ECS725P – Mobile Services Coursework
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Automatic Dispenser Application with Location Tracking

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1. Introduction

During pandemics, different governments have adopted different policies to combat the spreading of disease. Among all, contact tracking and the supply of personal protection equipment are of the fundamental important to disease prevention. To achieve contact tracking, GPS and Bluetooth are used in mobile device for location identification and infection individuals' detection. However, these methods have their own limitations. GPS functions poorly in indoor environment and Bluetooth is only available in a short range. Therefore, they might not be effective in controlling pandemics. Meanwhile, merely ensuring adequate supply of PPE does not guarantee individuals of its usage. Monitoring work is needed to track the real-time constant supply and operation of PPE.

Among all the PPE, automatic hand sanitizer dispenser is the focus in this paper. There are 2 existing problems of automatic dispensers in the current market, which are manual observation of remaining sanitizers in the container and the lack of user and location identification. First, manual observation is used to identify the amount of sanitizer left in the container and make refill when needed. This method consumes a lot of human power for constant checking of different dispenser and thus is not efficient in a pandemic situation where sanitizers is in high demand. Immediate refilling of sanitizes might not be provided. Second, since anyone can just use the dispenser by placing their hand underneath it, the users are not recorded. The hygiene level of the citizens and the mobility of infected user cannot be estimated and thus it is difficult for government to maintain public health by preventing the disease from spreading. Although the primary function of a dispenser is to dispense sanitizer only, it is important to provide add-on functions, including immediate refilling of sanitizer and monitoring of users' hygiene level, in a pandemic situation. As a result, 3 aims are proposed for the design of automatic hand sanitizer to solve the existing shortcomings of automatic dispenser. The aims are i) monitor both infected and uninfected individual mobility, ii) notify individuals about the presence of infected people in the area and iii) provide sanitizing services to individuals.

To achieve the abovementioned aims, In this paper, a 3-tier model is proposed, with dispenser and application as the client, application server as the middleware and the database server as the server. The government is suggested to be the initiator of this model for contact tracking and public health promotion. The model uses technologies such as QR code, wired and wireless connection between different components for location detection, availability of sanitizermeasurement and communication between different components. The model ensures sanitizers are refilled when the container is becoming empty and locations of infected individuals are identified. Users are notified with the number of infected user once they used the dispenser service. Data received can also be used for government's R&D in investigating factors affecting the spread of disease and be beneficial for healthcare policies formulation.

2. Use-Case

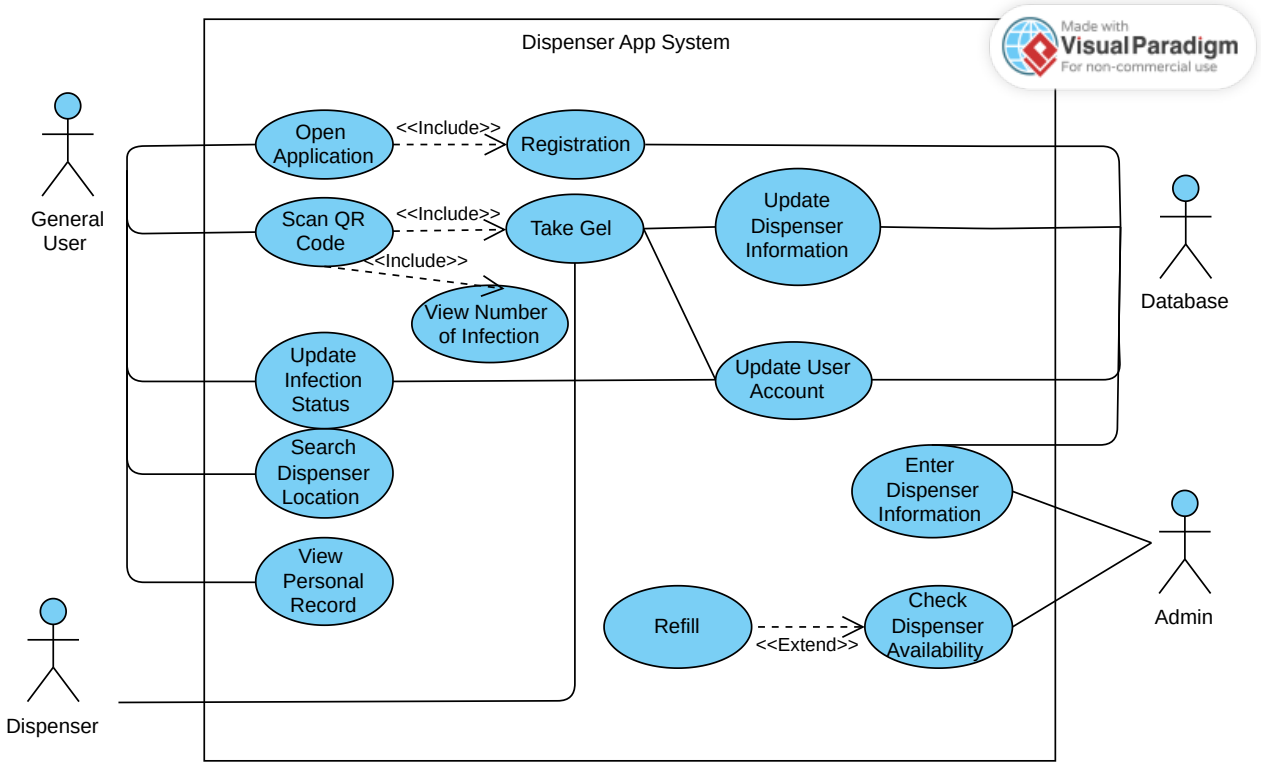

Figure 1. Use Case Diagram

2.1 Use Case 1 – General User Scans the QR Code of the Dispenser to Get the Sanitizer

Actors Involved: General User

Description:

General users register on the application with their personal information, including username, password, name, address, email, gender and infection status. Each user can only register once. User must register to use the dispenser. Then, to use any of the located dispenser, the user opens the application and scans the QR code displayed on the dispenser.

Precondition:

- Users needed to be in a close distance with the dispenser
- Users had the application installed and registered on the application
- Mobile phone must be connected to network.

Normal Flow:

1. Dispenser shows the QR code
2. User opens the application and scan the QR code shown on the dispenser
3. Application authenticates user's login credentials
4. User places their hands under the dispenser
5. Infra-red sensor in the dispenser detected there is a hand underneath the dispensing point
6. Sanitizer is ejected from the automatic dispenser
7. Application displays the number of infected users who used the dispenser in the past 2 hours

Alternative Flow: User does not put their hands under the dispenser

- Step 4 does not apply and sanitizer will not be ejected
- User receive a notification on the application asking for the user to put his hands under the dispensing point

Exception:

- At Step 1, QR code is not shown by the dispenser

- At Step 4, Infra-red sensor does not work
- For both exceptions, repairment on the dispenser is needed

Postcondition: Users successfully used the dispenser and database is updated

2.2 Use Case 2 – General User Search for a nearby Dispenser on the Application

Actors Involved: General User

Description:

The application provides a map of all the dispenser. Users can open the application and look for a dispenser located in the vicinity.

Precondition:

- User had the application and registers on their mobile devices
- User had access to the internet
- User enabled locations services on their mobile devices

Normal Flow:

1. User opens the application and select the 'map' function
2. Application asks for permission from the users for location access
3. User accepts to share location access to the application
4. Application displays a map with all the dispenser nearby (located as pin) and the location of the user
5. User clicks on a selected pin
6. Application displays the address of the dispenser

Alternative Flow: User decline to share location access in step 3

- Application show a notification to the users that location access is needed for the map function
- If the user still do not accept to share location, they will be returned to the main page

Postcondition: Users successfully spot the location of nearby dispenser

2.3 Use Case 3 – Administrators Check Dispenser Condition

Actors Involved: Administrators

Precondition:

- Administrator are logged in to the system
- Dispenser is connected to the system

Normal Flow:

1. Dispenser send to the application server the weight of sanitizer left in the container every 15 minutes
2. Application server send an alert to the system when the weight of the sanitizer is below 20% of its original weight
3. The administrator checks if there are any alerts on the system
4. The administrator goes to the dispenser location
5. The administrator opens the dispenser and makes the refilling of sanitizers

Alternative Flow:

- In step 2, if the dispenser is not connected to the system, the administrator goes and check the amount of sanitizer left and fix the connection problem

Postcondition: Dispenser is refilled with sanitizers

3. Requirement Analysis

3.1 Functional Requirement

<u>Dispenser</u>

- Detects if a hand is present under the dispensing point
- Sends the weight of the sanitizer in the container to the system every 15 minutes
- Shows the QR code

Application
- Allows user to register with personal information
- Allows user to report his infection status and update the status in the system
- Connects to the mobile phone's camera
- Connects to the server
- Shows a map with location of all dispensers and the users
- Shows the information of all dispenser when clicked
- Shows the total number of infected users using the dispenser in the past 2 hours
- Shows a record of dispenser usage for each user (with time and location)

System (Database)
- Updates the dispenser condition (amount of sanitizer left & infection count)
- Matches the user's infection status with the dispenser's usage record
- Keeps a record of all the dispenser's usage and corresponding users

Application Server
- Generates QR code and ID for every dispenser
- Receives signal from dispenser every 15 minutes
- Data transferal and receival from database, dispenser and application

3.2 Non-functional Requirement

Dispenser
- Operate for a long time with low power source (energy-efficient)

Application
- Interface should be easy and simple to use
- Fast response time to user's computer interaction
- Secured communication with application server

Database Server
- Secured communication with application server
- Secured data storage for the database storing dispenser and users' information
- Large data storage for potentially large number of information needed to be stored
- Handle simultaneous request from multiple users without performance degradation

3.3 Hardware Requirement

Every user must have their own mobile phone for application installation. The mobile phone must be equipped with a camera. Other than that, hardware requirement for each component are as follows:

For Each Dispenser

1. Pump (to dispense gel)
2. Container (to hold gel)
3. Socket

   Socket is used for power supply for pumping, infra-red sensor, weight sensor, screen and connection to the application server. Although the physical components do not require much energy, Wifi connection consume large amount of energy over a long time, and thus battery is not sufficient and sustainable option. A socket provides a steady supply of power for a dispenser which should works 24/7.

4. 1-kg Weight Sensor

Figure 2. 1-kgWeight Sensor

Figure 2 shows a weight sensor is used to monitor the amount of sanitizer left in the container of the dispenser. The weight sensor will be connected to microcontroller in the dispenser in order to send the data to the system every 15 minutes. Other sensing options are not chosen, such as optical sensor since the measurement can be interfered by light (Lobnik et.al, 2012) and is thus not suitable for outdoor environment that are affected by sunlight, and indoor environment where lights might be turned off. Flow meter is not chosen with its lower precision in measuring the amount of sanitizer left than weight sensor than weight sensor (Crossco, 2018). This would lead to a delay in refilling of sanitizer which is undesirable in a pandemic situation. 1-kg weight sensor is chosen since the dispenser is designed to hold a 1L of sanitizers in the container.

5. B&W E-ink Screen

Figure 3. E-ink Screen

Figure 3 shows an example of showing a QR code on a e-ink screen. E-ink screen is chosen to display the QR code on the dispenser. Digitally displaying QR code is chosen rather than having a printing of the QR code on the dispenser because physical printing might be damaged by users or degraded over time. Having digital QR code ensures its integrity and less maintenance work can be done. Also, E-ink screen is chosen rather than LCD or LED screen because of its low power consumption. The QR code will not be changed often or essentially will not be changed. E-ink screen is a good choice since it does not consume energy when the content on the screen is not changing, while LCD and LED screen still consume energy even though the content is static. With the same amount of power supply, the significant longer running time can be resulted using e-ink screen (Jin & Zhang, 2020). Thus, E-ink screen is chosen because of its energy efficiency.

6. Infrared Sensor

Figure 4. Infrared Sensor

Passive Infrared sensor is used to detect the presence of hands under the dispensing point. It is placed at the dispensing point of the dispenser. Where a hand is placed underneath the dispensing point, infrared energy fluctuates. The dispenser can be programmed to pump sanitizer after sensing the change in infrared level and complete the dispensing process.

7. Microcontroller

Figure 5. MKR1000 Wifi

Microcontroller is used to automatically function the dispenser, including dispensing sanitizer and performing weight check and communicating with the system. Communication includes

transferring weight data to the system every 15 minutes. MKR 1000 Wifi is suggested due to its features of in-built Wifi and security capability with ECC508 embedded, which is extremely important since the communication between the system and dispenser should be kept confidential.

Application Server

1. Network Interface Card (NIC)
   NIC is needed to maintain network connection between the computer running the application server and other devices (dispenser and other administrators).

Database Server

1. RAM
   RAM is the memory needed for storage. In general, more RAM can result in a faster database.

2. Solid State Drive (SSD)
   SSD is chosen since it allows fast reading and writing speed. Since the system might consists of frequent usage, fast retrieval of data from the database is required to provide immediate response to the application and fluency of user experience. The size of SSD depends on the number of users and number of dispenser information needed to be stored.

3. LAN Cable
   LAN Cable is used to establish the connection between the application server and database server.

3.4 Software Requirement

Dispenser

Each dispenser is programmed to dispense a fixed amount of sanitizer at a time. A timestamp is also included in the programming to trigger the weight scaler to measure the amount of sanitizer left.

Application

The following software requirements is required to be enabled on the user's mobile phone for the operation of the application:

1. Location access enabled for the application
2. Camera access enabled for the application
3. Mobile phone connects to the Internet

For the software development of application:

4. Basic Software Design of the Application
   Software design of the application is the basis of the application. Programming language such as Java and Swift can be used to design application for Android and iOS. Codes should be designed to provide the dispenser mapping, QR code scanning, personal record viewing and notification function for the user side. For the back-end side, the code should send query to the application server every time a user scans a QR code or click on the map to retrieve information for notification.

5. Dispenser Mapping Function
   The function is used to show the location of nearby dispenser around the user. To provide mapping function, Google Map API can be integrated to the application by adding the corresponding JavaScript code to the code of the application. Then, pins are added according to the location of the dispensers and users can also view their current location on the map of the application. Google Map API is chosen due to its accuracy in locating users' real-time location.

6. QR code Scanning Function
   User must scan the QR code in order to use the dispenser. Thus, the application should include the scanning function. To achieve this, the user presses the scan button in the application and the application will turn on the QR code reader in the mobile phone.

Database Server

Server is used to maintain and store the database containing user and dispenser information. Server also retrieves information from the database on request from the application and reply to the application. Server also receives information from dispenser and update the corresponding entry in the database. Suggested database server can be Microsoft SQL Server since it provides security, network protocol, data query and analytics functions.

Application Server

Application server serves as a middleware between the application, dispenser and the database server. On one hand, it receives client requests from the application. It also receives weight updates from the dispensers. On the other hand, the application server sends information or query to the database server about dispensers' information. Java with Javabase Connectivity (JDBC) is suggested since it can be connected to the Microsoft SQL server (the server we use in this system) and provides functions to manage web services that send data to the mobile application.

4. Design

4.1 Model

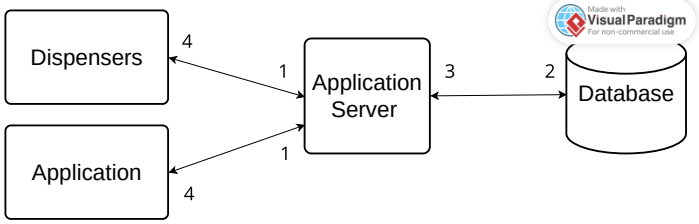

Figure 6. Client-Middleware-Server Model

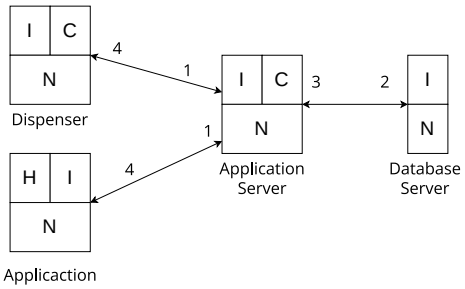

Figure 7. Model with Function Shown

The model aims to provide a record of alcohol hand sanitizer sanitizerusage for the government and general public. In this model, the number of infected users is calculated and linked with the dispenser they used. This allows the government to monitor the mobility of infected user and make analysis based on the numbers. Figure 6 and 7 shows the 3-tier architecture between the dispensers, application, application server and the database server. In Figure 7, H means human input/output, I means data, C means computation and N means networking.

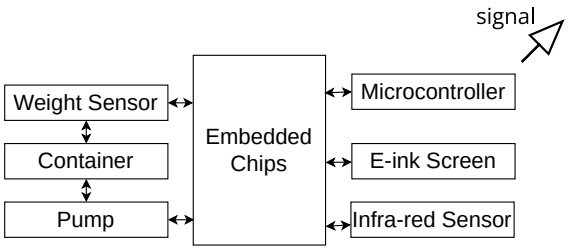

Figure 8. Physical Design of Dispenser

A unique identification number and QR code will be generated by the application server for each dispenser for identification of each dispenser. In each dispenser, it stores data about the previous calculated weight and its QR code. It is connected to the network via Wifi so the dispenser can communicate with the application server (indirectly through web server). TCP protocol is sufficient for data transmission from the dispenser to the web server since the data is not confidential and sensitive. Wifi connection function of the dispenser is provided by the microcontroller inside the dispenser as shown in Figure 8.

In the application, human I/O includes i) interactive map, login & register button, ii) username and password input for login and iii) personal information input for registration. Personal Information includes the name, gender, address, phone number and infection status. After successful registration, each user is assigned a unique member ID by the application server. Data, including the location of every dispenser and personal record and information are stored on the application. The application is connected to the network via any user-chosen network (either cellular network or Wifi) so the application can communicate with the application server (indirectly through service provider). SSL/TLS encryption protocol is used for the establishment of secured transmission of data between the application and the web server since the personal information should be kept confidential.

For the backend, there are the application server and the database server. Both servers are located in the same data center, and they are connected with each other with physical LAN cable. With the physically established linkage, this ensures the high security of data transmission between the 2 servers. In the application server, it generates QR code and user ID for dispenser and registered users. The main responsibility of the application server is to act as a middleware between the clients (dispenser or application) and the database server. If any query is sent from the clients, the application server forwards the query to the database server and retrieve the corresponding data for reply. If data are given from the clients or generated by the application server, application server updates the corresponding section in the database. Database server only stores given data from the application server or retrieve data for application server upon query. By default, Microsoft SQL used TCP protocol for communication with JDBC.

The following table 1 shows a summary of protocol used by different components in the model in different OSI layer.

	Dispenser	Application	Application Server	Database Server
Application	HTTP	HTTPS	JDBC	Microsoft SQL
Transport	TCP	SSL/TLS	TCP	TCP
Network	IP	IP	IP	N/A
Data-Link	Wifi	Wifi / Cellular Network	Cellular Network	N/A
Physical	N/A	N/A	LAN	LAN

Table 1. Protocol used in Different Layers

4.2 Flow Chart

4.2.1 Dispenser

Figure 9 presents a flow chart of the operation of each dispenser. After powering up the dispenser, the system is initialized. If it is the first time of booting up, the dispenser sends a query to the application server for the ID and QR code and display the received QR code on the E-ink screen. If the dispenser receives a signal from the application server that its QR code is scanned, it starts the infrared detection and dispense sanitizer if hand is detected. Otherwise, the dispenser send signal to

the application server that the process is unsuccessful. If no signal is received from the application server, the dispenser does not perform any action. Lastly, the dispenser is programmed with a 15-minute timestamp. When time is up, the dispenser activates the weight sensor and send the calculated weight information to the application server for record.

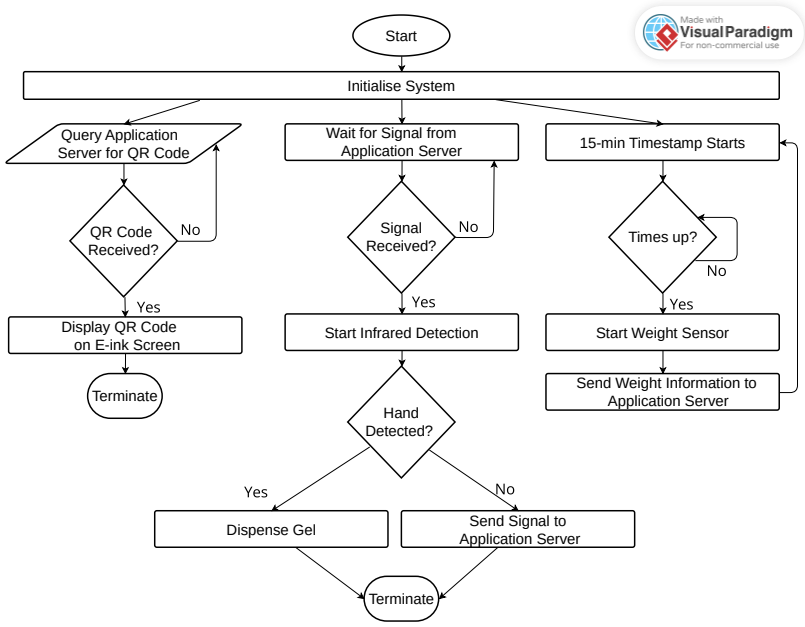

Figure 9. Flow Chart of Dispenser

4.2.2 Application

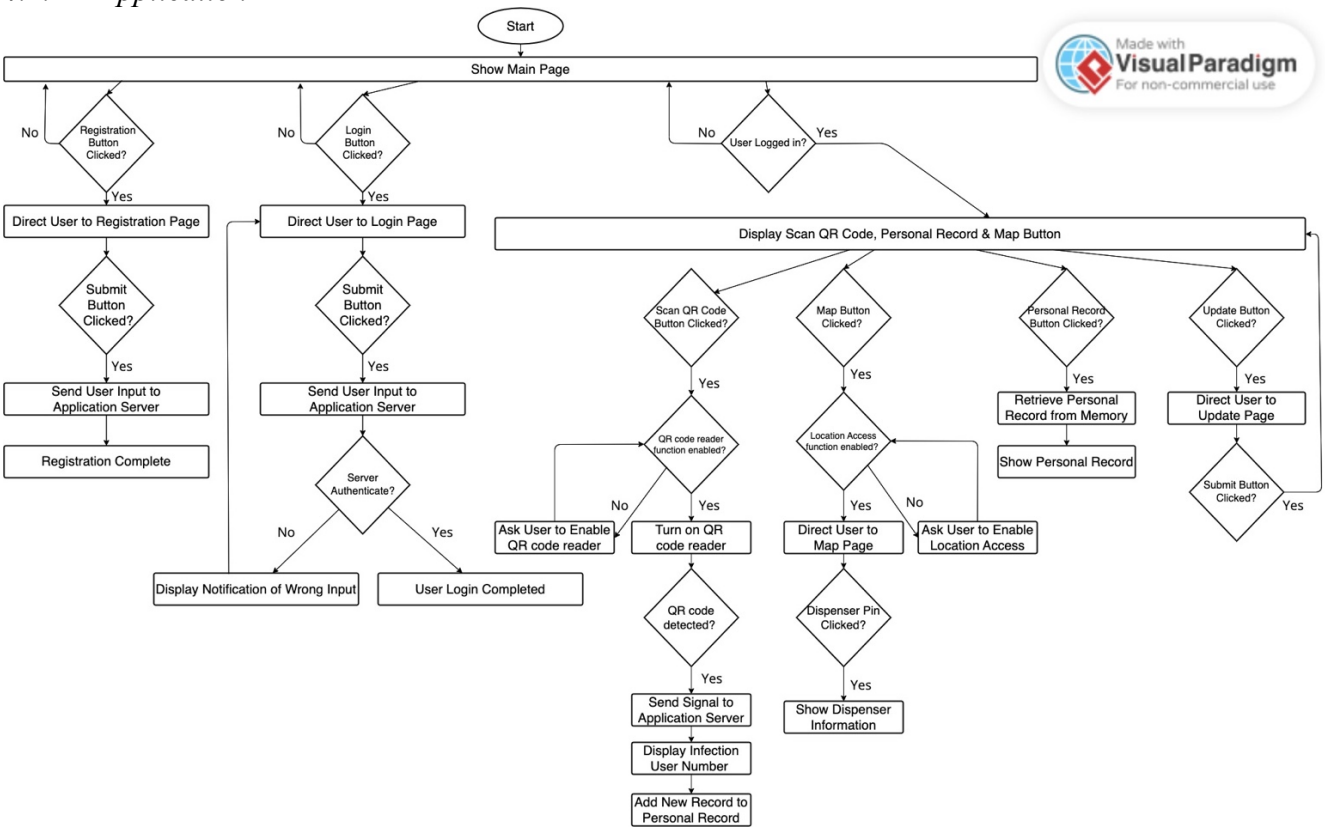

Figure 10. Flow Chart of Application

Figure 10 shows the flow chart once the application is opened by the users. It first shows the main page with 2 button, ‘register’ and ‘login’. If the ‘register’ button is clicked, the users will be directed to the registration page and user is required to input personal information and click the ‘submit’ button while finished. Then, the application will send the input to the application server and registration is completed. If the ‘login’ button is clicked, the user will be directed to the login page. User is required to input the login credentials (username and password) and click ‘submit’. The application will then send the input to the application server via Wifi with TLS/SSL for authentication. If the appliation server does not authenticate the credentials, the user will be directe back to the login page. If authenticated, the user will be directed to a page with 3 buttons, ‘Scan QR code’, ‘Map’, ‘Update’ and ‘Personal Record’.

When the ‘Scan QR code’ button is clicked, the application will first check if QR code reader function is enabled by the user for the application. If not, the application will show a notification to the user, asking for the permission of the use of QR code reader. If the reader is enabled, the application turn on the QR code reader. User has to place the reader in front of the QR code which is shown on the dispenser. The application keeps the reader turned on until a QR code is detected. Once a QR code is detected, the application sends a message to the applcation server for the retrieval of dispenser information. After receving the information from the application server, the application displays the infected user count of the dispenser and adds new record to the personal record section. The process is then completed.

When the ‘Map’ button is clicked, the application will first check if location access function is enabled by the user for the application. If not, the application will show a notification to the user, asking for the permission of the use of location acceses. If location access is enabled, the user will be directed to the map page. The map shows the user’s location and pins of dispenser indicating the loaction of the dispensers. If a pin is clicked, the application shows the address of the selected dispenser.

When the ‘Personal Record’ button is clicked, the application retreives the information from the memory. The user will be directed to page with all the previous dispenser usage records, including the time of usage and the location of dispenser.

When the ‘Update’ button is clicked, the user will be directed to the update page. User can only update his infection status by choosing among ‘Yes’ or ‘No’. User clicks the ‘submit’ button after updating his status and he will be sirected back to the main page. Otherwise, the application stay on the update page.

4.3 Information and Data Flow

In this section, the information flow will be described based on the functions of the application and the dispenser since all data flow are triggered by the action of dispenser and application.

4.3.1 Application – Registration

Once the ‘register’ button is clicked, the user is prompted to input the following information: username, password, name, address, email, gender and infection status. Once the ‘submit’ button is clicked in the registration page, the application send all the input to the application server. A user ID will be generated by the application server for the user. The input and the user ID will then be sent and stored in the database server. The database server sends an acknowledgement to the application server that registration record is stored. The application server sends an acknowledgement to the application that registration is completed.

4.3.2 Application – Login

After the user clicks the 'login' button, the user is prompted to input his username and password. Once the 'submit' button is clicked on the login page, the application send all the input to the application server. The application server sends a request to the database server for the retrieval of the user's password. If the 2 received information matched, then the application server replies to the application about the authenticated login and the application then directs the user to the page with other functions. Otherwise, the application server replies to the application about the unauthenticated login and the application then the user will be directed back to the main page.

4.3.3 Application – Scan QR Code

After the user scans a QR code, the application sends the QR code information, time of scanning and the user ID to the application server. The application server sends the received information to the database server with i) the request of the retrieval of IP address and infected user count in the past 2 hours of the dispenser and ii) the update of user record. First, the database retrieves the dispenser's IP address which matches its QR code and replies to the application server. The application server sends a request to the received IP address on activating the dispensing process. The dispenser replies for the acknowledgement of request. Second, the database replies to the application server with the infected user count in the past 2 hours of the dispenser. The application server sends the infected user count to the application and the application display it on the user's mobile phone. Lastly, the databases server updates the corresponding user record with the received user ID, dispenser ID and time of scanning. The updated user record with the time of scanning and location of dispenser is sent from the database server to the application server then to the application. The record will be saved in the application until further updates from the database.

4.3.4 Application – View Personal Record

After the user clicks the 'view personal record' button, the application retrieves the personal record from its cache, with the list of past dispensing time and the corresponding location of dispenser. There is no information flow between the components of the model.

4.3.5 Application – View Map

After the user clicks the 'view map' button, the application retrieves the dispenser information from its cache, with a map showing pins of dispenser location and user's current location. Address of the dispenser will be shown if the user clicks on the pin. There is no information flow between the components of the model.

4.3.6 Application – Update Infection Status

After the user clicks the 'update' button, the user is prompted to choose 'Yes' or 'No' for the infection status. Once the 'submit' button is clicked on the update page, the application send the input and the user ID to the application server. The application server then sends a request to the database server for the update of infection status with the given user ID. After updating the record, the database server sends an acknowledgement to the application server that update of infection status is completed.

4.3.7 Dispenser – Receive QR Code

When the dispenser is powered up and connect to the application server for the first time, the dispenser requests the application server for a unique QR code to be shown on the e-ink screen. The application server generates a unique QR code and ID for the dispenser and send the QR code and dispenser ID back to the dispenser. The QR code is saved in the dispenser and shown on the e-ink screen. Also, the application server sends the QR code, the dispenser ID and manually-input location

of the dispenser to the database server. Database replies to the application server with the acknowledgement of storage of dispenser's information.

4.3.8 Dispenser – Send Weight Measurement

For every 15 minutes, the dispenser activates the weight sensor to measure the weight of sanitizerleft in the container. The dispenser sends the calculated weight and dispenser ID to the application server. The application server replies an acknowledge of the receival of data. The application server then calculates if the weight received is lower than 20% of the original weight. If yes, the application server sends the dispenser ID and a request to the database server for the retrieval of address of dispenser. The database server replies to the application server with the address. The application server then notifies the administrator to go to the address and refill the dispenser.

5. Analysis of Design Issues and Design Options

5.1 Survey of Related Work

5.1.1 Contact Tracing Apps

Contact tracing is one of the strategies to prevent disease from spreading. It is based on identifying the related individuals who might have contact with the infected individuals in any circumstances (Eames, 2006). Different methods are used for contact tracing by the governments, for instance CCTV, drone camera and electronic payment location information (Urbaczewski & Lee, 2020). However, these tracing strategies are passive. Uninfected citizens are not notified by the government about their exposure to or contact with infected individual. Infected individuals are also not regulated by the government to avoid the spreading of disease in public area.

As the pandemic develops, mobile phone movement tracking apps are released and used by the governments to help keep track of infected individuals and notify the citizens about the presence of infected individuals in the area. These apps make use of GPS and Bluetooth to record individuals' location. With the mobile application, the governments are able to identify potentially dangerous areas with high number of infected individuals (Chan et. al., 2020) and implement mobility control on these areas. However, these mobile apps are proven to be unreliable and inaccurate in identifying close contact with infected people. Bay (2020) expressed his concern on solely relying on mobile application for contact tracing. His concerns stand since there are limitations for GPS and Bluetooth, which are the fundamental technologies used for location detection in mobile application. On one hand, GPS is inaccurate when individuals are in an indoor position. GPS works on receiving signals from the satellites. If there are any obstacles between the mobile device and the satellite, it causes disruption in the signal detecting process, which can lead to inaccurate estimation of individual's location. Thus, GPS might not be a good option for contact tracing for indoor areas. On the other hand, tracking apps that relies on Bluetooth denotes contacts when an individual's phone detects any signal from a phone of infected individuals (Anushka, 2020). This methodology is limited due to the short range of Bluetooth. Bluetooth Low-Energy, which are mostly used in tracking apps, has a range of 100m. While it takes an hour for the virus to be removed in the air with good ventilation (CDC, 2021), an infected person could have left the area and then another individual comes into the area without any notification from the mobile app. Thus, apps that use GPS and Bluetooth might not be effective in reducing the spread of the disease.

Meanwhile, contact tracing apps are not totally useless in controlling pandemic. It is proven that the use of contact tracing apps has a correlation with the reduction in Covid-19 cases (Urbaczewski & Lee, 2020). Thus, this paper aims to improve on the methods used for location detection on the mobile app. From the abovementioned model, QR code is used for contact tracing. Since QR code is shown on the dispenser, it represents a specific location that will not be changed. Whenever a user scans the QR code, the user must be in proximity of the dispenser (Poslad, 2009). This allows an

accurate location detection of the user at a specific time, ignoring other factors that might influence location detection. Meanwhile, the user receives notification of the infected user count in the past 2 hours after taking the gel. The time frame is set to be 2 hours because of 2 reasons. First, the infected user has a low possibility in staying in the same area for 2 hours. Second, virus can be potentially removed in 2 hours with good ventilation (CDC, 2021). Therefore, by displaying the number of infected users in the past 2 hours, uninfected user can be aware of the potential level of virus and danger in the area and plans his journey accordingly.

5.1.2 Detection of Sanitizer Availability and Usage

During the Covid-19 pandemic, different governments had adopted different strategies in ensuring the supply of personal protection equipment (PPE). For example, the United States government promoted the domestic production of PPE in order to meet the high demand (The White House, 2021) and the United Kingdom government released the 'Free Personal Protection Equipment Scheme' for all health, social care and public sector workers (GOV.UK, 2023). Despite the ways that different government used to ensure the supply of PPE, these methods cannot guarantee the usage of PPE after the individuals get the PPE. Although legislation can be used to mandatorily force the citizens to wear masks, it is hard for the governments to track mask usage, not to say other non-mandatory PPE usage. Difficulty in maintaining public health is resulted due to the lack of monitoring of PPE usage.

With the aim of tracking the usage of sanitizers, the mobile apps and the associated dispenser is proposed in this paper, which helps government to monitor individual hygiene condition, to ensure sanitizers' supply and to analyse factors of pandemics. The government is suggested to be the initiator in placing dispensers in different locations and setting up the application, application server and database server. By receiving weight data from the dispenser every 15 minutes, the government can ensure the real-time availability of sanitizers with immediate refilling of sanitizers. This help monitor the hygiene condition and ensure the constant supply of sanitizers in each area. Meanwhile, the government can also estimate and monitor the hygiene condition of each user by checking users' personal record of dispensers' usage. The personal record can also be used to for pandemic analysis in finding association in sanitizer usage and pandemic prevention.

5.1.3 Motivations for Individual Usage of the Mobile App

The function of 'view personal record' is used to motivate individuals to use the dispensers. Different studies in psychology have shown that record keeping can help motivate people in achieving a goal, which is maintaining personal hygiene in the pandemic case. Locke & Lathan (2002) stated that by keeping a record, it helps individual to constantly monitor personal progress and reflect on themselves in the strategies in achieving the goal. Hartmann-Boyrce (2018) also states that self-monitoring increases individual conscious awareness in changing habitual behaviors for goals achievement. Thus, by including the 'view personal record' function in the mobile application, it increases users' hygiene awareness and motivates the users to constantly use the dispenser.

5.2 Analysis of Design Issues, Constraint & Choices

The first limitation of this model is the tradeoff of convenience for data gathering. In order to measure the dispenser usage, user must first download, register and login to the application and then scan the QR code to use the dispenser. The extra procedures significantly increase the inconvenience of using the dispenser comparing to merely placing the hand under the dispenser. However, under a pandemic situation, inconvenience should be placed with less concern compared to personal hygiene. The 'view personal record' are also thus intentionally added to motivate user to focus on personal hygiene rather than inconvenience in taking the gel.

The second limitation of this model is the geographical constraints of the dispensers. Since NIC is not included in the dispensers, the dispensers must be located in areas with Wifi connection. Rural area with less Wifi connection might not be able to connect to the application server and thus the dispenser cannot be functioned. However, the problem can be solved if the government set up access point near the dispenser.

6. Conclusion

With the 3-tier model, comprised of the dispenser, application, application server and database server, the aim of this paper is achieved. First, the monitoring of individual mobility is achieved by using QR code as the medium of individual location detection. Second, individuals are notified by the application about the number of infected users of the dispenser. This is done by collecting users' infection status and record keeping of dispenser usage of every user. Lastly, the sanitizing services are kept available by constantly measuring the sanitizer left in the container in 15-minutes time interval. This model does not only benefits the individuals by promoting personal hygiene and increasing pandemic awareness, but also allows the government to collect individuals' hygiene data for future R&D.

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