The Open University of Sri Lanka

Department of Electrical and Computer Engineering

Bachelor of Software Engineering

EEX5362 – Performance Modelling

**Mini Project – Deliverable 01**

**Healthcare Delivery Process**

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## High-Level Problem Description

In modern healthcare systems, timely and efficient patient service delivery is essential for maintaining quality of care and patient satisfaction. However, healthcare delivery often involves several interconnected stages registration, consultation, diagnostic testing, treatment, and discharge each with limited resources and unpredictable demand.

These processes operate under real-world constraints such as varying patient arrival rates, limited medical staff, and shared diagnostic facilities. Consequently, bottlenecks and delays often occur, increasing waiting times and reducing service efficiency.

To better understand and improve this process, this study focuses on modeling the healthcare delivery process as a performance-driven system. The system will be evaluated in terms of measurable operational metrics such as waiting time, throughput, and resource utilization.

This model aims to identify how changes in resource allocation and process design impact overall efficiency, allowing decision-makers to optimize healthcare operations while maintaining quality of care.

## Identification of a Complex System

The chosen system is a Healthcare Delivery Process, representing patient movement from hospital entry to discharge.

This system qualifies as a complex service system because it involves:

* Multiple interdependent stages (registration, consultation, testing, and treatment).
* Human and equipment resources (doctors, nurses, lab technicians, and testing units).
* Random variations in patient arrivals and service durations.
* Competing queues and shared resource constraints.

These characteristics make the healthcare delivery process an excellent candidate for performance modeling and optimization studies.  
It is complex enough to evaluate bottlenecks, throughput, latency, and resource utilization, all of which are measurable through simulation or analytical modeling.

## Dataset and Input Parameters

The dataset for this system will be synthetically generated to resemble realistic hospital operations.  
It consists of patient arrival patterns, service times, and available resource counts.  
The table below summarizes the input parameters and their roles in the model.

|  |  |  |  |
| --- | --- | --- | --- |
| **Parameter** | **Description** | **Type / Source** | **Purpose** |
| **Patient Arrival Rate** | Number of patients arriving per hour | Random (Poisson / Exponential) | Models system demand and load variability |
| **Consultation Time** | Duration of doctor-patient session | Normal Distribution (μ = 15 min, σ = 5) | Represents doctor workload |
| **Diagnostic Test Time** | Time taken for lab/imaging test | Empirical / Assumed (Normal μ = 20 min) | Models resource delay |
| **Treatment Time** | Time spent in treatment stage | Gamma Distribution (Mean = 30 min) | Models care process time |
| **Resource Counts** | Number of doctors, nurses, testing units | Adjustable Parameters | Determines system capacity |
| **Operating Hours** | Duration of simulation | Fixed (8–12 hours) | Defines observation window |

These parameters can later be used in a Discrete-Event Simulation (DES) or analytical queuing model to evaluate how patient flow and performance change with different configurations.

## Performance Objectives

The primary goal of this study is to evaluate and improve the performance of the healthcare delivery process by analyzing how changes in resource allocation and workload distribution affect key operational outcomes.

|  |  |
| --- | --- |
| **Objective** | **Description** |
| **Minimize Patient Waiting Time** | Reduce the average time patients wait before consultation or treatment. |
| **Optimize Resource Utilization** | Ensure doctors, nurses, and diagnostic units are efficiently used without being overburdened. |
| **Increase System Throughput** | Maximize the number of patients treated within a fixed operational period. |
| **Identify Performance Bottlenecks** | Determine where congestion occurs most frequently (registration, testing, consultation, etc.). |
| **Balance Service Efficiency and Cost** | Find an optimal trade-off between faster service and efficient staffing levels. |

Each objective can be evaluated through simulation metrics such as queue lengths, average service time, and percentage utilization of staff and equipment.

## Modeling Approach

To study the behavior of this system, a Discrete-Event Simulation (DES) approach will be applied using Python.

Rationale for Using DES:

* It captures random, event-driven processes like patient arrivals and service durations.
* It allows for step-by-step process visualization (registration, consultation, testing, treatment).
* It enables testing of different staffing or scheduling scenarios to assess performance changes.
* It generates quantitative and graphical results for comparison and analysis.

The DES model will simulate the patient flow, measure performance under varying loads, and identify potential process improvements.

## Expected Analysis and Evaluation

The system will be analyzed under multiple scenarios, such as:

* Baseline Configuration: Standard number of doctors, nurses, and diagnostic units.
* Increased Staffing: Addition of one or more doctors or testing units.
* Balanced Configuration: Optimized allocation of all resources.

For each scenario, performance metrics like waiting time, utilization, and throughput will be measured and compared.  
Graphical visualizations (e.g., bar charts and line plots) will be used to show improvements or bottlenecks clearly.

## Expected Outcomes

This study aims to:

* Identify the stages contributing most to delays in patient service flow.
* Quantify the relationship between resource availability and service efficiency.
* Recommend strategic improvements for hospital scheduling and staffing.
* Provide a foundation for data-driven healthcare management decisions.

## Repository Link

This document and related project files are hosted in the following GitHub repository: