload all the captured video, audio or image to the cloud storage for being referenced by the users.

c) - Database
   ↳ A scalable cloud-based storage will be used by the smart lighting to store all the configurations or rules set by the users for deciding the smart lighting's working behavior.

   - Data visualization

↳ The smart lighting has provided a visual dashboard interface via mobile application to show the current status and electric usage graphs which are accessible by the remote users to observe patterns and trends.

d) - Unique data sets

↳ The smart lighting device will regularly collect the sensed data such as brightness of surrounding at different date and time, these unique IoT data sets will become a key resource for allowing the lighting device to smartly adjust the brightness at different time designated for individual user.

- Analytics

↳ The smart lighting device can utilize the algorithms to predict daily, weekly and monthly electric usage on the lighting bulb, and suggest or personalize the bulb brightness at different time to minimize the electrical usage and cost usage efficiently

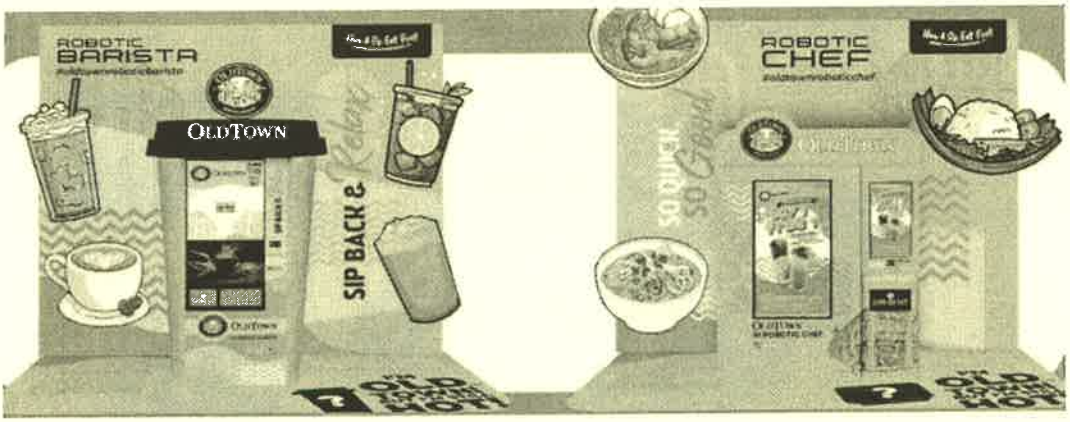
e) - Monitoring

↳ The smart lighting can monitor the surrounding light intensity or environmental brightness real-time for adjusting the brightness dynamically.

BAIT2123 INTERNET OF THINGS

Question 2

OldTown White Coffee, a popular Malaysian coffee chain, has ventured into the world of robotics with its ***Robotic Chef & Barista***. This automated system was unveiled at the Franchise International Malaysia 2024 event and aims to revolutionise the food and beverage industry.



- ***Robotic Barista:*** It prepares a variety of hot and iced coffee and tea-based drinks, including OldTown's signature white coffee, chocolate, lattes, and milk teas. It uses a bean-to-cup system for fresh coffee.

- ***Robotic Chef:*** It prepares a selection of simple dishes like dim sum and pasta. (This appears to be a collaboration with US Pizza, another Malaysian chain.)

Overall, the ***OldTown Robotic Chef & Barista*** represents an interesting development in the automation of food and beverage services. It has the potential to improve efficiency and consistency, but its success will depend on factors like cost-effectiveness, reliability, and consumer acceptance.

Source: *OldTown Robotic Chef & Barista*. Jacobs Douwe Egberts. (2024, May). https://linktr.ee/oldtownroboticmalaysia

a) Draw a system architecture block diagram of the ***Oldtown Robotic Chef & Barista*** (choose either one) with digital data flow direction, by including sensors, actuators / indicators and processing unit. *Do not provide a process flow diagram. (6 marks)

b) Describe how the ***Oldtown Robotic Chef & Barista*** receives customer orders, completes payment procedure, prepares and present the ordered food or beverage with the IoT implementation. (6 marks)

c) As the highest level of IoT Stacks, the X layer contains the applications that leverage fog computing to deliver innovative and intelligent application to end users.

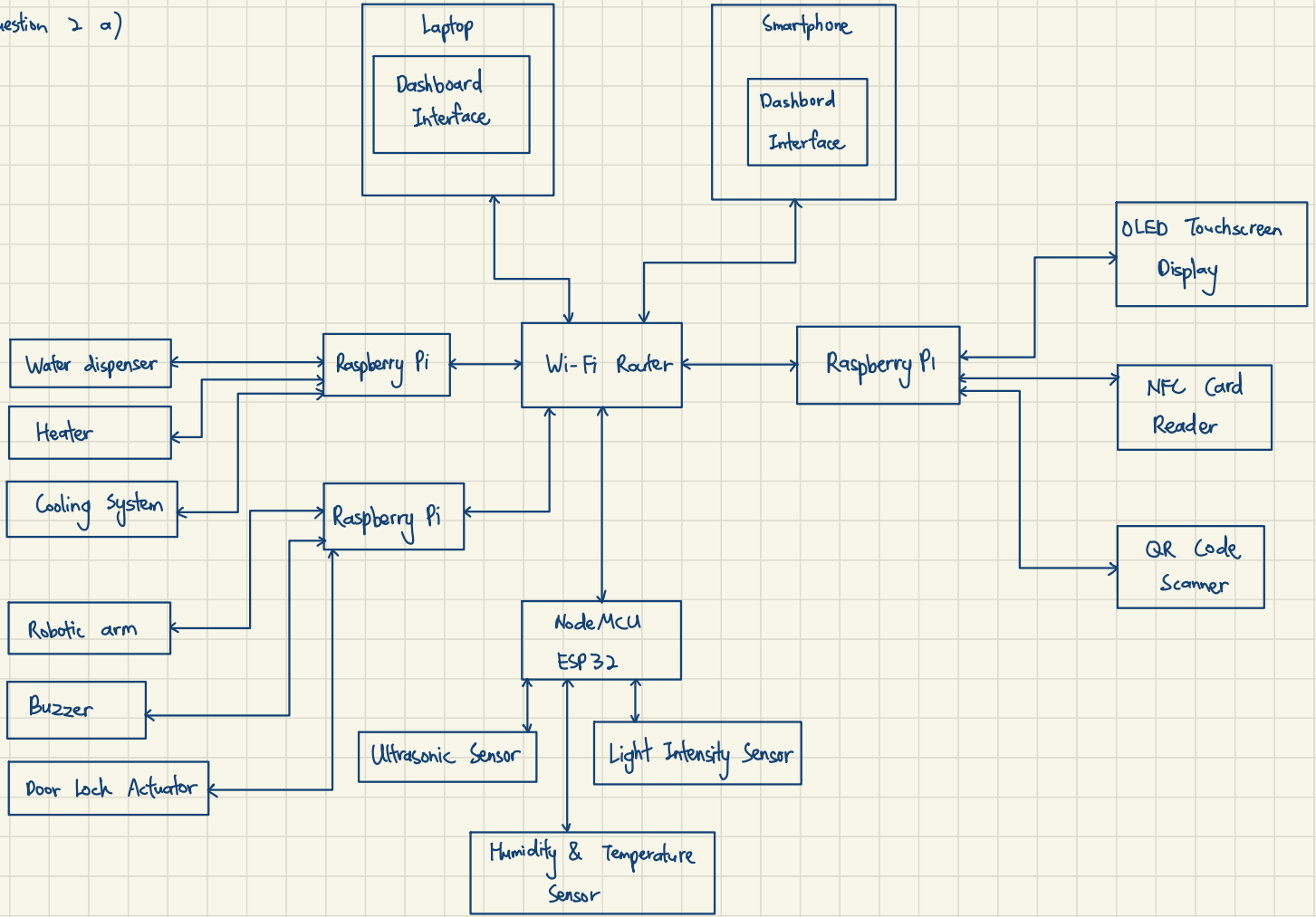
(i) Identify the name of the X layer. (1 mark)

(ii) From the scenario in **Question 2** b), illustrate **TWO (2)** use cases / extended features of the ***Oldtown robotic Chef & Barista*** machines in X layer. (6 marks)

(iii) Besides the X layer, state and describe the other **TWO (2)** layers names in IoT Stacks. (6 marks)

[Total: 25 marks]

Question 2 a)


Laptop
Dashboard Interface
Smartphone
Dashbord Interface
OLED Touchscreen Display
Water dispenser
Raspberry Pi
Wi-Fi Router
Raspberry Pi
Heater
NFC Card Reader
Cooling System
Raspberry Pi
QR Code Scanner
Robotic arm
NodeMCU ESP32
Buzzer
Ultrasonic Sensor
Light Intensity Sensor
Door Lock Actuator
Humidity & Temperature Sensor

Question 2 b)

- When there is customer approaching to the Oldtown Robotic Chef & Barista machine, the machine will immediately sense the customer via ultrasonic sensor and brighten up the touchscreen display for allowing the customer to make order.
- Customer will choose their preferred food and beverage via touching the touchscreen display. Once they have confirmed with their order, the machine will prompt payment interface to allow customer to choose payment method.
- If customer chose NFC Card Payment, the NFC Card Reader embedded with the machine will read the customer's payment card and automatically complete the transaction by connecting to the payment gateway via Wi-Fi connection.
- If customer chose QR Code Payment, the machine will enable the QR Code Scanner to scan customer's payment QR Code for completing the transaction via communicating with the corresponding payment gateway at the backend.
- After successful payment, the machine will operate and control the heater the heat the ordered food and beverage based on customer's selected preferences.
- When preparing beverage, the machine will control the robotic arm and water dispenser to take the cup and dispense the water into the cup
- After all the foods and beverages are get ready, the machine will control the robotic arm to place them on the small serving table and trigger the door lock actuator to open the door.
- Finally, the customer will be able to collect their food and beverage on the table.

Question 2 c)

(i) Solution layer

(ii) - Customer's ordering interface
  ↳ The machine integrates all the ordering and payment processes into an application with graphical user interface and display it on the touchscreen display for enabling customers to easily order the food and beverage and make payment.

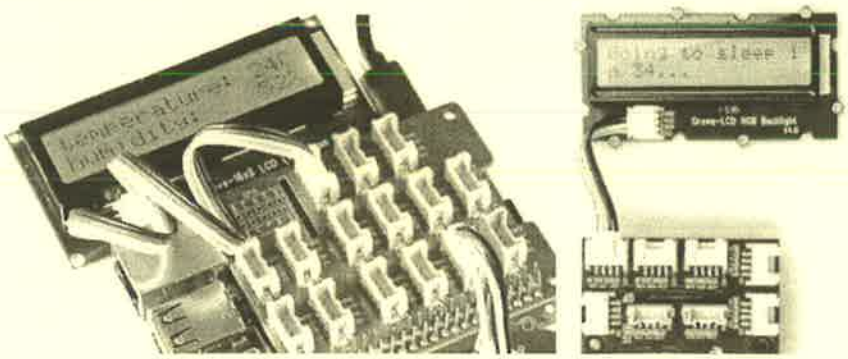
- Operator or administrator dashboard interface
  - ↳ The machine allows the operators or administrators to remotely monitor the current status of the machine via laptop or smartphone's mobile application
  - ↳ Meanwhile, they can control the machine by configuring the machine's settings through the mobile app such as updating product prices and stopping the machine services.

(iii) - Device layer
- ↳ At this layer, the machine has utilized a lot of sensors, actuators and indicators to perform a series of operation.
- ↳ The machine has used ultrasonic sensor to sense human who is approaching to the machine and use humidity and temperature sensor to detect the current status of the food and beverage inside the machine in real-time.
- ↳ The machine has also use robotic arm and water dispenser as actuators to complete the food and beverage preparing process.
- ↳ The machine use touchscreen display as indicator to display the ordering and payment interface to customers for ordering food and bererages.

- Communication layer
  - ↳ The machine has used the wired Ethernet connection to store the transaction records to the Internet cloud storage.
  - ↳ The machine also uses it for completing users' cashless transaction by connecting to various payment gateway.

Question 3

a) The LCD 16x2 module is a compact electronic display unit widely used in various electronics projects and devices. It features a liquid crystal display screen capable of showing two rows of 16 characters each. These characters can include letters, numbers, symbols, and even custom-designed characters. We connect this LCD 16x2 module to our Grove module (Grove Base Hat or Grove Pi+ board), as shown in the pictures below:



(i) Identify the ***full name*** of the protocol used by the LCD 16x2 module. (3 marks)

(ii) List and describe **TWO (2)** basic required hardware connections (lines) for communication, using the protocol in **Question 3** a) (i). (4 marks)

(iii) Illustrate the outcome if we connect more than one LCD 16x2 module on the same Grove board. (5 marks)

b) The following Python codes illustrate the procedure for LED output.

```
Line      Code
01        import time
02        from grovepi import *
03
04        led = 4
05        pinMode(led, "OUTPUT")
06        time.sleep(1)
07        while True:
08            try:
09                digitalWrite(led, 1)
10                time.sleep(0.5)
11                digitalWrite(led, 0)
12                time.sleep(0.5)
13            except KeyboardInterrupt:
14                digitalWrite(led, 0)
15                break
16            except IOError:
17                print("IOError")
```

(i) Explain the result/impact of removing code line 10 and line 12. (3 marks)

(ii) Explain the result/impact of removing code line 14. (3 marks)

(iii) Modify the code from line 09 to line 12, to produce a sequence of LED blinks with continuous three long durations and three short durations (as an emergency "SOS" signal). (7 marks)

[Total: 25 marks]

Question 3 a)

(i) Inter-Integrated Circuit (I^2C) communication protocol

(ii) - SDA (Serial Data Line)
↳ It carries the data being transmitted between the master and slave devices.

- SCL (Serial Clock Line)
↳ It carries the clock signal generated by the master device to synchronize data transmission.

(iii) - Bus collision might occurs since I^2C LCD 16X2 modules use a fixed address like 0x27 or 0x3F.
- Both devices might respond at the same time.
- Both devices might show garbled text, unreliable behavior or even no display would happen.

Question 3 b)

(i) - The LED light will be turn on, and then immediately turn off. The speed of switching the light power is too fast until human cannot see it.
- Human might only see the LED light always off visually.

(ii) - When users enter the key Ctrl + C, it will trigger the KeyboardInterrupt and cause the LED light to be turned off.

(iii)
```
for i in range(3):
    digitalWrite(led, 1)
    time.sleep(1)
```

```
    digitalWrite(led, 0)
    time.sleep(0.5)

for i in range(3):
    digitalWrite(led, 1)
    time.sleep(0.3)
    digitalWrite(led, 0)
    time.sleep(0.3)
```

Question 4

Left: Apple Watch (2024), RM1,799 Right: Redmi Watch (2024), RM129.00

Source: Apple Watch Series 10. (2024, May 24). Apple Inc. https://www.apple.com/my/apple-watch-series-10/
Redmi Watch 5 Active. (2024, Sept 23). Xiaomi. https://www.mi.com/my/product/redmi-watch-5-active/

Smartwatches are a prime example of an IoT (Internet of Things) product. They are wearable devices that connect to the internet, either directly via cellular connectivity or through a paired smartphone, allowing them to collect and transmit data, interact with other devices, and provide users with a personalised and connected experience.

The Apple Watch Series 10 is Apple's latest flagship smartwatch, offering a premium experience with a beautiful always-on OLED display, advanced health and fitness tracking features (including ECG, blood oxygen monitoring, and temperature sensing), and seamless integration with the Apple ecosystem. It delivers fast performance and runs the latest watchOS 11 with new watch faces and a Mindfulness app. However, this comes at a premium price, and battery life is limited to about 18 hours. On the other hand, the Xiaomi Redmi Watch 5 Active is a budget-friendly smartwatch that prioritises affordability and long battery life. It provides basic health and fitness tracking features like heart rate monitoring, sleep tracking, and over 100 sports modes, all in a lightweight and comfortable design. With a battery life of up to 12 days, it's ideal for those who want a simple and long-lasting smartwatch without breaking the bank. However, it lacks the advanced features, processing power, and vibrant display of the Apple Watch Series 10.

a) Discuss feasibility studies by analysing the *general market opportunity* and *time / channel to market* for using these smartwatches. (6 marks)

b) Sketch a health care solution by using smartwatches product, based on the Usage Viewpoint in the Industry IoT Consortium Reference Architecture (IIC RA). Your solution should include *the relevant stakeholders, User Interfaces, Processes*, *Rules*, *Data,* and *its Benefits / Goals*. (8 marks)

c) Besides the health care solution, identify **TWO (2)** other use cases of smartwatches. (6 marks)

d) Discuss **ONE (1)** issue of *Autonomous and unpredictable behaviour* that could occur while using the smartwatches in our daily life. (5 marks)

[Total: 25 marks]

Question 4 a)

General market opportunity

↳ There are increasing number of people all around the world start to concern with their body health and desire to build a healthy lifestyle.

↳ Thus, it is a good opportunity to deliver these smartwatches to the market because they come with various health monitoring features such as heart rate monitoring, sleep tracking, blood oxygen monitoring and temperature sensing.

↳ The users can effectively adjust their lifestyles via regularly checking with their health condition via smartwatches.

Time/channel to market

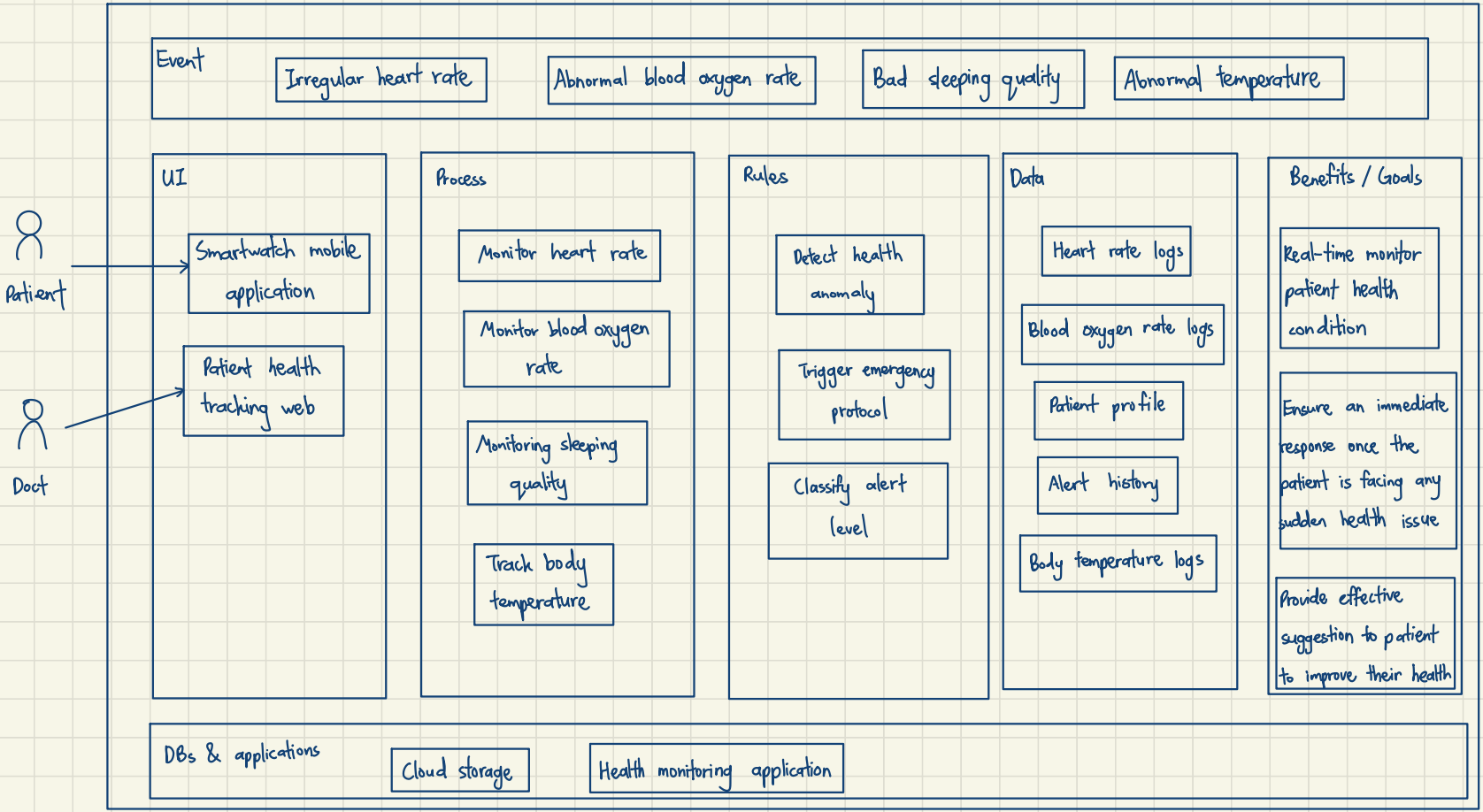
↳ These smartwatches can be delivered to market via direct retail stores such as Apple and Xiaomi physical stores.

↳ They can also be presented on the official website or online shopping platform such as Shopee and Lazada.

↳ They can also corporate with fitness apps and wellness programs to offer special discounts to the users or participants.

Question 4 b)

Health care solution



Question 4 c)

- Smartwatches can be used to help users to track the duration and number of times in various sport activities. This allows users to view their progress after sport activities.

- Smartwatches can synchronize the notifications and calls on users' smartphone once it is linked to users' smartphone using bluetooth. Thus, the users do not need to frequently take out their smartphone to view the notifications every time there is a notification. They can directly view it by looking at the smartwatch's screen.

Question 4 d)

- The results analyzed from the smartwatches may not always accurate. When the machine learning algorithms are not trained well, it might provide a wrong result.
- For example, the user has been run for 1.5 km but the smartwatch shows that he has been run for 1.2 km only. This has lead to a inaccurate sport progress result.
- As the result, it will cause the user to think that he has not achieve his goal of 1.5 km and make a false decision to continue to run for another 0.3 km.