

# **CSE445/598 Project 2 (Assignment 2) – (100 Points)**

## **Fall 2014**

Team building due: **Saturday, September 13, 2014**, by 11:59pm (Arizona Time)

Project 2 due: **Saturday, September 27, 2014**, by 11:59pm (Arizona Time)

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### **Introduction**

The purpose of this project is to make sure that you understand and are familiar with the concepts covered in the lectures, including distributed computing, multithreading, thread definition, creation, management, synchronization, cooperation, event-driven programming, client and server architecture, service execution model of creating a new thread for each request, the performance of parallel computing, and the impact of multi-core processors to multithreading programs with complex coordination and cooperation. Furthermore, you are able to apply these concepts in a programming project.

You can choose to do this project as an **individual project** or as a **team project** of two or three members. In the case of the team project, a declaration must be given, which identifies the parts of individual contributions and team efforts. An overall percentage of contribution of each member (e.g., 50% and 50%, or 30%, 35% and 35%) must be given, which will be used as a reference of assigning (scaling) grades. Only one copy of the project should be submitted by one of the team members. Teams built from mixed classes 445, 598, and 598 online classes are allowed.

A team-building document is given separately for assignments 3 and 5. We need to know the teams in advance, because we need to create a server for each team.

### **Section I Preparation and Practice Exercises (No submission required)**

No submission is required for this section of exercises. However, doing these exercises can help you better understand the concepts and thus help you in quizzes, exams, as well as the assignment questions.

1. Reading: Textbook Chapter 2.
2. Answer the multiple choice questions in text section 2.8. Studying the material covered in these questions can help you prepare for the lecture exercises, quizzes, and the exams.
3. Study for the questions 2 through 20 in text section 2.8. Make sure that you understand these questions and can briefly answer these questions. Studying the material covered in these questions can help you prepare for the exams and understand the homework assignment.
4. Test the programs given in questions 24 and 25 in text section 2.8. Identify the problems in the program and give correct versions of the programs.
5. If you want solve a more challenging problem in multithreading, you can do question 26 in text section 2.8.

6. **Tutorial.** To help you complete the project in Section II, you may want go through the tutorial given in the textbook chapter 2, which consists of
  - 6.1 Read the case study in text section 2.6.3.
  - 6.2 Test the program given in the case study. The program can be used as the starting point for your project in Section II.
  - 6.3 Extend the program based on the requirement in Section II.

## Section II Project (Submission required)

**Warning:** This is a long programming project designed for a study load for three weeks of estimated  $3 \times 8 = 24$  hours. It is challenging at both conceptual level and implementation level. You must distribute the load in the given three weeks. You would not have enough time to complete it if you start the project only in the last week before the project is due.

**Purpose** of this project is to exercise the concepts learned in this chapter. It is not the purpose of this project to create realistic services and applications. We will create more realistic services and applications in the subsequent projects. In this project, you can use a console application or a simple GUI application to implement the user interface to your program.

**Description:** Consider that you are creating a simplified hotel block booking system that involves hotel retailers (agencies) and wholesalers (hotel chains). The system consists of multiple travel agencies (clients), e.g., hotels.com, hotwire.com, and priceline.com, where they can book blocks of hotel rooms, and multiple hotel chains (servers), e.g., Days Inn, Holiday Inn, and Hilton, that supply blocks of hotel rooms to the agencies. The required architecture and the major components of the system are shown in the diagram below.

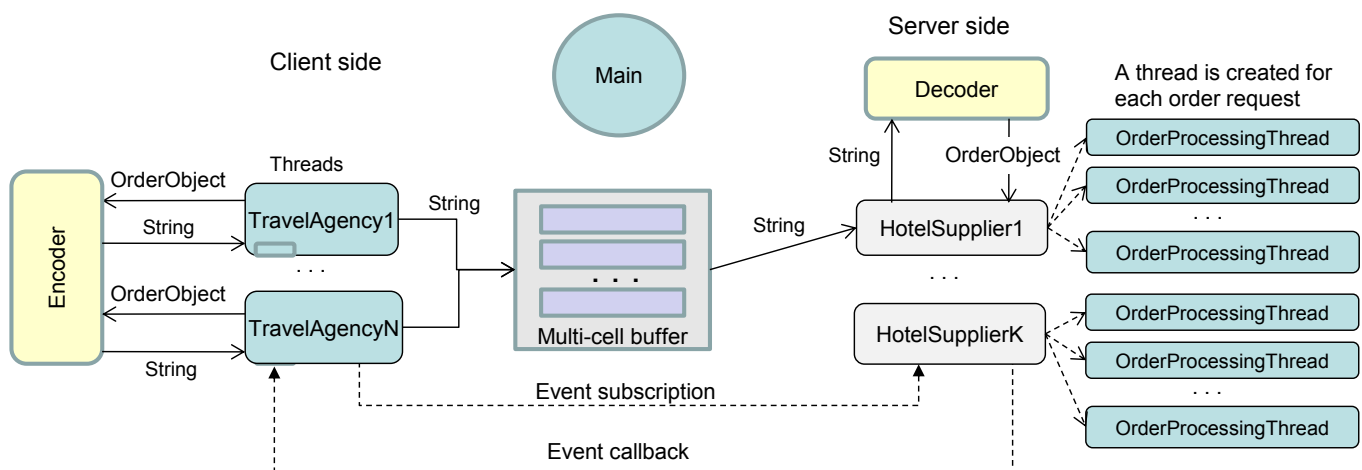


Figure 1 Architecture of a hotel block booking system

An **Operation Scenario** of the hotel block booking system is outlined below:

- (1) The **HotelSupplier** uses a pricing model to calculate the room price. If the new price is lower than the previous price, it emits a (promotional) event and calls the event handlers in the travel agencies that have subscribed to the event.

- (2) A **TravelAgency** evaluates the price, generates an **OrderObject** (consisting of multiple values), and sends the order to the **Encoder** to convert the order object into a plain string.
- (3) The **Encoder** converts the object into a string.
- (4) The **Encoder** sends the encoded string back to the caller.
- (5) The **TravelAgency** sends the encoded string to one of the free cells in the **MultiCellBuffer**.
- (6) The **HotelSupplier** receives the encoded string from the **MultiCellBuffer** and sends the string to the **Decoder** for decoding.
- (7) The **Decoder** sends the **OrderObject** to the **HotelSupplier**. The decoded object must contain the same values generated by the **TravelAgency**.
- (8) The **HotelSupplier** creates a new thread to process the order;
- (9) The **OrderProcessingThread** processes the order, e.g., checks the credit card number and calculates the amount.
- (10) The **OrderProcessingThread** sends a confirmation to the travel agency and prints the order (on screen).

**Components** in the diagram are explained in details as follows, with their grades (points) allocation:

1. **HotelSupplier1** through **HotelSupplierK\*** are the objects of a class on the server side: Each object has method to be started as a thread by the **Main** method and will perform a number of functions. It uses a **PricingModel** to determine the room prices. It defines a price-cut event that can emit an event and call the event handlers in the **TravelAgencys** if there is a price-cut according to the **PricingModel**. It receives the orders (in a string) from the **MultiCellBuffer**. It calls the **Decoder** to convert the string into the order object. For each order, you can use the existing thread or start a new thread (resulting in multiple threads for processing multiple orders) from **OrderProcessing** class (or method) to process the order based on the current price. There is a counter **p** in the **HotelSupplier**. After **p** (e.g.,  $p = 10$ ) price cuts have been made, a **HotelSupplier** thread will terminate. [15 points]

*\*Note 1: For the individual project,  $K = 1$ . For a group project (both two-member and three-member group),  $K > 1$ . You can set  $K = 3$  in your implementation.*

2. **PricingModel**: It can be a class or a method in **HotelSupplier** class. It decides the price of rooms. It can increase price or decrease the price. You must define a mathematical model (random function is fine) to determine the price based on the order received within a given time period and the number of rooms available in the **HotelSupplier** in the same time period. You can use a hard-coded table of the price in each week day. However, you must make sure that your model will allow the price goes up some time and goes down some other time. [5 points]

3. **OrderProcessing** is a class or a method in a class on the supplier's side. Whenever an order needs to be processed, a new thread is instantiated from this class (or method) to process the order. It will check the validity of the credit card number. If you are doing an individual project or a two-member group project, you can define your credit card format, for example, the credit card number from the travel agencies must be a number registered to the **HotelSupplier**, or a number between two given numbers (e.g., between 5000 and 7000). For the three-member group project, a bank service must be created. Each **OrderProcessing** thread will calculate the total amount of charge, e.g.,  $\text{unitPrice} * \text{NoOfRooms} + \text{Tax} + \text{LocationCharge}$ . For the group projects, a confirmation must be sent back to the travel agency when an order is completed. You can implement the confirmation in different ways. For example, you can use another buffer for the confirmation, where you can use a buffer cell for each thread, so that you do not have to consider the conflict among the threads. However, you still need to coordinate the write and read between the producer and the consumer. [10 points]

4. **TravelAgency1** through **TravelAgencyN**, each travel agency is a thread instantiated from the same class (or the same method) in a class. The travel agency's actions are event-driven. Each travel agency contains a call-back method (event handler) for the HotelSuppliers to call when a price-cut event occurs. The travel agency will calculate the number of rooms to order, for example, based on the need and the difference between the previous price and the current price. The thread will terminate after the HotelSupplier thread has terminated. Each order is an OrderClass object. The object is sent to the Encoder for encoding. The encoded string is sent back to the travel agency. Then, the travel agency will send the order in String format to the MultiCellBuffer. Before sending the order to the MultiCellBuffer, a time stamp must be saved. When the confirmation of order completion is received, the time of the order will be calculated and saved (or printed). You can set  $N = 5$  in your implementation. [10 points]

5. **OrderClass** is a class that contains at least the following private data members:

- senderId: the identity of the sender, you can use thread name or thread id;
- cardNo: an integer that represents a credit card number;
- receiverID: the identity of the receiver, you can use thread name or a unique name that defined for a hotel supplier; If you are doing an individual project, you do not need this field.
- amount: an integer that represents the number of room to order;

You must use public methods to set and get the private data members. You must decide if these methods need to be synchronized. The instances created from this class are of the OrderObject. [10 points]

6. **MultiCellBuffer** class is used for the communication between the travel agencies (clients) and the HotelSupplier (server): This class has  $n$  data cells (for individual project,  $n = 2$  and for group project,  $n = 3$ ). The number of cells available must be less than ( $<$ ) the max number of travel agencies in your experiment. A setOneCell and getOneCell methods can be defined to write data into and to read data from one of the available cells. You must use a semaphore of value  $n$  to manage the cells and use a lock on each buffer cell. You **cannot** use a queue for the buffer, which is a different data structure. The semaphore will allow an agency to gain the right to write into one of the buffer cells. But the HotelSupplier can still read at the same time. Synchronization is also required. [10 points]

7. **Encoder** is a class or a method in a class: The Encoder class will convert an OrderObject into a string. You can choose any way to encode the values into a string, as long as you can decode the string to the original order object. You can use a class or a method to implement the Encoder. [10 points]

8. **Decoder** is a class or a method in a class: The Decoder will convert the encoded string back into the OrderObject.

9. **Bank service** is a class: It allows the travel agency to apply for a credit card number. The travel agency will use this number to purchase rooms from the hotel suppliers. The hotel suppliers will send the credit card number to the bank for validation. The bank will return the message "valid" or "not valid". When the hotel suppliers send the credit card number to the bank, it will call the encryption service in ASU repository to encrypt the string number. If you use the .svc service, you should use "Add Service Reference". If you use the .asmx service, you must use "Add Web Reference". The recommendation is to use the .svc service, as it is the new standard. On the other hand, the bank will call ASU decryption service to decrypt the number before comparing with the valid credit card numbers. This question is for the three-member group projects only. [20 points]

10. **Main**: The Main thread will perform necessary preparation, create the buffer classes, instantiate the objects, create threads, and start threads. [10 points]

### **Additional Tasks for group projects**

**Two-member Teams:** If you are doing the project as a group of two members, you are required to complete the following additional tasks:

- [1] You must implement multiple suppliers with  $K = 3$ . You must deal with all the issues that are incurred because of the increase of the supplier number.
- [2] The supplier must send a confirmation back to the travel agency when an order is completed.
- [3] The buffer size (number of cells in the buffer) is 3, instead of 2.

In this option, one member must write the code of the travel agencies and the main program, The other member must write the code of the supplier. The tow members must jointly write the code for the buffer class.

**Three-member Teams:** If you are doing the project as a group of three members, you are required to complete the additional tasks for the two-member group project and the following additional tasks:

- [4] If you have a three-member team, you must also define the bank service.

The grades of students in team projects will be scaled to out of 100.

### **Notes:**

1. It is the purchase of this course to enforce the knowledge of C# (Visual Studio), as we have multiple courses in our program that use Java. We encourage you to use C#. However, we allow the use of Java (on Eclipse) in this assignment. You must indicate the environment (VS 2012 or 2013 or Eclipse) that you use, so that the TA can use the same environment to grade the project. We taught multithreading in both Java and C#. However, we did not teach the event-driven programming in Java. If you choose to do the project in Java, you need to study this part on your own. I suggest that you do the project in Java only if you are really good at Java and already know how to program events. The event handling in Java is not as easy as in C# for this project, and you need to take extra effort to implement the required functions.
2. You must follow what is defined in the assignment/project document. You have flexibility to choose your implementation details if they are not specified in the document. If you are not sure on any issue, ask the instructor or the TA by posting the question in the discussion board.
3. The program and each component of the program must be well commented.
4. You can choose to do this project as an individual project or a group project. I encourage you to do as a group project. Projects 3 and 5 will be required group projects and thus, you need to build a team anyway. The group used in assignment 2 do not have to be the same as the group for assignments 3 and 5. However, the group for assignment 3 and 5 will be the same, as the project in assignment 5 will be based on assignment 3.

### **Grading of Programming Assignment/Project**

The TA will grade your program following these steps:

(1) The TA will read your program and give points based on the points allocated to each component, the readability of your code (organization of the code and comments), logic, inclusion of the required functions, and correctness of the implementations of each function.

(2) Compile the code. If it does not compile, 40% of the points given in (1) will be deducted. For example, if you are given 20 points in step (1), your points will become 12 if the program fails to compile.

(3) If the code passes the compilation, the TA will execute and test the code. If, for any reason, the program gives an incorrect output or crashes for any input, 20% of the points given in (1) will be deducted.

Please notice that the TA will not debug your program to figure out how big or how small the error is. You may lose 40% or 20% of your points for a small error such missing a comma or a space!

### **Late submission deduction policy:**

- No penalty for late submissions that are received within 24 hours after the deadline;
- 1% grade deduction for every hour after the 24 hours!

### **Where to Submission?**

All submissions must be electronically submitted to the assignment folder where you downloaded the assignment paper. All files must be zipped into a single file.