Simulation Modeling and Performance Evaluation

Lecture 04

Simulation Development Example

Single Server Queueing System (SSQS)

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SSQS: Problem Statement

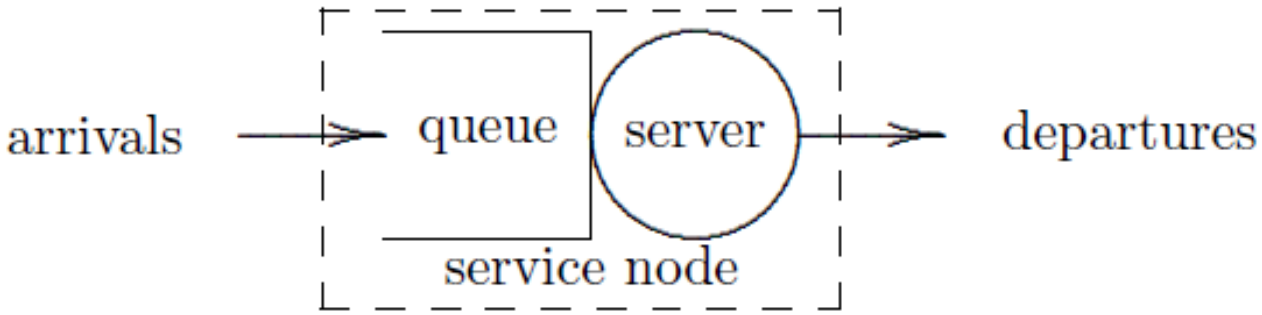
- Customers arrive at random time-points seeking service which requires a random time
- If arriving customer finds the server idle
  - Immediately enters service
  - Otherwise, enters the queue
- Quantity of interest for evaluation
  - Service quality improvement
  - Customer satisfaction
  - Effective use of system resources

SSQS – Step 1: Goals and Objectives

- Simple Boolean decision
  - Do we need an additional server
- Numeric Decision
  - How many parallel server do we need?
- Qualitative Decision
  - Do we need to decrease the customer waiting time in the queue

SSQS – Step 2: Conceptual Model (1/10)

1. System Diagram



Single Server Queueing System

SSQS – Step 2: Conceptual Model (2/10)

2. System State and State Variable (1/3)

- Definition (State): Complete characterization of the system at an instance of time
  - Comprehensive snapshot of the system
- Definition (State Variable): Quantitative characterization assigns numerical values to a set of variables
  - That set of variables are defined as state variables

SSQS – Step 2: Conceptual Model (3/10)

2. System State and State Variable (2/3)

- What an arriving customer will find?
  - Server is idle or busy
    - Server status
  - Long or small queue
    - Queue length
- System state may be represented by two variables – server status, queue length
- Relationship of state variables
  - If the queue length is non-zero, server must be busy
  - If the server is idle, queue length must be zero

SSQS – Step 2: Conceptual Model (4/10)

2. System State and State Variable (3/3)

- System state can also be represented by a single variable – total number of customer in the system
  - Other two can be derived from this
    - If total customer is zero, server is idle, queue is empty
    - If total customer is non-zero, server is busy, queue length = one less the total customer
  - Queue length = max (0, total customer -1)
  - Server status = total customer > 0 ? 1 : 0

SSQS – Step 2: Conceptual Model (5/10)

3. Events (1/2)

- Definition (Event): Occurrence of actions that may change the system state
  - System state cannot be changed without an event
- An event might not change the system state, but without an event system state never changes

SSQS – Step 2: Conceptual Model (6/10)

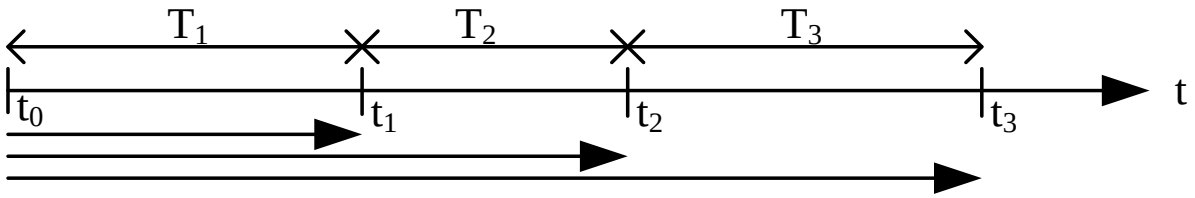
3. Events (2/2)

- System state changes only when customer arrives or leaves the system
  - Customer arrives (arrival event)
  - Service completed and customer leaves (departure event)
- System state (server status, queue length)
  - Arrival either changes the server status from idle to busy, or increases the queue length
  - Departure either changes the server status from busy to idle, or decreases the queue length
- System state (total customer in the system)
  - Arrival increases the total customer by 1,
  - Departure decreases the total customer by 1

SSQS – Step 2: Conceptual Model (9/10)

6. Input variables

- Exact time-point (Absolute time)
  - Arrival time of a customer
    - Instance of time when a particular customer arrives
  - Departure time of a customer
    - Instance of time when the service of a particular customer is completed
- Duration of time since last event (relative time)
  - Interarrial time of customers
  - Service time of the customers



SSQS – Step 2: Conceptual Model (10/10)

7. Output Variables

- Customer satisfaction
  - Average waiting time
  - Average queue length
  - Maximum queue length
- Management decision
  - Server utilization
  - Optimum number of servers
  - Optimum queue length