Project Artificial Inteligence
Bank branches

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1 GitHub

https://github.com/albertoosg/Practica-IA

2 Description of the project

The main objective of this project is to simulate the functioning of a bank branch, providing a realistic representation of customer service dynamics, employee roles, and operational workflow. The simulation will include multiple branches (A, B, and C), each designed to reflect the structure and organization of a real-world banking environment.

Each branch will have a designated number of service posts available to attend to customers. These posts will be responsible for handling various essential banking operations as:

- **Deposit and withdrawal of money:** Customers can deposit funds into their accounts or withdraw cash as needed.

- **Investments:** Bank employees will provide investment advice, manage financial portfolios, and assist customers in making informed investment decisions.

- **Bank loans and credits:** The bank will offer loan services, where customers can apply for personal or business loans, mortgages, and other credit-related products.

Each service post will be managed by a dedicated employee, who will be responsible for efficiently handling customer requests. In addition, each branch will have a branch manager, tasked with overseeing daily operations, ensuring workflow efficiency, and addressing any issues that arise.

Customers will arrive at the bank branch at a and will be organized into queues based on their order of arrival. They will then be directed to the appropriate service posts based on their specific banking needs. After performing operations in the branch, the customers leave.

Each action that happened during the simulation occurs at a specific moment in time, from the moment a customer enters the branch to the moment the customer leaves. Moreover, the simulation shows how long a customer waits in the queue until its attended by an employee in a post of the branch.

3 Code structure

3.1 Main

Here we find the customer generator function, which creates customers during the simulation process. The random time between customer arrivals and transactions is specified, and customers are randomly assigned a counter and branch. Then the simulation environment is initialized, with the creation of as many branches as desired, with the creation of the bank, and with the generation of customers for the duration of the simulation.

In the end, we obtain a summary of the data of each branch with which we can make a comparison of which one is more efficient, which one has more clients, or the ones that lend or receive more money for investments.

3.2 Bank

The Bank class serves as the central entity in the simulation, managing the overall structure and operations of the bank. It contains general information about the bank, such as its name, the total number of branches, and any additional attributes that may define its operations. This class is responsible for assigning customers to branches and ensuring a balanced distribution of clients across multiple locations.

3.3 Clients

The Clients class is designed to represent a customer who interacts with a bank branch in a simulated environment. This class stores and manages essential customer information while tracking their journey through the bank, from arrival to departure. Clients will be able to perform different operations, such as depositing or withdrawing money, investing, or borrowing with probability.

Each instance of this class will hold details about an individual customer, such as their unique identification, financial status, and the type of banking operations they may require.

3.4 Branches

The branch class provides information on the branches and the number of counters in each branch. It has counters for the total number of customers who come to the branch, the money lent by the bank, and the money invested by the customers.

4 Technical Aspects

The code simulates the activity of a multi-branch bank using the simpy library for event simulation. It is structured in four main files: main.py, which organizes the simulation; branch-client.py, which defines the clients and their operations; branch-bank.py, which handles branch assignment and summary generation; and branch.py, which stores the data for each branch.

From the design point of view, the code seeks to follow very good encapsulation practices, trying to organize the functionality in specific classes such as Client, Bank and Bank-Branch. In practice, static typing is used, which improves code clarity, and an efficient structure is used to store transactions (self.history in the Bank class). In addition, the use of the simpy library allows modeling attention queues and waiting times in a realistic way.

Performing a more technical analysis of each file, it can be observed that:

- main.py: Presents a well-structured flow, since it configures branches, requests simulation parameters to the user, executes the process and generates a summary.

- branch-client.py: In this class, clients execute banking operations randomly, waiting for their turn in the assigned branch.

- branch-bank.py: This class manages branch randomization and generates a CSV report.

5 Execution analysis

5.1 Explanation

By executing the project code, the program asks the user how many customers the user wants to generate to enter and operate in a branch. In addition, the program asks the user to specify the minimum and maximum amount of money that clients will have available during the simulation. Once the user answers the three requirements, the simulation starts.

These customers enter a branch at a moment in time to try to withdraw or deposit money, invest, create a bank account, manage a bank account, or request a loan. Once they perform one or more of the operations that can be performed in the branch, the customers finish their appointment in the branch.

These customers can just withdraw money if their card balance allows them to withdraw the amount of money they want. Moreover, the investment operation, in the same way that occurs with the money withdrawal, can just be carried through if the card balance allows it. As explained in the project description, the card balance allows a customer to make a money withdrawal or investment if the card balance is higher or equal to the amount of money the customer is trying to operate with.

The program shows, when running, everything that happens during the simulation. The messages that could be shown during the simulation are:

- "Client x arrives to Bank Branch X at x time units": This message is shown when a customer enters a branch. Specifies the number of the client, the branch it is entering, and the time at which the client has entered.

- "Client x is being attended to at Bank Branch X at x time units. (Time waiting x time units)": This message is shown when a customer is attended at a post by an employee. Specifies the number of the client, the branch it is in being attended to, the time at which the client has been attended to, and how long the client waited in the queue.

- "Client x apply for a loan of x€. Current balance: x€": This message is shown when a customer applies for a loan at a branch post. Specifies the number of the client, the amount the client applied, and the balance after performing the operation.

- "Client x withdraw x€. Current balance: x€": This message is shown when a customer withdraws an amount of money. Specifies the number of the client, the amount of money the customer wants to withdraw, and the balance after performing the operation (the balance must be higher than or equal to the amount invested).

- "Client x tries to withdraw x€, but only has x€": This message is shown when a customer tries to withdraw money, but the amount the customer wants to withdraw is not available because the card balance is not enough. Specifies the number of the client, the amount of money the customer wants to withdraw, and the balance before performing the operation (the balance must be less than the amount tried to withdraw).

- "Client x invest x€. Current balance: x€": This message is shown when a customer invests in a financial portfolio. Specifies the number of the client, the amount of money the customer wants to invest, and the balance after performing the operation (the balance must be higher than or equal to the amount invested).

- "Client x cant invest x€, insufficient balance.": This message is shown when a customer tries to invest money, but the amount the customer wants to withdraw is not available because the card balance is not enough. Specifies the number of the client, the amount of money the customer wants to invest, and the balance before performing the operation (the balance must be less than the amount tried to invest).

- "Client x deposit x€. Current balance: x€": This message is shown when a customer deposits an amount of money. Specifies the number of the client, the amount the customer is depositing, and the balance after performing the operation.

- "Client x finishes his appointment at Bank Branch X at x time units": This message is shown when a customer leaves the branch after performing one or more operations. Specifies the number of the client, the branch at which the customer has been operating, and the time at which the client has finished his appointment and leaves.

As explained in the description of the project, each operation is performed in a moment of time during the simulation, depending on when each customer has entered the branch and it is organized in the queue to be attended.

Once the simulation is finished, the program generates a summary of each branch. This summary collects all the information and every event that happened during the simulation. It shows the user the number of clients that attended each branch, the total amount of money lent by the bank in each branch, and the total amount of money invested by the clients in each branch during the simulation.

All the information is stored at the end of the simulation in eight files .csv. These files name and content are different because of the number of clients that are in the simulation of each file, and because of the minimum and the maximum amount of money the clients can have at the beginning, in the simulation of each file. These files are called: "simulation-x-y-z.csv", where x represents the number of clients, y represents the minimum amount of money the

clients can have at the beginning of the simulation, and z represents the maximum amount of money the clients can have at the beginning of the simulation.

Moreover, all the data is analyzed in "bank-analisys.ipynb", where seven graphics are created to represent some simulation data. This seven graphics represent: the quantity of operations made by the clients; the total deposits made by each client; the total withdrawals made by each client; the total amount operated with in each branch; the number of operations per type of operation made by the clients in each branch; the average of money transacted per operation in each branch; an the deposits made by each client during the simulation.

5.2 Screenshots

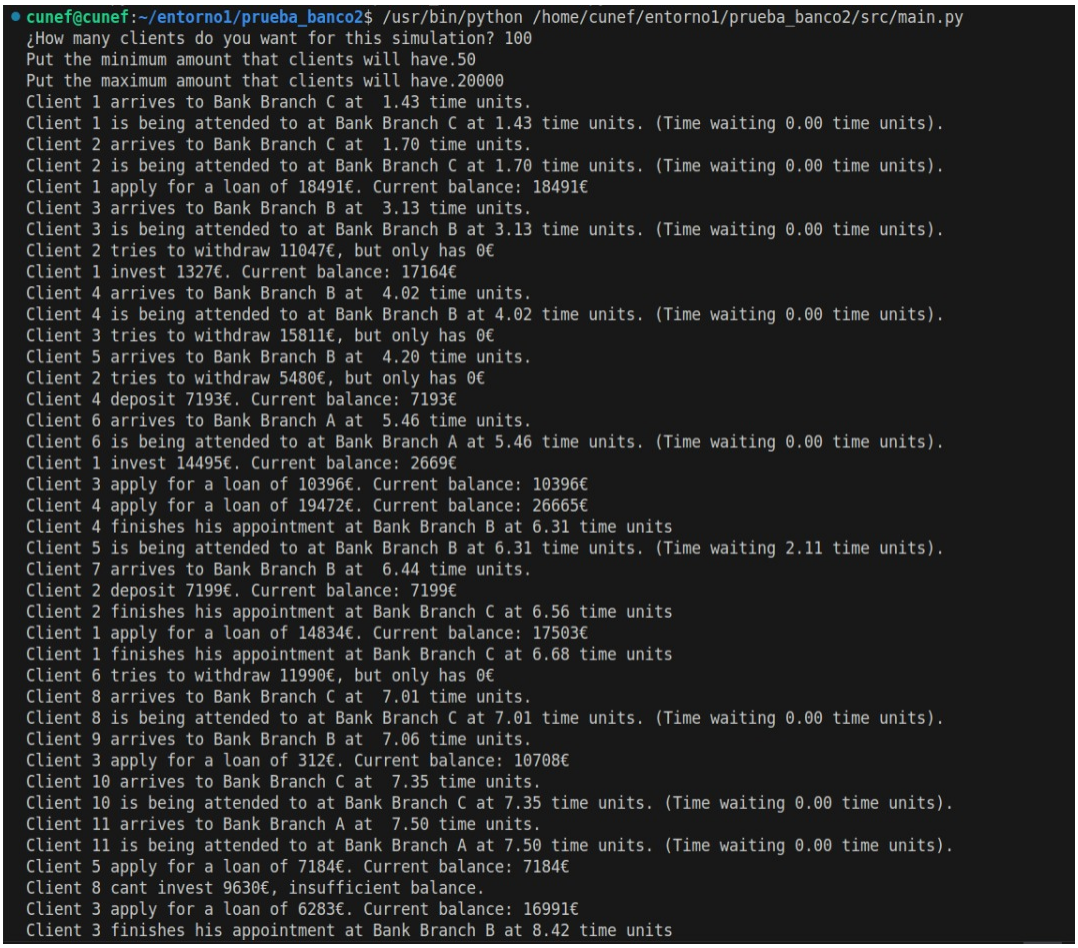

Figure 1: Example Simulation 1.1

```
Client 7 is being attended to at Bank Branch B at 8.42 time units. (Time waiting 1.98 time units).
Client 6 deposit 6224€. Current balance: 6224€
Client 10 tries to withdraw 17428€, but only has 0€
Client 12 arrives to Bank Branch B at  9.08 time units.
Client 11 deposit 18079€. Current balance: 18079€
Client 5 apply for a loan of 5006€. Current balance: 12190€
Client 8 deposit 10545€. Current balance: 10545€
Client 8 finishes his appointment at Bank Branch C at 9.85 time units
Client 13 arrives to Bank Branch C at  10.06 time units.
Client 13 is being attended to at Bank Branch C at 10.06 time units. (Time waiting 0.00 time units).
Client 7 apply for a loan of 14270€. Current balance: 14270€
Client 6 invest 4136€. Current balance: 2088€
Client 10 cant invest 5550€, insufficient balance.
Client 10 finishes his appointment at Bank Branch C at 10.46 time units
Client 5 invest 3064€. Current balance: 9126€
Client 5 finishes his appointment at Bank Branch B at 10.70 time units
Client 9 is being attended to at Bank Branch B at 10.70 time units. (Time waiting 3.64 time units).
Client 11 deposit 357€. Current balance: 18436€
Client 7 deposit 4848€. Current balance: 19118€
Client 13 cant invest 15819€, insufficient balance.
Client 9 apply for a loan of 1213€. Current balance: 1213€
Client 9 finishes his appointment at Bank Branch B at 11.84 time units
Client 12 is being attended to at Bank Branch B at 11.84 time units. (Time waiting 2.76 time units).
Client 14 arrives to Bank Branch A at  11.96 time units.
Client 6 apply for a loan of 5472€. Current balance: 7560€
Client 6 finishes his appointment at Bank Branch A at 12.19 time units
Client 14 is being attended to at Bank Branch A at 12.19 time units. (Time waiting 0.23 time units).
Client 7 withdraw 17802€. Current balance: 1316€
Client 7 finishes his appointment at Bank Branch B at 12.42 time units
Client 11 cant invest 19749€, insufficient balance.
Client 11 finishes his appointment at Bank Branch A at 12.54 time units
Client 13 tries to withdraw 17243€, but only has 0€
Client 15 arrives to Bank Branch A at  12.88 time units.
Client 15 is being attended to at Bank Branch A at 12.88 time units. (Time waiting 0.00 time units).
Client 14 tries to withdraw 4829€, but only has 0€
Client 12 tries to withdraw 11806€, but only has 0€
Client 13 deposit 11900€. Current balance: 11900€
Client 13 finishes his appointment at Bank Branch C at 13.73 time units
Client 15 cant invest 12315€, insufficient balance.
Client 16 arrives to Bank Branch A at  14.17 time units.
Client 14 apply for a loan of 9696€. Current balance: 9696€
Client 12 apply for a loan of 12852€. Current balance: 12852€
Client 12 finishes his appointment at Bank Branch B at 14.92 time units
Client 15 cant invest 5567€, insufficient balance.
Client 17 arrives to Bank Branch B at  15.21 time units.
```

Figure 2: Example Simulation 1.2

```
Client 54 is being attended to at Bank Branch B at 49.30 time units. (Time waiting 2.66 time units).
Client 52 withdraw 11898€. Current balance: 16416€
Client 56 cant invest 1313€, insufficient balance.
Client 50 cant invest 10833€, insufficient balance.
Client 50 finishes his appointment at Bank Branch A at 49.78 time units
Client 58 arrives to Bank Branch C at  50.23 time units.
Client 51 invest 390€. Current balance: 20138€
Client 53 apply for a loan of 9820€. Current balance: 26130€
Client 52 cant invest 17248€, insufficient balance.
Client 52 finishes his appointment at Bank Branch C at 51.10 time units
Client 57 is being attended to at Bank Branch C at 51.10 time units. (Time waiting 1.98 time units).
Client 54 deposit 724€. Current balance: 724€
Client 56 cant invest 13202€, insufficient balance.
Client 59 arrives to Bank Branch C at  51.83 time units.
Client 51 withdraw 13937€. Current balance: 6201€
Client 51 finishes his appointment at Bank Branch B at 52.13 time units
Client 55 is being attended to at Bank Branch B at 52.13 time units. (Time waiting 5.19 time units).
Client 54 tries to withdraw 18306€, but only has 724€
Client 54 finishes his appointment at Bank Branch B at 52.50 time units
Client 53 deposit 5621€. Current balance: 31751€
Client 53 finishes his appointment at Bank Branch A at 52.56 time units
Client 57 deposit 4159€. Current balance: 4159€
Client 56 apply for a loan of 16276€. Current balance: 17281€
Client 56 finishes his appointment at Bank Branch C at 53.04 time units
Client 58 is being attended to at Bank Branch C at 53.04 time units. (Time waiting 2.81 time units).
Client 60 arrives to Bank Branch C at  53.11 time units.
Client 55 deposit 12116€. Current balance: 12116€
Client 61 arrives to Bank Branch C at  54.11 time units.
Client 57 apply for a loan of 9391€. Current balance: 13550€
Client 62 arrives to Bank Branch C at  54.80 time units.
Client 55 deposit 397€. Current balance: 12513€
Client 58 cant invest 8992€, insufficient balance.
Client 57 invest 4633€. Current balance: 8917€
Client 57 finishes his appointment at Bank Branch C at 55.87 time units
Client 59 is being attended to at Bank Branch C at 55.87 time units. (Time waiting 4.04 time units).
Client 55 tries to withdraw 18981€, but only has 12513€
Client 55 finishes his appointment at Bank Branch B at 56.46 time units
Client 63 arrives to Bank Branch C at  56.51 time units.
Client 58 cant invest 17609€, insufficient balance.
Client 59 cant invest 11710€, insufficient balance.
Client 59 finishes his appointment at Bank Branch C at 56.95 time units
Client 60 is being attended to at Bank Branch C at 56.95 time units. (Time waiting 3.84 time units).
Client 60 deposit 3298€. Current balance: 3298€
Client 64 arrives to Bank Branch C at  58.29 time units.
Client 58 cant invest 5574€, insufficient balance.
```

Figure 3: Example Simulation 1.3

```
Client 89 tries to withdraw 5678€, but only has 0€
Client 89 finishes his appointment at Bank Branch B at 89.99 time units
Client 92 is being attended to at Bank Branch B at 89.99 time units. (Time waiting 1.10 time units).
Client 88 apply for a loan of 16106€. Current balance: 27927€
Client 88 finishes his appointment at Bank Branch B at 90.44 time units
Client 96 is being attended to at Bank Branch B at 90.44 time units. (Time waiting 0.95 time units).
Client 98 arrives to Bank Branch A at  90.52 time units.
Client 98 is being attended to at Bank Branch A at 90.52 time units. (Time waiting 0.00 time units).
Client 94 deposit 5887€. Current balance: 5887€
Client 91 apply for a loan of 6883€. Current balance: 6883€
Client 93 tries to withdraw 8951€, but only has 0€
Client 99 arrives to Bank Branch C at  91.63 time units.
Client 92 apply for a loan of 14422€. Current balance: 14422€
Client 91 deposit 6378€. Current balance: 13261€
Client 91 finishes his appointment at Bank Branch C at 92.06 time units
Client 95 is being attended to at Bank Branch C at 92.06 time units. (Time waiting 2.70 time units).
Client 96 deposit 10965€. Current balance: 10965€
Client 100 arrives to Bank Branch C at  92.41 time units.
Client 98 tries to withdraw 3230€, but only has 0€
Client 93 apply for a loan of 18455€. Current balance: 18455€
Client 94 tries to withdraw 18677€, but only has 5887€
Client 94 finishes his appointment at Bank Branch A at 92.69 time units
Client 92 apply for a loan of 7977€. Current balance: 22399€
Client 92 finishes his appointment at Bank Branch B at 93.39 time units
Client 97 is being attended to at Bank Branch B at 93.39 time units. (Time waiting 3.78 time units).
Client 95 apply for a loan of 19575€. Current balance: 19575€
Client 98 cant invest 4912€, insufficient balance.
Client 98 finishes his appointment at Bank Branch A at 93.64 time units
Client 96 deposit 5134€. Current balance: 16099€
Client 93 withdraw 6948€. Current balance: 11507€
Client 93 finishes his appointment at Bank Branch C at 94.00 time units
Client 99 is being attended to at Bank Branch C at 94.00 time units. (Time waiting 2.38 time units).
Client 96 withdraw 4857€. Current balance: 11242€
Client 96 finishes his appointment at Bank Branch B at 94.82 time units
Client 97 apply for a loan of 3185€. Current balance: 3185€
Client 95 withdraw 11440€. Current balance: 8135€
Client 99 deposit 1510€. Current balance: 1510€
Client 99 finishes his appointment at Bank Branch C at 95.77 time units
Client 100 is being attended to at Bank Branch C at 95.77 time units. (Time waiting 3.35 time units).
Client 95 invest 541€. Current balance: 7594€
Client 95 finishes his appointment at Bank Branch C at 96.34 time units
Client 97 withdraw 1411€. Current balance: 1774€
Client 97 finishes his appointment at Bank Branch B at 96.51 time units
Client 100 tries to withdraw 586€, but only has 0€
Client 100 finishes his appointment at Bank Branch C at 97.02 time units
```

Figure 4: Example Simulation 1.4

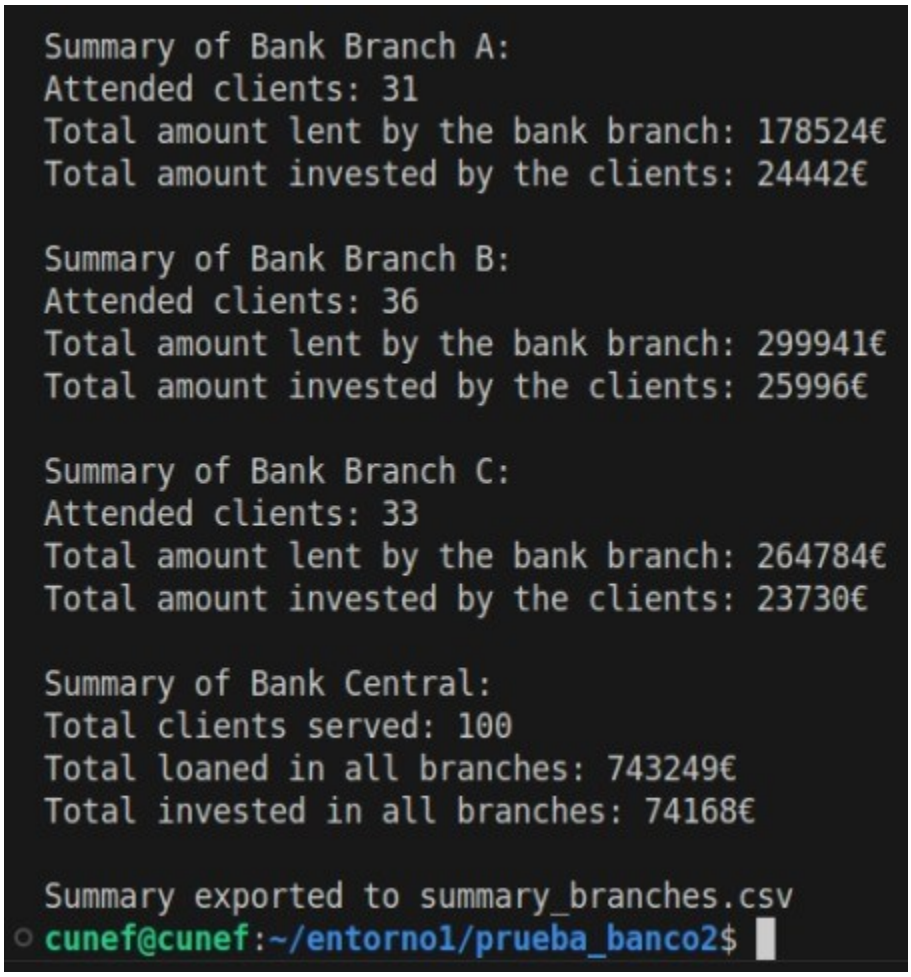

Figure 5: Summary Simulation 1

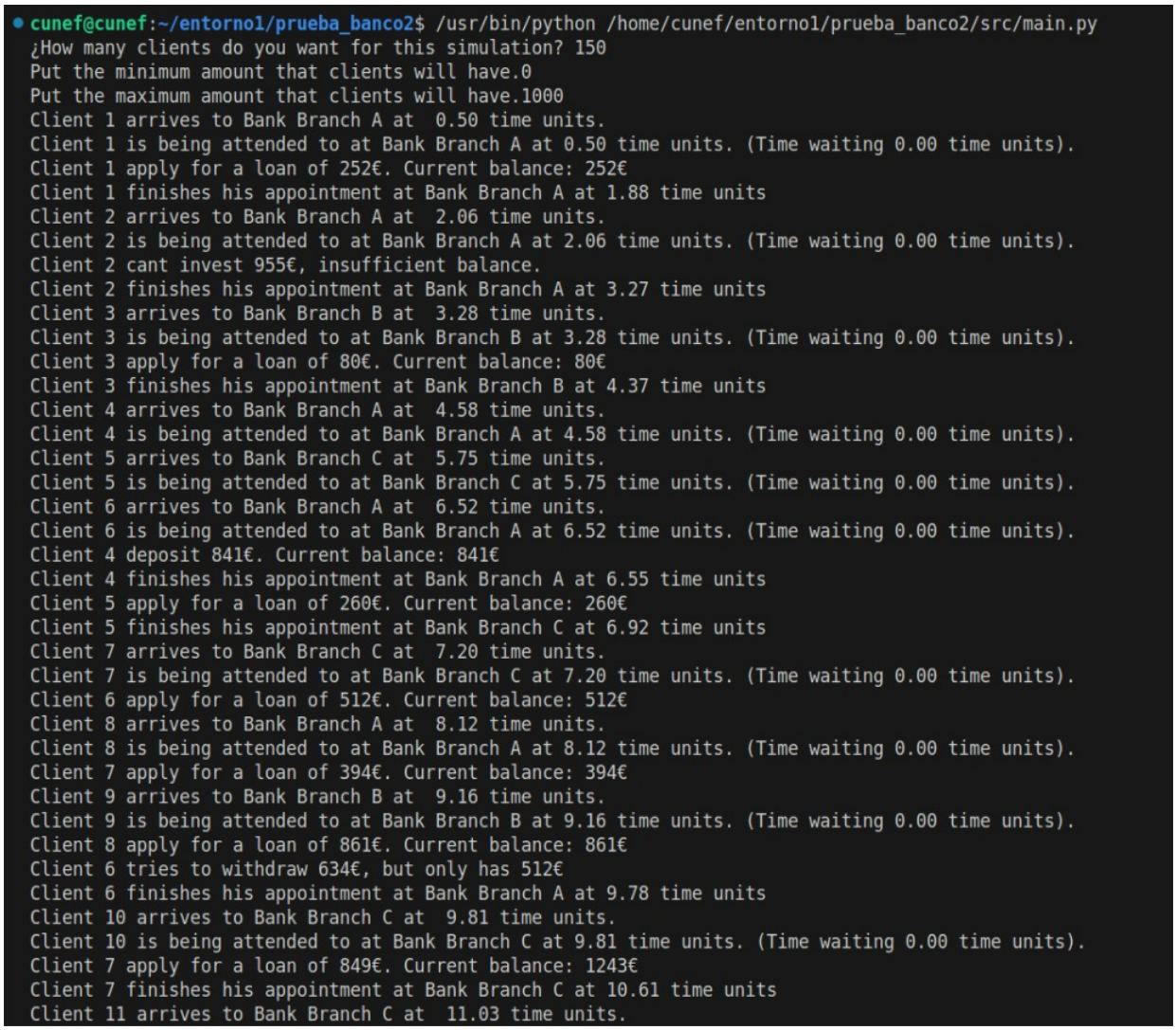

Figure 6: Example Simulation 2.1

```
Client 37 deposit 896€. Current balance: 1029€
Client 37 finishes his appointment at Bank Branch B at 48.04 time units
Client 44 is being attended to at Bank Branch B at 48.04 time units. (Time waiting 2.21 time units).
Client 39 apply for a loan of 937€. Current balance: 1513€
Client 39 finishes his appointment at Bank Branch C at 48.07 time units
Client 45 is being attended to at Bank Branch C at 48.07 time units. (Time waiting 1.63 time units).
Client 43 cant invest 331€, insufficient balance.
Client 43 finishes his appointment at Bank Branch B at 48.17 time units
Client 48 arrives to Bank Branch A at  48.72 time units.
Client 48 is being attended to at Bank Branch A at 48.72 time units. (Time waiting 0.00 time units).
Client 49 arrives to Bank Branch C at  48.82 time units.
Client 47 tries to withdraw 417€, but only has 0€
Client 47 finishes his appointment at Bank Branch A at 49.08 time units
Client 41 apply for a loan of 99€. Current balance: 728€
Client 44 apply for a loan of 287€. Current balance: 287€
Client 44 finishes his appointment at Bank Branch B at 49.56 time units
Client 45 apply for a loan of 921€. Current balance: 921€
Client 48 apply for a loan of 432€. Current balance: 432€
Client 50 arrives to Bank Branch C at  50.70 time units.
Client 41 invest 255€. Current balance: 473€
Client 41 finishes his appointment at Bank Branch C at 50.73 time units
Client 46 is being attended to at Bank Branch C at 50.73 time units. (Time waiting 3.66 time units).
Client 45 apply for a loan of 442€. Current balance: 1363€
Client 45 finishes his appointment at Bank Branch C at 51.00 time units
Client 49 is being attended to at Bank Branch C at 51.00 time units. (Time waiting 2.19 time units).
Client 48 deposit 869€. Current balance: 1301€
Client 51 arrives to Bank Branch A at  52.01 time units.
Client 51 is being attended to at Bank Branch A at 52.01 time units. (Time waiting 0.00 time units).
Client 46 apply for a loan of 699€. Current balance: 699€
Client 48 deposit 444€. Current balance: 1745€
Client 48 finishes his appointment at Bank Branch A at 52.38 time units
Client 49 tries to withdraw 21€, but only has 0€
Client 51 cant invest 358€, insufficient balance.
Client 52 arrives to Bank Branch A at  53.89 time units.
Client 52 is being attended to at Bank Branch A at 53.89 time units. (Time waiting 0.00 time units).
Client 46 deposit 722€. Current balance: 1421€
Client 51 tries to withdraw 105€, but only has 0€
Client 51 finishes his appointment at Bank Branch A at 54.35 time units
Client 53 arrives to Bank Branch B at  54.68 time units.
Client 53 is being attended to at Bank Branch B at 54.68 time units. (Time waiting 0.00 time units).
Client 49 apply for a loan of 829€. Current balance: 829€
Client 52 tries to withdraw 776€, but only has 0€
```

Figure 7: Example Simulation 2.2

```
Client 144 invest 42€. Current balance: 535€
Client 146 tries to withdraw 524€, but only has 414€
Client 140 cant invest 298€, insufficient balance.
Client 140 finishes his appointment at Bank Branch A at 142.39 time units
Client 143 is being attended to at Bank Branch A at 142.39 time units. (Time waiting 4.02 time units).
Client 144 cant invest 774€, insufficient balance.
Client 149 arrives to Bank Branch A at  143.45 time units.
Client 142 withdraw 773€. Current balance: 739€
Client 148 apply for a loan of 718€. Current balance: 718€
Client 143 apply for a loan of 388€. Current balance: 388€
Client 146 cant invest 985€, insufficient balance.
Client 150 arrives to Bank Branch C at  144.27 time units.
Client 148 withdraw 568€. Current balance: 150€
Client 143 apply for a loan of 597€. Current balance: 985€
Client 143 finishes his appointment at Bank Branch A at 145.18 time units
Client 145 is being attended to at Bank Branch A at 145.18 time units. (Time waiting 5.51 time units).
Client 144 cant invest 975€, insufficient balance.
Client 144 finishes his appointment at Bank Branch B at 145.21 time units
Client 142 cant invest 859€, insufficient balance.
Client 142 finishes his appointment at Bank Branch A at 145.58 time units
Client 147 is being attended to at Bank Branch A at 145.58 time units. (Time waiting 4.86 time units).
Client 146 apply for a loan of 934€. Current balance: 1348€
Client 146 finishes his appointment at Bank Branch C at 146.09 time units
Client 150 is being attended to at Bank Branch C at 146.09 time units. (Time waiting 1.82 time units).
Client 147 tries to withdraw 699€, but only has 0€
Client 147 finishes his appointment at Bank Branch A at 146.61 time units
Client 149 is being attended to at Bank Branch A at 146.61 time units. (Time waiting 3.16 time units).
Client 148 tries to withdraw 318€, but only has 150€
Client 145 apply for a loan of 664€. Current balance: 664€
Client 150 cant invest 571€, insufficient balance.
Client 150 finishes his appointment at Bank Branch C at 147.41 time units
Client 145 apply for a loan of 897€. Current balance: 1561€
Client 149 apply for a loan of 115€. Current balance: 115€
Client 148 cant invest 589€, insufficient balance.
Client 148 finishes his appointment at Bank Branch C at 148.68 time units
Client 145 invest 490€. Current balance: 1071€
Client 145 finishes his appointment at Bank Branch A at 150.20 time units
Client 149 deposit 476€. Current balance: 591€
Client 149 deposit 86€. Current balance: 677€
Client 149 invest 192€. Current balance: 485€
Client 149 finishes his appointment at Bank Branch A at 154.36 time units
```

Figure 8: Example Simulation 2.3

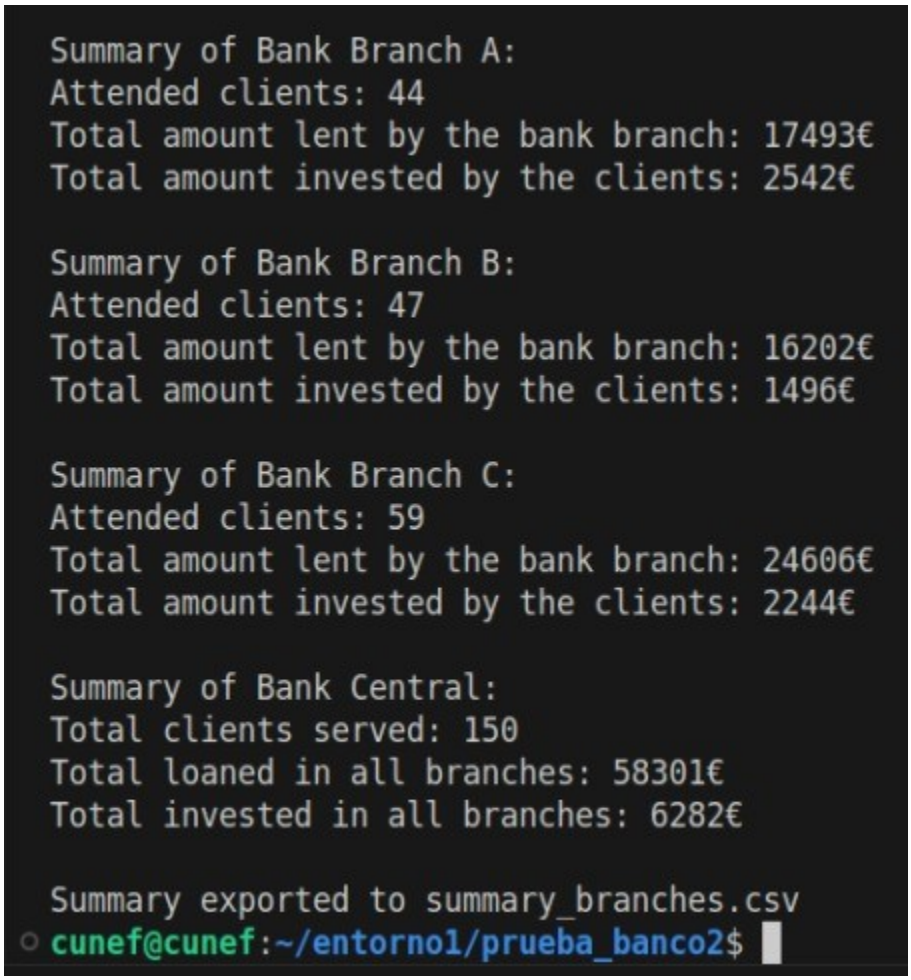

Figure 9: Summary Simulation 2