

**Technical University of Cluj-Napoca**

**Faculty of Automation and Computer Science**

Programming Techniques

Assignment 2

Queues simulator

Teacher: Prof. Ioan Salomie Student: Alina Mihuț

Teaching assistant: Ing. Ciprian Adrian Stan Group 30422

Table of contents

1. Assignment objective
2. Problem analysis, modeling, scenarios, use cases
3. Design (design decisions, UML diagrams, class design, relationships, packages, algorithms, user interfaces)
4. Implementation
5. Results
6. Conclusions
7. Bibliography
8. Assignment objective

Design and implement a simulation application aiming to analyse queuing based systems for determining and minimizing clients’ waiting time.

Queues are commonly used to model real world domains. The main objective of a queue is to provide a place for a "client" to wait before receiving a "service". The management of queue-based systems is interested in minimizing the time amount their "clients" are waiting in queues before they are served. One way to minimize the waiting time is to add more servers, i.e. more queues in the system (each queue is considered as having an associated processor) but this approach increases the costs of the service supplier.

The application should simulate (by defining a simulation time 𝑡𝑠𝑖𝑚𝑢𝑙𝑎𝑡𝑖𝑜𝑛) a series of N clients arriving for service, entering Q queues, waiting, being served and finally leaving the queues. All clients are generated when the simulation is started, and are characterized by three parameters: ID (a number between 1 and N), 𝑡𝑎𝑟𝑟𝑖𝑣𝑎𝑙 (simulation time when they are ready to go to the queue; i.e. time when the client finished shopping) and 𝑡𝑠𝑒𝑟𝑣𝑖𝑐𝑒 (time interval or duration needed to serve the client; i.e. waiting time when the client is in front of the queue). The application tracks the total time spent by every client in the queues and computes the average waiting time. Each client is added to the queue with minimum waiting time when its 𝑡𝑎𝑟𝑟𝑖𝑣𝑎𝑙 time is greater than or equal to the simulation time (𝑡𝑎𝑟𝑟𝑖𝑣𝑎𝑙 >= 𝑡𝑠𝑖𝑚𝑢𝑙𝑎𝑡𝑖𝑜𝑛).

The following data should be considered as input datafor the application that should be inserted by the user in the application’s user interface:

- Number of clients;

- Number of queues;

- Simulation interval;

- Minimum and maximum arrival time (𝑡𝑎𝑟𝑟𝑖𝑣𝑎𝑙𝑀𝐼𝑁 ≤ 𝑡𝑎𝑟𝑟𝑖𝑣𝑎𝑙 ≤ 𝑡𝑎𝑟𝑟𝑖𝑣𝑎𝑙𝑀𝐴𝑋);

- Minimum and maximum service time (𝑡𝑠𝑒𝑟𝑣𝑖𝑐𝑒𝑀𝐼𝑁 ≤ 𝑡𝑠𝑒𝑟𝑣𝑖𝑐𝑒 ≤ 𝑡𝑠𝑒𝑟𝑣𝑖𝑐𝑒𝑀𝐴𝑋);

1. Problem analysis, modeling, scenarios, use cases
2. Analysis

The application should simulate the flow of customers which have to wait an amount of time in queues to get served, just like in real life in a supermarket for example. The parameters to be introduces by the user are the number of queues and of clients, the duration of the simulation process (in seconds), the minimum and the maximum arrival time for the clients and the minimum and maximum service time, meaning the amount of time the clients stay wait while being the first in line in the queue. The application should model the behavior of a queues’ system and send all the clients to one of the queues in an efficient way.

B) Modeling, scenarios and use cases

The main scenario is the following one:

The user introduces the input data and presses the START button. Then, a number of N customers are generated with random arrival times and processing times in the selected interval. One unit of time is the equivalent of one second. The users are each sent to the M queues in the order of their arrival time after one of the two strategies: SHORTEST\_QUEUE (meaning the user is sent to the queue with the smallest number of clients) or SHORTEST\_TIME (meaning the user is sent to the queue with the smallest waiting time). Once sent to the queues, each client is processed in order of their arrival time and then removed from the queue. The simulation stops when all clients are processed and the final time is reached. The evolution of the queues by time is displayed in the log of events as well of the results of simulation: the average service time, waiting time and peak hour.

1. Design

On the top level, the overall system design of the queues simulator is represented by the main inputs: the number of queues, clients, strategy, simulation duration and the interval of arrival times and service times. The outputs of the application are the real time evolution of the queues, and the statistics computed at the end of the simulation.

On a second level, the design is represented by the division of the program in multiple packages with different responsibilities.

The Model-View Controller pattern is an architectural design pattern which divides the project in three main components: model, view and controller.

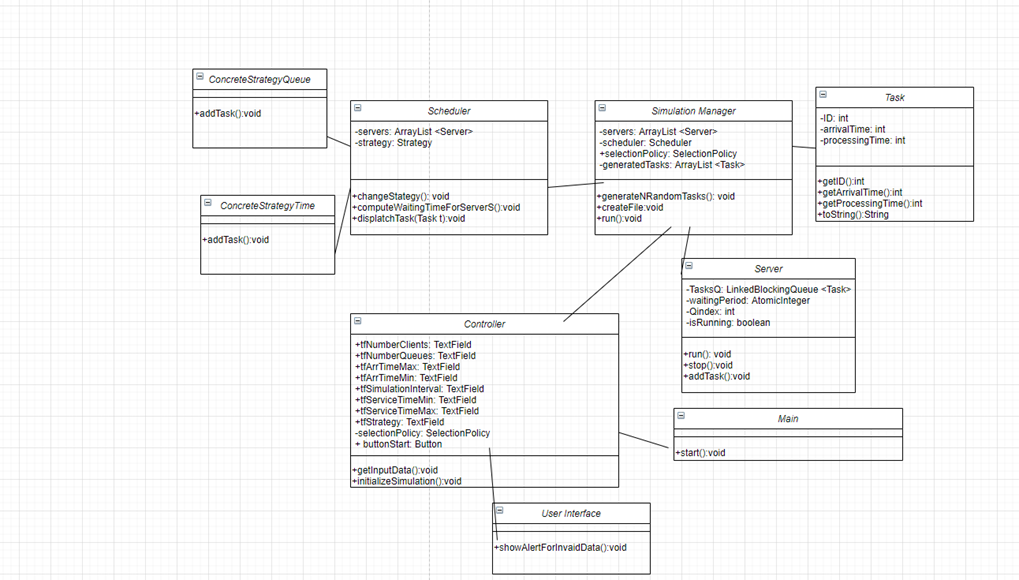
* Model – represents the business layer of the application and contains the classes modeling the application data;
* View –represents the visualization of the data the model contains and keeps the classes which implement the graphical user interface;
* Controller - acts on both model and view. It controls the data flow into model object and updates the view whenever data changes.

In order to ensure a concurrent implementation of the simulation, I designed the program using threads. Threads allows a program to operate more efficiently by doing multiple things at the same time. Threads can be used to perform tasks in the background without interrupting the main program. The tasks are represented by the generated clients, the servers are the queues. There is a thread running for each of the queues, which processes the clients and a thread which manages the whole flow of the simulation. These all run concurrently, for a time period equal to the simulation time.

I designed my project in accordance to the Model-View Controller pattern, so I divided my classes into four main packages:

* Application – the main package which keeps only one class – Main, which runs the whole project.
* Model – the package which holds the objects I worked with in this project : Task (representing each client), Server (the queues), as well as the Scheduler, Simulation Manager and the strategies: Concrete Strategy Queue and Concrete Strategy Time.
* View – the package which contains the User Interface class, with the methods concerning the running of the Graphical User Interface and its’ proper working.
* Controller- the package with the Controller class, as its name suggests, which controls both the GUI classes and the model classes and the data flow between the two. It receives keyboard inputs from the GUI as well as button presses and translates the events into requests, which are sent to the model.

Each package is divided into several classes, having their own attributes and containing specific methods. The methods used by each class and the relationships between classes are presented in the following UML diagram.



In the design of the model, apart from the Task and Server classes, there is the strategy interface and two classes which implement the shortest time strategy and the shortest queue strategy, which basically select the best queue where to place the current customer, based on the strategy the user selects.

1. Implementation

Each of the three packages in the Model-View Controller pattern is divided into several classes, containing specific methods.

The model package is divided into 6 classes: Task, Server, Simulation Manager, Scheduler, Concrete

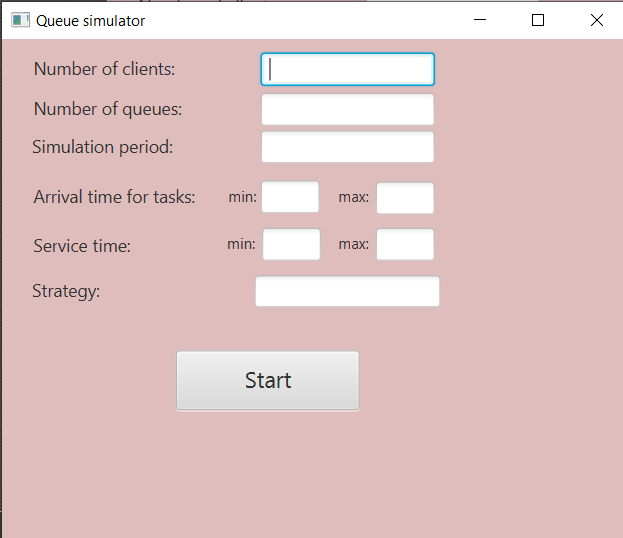
Strategy Queue and Concrete Strategy Time, which implement the Strategy Interface. The Task class represents each of the clients and has the attributes ID, arrival time and processing time, all generated randomly in the Controller class. The Server class has as attributes a Linked Blocking Queue of type Task, which keeps all the clients in that specific queue, a waiting period of type Atomic Integer, an index for the queue of type int and a Boolean, which keeps track of whether the thread is running or not. The override of the **run()** method is the thread which simulate what happens inside each queue and how its clients are processed. There is also a **stop()** method which stops the queues and an **addTask()** method, which adds a task to the linked blocking queue. I chose to work with attributes such as BlockingQueue and AtomicInteger for the purpose of thread safety. The Scheduler launches the threads from Server and Sends tasks to Servers according to the established strategy. Simulation Manager generates randomly the tasks with their attributes and contains the thread which simulates the whole process for the given simulation period. It also calls the Call scheduler to dispatch tasks according to one of the two strategies and displays the log of events in a .txt file.

The UserInterface class, in the view package, has the methods which perform actions on buttons or display alerts in the graphical interface for data validation.

The Controller class in the controller package keeps the methods which set the data flow between the models and the user interface. The **getInputData()** method takes and validates the data introduced by the user in the text fields and sets all the parameters which will be used next ( the number of queues, number of clients, simulation time, minimum and maximum arrival time and service time and the strategy) and an **initializeSimulation()** method, which starts the thread from Simulation Manager.

The Main class in the application package initializes the primary stage and displays it on the running of the application.

In the implementation of the graphical user interface, I used Scene Builder. The GUI contains only one window, where the user inserts the parameters needed for the simulation setup. The user has to enter in each of the text field the required parameters. The data he enters is verified and in case it’s not correct, he receives an alert box on the screen. I designed the user interface in order to be easy and inductive for the user. The design of the user interface window can be seen in the following picture.



1. Results

I chose to display the results of the simulation as logs of events in .txt files. The logs contain the evolution of the queues by each time unit, and the statistics of the simulations: the average service time, the average waiting time and the peak hour.

For the input data of N = 4 clients, Q = 2 queues, 𝑡𝑠𝑖𝑚𝑢𝑙𝑎𝑡𝑖𝑜𝑛𝑀𝐴𝑋= 60 seconds, [𝑡𝑎𝑟𝑟𝑖𝑣𝑎𝑙𝑀𝐼𝑁, 𝑡𝑎𝑟𝑟𝑖𝑣𝑎𝑙𝑀𝐴𝑋] = [2, 30] and [𝑡𝑠𝑒𝑟𝑣𝑖𝑐𝑒𝑀𝐼𝑁,𝑡𝑠𝑒𝑟𝑣𝑖𝑐𝑒𝑀𝐴𝑋]= [2, 4], the result of the simulation is the following one.

START OF SIMULATION   
TIME: 0  
Waiting clients: (1, 15, 3)(3, 16, 2)(4, 19, 3)(2, 27, 2)  
  
 Queue1: empty  
 Queue2: empty  
TIME: 1  
Waiting clients: (1, 15, 3)(3, 16, 2)(4, 19, 3)(2, 27, 2)  
  
 Queue1: empty  
 Queue2: empty  
TIME: 2  
Waiting clients: (1, 15, 3)(3, 16, 2)(4, 19, 3)(2, 27, 2)  
  
 Queue1: empty  
 Queue2: empty  
TIME: 3  
Waiting clients: (1, 15, 3)(3, 16, 2)(4, 19, 3)(2, 27, 2)  
  
 Queue1: empty  
 Queue2: empty  
TIME: 4  
Waiting clients: (1, 15, 3)(3, 16, 2)(4, 19, 3)(2, 27, 2)  
  
 Queue1: empty  
 Queue2: empty  
TIME: 5  
Waiting clients: (1, 15, 3)(3, 16, 2)(4, 19, 3)(2, 27, 2)  
  
 Queue1: empty  
 Queue2: empty  
TIME: 6  
Waiting clients: (1, 15, 3)(3, 16, 2)(4, 19, 3)(2, 27, 2)  
  
 Queue1: empty  
 Queue2: empty  
TIME: 7  
Waiting clients: (1, 15, 3)(3, 16, 2)(4, 19, 3)(2, 27, 2)  
  
 Queue1: empty  
 Queue2: empty  
TIME: 8  
Waiting clients: (1, 15, 3)(3, 16, 2)(4, 19, 3)(2, 27, 2)  
  
 Queue1: empty  
 Queue2: empty  
TIME: 9  
Waiting clients: (1, 15, 3)(3, 16, 2)(4, 19, 3)(2, 27, 2)  
  
 Queue1: empty  
 Queue2: empty  
TIME: 10  
Waiting clients: (1, 15, 3)(3, 16, 2)(4, 19, 3)(2, 27, 2)  
  
 Queue1: empty  
 Queue2: empty  
TIME: 11  
Waiting clients: (1, 15, 3)(3, 16, 2)(4, 19, 3)(2, 27, 2)  
  
 Queue1: empty  
 Queue2: empty  
TIME: 12  
Waiting clients: (1, 15, 3)(3, 16, 2)(4, 19, 3)(2, 27, 2)  
  
 Queue1: empty  
 Queue2: empty  
TIME: 13  
Waiting clients: (1, 15, 3)(3, 16, 2)(4, 19, 3)(2, 27, 2)  
  
 Queue1: empty  
 Queue2: empty  
TIME: 14  
Waiting clients: (1, 15, 3)(3, 16, 2)(4, 19, 3)(2, 27, 2)  
  
 Queue1: empty  
 Queue2: empty  
TIME: 15  
Waiting clients: (3, 16, 2)(4, 19, 3)(2, 27, 2)  
  
 Queue1: (1, 15, 2)  
 Queue2: empty  
TIME: 16  
Waiting clients: (4, 19, 3)(2, 27, 2)  
  
 Queue1: (1, 15, 1)  
 Queue2: (3, 16, 1)  
TIME: 17  
Waiting clients: (4, 19, 3)(2, 27, 2)  
  
 Queue1: empty  
 Queue2: empty  
TIME: 18  
Waiting clients: (4, 19, 3)(2, 27, 2)  
  
 Queue1: empty  
 Queue2: empty  
TIME: 19  
Waiting clients: (2, 27, 2)  
  
 Queue1: (4, 19, 3)  
 Queue2: empty  
TIME: 20  
Waiting clients: (2, 27, 2)  
  
 Queue1: (4, 19, 1)  
 Queue2: empty  
TIME: 21  
Waiting clients: (2, 27, 2)  
  
 Queue1: empty  
 Queue2: empty  
TIME: 22  
Waiting clients: (2, 27, 2)  
  
 Queue1: empty  
 Queue2: empty  
TIME: 23  
Waiting clients: (2, 27, 2)  
  
 Queue1: empty  
 Queue2: empty  
TIME: 24  
Waiting clients: (2, 27, 2)  
  
 Queue1: empty  
 Queue2: empty  
TIME: 25  
Waiting clients: (2, 27, 2)  
  
 Queue1: empty  
 Queue2: empty  
TIME: 26  
Waiting clients: (2, 27, 2)  
  
 Queue1: empty  
 Queue2: empty  
TIME: 27  
Waiting clients:   
  
 Queue1: (2, 27, 1)  
 Queue2: empty  
TIME: 28  
Waiting clients:   
  
 Queue1: empty  
 Queue2: empty  
TIME: 29  
Waiting clients:   
  
 Queue1: empty  
 Queue2: empty  
TIME: 30  
Waiting clients:   
  
 Queue1: empty  
 Queue2: empty  
TIME: 31  
Waiting clients:   
  
 Queue1: empty  
 Queue2: empty  
TIME: 32  
Waiting clients:   
  
 Queue1: empty  
 Queue2: empty  
TIME: 33  
Waiting clients:   
  
 Queue1: empty  
 Queue2: empty  
TIME: 34  
Waiting clients:   
  
 Queue1: empty  
 Queue2: empty  
TIME: 35  
Waiting clients:   
  
 Queue1: empty  
 Queue2: empty  
TIME: 36  
Waiting clients:   
  
 Queue1: empty  
 Queue2: empty  
TIME: 37  
Waiting clients:   
  
 Queue1: empty  
 Queue2: empty  
TIME: 38  
Waiting clients:   
  
 Queue1: empty  
 Queue2: empty  
TIME: 39  
Waiting clients:   
  
 Queue1: empty  
 Queue2: empty  
TIME: 40  
Waiting clients:   
  
 Queue1: empty  
 Queue2: empty  
TIME: 41  
Waiting clients:   
  
 Queue1: empty  
 Queue2: empty  
TIME: 42  
Waiting clients:   
  
 Queue1: empty  
 Queue2: empty  
TIME: 43  
Waiting clients:   
  
 Queue1: empty  
 Queue2: empty  
TIME: 44  
Waiting clients:   
  
 Queue1: empty  
 Queue2: empty  
TIME: 45  
Waiting clients:   
  
 Queue1: empty  
 Queue2: empty  
TIME: 46  
Waiting clients:   
  
 Queue1: empty  
 Queue2: empty  
TIME: 47  
Waiting clients:   
  
 Queue1: empty  
 Queue2: empty  
TIME: 48  
Waiting clients:   
  
 Queue1: empty  
 Queue2: empty  
TIME: 49  
Waiting clients:   
  
 Queue1: empty  
 Queue2: empty  
TIME: 50  
Waiting clients:   
  
 Queue1: empty  
 Queue2: empty  
TIME: 51  
Waiting clients:   
  
 Queue1: empty  
 Queue2: empty  
TIME: 52  
Waiting clients:   
  
 Queue1: empty  
 Queue2: empty  
TIME: 53  
Waiting clients:   
  
 Queue1: empty  
 Queue2: empty  
TIME: 54  
Waiting clients:   
  
 Queue1: empty  
 Queue2: empty  
TIME: 55  
Waiting clients:   
  
 Queue1: empty  
 Queue2: empty  
TIME: 56  
Waiting clients:   
  
 Queue1: empty  
 Queue2: empty  
TIME: 57  
Waiting clients:   
  
 Queue1: empty  
 Queue2: empty  
TIME: 58  
Waiting clients:   
  
 Queue1: empty  
 Queue2: empty  
TIME: 59  
Waiting clients:   
  
 Queue1: empty  
 Queue2: empty  
------------------------------------------   
Average service time:2.25   
Average waiting time:2.5   
Peak Hour: 16 with 2 clients in the queues   
END OF SIMULATION

For the second test, with the input data of N = 50 clients, Q = 5 queues, 𝑡𝑠𝑖𝑚𝑢𝑙𝑎𝑡𝑖𝑜𝑛𝑀𝐴𝑋= 60 seconds, [𝑡𝑎𝑟𝑟𝑖𝑣𝑎𝑙𝑀𝐼𝑁, 𝑡𝑎𝑟𝑟𝑖𝑣𝑎𝑙𝑀𝐴𝑋] = [2, 40] and [𝑡𝑠𝑒𝑟𝑣𝑖𝑐𝑒𝑀𝐼𝑁,𝑡𝑠𝑒𝑟𝑣𝑖𝑐𝑒𝑀𝐴𝑋]= [1,7], the result of the simulation is the following one.

START OF SIMULATION   
TIME: 0  
Waiting clients: (43, 4, 5)(33, 5, 1)(2, 6, 6)(15, 6, 1)(34, 6, 2)(50, 6, 1)(30, 9, 5)(36, 9, 3)(10, 10, 6)(28, 12, 2)(32, 12, 4)(47, 12, 6)(14, 14, 5)(22, 14, 4)(48, 14, 2)(6, 16, 3)(35, 16, 3)(41, 16, 1)(9, 18, 5)(25, 18, 4)(27, 18, 4)(13, 20, 2)(17, 21, 5)(3, 22, 1)(20, 22, 3)(31, 22, 3)(39, 22, 4)(40, 22, 3)(26, 23, 6)(7, 25, 4)(12, 25, 1)(16, 26, 4)(23, 26, 3)(49, 26, 6)(37, 27, 1)(5, 28, 6)(19, 29, 6)(21, 31, 4)(11, 32, 4)(4, 33, 2)(8, 33, 1)(45, 33, 1)(38, 34, 4)(1, 35, 5)(42, 36, 2)(18, 37, 6)(29, 37, 1)(46, 37, 1)(24, 39, 2)(44, 39, 5)  
  
 Queue1: empty  
 Queue2: empty  
 Queue3: empty  
 Queue4: empty  
 Queue5: empty  
TIME: 1  
Waiting clients: (43, 4, 5)(33, 5, 1)(2, 6, 6)(15, 6, 1)(34, 6, 2)(50, 6, 1)(30, 9, 5)(36, 9, 3)(10, 10, 6)(28, 12, 2)(32, 12, 4)(47, 12, 6)(14, 14, 5)(22, 14, 4)(48, 14, 2)(6, 16, 3)(35, 16, 3)(41, 16, 1)(9, 18, 5)(25, 18, 4)(27, 18, 4)(13, 20, 2)(17, 21, 5)(3, 22, 1)(20, 22, 3)(31, 22, 3)(39, 22, 4)(40, 22, 3)(26, 23, 6)(7, 25, 4)(12, 25, 1)(16, 26, 4)(23, 26, 3)(49, 26, 6)(37, 27, 1)(5, 28, 6)(19, 29, 6)(21, 31, 4)(11, 32, 4)(4, 33, 2)(8, 33, 1)(45, 33, 1)(38, 34, 4)(1, 35, 5)(42, 36, 2)(18, 37, 6)(29, 37, 1)(46, 37, 1)(24, 39, 2)(44, 39, 5)  
  
 Queue1: empty  
 Queue2: empty  
 Queue3: empty  
 Queue4: empty  
 Queue5: empty  
TIME: 2  
Waiting clients: (43, 4, 5)(33, 5, 1)(2, 6, 6)(15, 6, 1)(34, 6, 2)(50, 6, 1)(30, 9, 5)(36, 9, 3)(10, 10, 6)(28, 12, 2)(32, 12, 4)(47, 12, 6)(14, 14, 5)(22, 14, 4)(48, 14, 2)(6, 16, 3)(35, 16, 3)(41, 16, 1)(9, 18, 5)(25, 18, 4)(27, 18, 4)(13, 20, 2)(17, 21, 5)(3, 22, 1)(20, 22, 3)(31, 22, 3)(39, 22, 4)(40, 22, 3)(26, 23, 6)(7, 25, 4)(12, 25, 1)(16, 26, 4)(23, 26, 3)(49, 26, 6)(37, 27, 1)(5, 28, 6)(19, 29, 6)(21, 31, 4)(11, 32, 4)(4, 33, 2)(8, 33, 1)(45, 33, 1)(38, 34, 4)(1, 35, 5)(42, 36, 2)(18, 37, 6)(29, 37, 1)(46, 37, 1)(24, 39, 2)(44, 39, 5)  
  
 Queue1: empty  
 Queue2: empty  
 Queue3: empty  
 Queue4: empty  
 Queue5: empty  
TIME: 3  
Waiting clients: (43, 4, 5)(33, 5, 1)(2, 6, 6)(15, 6, 1)(34, 6, 2)(50, 6, 1)(30, 9, 5)(36, 9, 3)(10, 10, 6)(28, 12, 2)(32, 12, 4)(47, 12, 6)(14, 14, 5)(22, 14, 4)(48, 14, 2)(6, 16, 3)(35, 16, 3)(41, 16, 1)(9, 18, 5)(25, 18, 4)(27, 18, 4)(13, 20, 2)(17, 21, 5)(3, 22, 1)(20, 22, 3)(31, 22, 3)(39, 22, 4)(40, 22, 3)(26, 23, 6)(7, 25, 4)(12, 25, 1)(16, 26, 4)(23, 26, 3)(49, 26, 6)(37, 27, 1)(5, 28, 6)(19, 29, 6)(21, 31, 4)(11, 32, 4)(4, 33, 2)(8, 33, 1)(45, 33, 1)(38, 34, 4)(1, 35, 5)(42, 36, 2)(18, 37, 6)(29, 37, 1)(46, 37, 1)(24, 39, 2)(44, 39, 5)  
  
 Queue1: empty  
 Queue2: empty  
 Queue3: empty  
 Queue4: empty  
 Queue5: empty  
TIME: 4  
Waiting clients: (33, 5, 1)(2, 6, 6)(15, 6, 1)(34, 6, 2)(50, 6, 1)(30, 9, 5)(36, 9, 3)(10, 10, 6)(28, 12, 2)(32, 12, 4)(47, 12, 6)(14, 14, 5)(22, 14, 4)(48, 14, 2)(6, 16, 3)(35, 16, 3)(41, 16, 1)(9, 18, 5)(25, 18, 4)(27, 18, 4)(13, 20, 2)(17, 21, 5)(3, 22, 1)(20, 22, 3)(31, 22, 3)(39, 22, 4)(40, 22, 3)(26, 23, 6)(7, 25, 4)(12, 25, 1)(16, 26, 4)(23, 26, 3)(49, 26, 6)(37, 27, 1)(5, 28, 6)(19, 29, 6)(21, 31, 4)(11, 32, 4)(4, 33, 2)(8, 33, 1)(45, 33, 1)(38, 34, 4)(1, 35, 5)(42, 36, 2)(18, 37, 6)(29, 37, 1)(46, 37, 1)(24, 39, 2)(44, 39, 5)  
  
 Queue1: (43, 4, 4)  
 Queue2: empty  
 Queue3: empty  
 Queue4: empty  
 Queue5: empty  
TIME: 5  
Waiting clients: (2, 6, 6)(15, 6, 1)(34, 6, 2)(50, 6, 1)(30, 9, 5)(36, 9, 3)(10, 10, 6)(28, 12, 2)(32, 12, 4)(47, 12, 6)(14, 14, 5)(22, 14, 4)(48, 14, 2)(6, 16, 3)(35, 16, 3)(41, 16, 1)(9, 18, 5)(25, 18, 4)(27, 18, 4)(13, 20, 2)(17, 21, 5)(3, 22, 1)(20, 22, 3)(31, 22, 3)(39, 22, 4)(40, 22, 3)(26, 23, 6)(7, 25, 4)(12, 25, 1)(16, 26, 4)(23, 26, 3)(49, 26, 6)(37, 27, 1)(5, 28, 6)(19, 29, 6)(21, 31, 4)(11, 32, 4)(4, 33, 2)(8, 33, 1)(45, 33, 1)(38, 34, 4)(1, 35, 5)(42, 36, 2)(18, 37, 6)(29, 37, 1)(46, 37, 1)(24, 39, 2)(44, 39, 5)  
  
 Queue1: (43, 4, 3)  
 Queue2: empty  
 Queue3: empty  
 Queue4: empty  
 Queue5: empty  
TIME: 6  
Waiting clients: (30, 9, 5)(36, 9, 3)(10, 10, 6)(28, 12, 2)(32, 12, 4)(47, 12, 6)(14, 14, 5)(22, 14, 4)(48, 14, 2)(6, 16, 3)(35, 16, 3)(41, 16, 1)(9, 18, 5)(25, 18, 4)(27, 18, 4)(13, 20, 2)(17, 21, 5)(3, 22, 1)(20, 22, 3)(31, 22, 3)(39, 22, 4)(40, 22, 3)(26, 23, 6)(7, 25, 4)(12, 25, 1)(16, 26, 4)(23, 26, 3)(49, 26, 6)(37, 27, 1)(5, 28, 6)(19, 29, 6)(21, 31, 4)(11, 32, 4)(4, 33, 2)(8, 33, 1)(45, 33, 1)(38, 34, 4)(1, 35, 5)(42, 36, 2)(18, 37, 6)(29, 37, 1)(46, 37, 1)(24, 39, 2)(44, 39, 5)  
  
 Queue1: (43, 4, 2)  
 Queue2: (2, 6, 5)  
 Queue3: (34, 6, 2)  
 Queue4: empty  
 Queue5: empty  
TIME: 7  
Waiting clients: (30, 9, 5)(36, 9, 3)(10, 10, 6)(28, 12, 2)(32, 12, 4)(47, 12, 6)(14, 14, 5)(22, 14, 4)(48, 14, 2)(6, 16, 3)(35, 16, 3)(41, 16, 1)(9, 18, 5)(25, 18, 4)(27, 18, 4)(13, 20, 2)(17, 21, 5)(3, 22, 1)(20, 22, 3)(31, 22, 3)(39, 22, 4)(40, 22, 3)(26, 23, 6)(7, 25, 4)(12, 25, 1)(16, 26, 4)(23, 26, 3)(49, 26, 6)(37, 27, 1)(5, 28, 6)(19, 29, 6)(21, 31, 4)(11, 32, 4)(4, 33, 2)(8, 33, 1)(45, 33, 1)(38, 34, 4)(1, 35, 5)(42, 36, 2)(18, 37, 6)(29, 37, 1)(46, 37, 1)(24, 39, 2)(44, 39, 5)  
  
 Queue1: (43, 4, 1)  
 Queue2: (2, 6, 4)  
 Queue3: (34, 6, 1)  
 Queue4: empty  
 Queue5: empty  
TIME: 8  
Waiting clients: (30, 9, 5)(36, 9, 3)(10, 10, 6)(28, 12, 2)(32, 12, 4)(47, 12, 6)(14, 14, 5)(22, 14, 4)(48, 14, 2)(6, 16, 3)(35, 16, 3)(41, 16, 1)(9, 18, 5)(25, 18, 4)(27, 18, 4)(13, 20, 2)(17, 21, 5)(3, 22, 1)(20, 22, 3)(31, 22, 3)(39, 22, 4)(40, 22, 3)(26, 23, 6)(7, 25, 4)(12, 25, 1)(16, 26, 4)(23, 26, 3)(49, 26, 6)(37, 27, 1)(5, 28, 6)(19, 29, 6)(21, 31, 4)(11, 32, 4)(4, 33, 2)(8, 33, 1)(45, 33, 1)(38, 34, 4)(1, 35, 5)(42, 36, 2)(18, 37, 6)(29, 37, 1)(46, 37, 1)(24, 39, 2)(44, 39, 5)  
  
 Queue1: empty  
 Queue2: (2, 6, 3)  
 Queue3: empty  
 Queue4: empty  
 Queue5: empty  
TIME: 9  
Waiting clients: (10, 10, 6)(28, 12, 2)(32, 12, 4)(47, 12, 6)(14, 14, 5)(22, 14, 4)(48, 14, 2)(6, 16, 3)(35, 16, 3)(41, 16, 1)(9, 18, 5)(25, 18, 4)(27, 18, 4)(13, 20, 2)(17, 21, 5)(3, 22, 1)(20, 22, 3)(31, 22, 3)(39, 22, 4)(40, 22, 3)(26, 23, 6)(7, 25, 4)(12, 25, 1)(16, 26, 4)(23, 26, 3)(49, 26, 6)(37, 27, 1)(5, 28, 6)(19, 29, 6)(21, 31, 4)(11, 32, 4)(4, 33, 2)(8, 33, 1)(45, 33, 1)(38, 34, 4)(1, 35, 5)(42, 36, 2)(18, 37, 6)(29, 37, 1)(46, 37, 1)(24, 39, 2)(44, 39, 5)  
  
 Queue1: (30, 9, 4)  
 Queue2: (2, 6, 2)  
 Queue3: (36, 9, 2)  
 Queue4: empty  
 Queue5: empty  
TIME: 10  
Waiting clients: (28, 12, 2)(32, 12, 4)(47, 12, 6)(14, 14, 5)(22, 14, 4)(48, 14, 2)(6, 16, 3)(35, 16, 3)(41, 16, 1)(9, 18, 5)(25, 18, 4)(27, 18, 4)(13, 20, 2)(17, 21, 5)(3, 22, 1)(20, 22, 3)(31, 22, 3)(39, 22, 4)(40, 22, 3)(26, 23, 6)(7, 25, 4)(12, 25, 1)(16, 26, 4)(23, 26, 3)(49, 26, 6)(37, 27, 1)(5, 28, 6)(19, 29, 6)(21, 31, 4)(11, 32, 4)(4, 33, 2)(8, 33, 1)(45, 33, 1)(38, 34, 4)(1, 35, 5)(42, 36, 2)(18, 37, 6)(29, 37, 1)(46, 37, 1)(24, 39, 2)(44, 39, 5)  
  
 Queue1: (30, 9, 3)  
 Queue2: (2, 6, 1)  
 Queue3: (36, 9, 1)  
 Queue4: (10, 10, 5)  
 Queue5: empty  
TIME: 11  
Waiting clients: (28, 12, 2)(32, 12, 4)(47, 12, 6)(14, 14, 5)(22, 14, 4)(48, 14, 2)(6, 16, 3)(35, 16, 3)(41, 16, 1)(9, 18, 5)(25, 18, 4)(27, 18, 4)(13, 20, 2)(17, 21, 5)(3, 22, 1)(20, 22, 3)(31, 22, 3)(39, 22, 4)(40, 22, 3)(26, 23, 6)(7, 25, 4)(12, 25, 1)(16, 26, 4)(23, 26, 3)(49, 26, 6)(37, 27, 1)(5, 28, 6)(19, 29, 6)(21, 31, 4)(11, 32, 4)(4, 33, 2)(8, 33, 1)(45, 33, 1)(38, 34, 4)(1, 35, 5)(42, 36, 2)(18, 37, 6)(29, 37, 1)(46, 37, 1)(24, 39, 2)(44, 39, 5)  
  
 Queue1: (30, 9, 2)  
 Queue2: empty  
 Queue3: empty  
 Queue4: (10, 10, 4)  
 Queue5: empty  
TIME: 12  
Waiting clients: (14, 14, 5)(22, 14, 4)(48, 14, 2)(6, 16, 3)(35, 16, 3)(41, 16, 1)(9, 18, 5)(25, 18, 4)(27, 18, 4)(13, 20, 2)(17, 21, 5)(3, 22, 1)(20, 22, 3)(31, 22, 3)(39, 22, 4)(40, 22, 3)(26, 23, 6)(7, 25, 4)(12, 25, 1)(16, 26, 4)(23, 26, 3)(49, 26, 6)(37, 27, 1)(5, 28, 6)(19, 29, 6)(21, 31, 4)(11, 32, 4)(4, 33, 2)(8, 33, 1)(45, 33, 1)(38, 34, 4)(1, 35, 5)(42, 36, 2)(18, 37, 6)(29, 37, 1)(46, 37, 1)(24, 39, 2)(44, 39, 5)  
  
 Queue1: (30, 9, 1)  
 Queue2: (28, 12, 1)  
 Queue3: (32, 12, 3)  
 Queue4: (10, 10, 3)  
 Queue5: (47, 12, 5)  
TIME: 13  
Waiting clients: (14, 14, 5)(22, 14, 4)(48, 14, 2)(6, 16, 3)(35, 16, 3)(41, 16, 1)(9, 18, 5)(25, 18, 4)(27, 18, 4)(13, 20, 2)(17, 21, 5)(3, 22, 1)(20, 22, 3)(31, 22, 3)(39, 22, 4)(40, 22, 3)(26, 23, 6)(7, 25, 4)(12, 25, 1)(16, 26, 4)(23, 26, 3)(49, 26, 6)(37, 27, 1)(5, 28, 6)(19, 29, 6)(21, 31, 4)(11, 32, 4)(4, 33, 2)(8, 33, 1)(45, 33, 1)(38, 34, 4)(1, 35, 5)(42, 36, 2)(18, 37, 6)(29, 37, 1)(46, 37, 1)(24, 39, 2)(44, 39, 5)  
  
 Queue1: empty  
 Queue2: empty  
 Queue3: (32, 12, 2)  
 Queue4: (10, 10, 2)  
 Queue5: (47, 12, 4)  
TIME: 14  
Waiting clients: (6, 16, 3)(35, 16, 3)(41, 16, 1)(9, 18, 5)(25, 18, 4)(27, 18, 4)(13, 20, 2)(17, 21, 5)(3, 22, 1)(20, 22, 3)(31, 22, 3)(39, 22, 4)(40, 22, 3)(26, 23, 6)(7, 25, 4)(12, 25, 1)(16, 26, 4)(23, 26, 3)(49, 26, 6)(37, 27, 1)(5, 28, 6)(19, 29, 6)(21, 31, 4)(11, 32, 4)(4, 33, 2)(8, 33, 1)(45, 33, 1)(38, 34, 4)(1, 35, 5)(42, 36, 2)(18, 37, 6)(29, 37, 1)(46, 37, 1)(24, 39, 2)(44, 39, 5)  
  
 Queue1: (14, 14, 4)(48, 14, 2)  
 Queue2: (22, 14, 3)  
 Queue3: (32, 12, 1)  
 Queue4: (10, 10, 1)  
 Queue5: (47, 12, 3)  
TIME: 15  
Waiting clients: (6, 16, 3)(35, 16, 3)(41, 16, 1)(9, 18, 5)(25, 18, 4)(27, 18, 4)(13, 20, 2)(17, 21, 5)(3, 22, 1)(20, 22, 3)(31, 22, 3)(39, 22, 4)(40, 22, 3)(26, 23, 6)(7, 25, 4)(12, 25, 1)(16, 26, 4)(23, 26, 3)(49, 26, 6)(37, 27, 1)(5, 28, 6)(19, 29, 6)(21, 31, 4)(11, 32, 4)(4, 33, 2)(8, 33, 1)(45, 33, 1)(38, 34, 4)(1, 35, 5)(42, 36, 2)(18, 37, 6)(29, 37, 1)(46, 37, 1)(24, 39, 2)(44, 39, 5)  
  
 Queue1: (14, 14, 3)(48, 14, 2)  
 Queue2: (22, 14, 2)  
 Queue3: empty  
 Queue4: empty  
 Queue5: (47, 12, 2)  
TIME: 16  
Waiting clients: (9, 18, 5)(25, 18, 4)(27, 18, 4)(13, 20, 2)(17, 21, 5)(3, 22, 1)(20, 22, 3)(31, 22, 3)(39, 22, 4)(40, 22, 3)(26, 23, 6)(7, 25, 4)(12, 25, 1)(16, 26, 4)(23, 26, 3)(49, 26, 6)(37, 27, 1)(5, 28, 6)(19, 29, 6)(21, 31, 4)(11, 32, 4)(4, 33, 2)(8, 33, 1)(45, 33, 1)(38, 34, 4)(1, 35, 5)(42, 36, 2)(18, 37, 6)(29, 37, 1)(46, 37, 1)(24, 39, 2)(44, 39, 5)  
  
 Queue1: (14, 14, 2)(48, 14, 2)  
 Queue2: (22, 14, 1)(41, 16, 1)  
 Queue3: (6, 16, 2)  
 Queue4: (35, 16, 2)  
 Queue5: (47, 12, 1)  
TIME: 17  
Waiting clients: (9, 18, 5)(25, 18, 4)(27, 18, 4)(13, 20, 2)(17, 21, 5)(3, 22, 1)(20, 22, 3)(31, 22, 3)(39, 22, 4)(40, 22, 3)(26, 23, 6)(7, 25, 4)(12, 25, 1)(16, 26, 4)(23, 26, 3)(49, 26, 6)(37, 27, 1)(5, 28, 6)(19, 29, 6)(21, 31, 4)(11, 32, 4)(4, 33, 2)(8, 33, 1)(45, 33, 1)(38, 34, 4)(1, 35, 5)(42, 36, 2)(18, 37, 6)(29, 37, 1)(46, 37, 1)(24, 39, 2)(44, 39, 5)  
  
 Queue1: (14, 14, 1)(48, 14, 2)  
 Queue2: (41, 16, 1)  
 Queue3: (6, 16, 1)  
 Queue4: (35, 16, 1)  
 Queue5: empty  
TIME: 18  
Waiting clients: (13, 20, 2)(17, 21, 5)(3, 22, 1)(20, 22, 3)(31, 22, 3)(39, 22, 4)(40, 22, 3)(26, 23, 6)(7, 25, 4)(12, 25, 1)(16, 26, 4)(23, 26, 3)(49, 26, 6)(37, 27, 1)(5, 28, 6)(19, 29, 6)(21, 31, 4)(11, 32, 4)(4, 33, 2)(8, 33, 1)(45, 33, 1)(38, 34, 4)(1, 35, 5)(42, 36, 2)(18, 37, 6)(29, 37, 1)(46, 37, 1)(24, 39, 2)(44, 39, 5)  
  
 Queue1: (48, 14, 2)  
 Queue2: (9, 18, 5)  
 Queue3: (25, 18, 4)  
 Queue4: (27, 18, 4)  
 Queue5: empty  
TIME: 19  
Waiting clients: (13, 20, 2)(17, 21, 5)(3, 22, 1)(20, 22, 3)(31, 22, 3)(39, 22, 4)(40, 22, 3)(26, 23, 6)(7, 25, 4)(12, 25, 1)(16, 26, 4)(23, 26, 3)(49, 26, 6)(37, 27, 1)(5, 28, 6)(19, 29, 6)(21, 31, 4)(11, 32, 4)(4, 33, 2)(8, 33, 1)(45, 33, 1)(38, 34, 4)(1, 35, 5)(42, 36, 2)(18, 37, 6)(29, 37, 1)(46, 37, 1)(24, 39, 2)(44, 39, 5)  
  
 Queue1: (48, 14, 1)  
 Queue2: (9, 18, 4)  
 Queue3: (25, 18, 3)  
 Queue4: (27, 18, 3)  
 Queue5: empty  
TIME: 20  
Waiting clients: (17, 21, 5)(3, 22, 1)(20, 22, 3)(31, 22, 3)(39, 22, 4)(40, 22, 3)(26, 23, 6)(7, 25, 4)(12, 25, 1)(16, 26, 4)(23, 26, 3)(49, 26, 6)(37, 27, 1)(5, 28, 6)(19, 29, 6)(21, 31, 4)(11, 32, 4)(4, 33, 2)(8, 33, 1)(45, 33, 1)(38, 34, 4)(1, 35, 5)(42, 36, 2)(18, 37, 6)(29, 37, 1)(46, 37, 1)(24, 39, 2)(44, 39, 5)  
  
 Queue1: (13, 20, 2)  
 Queue2: (9, 18, 3)  
 Queue3: (25, 18, 2)  
 Queue4: (27, 18, 2)  
 Queue5: empty  
TIME: 21  
Waiting clients: (3, 22, 1)(20, 22, 3)(31, 22, 3)(39, 22, 4)(40, 22, 3)(26, 23, 6)(7, 25, 4)(12, 25, 1)(16, 26, 4)(23, 26, 3)(49, 26, 6)(37, 27, 1)(5, 28, 6)(19, 29, 6)(21, 31, 4)(11, 32, 4)(4, 33, 2)(8, 33, 1)(45, 33, 1)(38, 34, 4)(1, 35, 5)(42, 36, 2)(18, 37, 6)(29, 37, 1)(46, 37, 1)(24, 39, 2)(44, 39, 5)  
  
 Queue1: (13, 20, 1)  
 Queue2: (9, 18, 2)  
 Queue3: (25, 18, 1)  
 Queue4: (27, 18, 1)  
 Queue5: (17, 21, 4)  
TIME: 22  
Waiting clients: (26, 23, 6)(7, 25, 4)(12, 25, 1)(16, 26, 4)(23, 26, 3)(49, 26, 6)(37, 27, 1)(5, 28, 6)(19, 29, 6)(21, 31, 4)(11, 32, 4)(4, 33, 2)(8, 33, 1)(45, 33, 1)(38, 34, 4)(1, 35, 5)(42, 36, 2)(18, 37, 6)(29, 37, 1)(46, 37, 1)(24, 39, 2)(44, 39, 5)  
  
 Queue1: (3, 22, 1)(39, 22, 4)  
 Queue2: (9, 18, 1)(40, 22, 3)  
 Queue3: (20, 22, 3)  
 Queue4: (31, 22, 3)  
 Queue5: (17, 21, 3)  
TIME: 23  
Waiting clients: (7, 25, 4)(12, 25, 1)(16, 26, 4)(23, 26, 3)(49, 26, 6)(37, 27, 1)(5, 28, 6)(19, 29, 6)(21, 31, 4)(11, 32, 4)(4, 33, 2)(8, 33, 1)(45, 33, 1)(38, 34, 4)(1, 35, 5)(42, 36, 2)(18, 37, 6)(29, 37, 1)(46, 37, 1)(24, 39, 2)(44, 39, 5)  
  
 Queue1: (39, 22, 4)(26, 23, 6)  
 Queue2: (40, 22, 3)  
 Queue3: (20, 22, 2)  
 Queue4: (31, 22, 2)  
 Queue5: (17, 21, 2)  
TIME: 24  
Waiting clients: (7, 25, 4)(12, 25, 1)(16, 26, 4)(23, 26, 3)(49, 26, 6)(37, 27, 1)(5, 28, 6)(19, 29, 6)(21, 31, 4)(11, 32, 4)(4, 33, 2)(8, 33, 1)(45, 33, 1)(38, 34, 4)(1, 35, 5)(42, 36, 2)(18, 37, 6)(29, 37, 1)(46, 37, 1)(24, 39, 2)(44, 39, 5)  
  
 Queue1: (39, 22, 3)(26, 23, 6)  
 Queue2: (40, 22, 2)  
 Queue3: (20, 22, 1)  
 Queue4: (31, 22, 1)  
 Queue5: (17, 21, 1)  
TIME: 25  
Waiting clients: (16, 26, 4)(23, 26, 3)(49, 26, 6)(37, 27, 1)(5, 28, 6)(19, 29, 6)(21, 31, 4)(11, 32, 4)(4, 33, 2)(8, 33, 1)(45, 33, 1)(38, 34, 4)(1, 35, 5)(42, 36, 2)(18, 37, 6)(29, 37, 1)(46, 37, 1)(24, 39, 2)(44, 39, 5)  
  
 Queue1: (39, 22, 2)(26, 23, 6)  
 Queue2: (40, 22, 1)  
 Queue3: (7, 25, 4)  
 Queue4: (12, 25, 1)  
 Queue5: empty  
TIME: 26  
Waiting clients: (37, 27, 1)(5, 28, 6)(19, 29, 6)(21, 31, 4)(11, 32, 4)(4, 33, 2)(8, 33, 1)(45, 33, 1)(38, 34, 4)(1, 35, 5)(42, 36, 2)(18, 37, 6)(29, 37, 1)(46, 37, 1)(24, 39, 2)(44, 39, 5)  
  
 Queue1: (39, 22, 1)(26, 23, 6)  
 Queue2: (16, 26, 4)  
 Queue3: (7, 25, 3)  
 Queue4: (23, 26, 3)  
 Queue5: (49, 26, 5)  
TIME: 27  
Waiting clients: (5, 28, 6)(19, 29, 6)(21, 31, 4)(11, 32, 4)(4, 33, 2)(8, 33, 1)(45, 33, 1)(38, 34, 4)(1, 35, 5)(42, 36, 2)(18, 37, 6)(29, 37, 1)(46, 37, 1)(24, 39, 2)(44, 39, 5)  
  
 Queue1: (26, 23, 6)(37, 27, 1)  
 Queue2: (16, 26, 3)  
 Queue3: (7, 25, 2)  
 Queue4: (23, 26, 2)  
 Queue5: (49, 26, 4)  
TIME: 28  
Waiting clients: (19, 29, 6)(21, 31, 4)(11, 32, 4)(4, 33, 2)(8, 33, 1)(45, 33, 1)(38, 34, 4)(1, 35, 5)(42, 36, 2)(18, 37, 6)(29, 37, 1)(46, 37, 1)(24, 39, 2)(44, 39, 5)  
  
 Queue1: (26, 23, 5)(37, 27, 1)  
 Queue2: (16, 26, 2)(5, 28, 6)  
 Queue3: (7, 25, 1)  
 Queue4: (23, 26, 1)  
 Queue5: (49, 26, 3)  
TIME: 29  
Waiting clients: (21, 31, 4)(11, 32, 4)(4, 33, 2)(8, 33, 1)(45, 33, 1)(38, 34, 4)(1, 35, 5)(42, 36, 2)(18, 37, 6)(29, 37, 1)(46, 37, 1)(24, 39, 2)(44, 39, 5)  
  
 Queue1: (26, 23, 4)(37, 27, 1)  
 Queue2: (16, 26, 1)(5, 28, 6)  
 Queue3: (19, 29, 6)  
 Queue4: empty  
 Queue5: (49, 26, 2)  
TIME: 30  
Waiting clients: (21, 31, 4)(11, 32, 4)(4, 33, 2)(8, 33, 1)(45, 33, 1)(38, 34, 4)(1, 35, 5)(42, 36, 2)(18, 37, 6)(29, 37, 1)(46, 37, 1)(24, 39, 2)(44, 39, 5)  
  
 Queue1: (26, 23, 3)(37, 27, 1)  
 Queue2: (5, 28, 6)  
 Queue3: (19, 29, 5)  
 Queue4: empty  
 Queue5: (49, 26, 1)  
TIME: 31  
Waiting clients: (11, 32, 4)(4, 33, 2)(8, 33, 1)(45, 33, 1)(38, 34, 4)(1, 35, 5)(42, 36, 2)(18, 37, 6)(29, 37, 1)(46, 37, 1)(24, 39, 2)(44, 39, 5)  
  
 Queue1: (26, 23, 2)(37, 27, 1)  
 Queue2: (5, 28, 5)  
 Queue3: (19, 29, 4)  
 Queue4: (21, 31, 3)  
 Queue5: empty  
TIME: 32  
Waiting clients: (4, 33, 2)(8, 33, 1)(45, 33, 1)(38, 34, 4)(1, 35, 5)(42, 36, 2)(18, 37, 6)(29, 37, 1)(46, 37, 1)(24, 39, 2)(44, 39, 5)  
  
 Queue1: (26, 23, 1)(37, 27, 1)  
 Queue2: (5, 28, 4)  
 Queue3: (19, 29, 3)  
 Queue4: (21, 31, 2)  
 Queue5: (11, 32, 3)  
TIME: 33  
Waiting clients: (38, 34, 4)(1, 35, 5)(42, 36, 2)(18, 37, 6)(29, 37, 1)(46, 37, 1)(24, 39, 2)(44, 39, 5)  
  
 Queue1: (37, 27, 1)(4, 33, 2)  
 Queue2: (5, 28, 3)(8, 33, 1)  
 Queue3: (19, 29, 2)(45, 33, 1)  
 Queue4: (21, 31, 1)  
 Queue5: (11, 32, 2)  
TIME: 34  
Waiting clients: (1, 35, 5)(42, 36, 2)(18, 37, 6)(29, 37, 1)(46, 37, 1)(24, 39, 2)(44, 39, 5)  
  
 Queue1: (4, 33, 2)  
 Queue2: (5, 28, 2)(8, 33, 1)  
 Queue3: (19, 29, 1)(45, 33, 1)  
 Queue4: (38, 34, 4)  
 Queue5: (11, 32, 1)  
TIME: 35  
Waiting clients: (42, 36, 2)(18, 37, 6)(29, 37, 1)(46, 37, 1)(24, 39, 2)(44, 39, 5)  
  
 Queue1: (4, 33, 1)  
 Queue2: (5, 28, 1)(8, 33, 1)  
 Queue3: (45, 33, 1)  
 Queue4: (38, 34, 3)  
 Queue5: (1, 35, 5)  
TIME: 36  
Waiting clients: (18, 37, 6)(29, 37, 1)(46, 37, 1)(24, 39, 2)(44, 39, 5)  
  
 Queue1: (42, 36, 2)  
 Queue2: (8, 33, 1)  
 Queue3: empty  
 Queue4: (38, 34, 2)  
 Queue5: (1, 35, 4)  
TIME: 37  
Waiting clients: (24, 39, 2)(44, 39, 5)  
  
 Queue1: (42, 36, 1)  
 Queue2: (18, 37, 6)  
 Queue3: (46, 37, 1)  
 Queue4: (38, 34, 1)  
 Queue5: (1, 35, 3)  
TIME: 38  
Waiting clients: (24, 39, 2)(44, 39, 5)  
  
 Queue1: empty  
 Queue2: (18, 37, 5)  
 Queue3: (46, 37, 1)  
 Queue4: empty  
 Queue5: (1, 35, 2)  
TIME: 39  
Waiting clients:   
  
 Queue1: (24, 39, 1)  
 Queue2: (18, 37, 4)  
 Queue3: (44, 39, 4)  
 Queue4: empty  
 Queue5: (1, 35, 1)  
TIME: 40  
Waiting clients:   
  
 Queue1: empty  
 Queue2: (18, 37, 3)  
 Queue3: (44, 39, 3)  
 Queue4: empty  
 Queue5: empty  
TIME: 41  
Waiting clients:   
  
 Queue1: empty  
 Queue2: (18, 37, 2)  
 Queue3: (44, 39, 2)  
 Queue4: empty  
 Queue5: empty  
TIME: 42  
Waiting clients:   
  
 Queue1: empty  
 Queue2: (18, 37, 1)  
 Queue3: (44, 39, 1)  
 Queue4: empty  
 Queue5: empty  
TIME: 43  
Waiting clients:   
  
 Queue1: empty  
 Queue2: empty  
 Queue3: empty  
 Queue4: empty  
 Queue5: empty  
TIME: 44  
Waiting clients:   
  
 Queue1: empty  
 Queue2: empty  
 Queue3: empty  
 Queue4: empty  
 Queue5: empty  
TIME: 45  
Waiting clients:   
  
 Queue1: empty  
 Queue2: empty  
 Queue3: empty  
 Queue4: empty  
 Queue5: empty  
TIME: 46  
Waiting clients:   
  
 Queue1: empty  
 Queue2: empty  
 Queue3: empty  
 Queue4: empty  
 Queue5: empty  
TIME: 47  
Waiting clients:   
  
 Queue1: empty  
 Queue2: empty  
 Queue3: empty  
 Queue4: empty  
 Queue5: empty  
TIME: 48  
Waiting clients:   
  
 Queue1: empty  
 Queue2: empty  
 Queue3: empty  
 Queue4: empty  
 Queue5: empty  
TIME: 49  
Waiting clients:   
  
 Queue1: empty  
 Queue2: empty  
 Queue3: empty  
 Queue4: empty  
 Queue5: empty  
TIME: 50  
Waiting clients:   
  
 Queue1: empty  
 Queue2: empty  
 Queue3: empty  
 Queue4: empty  
 Queue5: empty  
TIME: 51  
Waiting clients:   
  
 Queue1: empty  
 Queue2: empty  
 Queue3: empty  
 Queue4: empty  
 Queue5: empty  
TIME: 52  
Waiting clients:   
  
 Queue1: empty  
 Queue2: empty  
 Queue3: empty  
 Queue4: empty  
 Queue5: empty  
TIME: 53  
Waiting clients:   
  
 Queue1: empty  
 Queue2: empty  
 Queue3: empty  
 Queue4: empty  
 Queue5: empty  
TIME: 54  
Waiting clients:   
  
 Queue1: empty  
 Queue2: empty  
 Queue3: empty  
 Queue4: empty  
 Queue5: empty  
TIME: 55  
Waiting clients:   
  
 Queue1: empty  
 Queue2: empty  
 Queue3: empty  
 Queue4: empty  
 Queue5: empty  
TIME: 56  
Waiting clients:   
  
 Queue1: empty  
 Queue2: empty  
 Queue3: empty  
 Queue4: empty  
 Queue5: empty  
TIME: 57  
Waiting clients:   
  
 Queue1: empty  
 Queue2: empty  
 Queue3: empty  
 Queue4: empty  
 Queue5: empty  
TIME: 58  
Waiting clients:   
  
 Queue1: empty  
 Queue2: empty  
 Queue3: empty  
 Queue4: empty  
 Queue5: empty  
TIME: 59  
Waiting clients:   
  
 Queue1: empty  
 Queue2: empty  
 Queue3: empty  
 Queue4: empty  
 Queue5: empty  
------------------------------------------   
Average service time:3.1   
Average waiting time:3.92   
Peak Hour: 33 with 8 clients in the queues   
END OF SIMULATION

1. Conclusions

Working on this project was a good opportunity for me to gain a deeper understanding of the OOP concepts learned in the first semester as well as working on an application with a graphical user interface. It was a bit challenging at first, until I understood how to work with threads and how to structure and organize the project but I realized that a good modelling of the problem from the beginning really helps a lot in the future development. All in all, I liked working on this project and I feel like I gained a lot of knowledge from it.

As further improvements, I feel like I could also display the real time evolution of the queues in the GUI.

1. Bibliography

- ***Assignment\_2\_Support Presentation*** PowerPoint presentation