HOSPITAL TO COMMUNITY CARE MODEL

Group 18 Team Members: Berenice Teo Su Yun, Eka Buyung Lienadi, Gabriel Kok Zi Yao, Ngo Chanh Anh Minh

NUS Supervisor: Professor Andrew Lim, Research Assistant Professor Cao Zhiguang

Industry Supervisors: Adjunct Associate Professor Ayliana Dharmawan, Ms. Zhang Xiaojin, Mr. Heng Yong Sheng

IE3100M Systems Design Project | Department of Industrial Systems Engineering and Management | AY 2019/2020

Problem Overview

Growing ageing population will lead to an increase in demand for healthcare services that go beyond the **hospital**'s physical compound and into the **community**.

This project aims to help TTSH to improve their current Hospital to Community process by:

- Automate their data mapping process and providing the visualization of the mapped data
- Reduce the possibility of delayed or missed last-mile care delivery services
- Reduce the inconveniences and increase the accessibility of the medicine collection process

KEY DELIVERABLES

Interactive Dashboard that automates the mapping processes and provides visualization of the data

Propose an **optimal route** in assigning each nurse conducting the last-mile care delivery to the residents

Propose a list of possible self-collection **medicine locker locations**

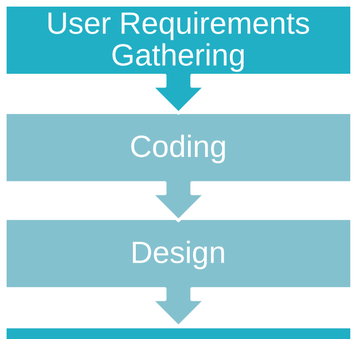
KEY SKILLSETS

- Project management concepts are applied in the development life cycle of the Interactive Dashboard
- Software development skills for Dashboard Backend
- Human factor engineering for Dashboard User Interface
- Optimization skills in Nurse Scheduling Solution
- Modelling and Analytics skills for Medicine Locker Solution

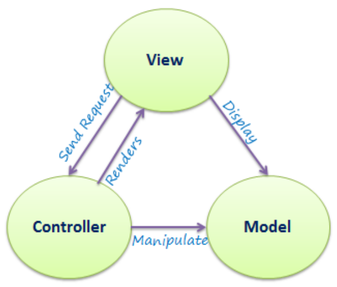
Methodology

Interactive Dashboard

Project Management Approach



Software Architecture



MVC Architecture

Dashboard software architecture is designed based on Model View Controller (MVC) architecture

Dashboards is implemented using **Django** framework in Python

MySQL is integrated to handle database management

Pandas used to assist input file processing and data analytics

Nurse Routing & Assignment

- Modelled as Asymmetric Multi-vehicle Routing Problem
- Solve using IBM ILOG CPLEX Optimization Studio

Parameters:

- C - Transportation cost (SGD/m)
- D_{ij} - Transportation distance from location i to location j by car (m)
- P - Outsourcing cost for one patient
- L - Max no.of patients a nurse can provide care a day
- V_i - Number of nurses available at medical centre i

$$Min\ z = C\sum_{i\in N}\sum_{j\in N}\sum_{k\in K} D_{ij}x_{ijk} + \sum_{j\in J} P(1-\sum_{i\in N}\sum_{k\in K} x_{ijk})$$

Subject to:

$$\sum_{i\in N,\ i\neq j}\sum_{k\in K} x_{ijk} \leq 1 \qquad \forall\, j \in J$$

$$\sum_{i\in N}\sum_{j\in J} x_{ijk} \leq L \qquad \forall\, k \in K, i \neq j$$

$$\sum_{j\in N,\ j\neq i} x_{ijk} = \sum_{j\in N,\ j\neq i} x_{jik} \qquad \forall\, i \in N, k \in K$$

$$\sum_{i\in I}\sum_{j\in J} x_{ijk} \leq 1 \qquad \forall\, k \in K$$

$$\sum_{j\in N}\sum_{k\in K} x_{ijk} \leq V_i \qquad \forall\, i \in I$$

$$u_{ik} + u_{jk} + Lx_{ijk} \leq L - 1 \qquad \forall\, i, j \in J, k \in K, i \neq j$$

$$x_{ijk} = 0\ or\ 1 \qquad \forall i, j \in N, k \in K$$

$$u_{ik} = 0\ or\ 1 \qquad \forall i \in J, k \in K$$

Sets:

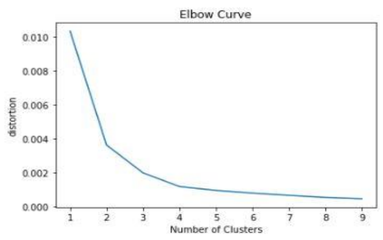
- I - Set of all health centers
- J - Set of all patients
- $N = I \cup J$
- K - Set of all nurses

Optimal Medicine Locker Locations

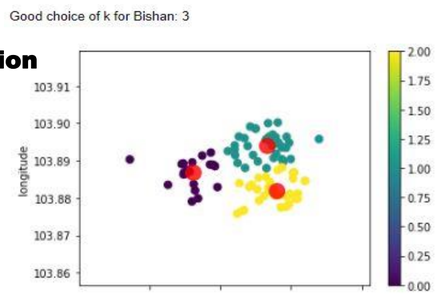
I. **K-means** clustering algorithm to identify centroid location

II. **Elbow method** to determine optimal number of lockers per location

Elbow Curve

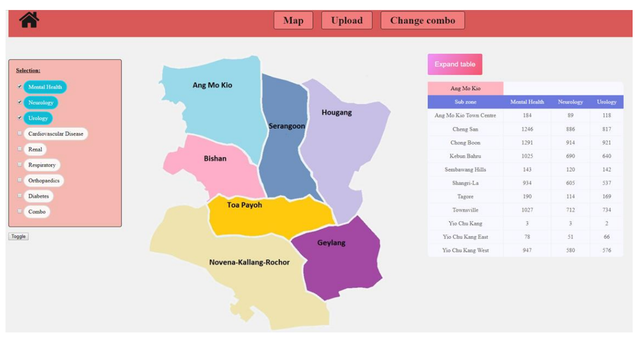


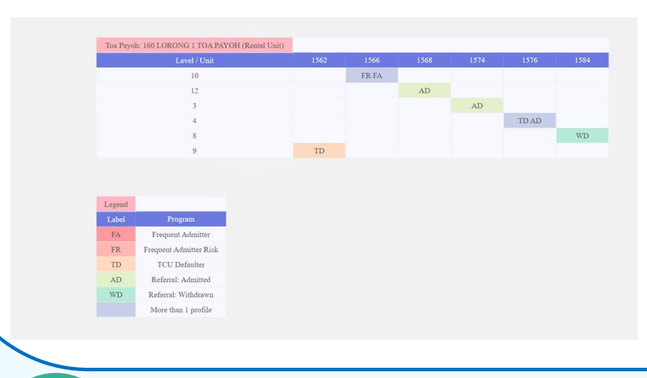
Cluster Visualisation



Results and Deliverables

Interactive Dashboard





Block Level Mapping

A map of central Singapore that shows any combination of diseases in each region

- Simple and intuitive User Interface
- Advanced visualization capabilities
- Toggle function
- Combine disease function

Unit Level Mapping

Table shows patient's status summarized in selected address

- Automated data consolidation process
- Easy visualization with multi-color scheme

Optimal Nurse Routing & Assignment

Medical centre	Nurse ID	First patient ID	Second Patient ID	Third patient ID
TTSH	Nurse-1	Patient-2	Patient-4	Patient-3
TTSH	Nurse-2	Patient-6	Patient-15	Patient-10
Centre 1	Nurse-3	Patient-7	Patient-9	Patient-12
Centre 2	Nurse-4	Patient-8	Patient-1	Patient-5
Centre 2	Nurse-5	Patient-14	Patient-18	Patient-17

Example routing of 18 patients, 5 nurses from 3 different medical centres

Result:

1. 15 out of 18 patients directly served by TTSH and partners
2. Remaining 3 outsourced

Optimal Medicine Locker Locations

Recommended Locations for Medicine lockers

Additional information:

- Corresponding building type
- Alternative address location in case output is inaccessible

Future Directions

- Graphical function for Dashboard
- Develop an efficient heuristic for Nurse Routing problem
- Mobile App Dashboard
- Utilize Human Factor Engineering to design Medicine Collection Lockers
- Integrate Nurse Routing function into Dashboard

Conclusion

Automated Data Mapping Process

- ✓ Reduces the repetitive task of mapping data
- ✓ Reduces the time taken of mapping data
- ✓ Reduces the error occurred in mapping data

Interactive Dashboard

- ✓ Creates interactive visualisation platform
- ✓ Allows easy identification of trends in each region
- ✓ Allows easy identification of unit-at-risk

Nurse Routing & Assignment

- ✓ Increases the efficiency of coordinating and delivering the last-mile care services

Medicine Lockers

- ✓ Increases the accessibility in the collection of medications at lockers at convenient locations