**Performance Modeling and Evaluation of ATM Queue System at Jaffna Market**

**Mini Project Report**

**By**

**G. Shamini**

**Reg No:222515885**

**Student ID: S22010588**

**EEX5362 Performance Modelling**

**Department of Electrical & Computer Engineering Faculty of Engineering Technology**

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**1.System Description and Performance Goal**

The ATM queue system at Jaffna Market, Sri Lanka, serves a diverse customer base, including vendors, shoppers, and residents, performing transactions such as cash withdrawals, balance inquiries, and fund transfers. The system features two ATMs operated by a single bank, with customers forming a single queue to access either machine, creating a multi-server setup. The system's complexity stems from:

Random customer arrivals, driven by the market's dynamic activity, peaking during morning hours (9 AM–12 PM).

Variable transaction times, ranging from quick withdrawals (1–2 minutes) to complex inquiries (4–5 minutes).

Periodic ATM downtimes, due to cash refills, software updates, technical failures, reducing service capacity.

Peak-hour congestion, leading to long queues and delays.

This complexity enables modelling of performance bottlenecks (e.g., limited-service capacity), throughput (customers served per hour), resource utilization (ATM usage), and latency (waiting time), with implications for system scalability during high-demand periods.

**Performance Goal:**

Minimize customer waiting time in the queue to enhance customer satisfaction and reduce congestion.

This goal targets the primary issue of excessive waiting times, critical for maintaining customer loyalty and operational efficiency in a busy market environment.

**2. Modeling Approach and Assumptions**

**Modeling Technique**

The system is modeled using an M/M/c queuing model, where:

M (Poisson process) models random customer arrivals, reflecting market-driven demand.

M (exponential distribution) models service times, capturing transaction variability

c = 2 represents two ATMs sharing a single queue.

The M/M/c model is suitable for a two-ATM setup, accurately capturing queue dynamics, bottlenecks, and latency under varying loads. It is ideal for analysing waiting times in a complex system with multiple servers and scalability challenges. Discrete-event simulation complements the analytical model to account for dynamic behaviour like downtimes.

**Assumptions**

Arrival Rate (λ): 30 customers/hour during peak hours (9 AM–12 PM), 15 customers/hour during off-peak hours (1 PM–4 PM), based on observed data.

Service Rate (μ): Each ATM serves 20 customers/hour (average 3 minutes per transaction).

Number of Servers (c): 2 ATMs, operating independently with a shared queue.

Queue Discipline: First-Come-First-Served (FCFS), consistent with observed behaviour

ATM Availability: Each ATM is operational 90% of the time, with 10% downtime (e.g., cash refills, technical issues), modeled as a reduced effective service rate (μ\_eff = 18 customers/hour per ATM).

Steady-State: The system reaches a steady state when λ < cμ, though peak hours may approach instability.

Homogeneous Transactions: Transaction times follow an exponential distribution, approximating real-world variability.

**Tools**

Analytical: M/M/c queuing formulas to compute waiting time (Wq), queue length (Lq), and utilization (ρ).

Simulation: Python with simpy for discrete-event simulation, modelling arrivals, service times, and random downtimes (10% probability of server unavailability).

Visualization: histograms and line charts to illustrate queue dynamics and waiting time distributions.