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Car Service Point

Gasoline station simulation

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Information and communication technologies

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Software project

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# Introduction

This document serves as the foundational description of a simulation project focused on a car service point. The primary goal of this project is to create a model that simulates customer interactions with five key services: a gas station, car wash, drying station, a drive-through store and a cashier. This simulation focuses solely on modelling the queueing behaviour at each service point and does not include financial transactions. The cashier service serves as a unified exit point for all customers after completing their chosen services.

The simulation allows users to choose any individual service, with the exception that the drying station can only be selected after the car wash. Additionally, customers may leave the service point from any service's exit, reflecting the flexibility of real-world scenarios.

The purpose of this document is to provide a detailed overview of the simulation project, its vision, conceptual definitions, and the non-software-specific model to be implemented. It will also serve as a reference for understanding the key assumptions, design, and structure of the simulation.

The content of this document is structured as follows:

* **Visio**: Outlines the end product of the simulation project and the goals it aims to achieve.
* **Concepts, Definitions**: Defines the key terms and elements used throughout the document.
* **Conceptual Model**: Presents the objectives, assumptions, and components of the simulation model.

This document will be updated as the project progresses, reflecting refinements to the model and its implementation.

# Visio

The goal of this project is to simulate a modular car service point where users can customize their journey based on their specific needs. The simulation replicates five distinct service modules: a gas station, a car wash, a drying station, a store, and a cashier. The cashier acts as a unified point where all customers finalize their service process before leaving the system.

Core features of the simulation include:

* Modular Service Selection: Users can choose any individual service. For example, some may only refuel, while others may opt for a car wash followed by drying.
* Unified Exit Point: All services culminate at the cashier module, ensuring an organized flow and a clear endpoint for the simulation.
* Realistic Constraint: Some dependencies exist, such as the drying station being accessible only after the car wash.

Service Modules Overview:

* Gas Station: Offers fast refuelling services.
* Car Wash: Includes automated vehicle washing.
* Drying Station: Optional service that follows a car wash.
* Drive-through Store / Drive-through: Allows customers to purchase items quickly without leaving their car.
* Cashier: A unified exit point for all customers to finalize their chosen services.

The simulation aims to provide insights into operational efficiency, customer satisfaction, and optimal service layouts. It also serves as a testing ground for various scenarios, such as peak service times, queue management, and resource allocation.

# Concepts, definitions

This section defines the key concepts used in the simulation and document to ensure consistent terminology and understanding.

* **Key Concepts:**

1. Service Point

A location offering specific car-related services. The simulated service point includes five distinct modules: gas station, car wash, drying station, drive-through store and cashier. Each module functions independently but allows sequential interactions.

1. Customer

A user of the service point who selects one or more services based on their preferences and may exit the system at any module. Customers have varying arrival intervals and service requirements.

1. Queue

The line of customers waiting for a specific service module. Each module has its own queue, which operates on a first-come, first-served basis. Queue length can impact customer satisfaction and service efficiency.

1. Service Time

The time taken for a service module to complete a customer's request. This may vary depending on the service type and simulation parameters, often modeled using probability distributions such as exponential or normal distributions.

1. Simulation Time

The total time span over which the simulation runs, during which customer arrivals, service completions, and queue dynamics are tracked.

1. Idle Time

The period when a service module is not actively serving customers. Idle time impacts the overall utilization rate of a module.

1. Arrival Rate

The frequency at which customers arrive at the service point. Typically expressed as the number of arrivals per unit of time. Arrival rates can be uniform or fluctuate over time.

1. System State

A snapshot of the system at any given time, including the number of customers in queues, the status of each service module (idle or busy), and ongoing service times.

* **Key Definitions**

1. Service Dependency

A restriction where certain services can only be accessed after completing others. For example, the drying station is only available after the car wash.

1. Throughput

The number of customers successfully served within the simulation time.

1. Utilization Rate

The percentage of time a service module is actively serving customers during the simulation.

1. Queue Length

The number of customers waiting in line for a service module at a given time.

1. Customer Satisfaction

A qualitative measure of how well the service point meets customer expectations, often influenced by waiting times and service quality.

1. Event-Based Simulation

A simulation approach where system changes are driven by discrete events such as customer arrivals or service completions.

# Conceptual model

This chapter presents the non-software-specific description of the simulation model, detailing its objectives, inputs, outputs, assumptions, and simplifications. The conceptual model outlines the framework for the system that will be implemented in the simulation.

## Objective

The main objective of this simulation is to model the operations of a car service point, where users can select from five service modules: a gas station, car wash, drying station, store, and cashier. The goal is to analyse queue dynamics, optimize service time, and improve customer satisfaction by simulating various scenarios such as varying customer arrival rates, queue lengths, and service times.

## Feeds

The simulation receives various inputs that influence the system’s operation. Key inputs include:

* Number of Service Points: The number of stations available for each service module (e.g., gas pumps, wash bays).
* Customer Arrival Rate: The rate at which customers arrive at the service point. It can vary depending on the time of day or external factors.
* Service Time Distributions: The time required to serve a customer at each service point, typically modelled using a probability distribution (e.g., exponential, normal).
* Queueing Rules: The method for managing queues at each service module, such as first-come, first-served (FCFS).
* Capacity of Service Points: The maximum number of customers that can be served simultaneously at each station.

## Printouts

The outputs of the simulation provide valuable performance metrics that reflect how well the system is functioning. Key outputs include:

* Utilization Rate: The percentage of time each service point is in use during the simulation. This helps identify any underutilized or overburdened modules.
* Throughput: The total number of customers served by the system within a given simulation time.
* Queue Length: The average number of customers waiting in line at each service point. Long queues may indicate inefficiencies.
* Waiting Time: The average time customers spend in the queue before receiving service.
* Service Time: average service time in the service point.

## Content

This model simulates the flow of customers through various service modules at the car service point. The model’s boundaries are defined by the service modules that make up the service point, and the queues at each of these modules.

**The limits of the model:**

The model focuses on simulating customer interactions with the five service modules—gas station, car wash, drying station, drive-through store and cashier. It does not account for certain real-world issues such as:

* Staffing and resource allocation: The model does not simulate the effect of having insufficient staff or resources in certain modules, which could affect the speed and quality of service.
* Traffic flow and parking: The movement of cars within the service point area (e.g., how they park or how traffic congestion affects service time) is not included in the model.
* Real-world interruptions: Events like machine breakdowns, customer complaints, or external factors (e.g., weather) that could delay or stop services are not simulated.
* Environmental and safety factors: Real-world safety regulations, such as safety measures at the car wash or drying station, are not modelled.
* No monetary transactions: The project does not include real-world monetary transactions, which means the model cannot simulate overall revenue or financial performance.
* No direct customer satisfaction parameter: The model does not provide a direct metric for customer satisfaction based on factors like excessive waiting times, which limits its ability to suggest improvements to system users.

**Model detail:**

The model is designed to reflect the core operations of the service point, but it simplifies real-world components for ease of simulation. For example:

* Service time distributions: While real-world service times may vary due to various unpredictable factors, the model uses simplified probability distributions (e.g., exponential or normal distributions) to represent these times. This abstraction helps to simulate the flow without getting into the complexities of each individual service process.
* Queue management: The queue management system follows basic rules such as first-come, first-served (FCFS), whereas in reality, certain services may prioritize VIP customers or provide different queue systems (e.g., fast lanes).
* Service modules: Each service module is treated as a single unit with a fixed capacity, though in the real world, the service point may have additional complexities, such as variations in the number of service stations at peak times or during maintenance periods.

## Assumptions and simplications

The model assumes several factors to simplify its implementation and make it computationally feasible. Key assumptions include:

* Infinite Queue Capacity: The model assumes that there is no limit to the number of customers that can wait in the queue, even though real-world systems might have physical capacity constraints.
* Fixed Service Times: In some modules, service times are assumed to be constant or follow a simplified distribution, although in practice, they may vary.
* No Customer Priority: The model assumes that all customers are treated equally, without any priority based on factors such as VIP status.

## Description of the model

The model simulates the interactions between customers and various service modules at the car service point. It is composed of several key components that represent the different aspects of the service point. Each component serves a specific role in the simulation, and their interactions define the system's behavior.

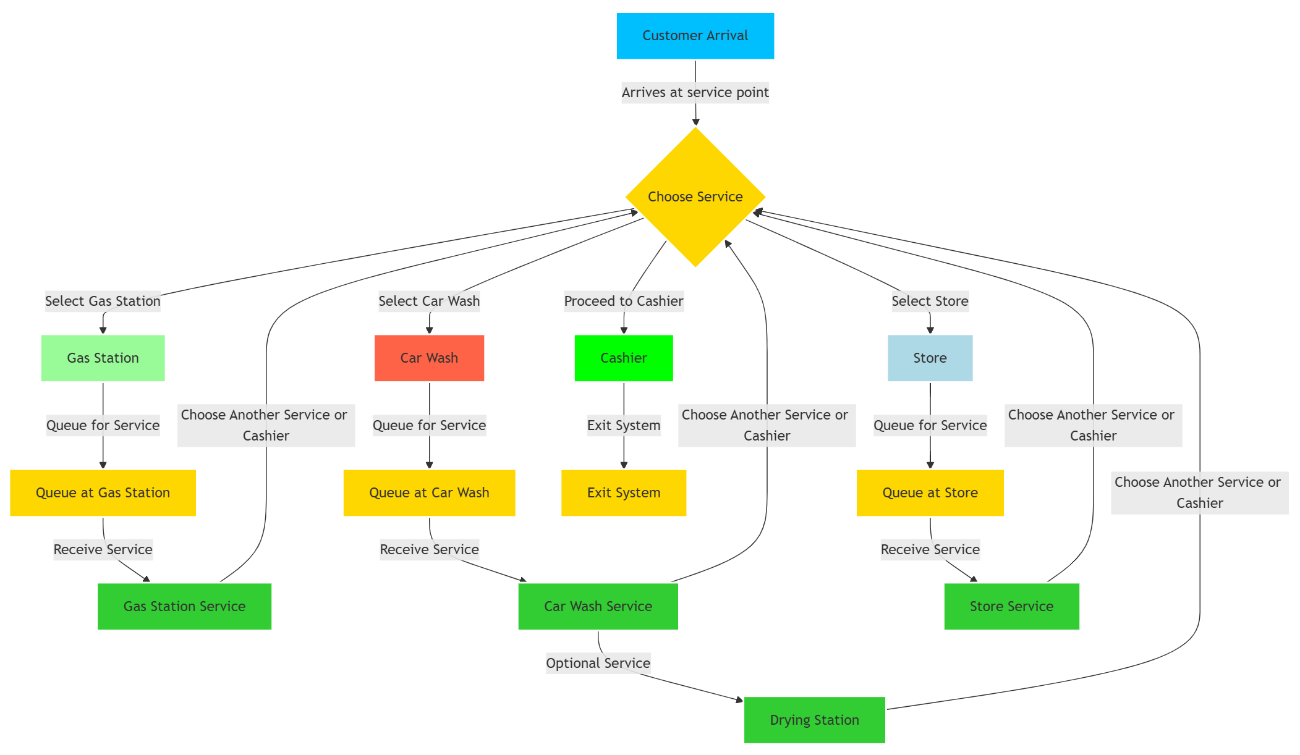
### List of components

The following table provides a list of the main components that are included in the simulation model. Each component represents a distinct entity or process in the system. Note that this is a simplified model; real-world components such as clocks, events, and event lists are excluded for clarity.

|  |  |
| --- | --- |
| **Component** | **Features** |
| Customer | Distribution of arrival delays (random intervals). |
| Car Station | Queue at gas pump, service time distribution (fueling time). |
| Car Wash | Queue at wash bay, service time distribution (washing time). |
| Drying Station | Queue after car wash, service time distribution (drying time). |
| Drive-Through Store | Queue at store, service time distribution (shopping time). |
| Queue (general) | Infinite capacity by default, but can be limited for specific modules. |
| Cashier | Final queue and exit point. |

Each component has its own set of features that define how it interacts with customers and other components. For example, each service module has its own queue with a specific service time distribution. The queues generally have infinite capacity, except in certain cases where a queue’s capacity is limited, such as in the drive-through store, which could be modeled to simulate physical space limitations.

### Process diagram



# Programming implementation of the model

## Programming languages and libraries used (exernal APIs)

## Architecture

High-level components and the connections between them in a graph (e.g., MVC).

## Structural description of the user interface

It is worth presenting with screenshots.

## Description of internal logic

(Event list, Events, Clock, etc.)

## Descriptions of external data repositories (files, databases)

## Testing

Testing in general + Junit tests

# Simulator user manual

Tells the user what to do (inputs).

The results data, and how to read/interpret them are also explained.

This part of the document can be detached and will work as such.

Make sufficient use of the user interface images.

# Simulation tests carried out

What was tried and what was found out.

It is worthwhile to contribute to this section by presenting different simulation runs.

# Summary