Institute of Systems Science
National University of Singapore

MASTER OF TECHNOLOGY IN SOFTWARE ENGINEERING

Graduate Certificate Examination

Subject: *Architecting Scalable Systems*

Sample Examination Questions 2

APPENDIX A

'ONE Health CASE STUDY

'ONE Health' Case Study

In pursuit of the Smart City, one of the initiatives is to outsource and integrate the pharmacies of the major healthcare providers such as hospitals. The vision is to extend the pharmacy facilities to other smaller hospitals, health organisations and clinics. The goal is to save on the space taken up by the pharmacy operations as well as drug and equipment inventory management. It is also to remove the 'middle-man' operations that hospitals operate at their pharmacies and to give direct interaction between the suppliers and patients. In addition, another associated initiative is to encourage the general population to stay healthy by improving their fitness via various kinds of workouts. This can be facilitated by the users adopting more disciplined and motivated approaches in their fitness undertakings. Building a platform is one of the best ways of achieving this vision. The following sections describe the platform and four pilot applications built on the platform – the PharmaMed app focusing on ordering of medicines; the PharmaEquip app on ordering of health equipment; the WeFitRun app on tracking of runs; and the WeFitYoga on tracking of Yoga sessions.

Platform named ONE Health should be accessible to any hospital, clinic and supplier of drugs and equipment as well as runners and Yoga practitioners, who wish to come onboard. Hospitals should be able to pick their preferred suppliers and give access to patients to make use of relevant platform services. Patients should be able to register and login to the platform to view their prescriptions and order the required medicines or equipment. Once they pay for the medicines or equipment, the suppliers should be able to deliver them to their preferred locations. Runners and Yoga practitioners need not be a patient.

You are appointed as the Chief Solution Architect of the team tasked to develop this platform. You are responsible for the technical delivery of the system which includes the design, development and deployment of the platform and two pilot applications in the first phase. When the first phase completes successfully, the platform should allow the expansion of new services and inclusion of new actors.

1.   Initial Requirements of the Platform

The new platform should be able to support the following actors:
1. Healthcare Providers (Hospital/Clinic administrators) responsible for uploading the prescriptions onto the platform, managing the preferred suppliers of drugs etc.
2. Drug Suppliers who wish to supply drugs to the healthcare providers.
3. Equipment Suppliers who wish to supply equipment to the healthcare providers.
4. Patients who wish to order medicines prescribed to them on a one-time/prescribed duration/monthly basis.
5. Patients who wish to order equipment that are recommended to them.
6. Runners who wish to be disciplined in managing their runs.
7. Yoga practitioners who wish to be disciplined in managing their Yoga sessions.

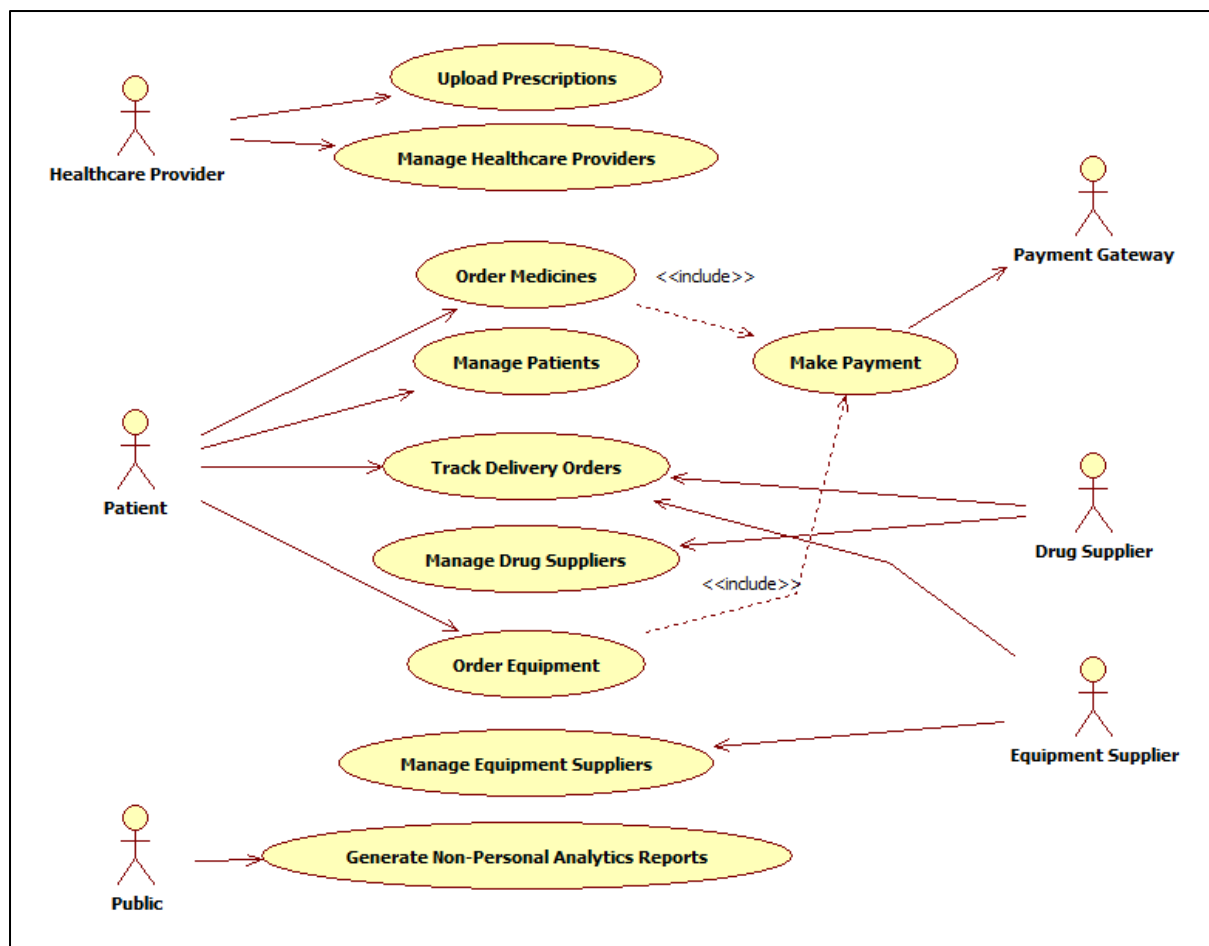The high level functionality of the system is described in Figures 1, 2 and 3 in the next few pages.

Figure 1: High Level System Context for PharmaMed and PharmaEquip

Here is a brief description of the use cases for PharmaMed and PharmaEquip:

Use Case	Description
Upload Prescriptions	Healthcare Provider uploads a patient's prescription onto the platform. This prescription is only accessible to the patient and all the administrators who work for the specific provider organisation from which the prescription was uploaded.
Order Medicines	Patient orders the required medicines. The patient browses the catalogue of products and specifies the quantity of the required medicines. The patient is required to permit the pharmacy to view the prescription explicitly. The placing of order is complete after the patient makes an online payment.
Order Equipment	Patient orders the required equipment. The patient browses the catalogue of products and selects the equipment. The placing of order is complete after the patient makes an online payment.
Track Delivery Orders	Includes tracking of delivery status and update of the status.
Manage Patients	Includes patient registration, patient information, and management of patient credentials.
Manage Healthcare Providers	Includes healthcare provider registration, healthcare provider information, and management of credentials. The Healthcare Providers also choose their preferred Drug Suppliers and specify the order of preference.

| Manage Drug Suppliers	Includes drug supplier registration, drug supplier information, and management of credentials.
Manage Equipment Suppliers	Includes equipment supplier registration, equipment supplier information, and management of credentials.
Make Payment	Payment related functions, which includes making payment for the ordered medicines, equipment, etc., including the delivery charges.
Generate Non-Personal Analytics Reports	Reporting of various non-personal information such as daily, weekly and monthly orders, fulfillments, and daily and monthly performance metrics. Other metrics.
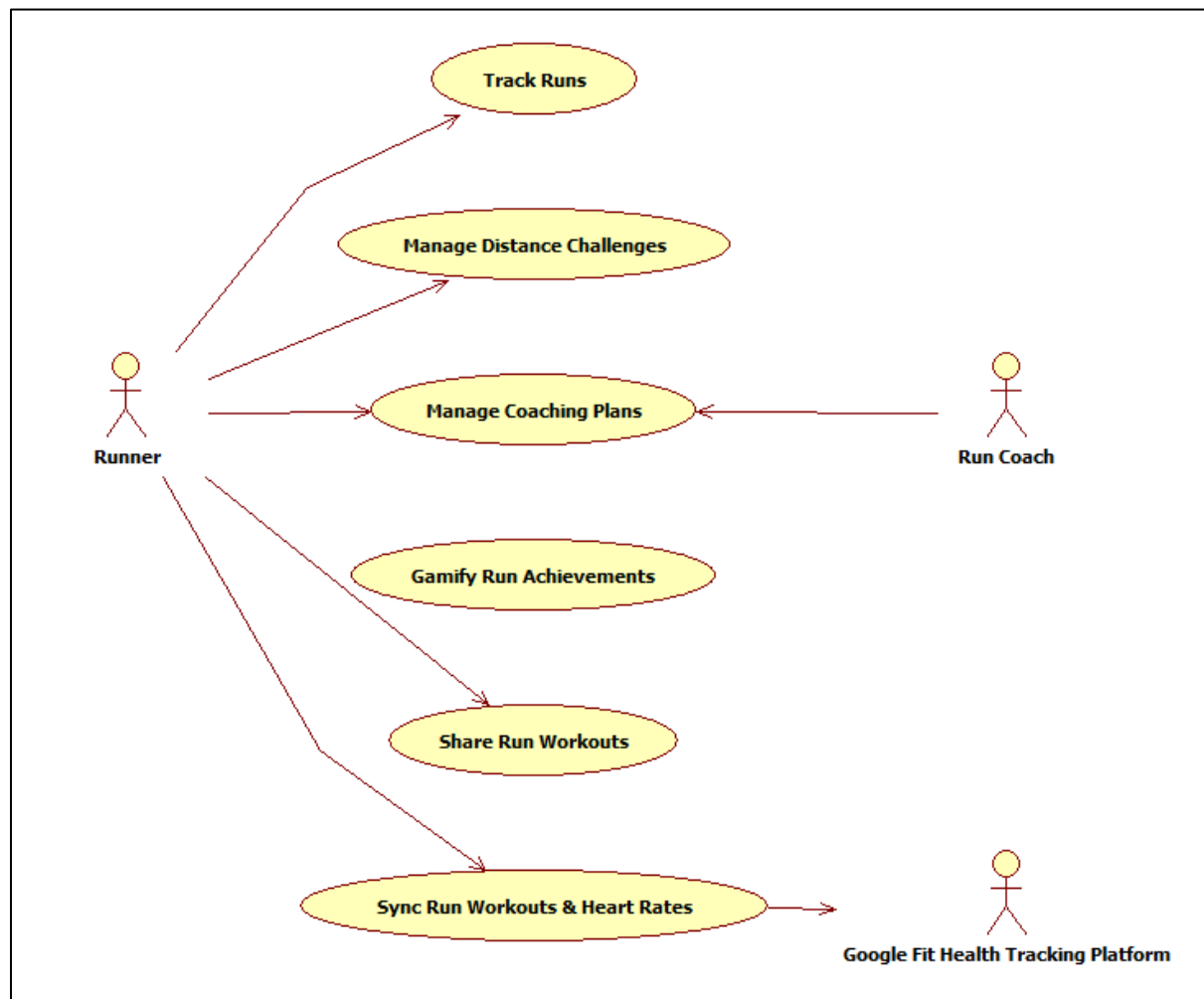
Figure 2: High Level System Context for WeFitRun

Here is a brief description of the use cases for WeFitRun:

Use Case	Description
Track Runs	Runner tracks the details of his/her runs. The details include the actual route, the total distance, the total duration, the overall speed, the lap duration (per km), etc.
Manage Distance Challenges	Runner joins an existing challenge or creates a new challenge and tries to meet its objective. For instance, "Run 20 km in a week" is a sample challenge.
Manage Coaching Plans	Runner signs up to a coaching plan offered by a Run Coach. Runner tries to follow the detailed schedule and workouts. Run Coach

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	reviews the progress of the Runner and provides advices and fine-tunes the plan.
Gamify Run Achievements	System provides a dashboard on the overall performance of Runners. System assigns badges for commendable achievements.
Share Run Workouts	Runner shares his/her run workout details with his/her friends via social media accounts.
Sync Run Workouts & Heart Rates	Runner synchronizes the details of run workouts and heart rates with the Google Fit Health Tracking Platform. System provides the details of run workouts while retrieving the heart rates from Google Fit via published API.
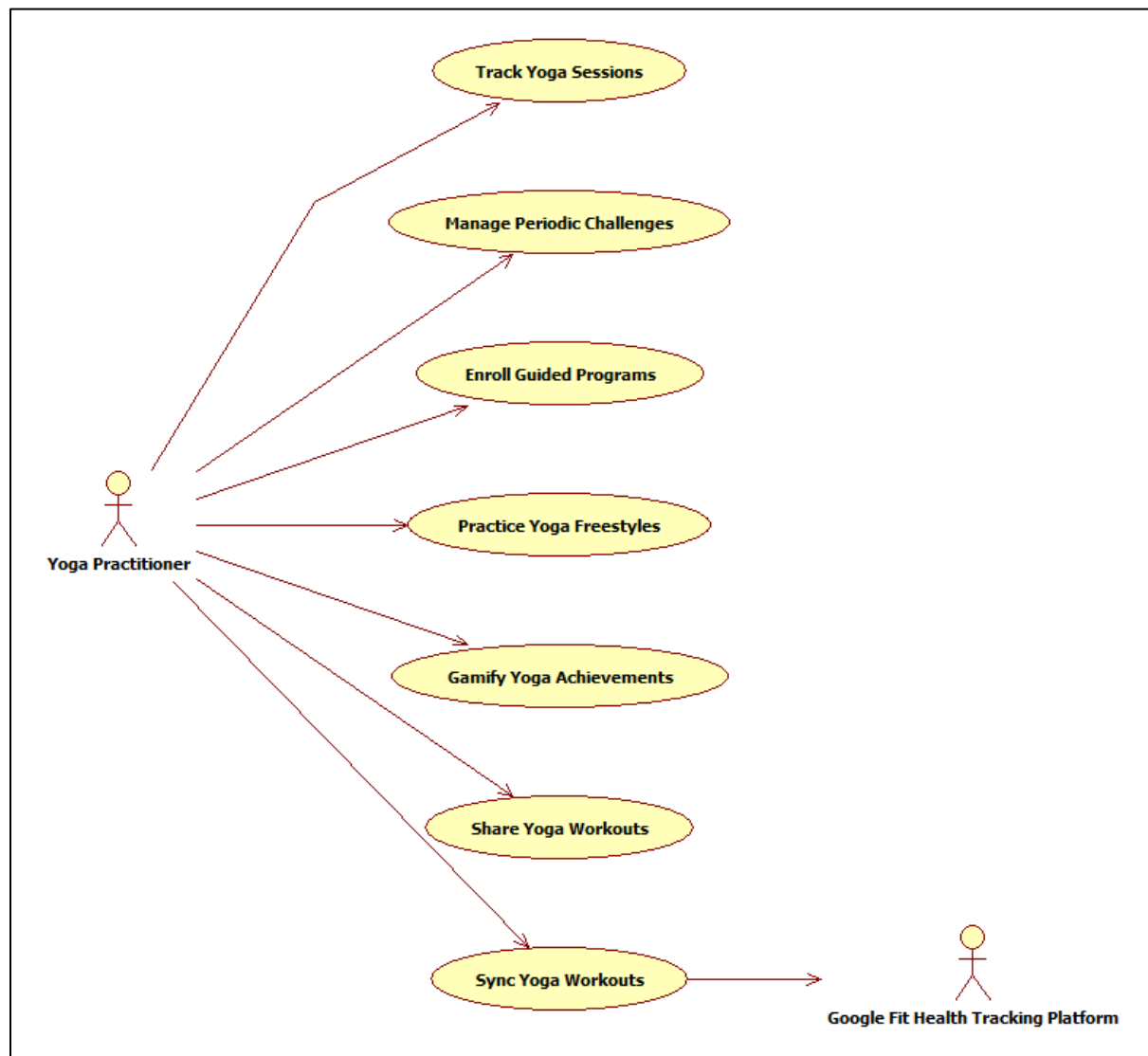
Figure 3: High Level System Context for WeFitYoga

Here is a brief description of the use cases for WeFitYoga:

Use Case	Description
Track Yoga Sessions	Yoga Practitioner tracks the details of his/her Yoga sessions. The details include the style of Yoga, the total duration, etc.
Manage Periodic Challenges	Yoga Practitioner joins an existing challenge or creates a new challenge and tries to meet its objective. For instance, "Practice 30 minutes each day for a week" is a sample challenge.

Enroll Guided Programs	Yoga Practitioner enrolls in a guided program. He/she tries to follow the detailed schedule and workouts.
Practice Yoga Freestyles	Yoga Practitioner picks a style of Yoga and tries to practice with step-by-step guidance by the system.
Gamify Yoga Achievements	System provides a dashboard on the overall performance of Yoga Practitioners. System assigns badges for commendable achievements.
Share Yoga Workouts	Yoga Practitioner shares his/her run workout details with his/her friends via social media accounts.
Sync Yoga Workouts	Yoga Practitioner synchronizes the details of Yoga workouts with the Google Fit Health Tracking Platform. System provides the details of Yoga workouts to Google Fit via published API.

2.   Extensibility Requirement for the Platform

The platform should contain common services and libraries that support and speed up the development of future services provided by the platform. In the short term, the design evaluation of the extensibility of the platform will be done based on how the platform can support the development of the medicine and equipment delivery functionality as well as new types of workouts.

The platform should be accessible from any computers including mobile devices and PCs.

3.   Performance and Scalability Requirement of the Platform

The platform should be designed for the following performance and scalability requirements:
-   The platform should be able to handle increasing amount of data while maintaining the response time of the application. The design should consider the possibility of sharding and partitioning of data for different healthcare providers, drug and equipment suppliers or service types when necessary.
-   For interactive request-response type of operation (e.g. checking the delivery status of an order), the expected response time should be less than 1 second for 90% of the requests.
-   The platform should be able to handle multitenancy with proper data and application isolation between tenants. Example of tenants would be different healthcare providers, drug and equipment suppliers or a subsidiary of ONE Health, which launches a new kind of service. As the multitenancy requirement is not known in detail at the moment, the architect should use his/her judgement to choose the optimal trade-off regarding multitenancy.

4.   Security Requirement of the Platform

The platform should be designed with the following security requirements:
-   The system should follow the general security best practices in infrastructure and application security e.g. reverse proxy in DMZ, etc.
-   Personal information should be stored in encrypted form and the platform should be able to find all information stored about an individual. According to GDPR, the actors should allow users to request access to user's data and the platform should be able to facilitate the compliance.
-   Sensitive tenant information should be encrypted with tenant-specific encryption key to avoid accidental data leakage due to software bugs. The encryption keys should be

stored securely and the system should able to handle change of encryption key through an automated process.
- Subsystems that handles payment and cardholder information should comply to PCI-DSS and therefore payment and cardholder information handling should be limited to as minimal subsystems as possible to minimize cost and minimize risk exposure.

5. Details on Some Significant Use Case Flows (Main Flows)

5.1 Upload Prescriptions Use Case
- The doctor from a specific participating healthcare provider prescribes medicines to the patient. The prescription is automatically uploaded into the National Health System.
- The patient clears the consultation dues to the Healthcare Provider. This is also updated on the National Health System.
- The Healthcare Provider Administrator (HPA) receives an alert on his/her screen from the National Health System.
- The HPA selects the 'Upload Prescription' option in the PharmaMed app.
- The HPA uploads the prescription via the PharmaMed app to the ONE Health platform by copying it from the National Health System. The prescription contains the Patient details such as name, NRIC, contact telephone numbers, address and medicines prescribed by the doctor.

Note: The National Health Systems is not a part of the ONE Health platform. Currently there are no plans to integrate it with ONE Health.

5.2 Order Medicines Use Case
- The Patient logs into the PharmaMed app and clicks on 'View Prescriptions' option.
- The System presents a list of prescriptions for the patient.
- The Patient selects a prescription. He/she then browses the catalogues of products and specifies the medicines and quantity to order, based on his/her needs (e.g: if the prescription is for a period of 6 months, the patient can order on a monthly basis).
  Note: In the first release of the platform, the Patient is only allowed to order medicines and quantity based on his/her prescriptions.
- The Patient then proceeds to make payment and confirms the delivery address (the patient is allowed to enter an address that is different from the one specified in the prescription).
- The System responds with an acknowledgement of the order and a delivery order number for tracking purposes. The message also contains information on the expected date and time of delivery.

5.3 Order Equipment Use Case
- The Patient logs into the PharmaEquip app.
- The System presents the catalogues of products that are carried by the Equipment Suppliers.
- The Patient selects one or more equipment and the quantities to order, based on his/her needs.
  Note: The Patient is not required to provide any prescription.
- The Patient then proceeds to make payment and confirms the delivery address (the patient is allowed to enter an address that is different from the one specified in the prescription).
- The System responds with an acknowledgement of the order and a delivery order number for tracking purposes. The message also contains information on the expected date and time of delivery.

5.4   Track Delivery Orders Use Case

- The Patient/Drug Supplier/Equipment Supplier logs into the PharmaMed/PharmaEquip app and selects the 'Track Deliveries' option.
- The System lists the delivery orders for medicines/equipment purchased/supplied by the User.
- The User selects a delivery order.
- The System displays the details of the delivery order.

5.5   Make Payment Use Case

- This use case is invoked by the other use cases for making payment for the ordering of medicines, equipment, etc.
- The System displays a list of online payment options.
- The User selects an option and enters the required details.
- The System invokes the Payment Gateway to complete the payment.
- The System displays the finalized payment details.

5.6   Generate Non-Personal Analytics reports Use Case

- Patient related data and analytics:
    - If a new patient registers, the System increments the Daily/Monthly/Yearly New Patient Counter by one. The respective counters are reset on appropriate days (e.g: daily patient counter is reset at the beginning of each day).
    - If an existing patient deregisters, the System increments the Daily/Monthly/Yearly Lost Patient Counter by one. The respective counters are reset on appropriate days (e.g: daily patient counter is reset at the beginning of each day).
    - If a patient places an order, the Daily/Monthly/Yearly Order Counter is incremented by one.
- Healthcare Provider related data and analytics:
    - Similar data is collected for registration/deregistration of healthcare providers.
    - Similar data regarding the number of prescription uploaded is collected.
- Drug supplier related data and analytics:
    - Similar data is collected for registration/deregistration of drug suppliers.
    - Number of orders placed on a daily/monthly/yearly basis is collected.
    - Number of orders successfully delivered to the patients on-time/delayed is collected
- These analytics can be viewed by anyone, as they do not contain any personal information. By doing so, ONE Health benefits in marketing their platform.

6.   Initial Architecture of the Platform

As the Chief Solution Architect, you have provided the following architectural guidelines for the platform and the two pilot applications.
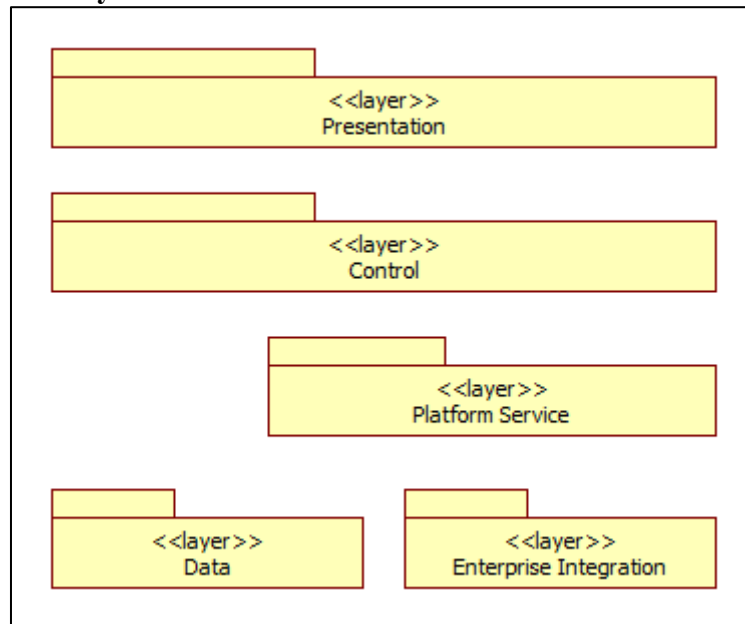
6.2   Architecture Layers

Figure 4: Architecture Layers

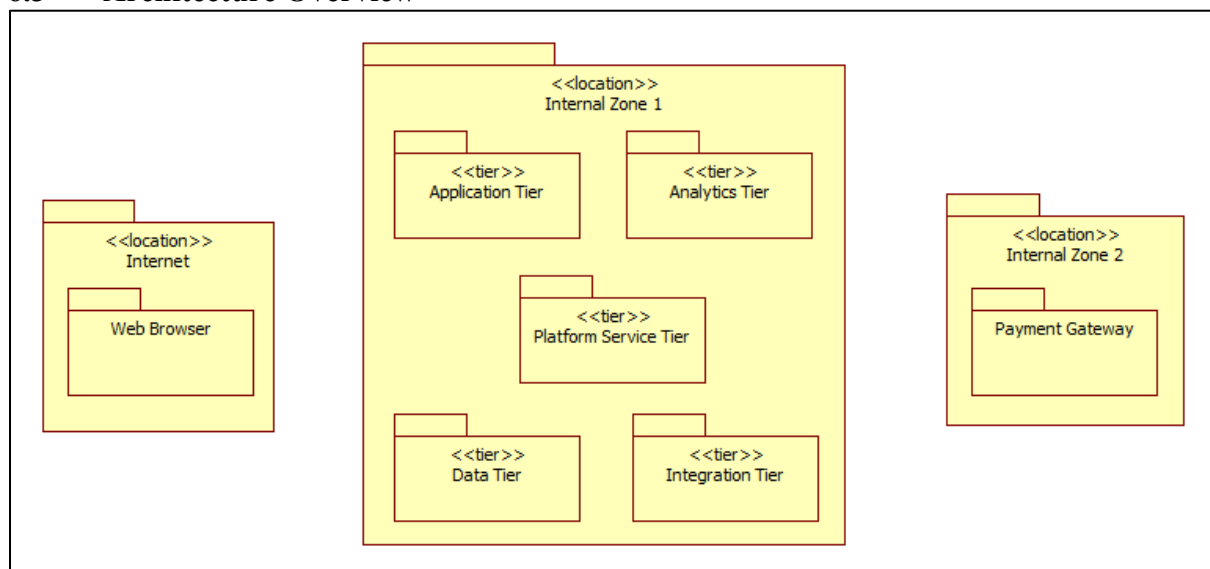## 6.3   Architecture Overview

Figure 5: Architecture Overview

6.4   Deployment Options

The platform is to be designed as a Cloud native solution. The reusable services should be implemented as microservices.