**COMP 6231 Assignment 3 Design Documentation**

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This project is to develop a distributed health care management system (DHMS) for managing medical appointments. Admins can use this system to add, list, remove, book, get, cancel, and swap appointments. And patients can use this system to book, list, cancel, swap appointments.

**Project Architecture**

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Figure 1 UML class diagram

As shown in *Figure 1*, there are 13 classes. The following are the details about 13 classes.

**Driver**: This class provides users with command line interface and checks users’ input. It uses web service to get three server instances and uses server instances as parameters to create new client objects and call methods.

**Client**: This class is an abstract class handling all methods of clients.

**Patient**: This class is a subclass of Client. It calls server’s methods in bookAppointment, getAppointment, cancelAppointment and swapAppointment. It calls printInvalidCommandMessage in the remaining methods.

**Admin**: This class is a subclass of Client. It calls server’s methods in all seven methods.

**Appointment**: This class is an interface to define all seven methods.

**MontrealServer**: This class is the Montreal server. It implements Appointment interface and provides implementations for all seven methods in the interface. It uses main method to listen other servers’ requests.

**QuebecServer**: This class is the Quebec server. It implements Appointment interface and provides implementations for all seven methods in the interface. It uses main method to listen other servers’ requests.

**SherbrookeServer**: This class is the Sherbrooke server. It implements Appointment interface and provides implementations for all seven methods in the interface. It uses main method to listen other servers’ requests.

**Publish**: This class is used to publish URLs with three corresponding servers.

**ReplyAppointment**: This class extends Thread and replies to other servers’ requests about get available appointments.

**ReplyRecord**: This class extends Thread and replies to other servers’ requests about get booking records.

**Constants**: This class stores common constants used by three servers. The constants details are omitted.

**TestMultipleThreads:** This class is used to test codes when running multiple threads.

**Data Structures**

Server mainly uses three data *appointmentOuter*, *recordList, recordOtherCities*. *appointmentOuter* is a concurrent hash map containing another concurrent hash map. The inner hash map (ConcurrentHashMap <String, Integer>) represents appointment ID and capacity. The outer hash map (ConcurrentHashMap <String, ConcurrentHashMap <String, Integer>>) represents appointment type and inner map.

*recordList* is a synchronized string linked list. *recordList* stores booking records in the format “patientID appointmentID appointmentType”.

*recordOtherCities* is similar to *recordList* but it only stores booking records that patients’ cities are different from appointments’ cities. *recordOtherCities* is used to check whether the patient books more than three appointments in other cities.

Apart from data parameters stored in server objects, I also use txt to store the appointments and records to response other cities’ requests for getting these data.

**Major Techniques**

**Web Service**

I used web service for client-server implementation. I defined all seven methods in the interface Appointment (*Figure 2*). I developed three servers to implement this interface (e.g. Figure 3) and publish them with proper URLs in Publish class (Figure 4). I discovered the published web services and called servers’ methods in Driver class (Figure 5).

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Figure 2 Appointment interface

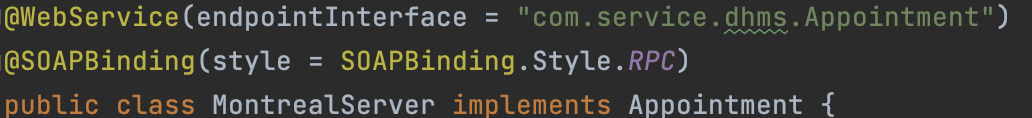


Figure 3 MontrealServer class

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Figure 4 Publish class

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Figure 5 Driver class

**UDP/IP**

I used UDP/IP to handle server-server communication. Server can send requests to get other servers’ data (appointments or booking records) and to book or cancel appointments in other cities (e.g.Figure 6). And other servers can listen to requests and give responses (Figure 7). In order to reply to different requests parallelly, servers use different threads (RelplyAppointment and ReplyRecord) (e.g. Figure 8).

A screen shot of a computer program

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Figure 6 Send UDP request

A computer screen shot of a program

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Figure 7 Receive UDP requests and send responses

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Figure 8 ReplyAppointment class

**Synchronization**

I used synchronized data types (ConcurrentHashMap, synchronizedList) (Figure 9) to handle the multiple threads for server methods.

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Figure 9 ConcurrentHahsMap and sychronizedList

**Test Scenarios**

1. **Description**: a patient cannot perform any admin operations. **Input**: (1) MTLP0001 (2) addAppointment MTLA080224 Physician 4 **Output**: Figure 10 **Pass**

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Description automatically generated

Figure 10 Patient cannot perform any admin operations

2. **Description**: an admin can add an appointment. **Input**: addAppointment MTLA080224 Physician 2 **Output**: Figure 11 **Pass**

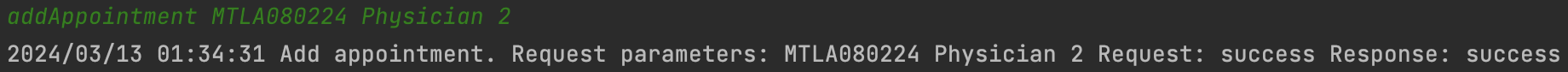


Figure 11 Admin can add appointment

3. **Description**: an admin cannot add same appointments twice. **Input**: (1) addAppointment MTLA080224 Physician 2 (2) addAppointment MTLA080224 Physician 2 **Output**: Figure 12 **Pass**

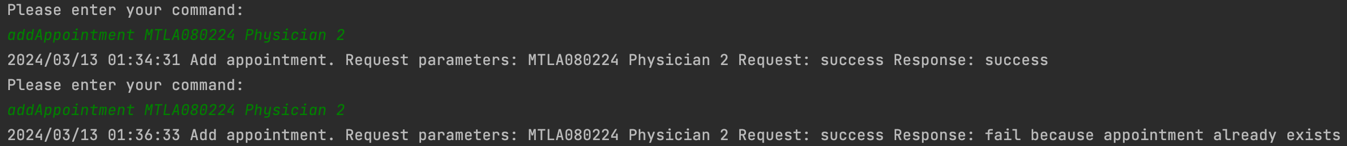


Figure 12 Admin cannot add same appointments twice

4. **Description**: an admin can remove appointment. **Pre-conditions**: Montreal server has appointment (ID: MTLA140224, type: Surgeon, capacity: 3). **Input**: removeAppointment MTLA140224 Surgeon **Output**: Figure 13 **Pass**

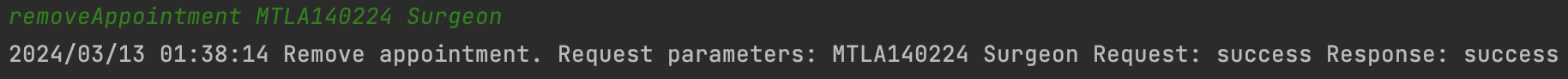


Figure 13 Admin can remove appointment

5. **Description**: an admin cannot remove a non-exist appointment. **Input**: removeAppointment MTLA080224 Surgeon **Output**: Figure 14 **Pass**



Figure 14 Admin cannot remove a non-exist appointment

6. **Description**: if an appointment is booked by a patient, admin will delete the appointment and book the next available appointment for the patient. **Pre-conditions**: (1) Montreal server has two appointments (ID: MTLA080224, type: Physician, capacity: 2; ID: MTLM080224, type: Physician, capacity: 2). (2) Patient (MTLP0001) books an appointment (ID: MTLM080224, type: Physician) **Input**: removeAppointment MTLM080224 Physician **Output**: Figure 15 **Pass**

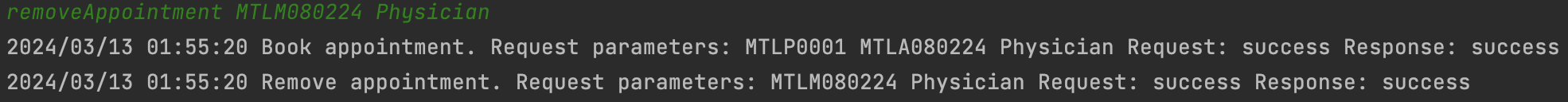


Figure 15 Delete a booked appointment

7. **Description**: admin can list appointments in three cities. **Pre-conditions**: (1) Montreal server has an appointment (ID: MTLA080224, type: Physician, capacity: 4). (2) Quebec server has an appointment (ID: QUEA100224, type: Physician, capacity: 1). (3) Sherbrooke server has an appointment (ID: SHEA090224, type: Physician, capacity: 4). **Input**: listAppointmentAvailability Physician **Output**: Figure 16 **Pass**



Figure 16 List appointment availability

8. **Description**: a patient can book an appointment **Pre-conditions**: Montreal server has an appointment (ID: MTLA080224, type: Physician, capacity: 2). **Input**: bookAppointment MTLP0001 MTLA080224 Physician **Output**: Figure 17 **Pass**



Figure 17 Book appointment

9. **Description**: a patient cannot book a same type of appointments multiple times in a day **Pre-conditions**: (1) Montreal server has an appointment (ID: MTLA080224, type: Physician, capacity: 2; ID: MTLM080224, type: Physician, capacity: 2). (2) Patient (MTLP0001) books an appointment (ID: MTLM080224, type: Physician) **Input**: bookAppointment MTLP0001 MTLA080224 Physician **Output**: Figure 18 **Pass**



Figure 18 Patient cannot book a same type of appointments multiple times in a day

10. **Description**: a patient can book an appointment in other cities **Pre-conditions**: Quebec server has an appointment (ID: QUEA100224, type: Physician, capacity: 2). **Input**: bookAppointment MTLP0002 QUEA100224 Physician **Output**: Figure 19 **Pass**



Figure 19 Book appointment in other cities

11. **Description**: a patient cannot book more than three appointments in other cities in a week. **Pre-conditions**: (1) Quebec server has four appointments (ID: QUEA100224, type: Physician, capacity: 2; ID: QUEA100224, type: Physician, capacity: 2; ID: QUEA110224, type: Physician, capacity: 2; ID: QUEA120224, type: Physician, capacity: 2; ID: QUEA130224, type: Physician, capacity: 2;). (2) Patient (MTLP0003) books appointments (ID: QUEA100224, type: Physician; ID: QUEA110224, type: Physician; ID: QUEA120224, type: Physician) **Input**: bookAppointment MTLP0003 QUEA130224 Physician **Output**: Figure *20* **Pass**



Figure 20 Patient cannot book more than three appointments in other cities in a week

12. **Description**: a patient can get appointment schedule **Pre-conditions**: (1) Quebec server has an appointment (ID: QUEA100224, type: Physician, capacity: 2). (2) Patient (MTLP0002) books appointments (ID: QUEA100224, type: Physician) **Input**: getAppointmentSchedule MTLP0002 **Output**: Figure 21 **Pass**



Figure 21 Get appointment schedule

13. **Description**: a patient can cancel appointment **Pre-conditions**: (1) Montreal server has an appointment (ID: MTLA140224, type: Dental, capacity: 4). (2) Patient (MTLP0002) books appointments (ID: MTLA140224, type Dental) **Input**: cancelAppointment MTLP0002 MTLA140224 **Output**: Figure 22 **Pass**

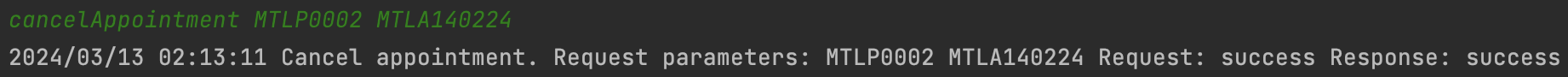


Figure 22 Cancel appointment

14. **Description**: a patient can cancel appointment in other cities **Pre-conditions**: (1) Quebec server has an appointment (ID: QUEA100224, type: Physician, capacity: 2). (2) Patient (MTLP0002) books appointments (ID: QUEA100224, type: Physician) **Input**: cancelAppointment MTLP0002 QUEA100224 **Output**: Figure 23 **Pass**



Figure 23 Cancel appointment in other cities

15. **Description**: a patient cannot cancel a non-exist appointment **Input**: cancelAppointment MTLP0002 MTLE080224 **Output**: Figure 24 **Pass**



Figure 24 Patient cannot cancel a nonexist appointment

16. **Description**: a patient can swap an appointment in other cities **Pre-conditions**: (1) Montreal server has an appointment (ID: MTLA080224, type: Physician, capacity: 2). (2) Quebec server has an appointment (ID: QUEA100224, type: Physician, capacity: 2). (3) Patient (MTLP0001) books an appointment (ID: MTLA080224, type: Physician). **Input**: swapAppointment MTLP0001 MTLA080224 Physician QUEA100224 Physician **Output**: Figure 25 **Pass**

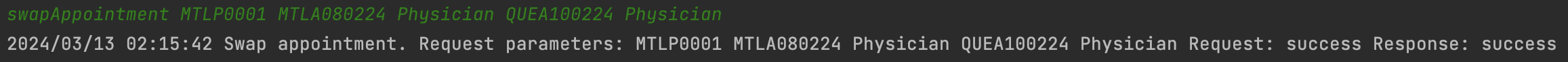


Figure 25 Swap appointment

17. **Description**: a patient cannot swap an appointment if the patient does not book the old appointment **Pre-conditions**: (1) Montreal server has an appointment (ID: MTLA080224, type: Physician, capacity: 2). (2) Quebec server has an appointment (ID: QUEA100224, type: Physician, capacity: 2). **Input**: swapAppointment MTLP0001 MTLA080224 Physician QUEA100224 Physician **Output**: Figure 26 **Pass**



Figure 26 Patient cannot swap appointment if the patient does not book the old appointment

18. **Description**: a patient cannot swap an appointment if the new appointment has no available slot. **Pre-conditions**: (1) Montreal server has an appointment (ID: MTLA080224, type: Physician, capacity: 2). (2) Quebec server has an appointment (ID: QUEA100224, type: Physician, capacity: 1). (3) Patient (QUEP0001) books appointment (ID: QUEA100224, type: Physician) (4) Patient (MTLP0001) books appointment (ID: MTLA080224, type: Physician). **Input**: swapAppointment MTLP0001 MTLA080224 Physician QUEA100224 Physician **Output**: Figure 27 **Pass**



Figure 27 Patient cannot swap an appointment if the new appointment has no available slot

19. **Description**: server can provide proper synchronization for multiple clients. **Pre-conditions**: In TestMultipleThreads class, patientMTL try to swap appointment and patientQUE try to book the same appointments at the same time. Before providing proper synchronization, patientMTL cancels old appointments successfully but books new appointment unsuccessfully since patientQUE books the same appointments successfully after cancelling and before booking a new one. **Output**: After providing synchronization, patientMTL will not swap appointment (Figure 28) **Pass**



Figure 28 Synchronization results

**Most difficult parts**

Use proper synchronization that allows multiple users to perform the operations, especially swap, at the same time.