Build a Coffee Shop Queuing Simulation using Python

Objectives:

- Simulate customer arrivals and wait times
- Track metrics like average queue length, customer wait time
- Create graphs to visualize results

Outline:

1. Set Up Minute-by-Minute Timeline

    Create a list from 0 to 179 (each number = 1 minute).
    Simulate events each minute.

2. Simulate Customer Arrivals

    At each minute, decide if a new customer arrives.
    Use a random method to make them arrive every 2–5 minutes on average.
    When someone arrives, note down the minute they arrived and add to a queue.

3. Track the Barista(s)

    Keep track of whether the barista is free or busy.
    When busy, count down how many minutes of drink-making are left.
    If free and someone is waiting in line, start serving them:

    - Record how long they waited (current minute minus arrival minute)
    - Set a new random service time (2–7 minutes)

4. Track the Queue

At each minute:

- Note how many people are waiting
- Keep track of that number in a list for plotting later

5. Record Key Stats

- Every time someone gets served, record their wait time
- Record how long the queue was each minute

6. After Simulation Ends (180 minutes)

- Calculate the average customer wait time
- Identify the longest wait
- Count how many people waited more than 5 minutes
- Find the average and max queue lengths over time
- Run again with 2 baristas
  - Each can serve separately.
  - If one is free and someone is waiting, they start serving.
- Try busy vs slow hours
  - Make customers arrive more often during the first 60 min (every 2–3 min), and slower later.
- Plotting/Visuals:
  - Use a graph of queue length over time
  - Bar chart: number of people waiting > 5 minutes with 1 vs 2 baristas
- Understand wait times and queuing under different staffing
- Describe the rules (arrival time, service time, barista rules)
- Add recommended modifications based on data found:
  - Average and Max wait time
  - How it changed with 2 baristas

Progress Tracker:

5/20-22/25: created 3-hr timeline, simulated customer arrivals every 2-5 minutes, stored arrival times in a list, and visualized arrival moments

5/23-26/25: simulated for loop of one barista, modeled waiting and serving times, logged served customers with full customer data in addition to arrival times

6/24/25: added tracking of queue lengths at every minute of simulation and appended to new list, analyzed list, added graph to visualize queue length changes over time

6/25-29/25: introduced second barista in second simulation, changed customer arrivals to incorporate rush hour, created code for two bar graphs to compare outcomes from before

Final Summary:

These were the simulation rules:

- Customers arrived every 2–5 minutes, with rush hour (0–59 min) set to 2–3-minute intervals.

- Each customer was assigned a random service time between 2–7 minutes.

- The queue was served by either one or two baristas, each working independently.

- Wait times and queue length were tracked every minute.

My Key Findings:

- With 1 barista, the average wait time was X.XX minutes, and Y customers waited more than 5 minutes.

- With 2 baristas, the average wait dropped to X.XX minutes, and only Y customers waited more than 5 minutes.

- The queue length was consistently shorter and steadier with 2 baristas.

My Recommendation:

Adding a second barista, especially during rush hour, significantly reduced wait times and prevented long queues. For busy periods, staffing 2 baristas would improve service efficiency and customer satisfaction.

Running Simulation:

Example Terminal Output:

```
1 Barista Simulation Complete!


Summary:

Total customers served: 38

Average wait time: 26.82

Longest wait time: 45

Customers who waited more than 5 minutes: 35


11 customers left in queue:

– Customer 40 (arrived at minute 137)

– Customer 41 (arrived at minute 139)

– Customer 42 (arrived at minute 143)

– Customer 43 (arrived at minute 145)
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- Customer 44 (arrived at minute 148)

- Customer 45 (arrived at minute 153)

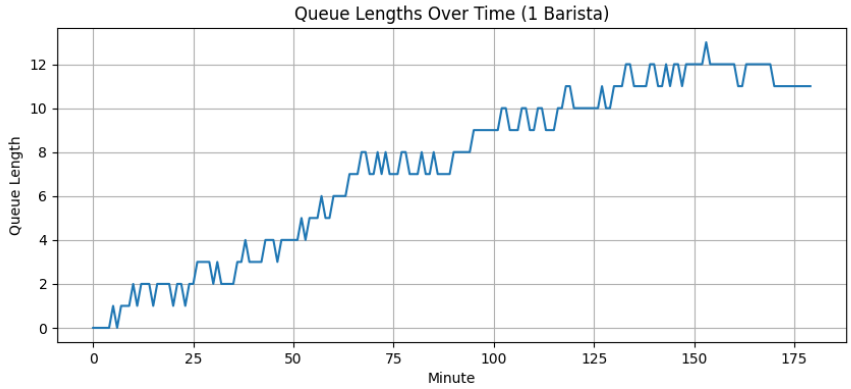
- Customer 46 (arrived at minute 158)

- Customer 47 (arrived at minute 163)

- Customer 48 (arrived at minute 168)

- Customer 49 (arrived at minute 173)

- Customer 50 (arrived at minute 175)



Queue Stats:

Average queue length: 7.36

Max queue length: 13

2 Baristas Simulation Complete!

Summary:

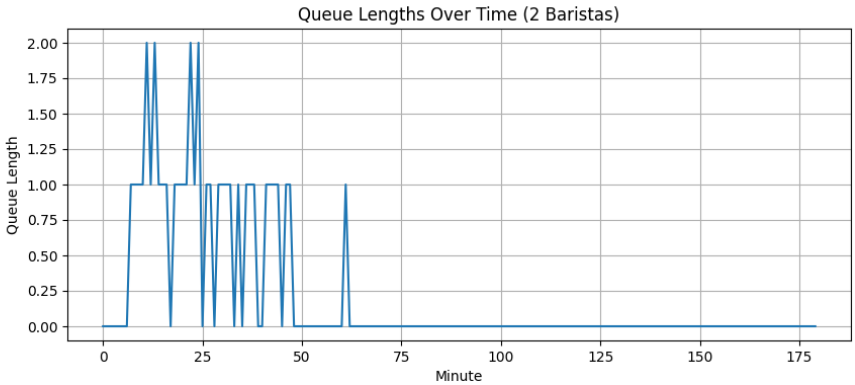
Total customers served: 47

Average wait time: 0.79

Longest wait time: 3

Customers who waited more than 5 minutes: 0

No customers left in queue!



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Queue Stats:

Average queue length: 0.21

Max queue length: 2
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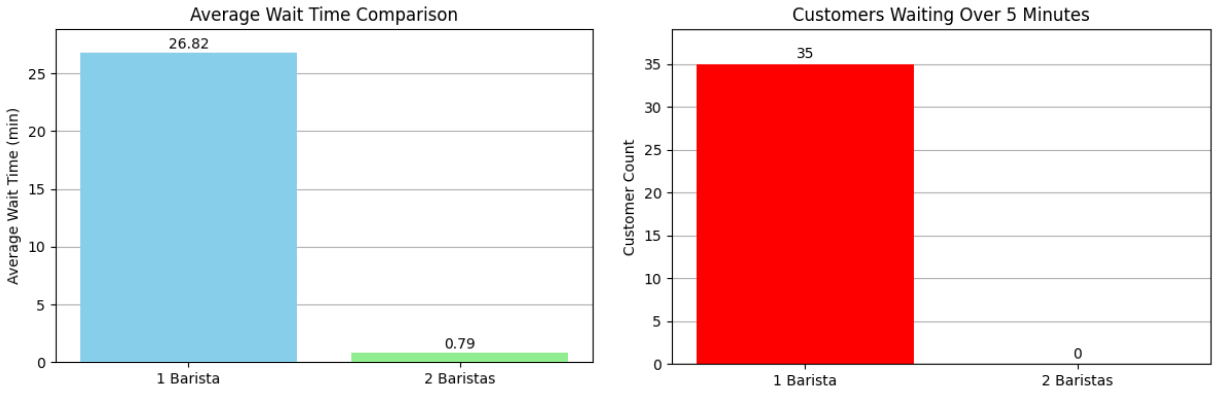

Output Data More Organized:

Metric	1 Barista	2 Baristas
Total Customers Served	38	47
Average Wait Time (min)	26.82	0.79
Longest Wait Time (min)	45	3
# Customers Waited > 5 mins	35	0
# Customers Left in Queue	11	0
Avg Queue Length	7.36	0.21
Max Queue Length	13	2

Conclusion:

Adding a second barista during busy hours significantly improved the efficiency of the coffee shop. With two baristas, the average wait time dropped by approximately 97%, and long wait times (over 5 minutes) were practically eliminated. The queue also remained shorter and more stable. This trend continued for 10 test runs of the simulation. Based on the random simulation, it's strongly recommended that a second barista be scheduled during peak periods to ensure better service quality and reduce customer frustration.