Performance Modeling

EEX - 5362

Deliverable 01

Name - K.LH.Pramuditha

S – Number - S20002583

Register Number - 520263574

Center - Colombo

Date - 31/10/2024

GitHub Repository with Sample Document & Dataset

https://github.com/hasindu200/EEX5362_520263574.git

Complex System Identification

Colombo Port Container Terminal Logistics Pipeline

The Colombo International Container Terminal (CICT) represents a complex queueing network that is critical to Sri Lanka's economy. As the primary transshipment hub for South Asia, this system involves multiple interconnected subsystems:

System Components:

- Vessel arrival and anchorage queue management
- Berth allocation and scheduling
- Quay crane operations (loading/unloading)
- Container transport vehicle network
- Yard storage and retrieval systems
- Gate processing for land-side transportation

Complexity Factors:

- Multiple interdependent queueing points
- Resource constraints (berths, cranes, vehicles)
- Stochastic arrival patterns of vessels
- Variable processing times
- Resource utilization conflicts
- Scalability challenges during peak demand

1. High-Level Problem Statement

Excessive Vessel Turnaround Time at Colombo Port

The core problem is the unpredictable and extended vessel turnaround time (total time from arrival to departure), which currently averages 28-36 hours for large container vessels. This inefficiency stems from:

Primary Issues:

- Bottlenecks in container flow between quay cranes and transport vehicles
- Yard congestion during simultaneous vessel operations
- Suboptimal resource allocation during peak arrival periods
- Inefficient berth planning for vessel arrival surges

Business Impact:

- Increased shipping costs for Sri Lankan exporters/importers
- Loss of competitive advantage against regional ports (Singapore, Dubai, India)
- Demurrage charges exceeding $15,000 daily per vessel
- Underutilization of port infrastructure despite high capacity demand
- Negative impact on Sri Lanka's position as a maritime hub

2. Dataset

Column	Type	Description
Container_ID	int	Unique ID for each container.
Subsystem	str	Stage in pipeline: Berthing, Yard, Gate, Transshipment, Control
Cycle_Time	float	Time to complete this stage (minutes)
Throughput	int	TEUs processed per hour at this subsystem
Utilization	float	% of resource capacity used
Defects	int	1 = delay/failure (e.g., refer alarm, mis-scan)
Timestamp	datetime	Exact time of record (hourly)

3. Performance Objectives

Primary Performance Objective

Reduce average vessel turnaround time by 25% (from current 32 hours to 24 hours) through systematic bottleneck identification and resource optimization.

1. Minimize Response Time

   Make everything faster: vessel < 24 hours, truck < 20 minutes.

2. Maximize Throughput

   Handle more containers: target > 7.8 million TEUs per year.

3. Identify Bottlenecks

   Find and fix slow spots (e.g., gate or yard > 85% busy).

4. Optimize Resource Allocation

   Use cranes, space, and staff efficiently: 80–90% usage, no waste.

5. Ensure Scalability

   Handle +20% more volume without delays or breakdowns.

Objective	Target
Minimize Response Time	Reduce end-to-end latency and service time across subsystems.(< 24 hrs (vessel turnaround))
Maximize Throughput	Increase system output rate and handling capacity
Identify Bottlenecks	Detect resource saturation and queue buildup
Optimize Resource Allocation	Achieve balanced utilization and minimum idle/overhead
Ensure Scalability	Support load increase without performance degradation