System Design of a Waiter Robot

This proposal outlines the architecture of a software system for a humanoid robot designed to fulfill a waiter's job at a restaurant, which aligns with the general trend in computer science of automating the routine tasks (Brookshear and Brylow, 2020, p. 21) and also takes advantage of the ability of the autonomous robots to work in dynamic environments (Ackerman, 2024).

The literature research for the term **"waiter robot"** shows that the use of robots in the industry is increasing for the reasons like lower operating costs and faster order processing (Asif, Sabeel and Mujeeb-ur Rahman, 2015; Cheong *et al.*, 2016), and there are multiple vendors that offer solutions for the domain (Bear Robotics, no date; Pudu Robotics, no date).

The research for the query **"labor cost AND robotics"** allows to elaborate on the economic implications of this trend. The businesses tend to replace low-skilled workforce with robots in order to reduce the production expenses, consequently prioritizing skilled labor and increasing compensation (Jung and Lim, 2020). Additionally, the technology eliminated the dependance on the low-skilled labor, allowing to bring the production back to the developed countries (Atkinson, 2019).

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Usage scenario

Figure 1 depicts a typical scenario for serving a customer: the robot accepts customers' order, and sends it to kitchen. Once food is ready, it is served to the customer. As soon as the customer is ready to pay, the robot processes the payment. It allows to pinpoint **the main operations that the robot supports**:

- accepting orders;
- serving food;
- processing payments.

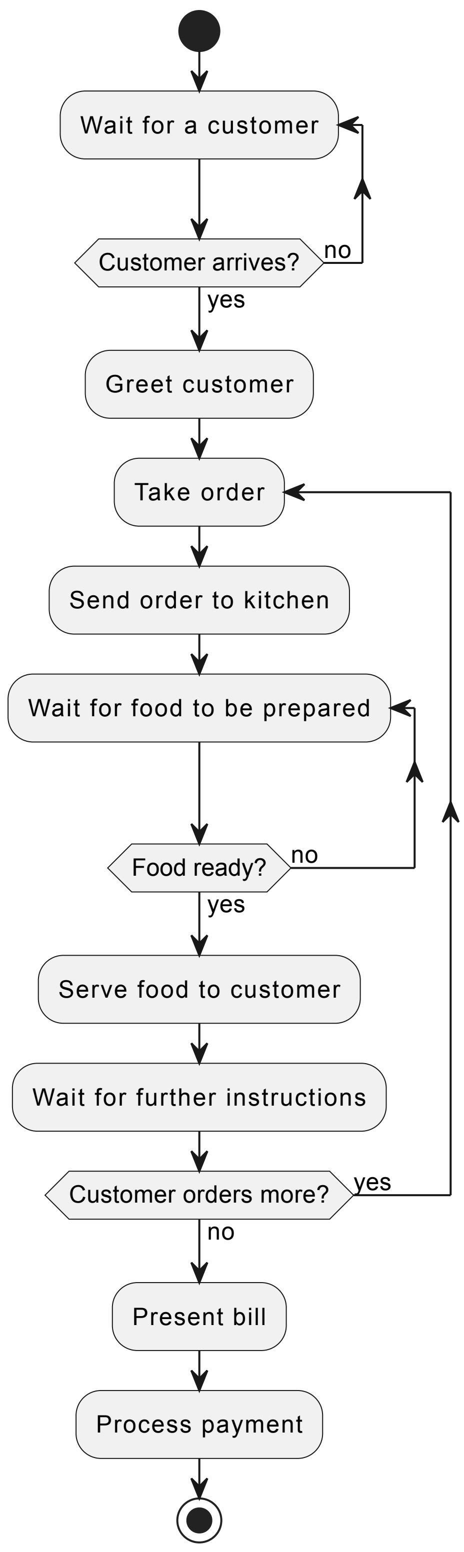

Figure 1. Typical usage scenario: Activity diagram

The interaction between the different actors is better presented in a form of a sequence diagram in the Figure 2:

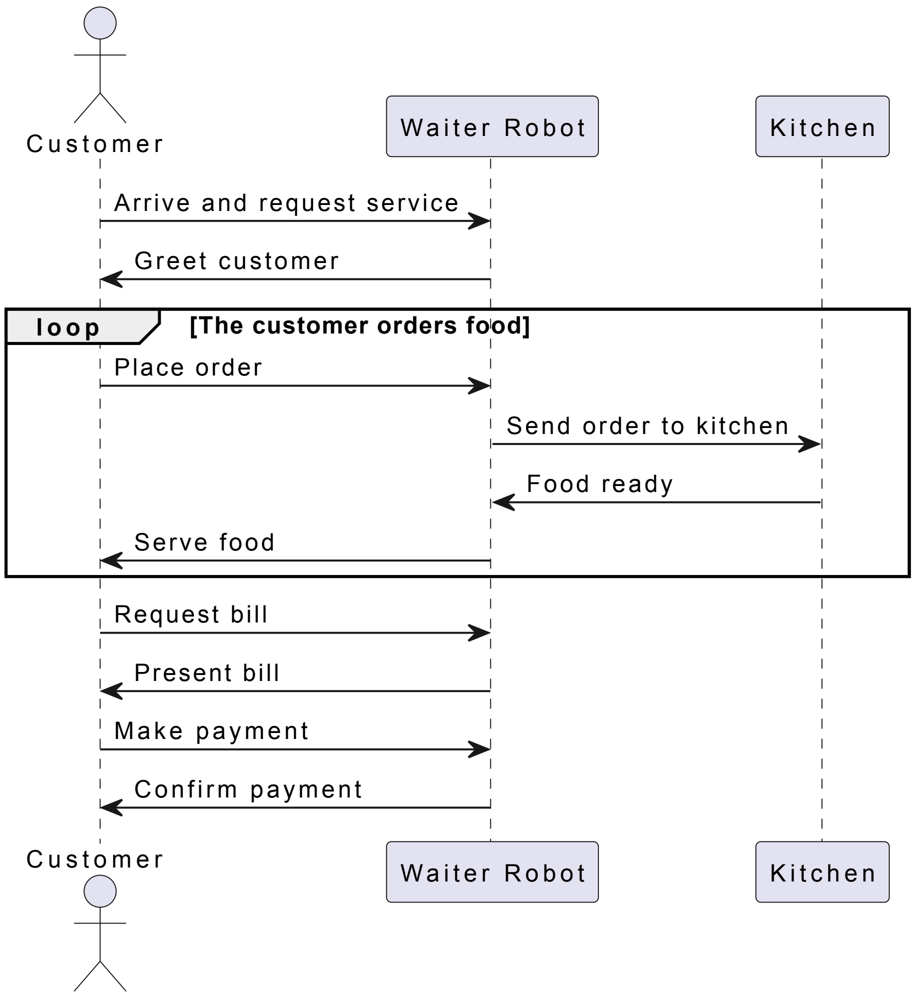

Figure 2. Interactions during the system operation: Sequence diagram

Processing requests

However, a robot should not wait until one customer has paid to start serving another. Figure 3 highlights the different operations (states) that can be processed independently. To best handle the tasks' distribution, the system requires an orchestrator service that accepts and manages the customers' requests.

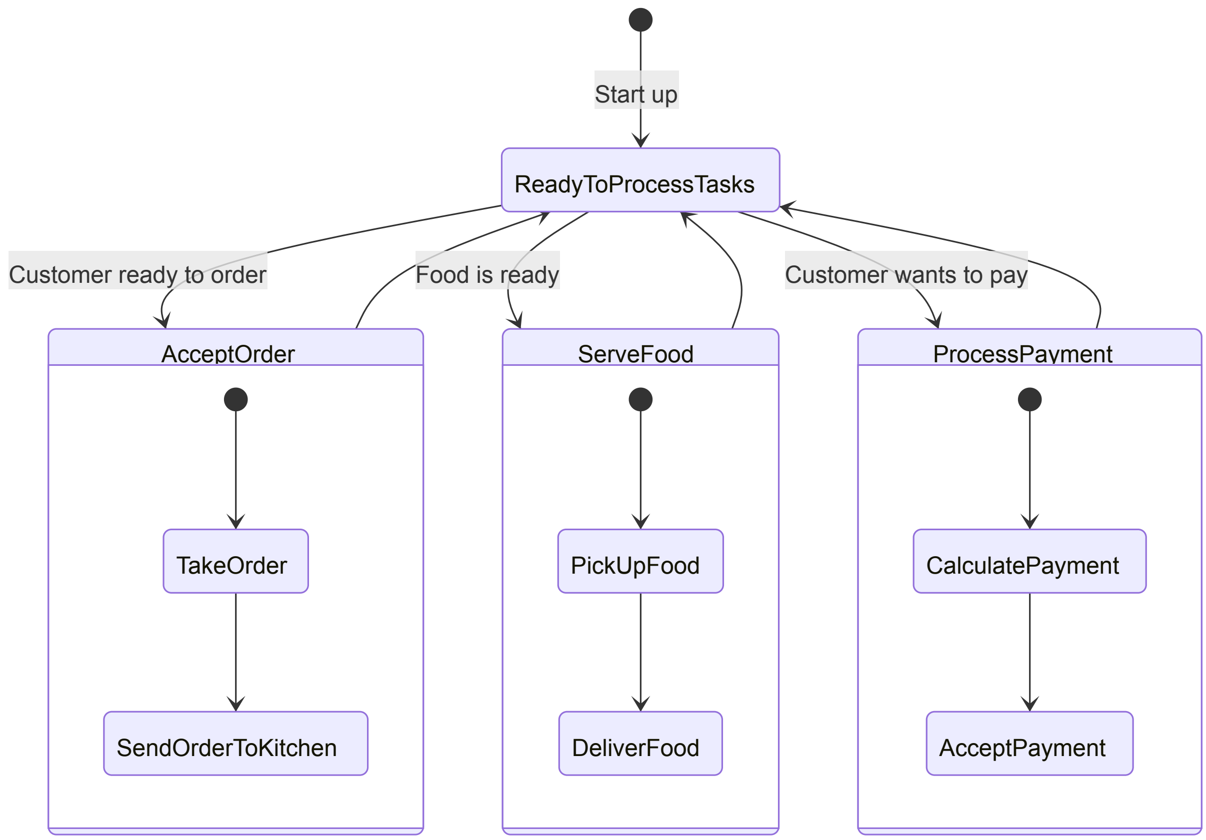

Figure 3. Processing different types of requests: State transition diagram

Software architecture

Based on the descriptions above, now it is possible to outline the software architecture for the system (Figure 4).

The `Request` abstract class encapsulates the core information of a request and has three implementations: `PaymentRequest`, `OrderRequest`, and `ServeRequest`, each representing a separate request type and containing additional information.

The `WaiterRobot` class describes a robot and provides an interface for assigning a request to each robot. The `status` field signalizes whether a robot is available for processing further tasks.

`OrchestratorService` manages the environment: it contains the robots', tables', and bills' records in lists and stores and forwards the queries to the robots and the kitchen. Queues are used to handle the requests fairly (first in–first out): the customers enjoy the shortest possible wait time, and the robots are utilized efficiently.

Notably, robots are assigned one task at a time to prevent blocking tasks by long operations.

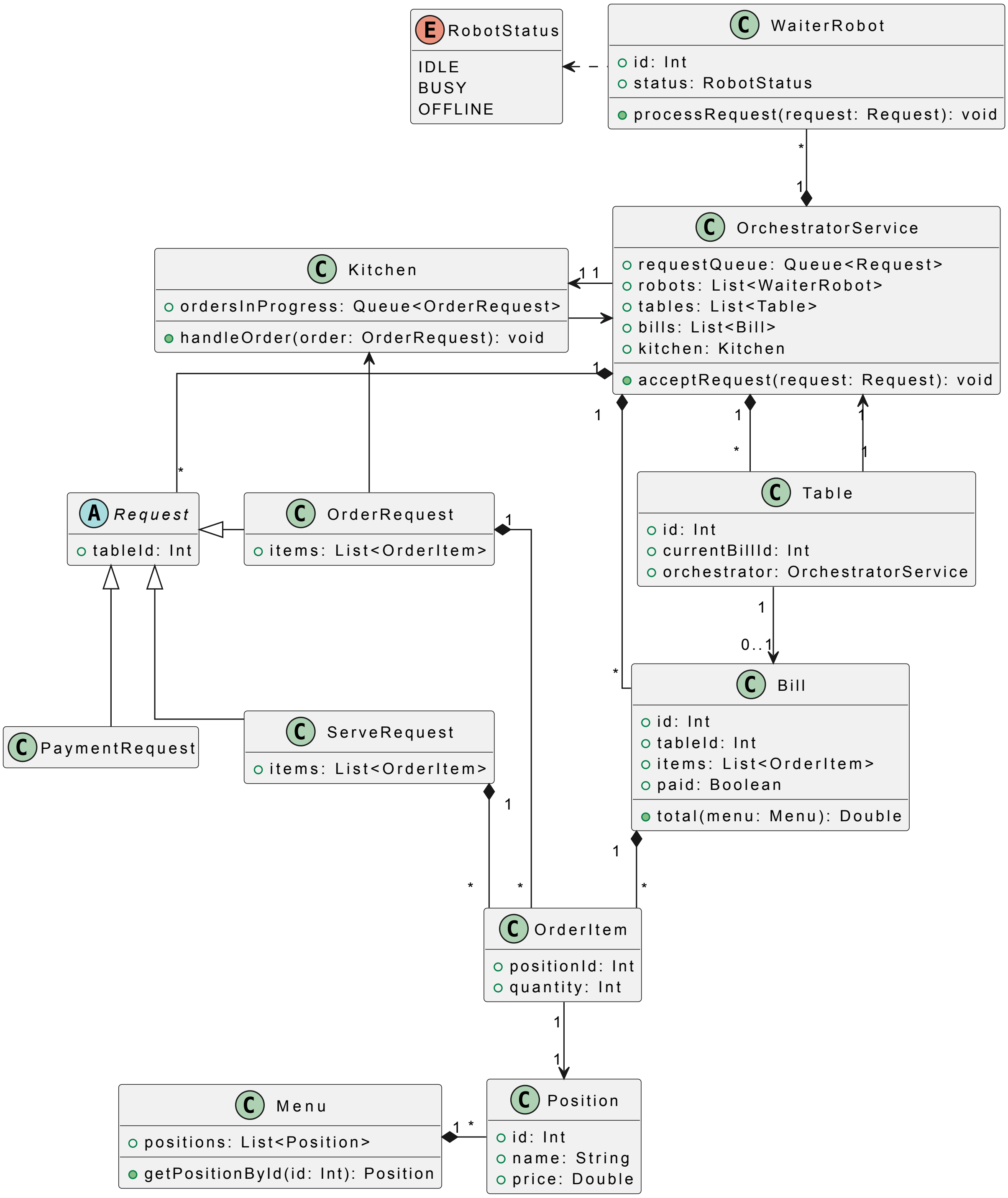

Figure 4. System design: Class diagram

This system design encompasses the key components for a solution for automating and optimizing order processing at a restaurant. The use of OOP principles allows for developing a robust, adaptive, and extensible system that is also easy in support.

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