# Welcome

## Analysis and Application of Queuing Theory in Supermarkets

# Introduction to Queuing Theory

- Mathematical study of waiting lines (queues)
- Applied in:
  - Supermarkets, banks, hospitals, transport systems
- Helps:
  - Minimize waiting time
  - Improve customer service
  - Reduce idle time and operational costs

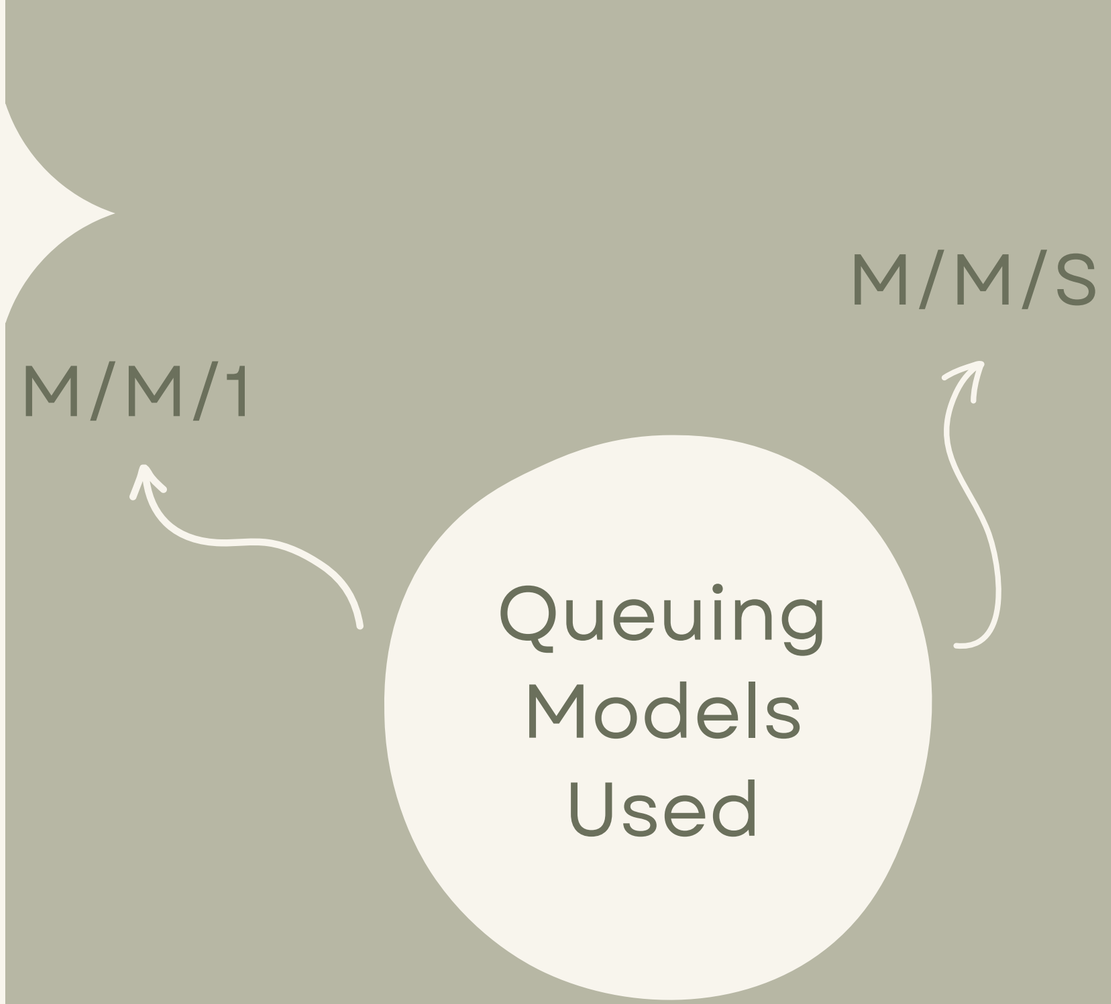
# Study Objective & Context

- Goal: Analyze supermarket checkout process using queuing models
- Focus:
  - Evaluate current multi-line setup
  - Propose more efficient alternative (M/M/S)
- Expected Benefit: Enhanced service & reduced cost

# Real-World Observation

- Studied checkout process at "XYZ Supermarket"
- Setup: 3 cashiers, each with a separate queue
- Issues noted:
  - Line imbalance
  - Inefficiency during peak hours
- Data sources:
  - Direct observation, interviews, surveys

- M/M/1 (Current system):
  - 3 independent queues (1 per cashier)
  - Poisson arrivals, exponential service times
- M/M/s (Proposed system):
  - Single line, multiple servers
  - Customers served by first available cashier



# M/M/1 – Key Formulas

- λ = Arrival rate | μ = Service rate
- Utilization: ρ = λ / μ
- Average in system: Ls = λ / (μ − λ)
- Average in queue: Lq = (λ²) / (μ(μ − λ))
- Wait in queue: Wq = ρ / (μ − λ)
- Time in system: Ws = 1 / (μ − λ)
- Probability of 0 customers: $P_0 = 1 - \rho$
- Probability of n customers: $P_n = P_0 * \varrho^n$

# M/M/S – Key Formulas

- ρ = λ / (sμ)
- $P_0 = \left(\left[\frac{\sum_{n=0}^{s-1}(sp)^n}{n!}\right] + \frac{(sp)^s}{[s!(1-p)]}\right)^{-1}$
- Lq = Ps × (ρ / (1 − ρ)²)
- Ws = Wq + (1/μ)
- Wait in queue: Wq = Ps / [sμ(1 − ρ)²]
- Total in system: Ls = Lq + λ / μ

# Model Assumptions

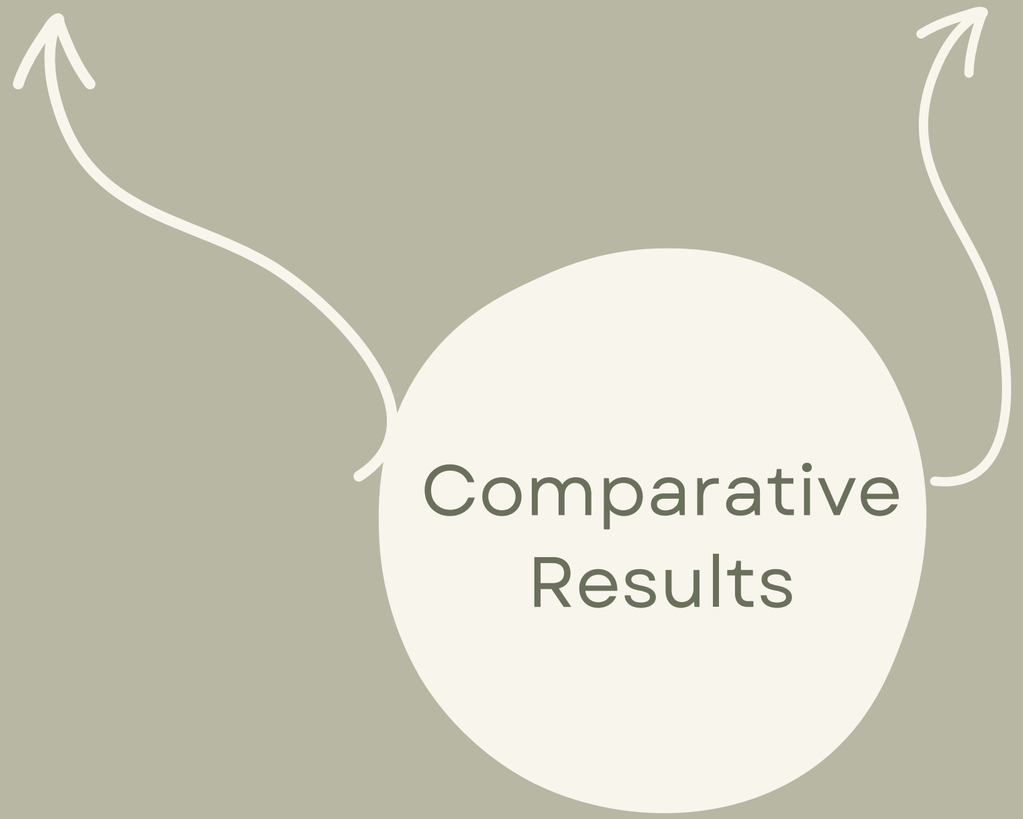
- Customer arrivals follow Poisson process
- Service time = exponential distribution
- No queue limit (infinite capacity)
- First-Come, First-Served (FCFS)
- No customer prioritization
- Employees (servers) work at full capacity
- No impact of queue length on speed
- Arrival rate slightly higher than service rate

## M/M/1

- Avg. waiting time: 9 min
- Total cost: ₹2475

## M/M/S

- Avg. waiting time: 4.33 min
- Total cost: ₹1578.8




# Results

- M/M/s reduced both waiting time & cost
- More efficient under all observed time slots

# Recommendations & Future Work

- Simulation: Use software tools to test complex or emergency scenarios
- Behavioral Study: Account for customers switching lines or leaving
- Self-Checkouts: Assess effect on queue lengths and staff workload

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# References


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