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Development of a Process Digital Twin in Camunda Modeler

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***Abstract* – Business process modeling is one of the most important steps in managing the lifecycle of a business process. A digital twin of a business process is a virtual model of a business process designed to replicate the behavior of a real business process. The difference between a digital twin and a business process simulation is that the simulation does not require real-time data, while a digital twin is created based on real-time data. A digital twin comprises a physical entity in the real world, a software-based digital counterpart, and the data that links them both. When a created process communicates in real time with IoT devices and adapts its execution based on the information received in real time, this is referred to as a process digital twin. As the field of digital twins becomes increasingly popular, the challenge is to investigate how the process digital twin communicates with IoT devices in real time and updates its execution state.**

***Keywords* – Digital twin, business process, IoT, Camunda.**

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1. Introduction

The goal of business process management (BPM) is to improve and optimize business processes, which is why it works closely with other scientific disciplines. A virtual replica of the organization's business processes is used to analyze weaknesses in business processes and assist in operational decision-making by simulating different scenarios instantly [1]. According to Dumas [2], digital twin is a model of an object or a system that, together with a set of event data related to the object or system, can accurately predict the performance of a physical object or system over time. The digital twin of a business process is a business process model that integrates real-time activities from different participants in the system and converts raw data into a format that can be regarded as information for participants, aiding in decision-making [3], [4], [5]. A digital twin fosters a synergistic connection between business and technology by utilizing existing business intelligence, rules, and artificial intelligence models powered by information technologies. The digital twin offers a special mechanism that generates new intellectual property in the company and makes it an important and unique asset for future-oriented organizations. This approach, based on models, allows companies to efficiently refine their business strategies.

There are many tools on the market that can be used to create digital twins of business processes. It is important to note that the development of a digital twin is a continuation of business process modeling based on the methodology of business process modeling, since in this way a solid connection is established with the entire process of managing business processes. A tool that can be used to develop a digital twin of a business process is Camunda. Camunda is an open source tool for implementing business processes that are described using the Business Process Modeling Notation (BPMN) [6].

The aim of the research is to investigate how a process digital twin can be developed in Camunda Modeler so that it can communicate with IoT devices in real time.

The research questions are:

1. How a process digital twin created in Camunda Modeler retrieves data from a temperature sensor?
2. How a process digital twin communicates with an actuator in real time?

The article is organized as follows: The literature review chapter presents the achievements in the field of business processes, digital twins and artificial intelligence. This is followed by a Methodology chapter in which the way of data collection and information about the sensor and actuator used in the research are explained. The results of how a process digital twin developed in the Camunda platform communicates with the sensor and the actuator are explained in the Results and Discussion chapter. The final ideas of the research are explained in the Conclusion.

2. Literature Review

The digital twin shows the constant integration of physical and virtual space before and during system operation with a permanent two-way exchange of data [7] in order to be continuously coherent and aligned with its actual twin [8]. The development of digital twins is thought to have originated with NASA, where they used simulators to monitor satellite performance and predict changes. Domain knowledge about the business process is essential to develop a digital twin of a business process in order to model the activities and roles involved in the business process [9], [10], and it is necessary to establish connections with the real business process that will exchange data in real time. In addition to domain knowledge, it is necessary to know the methods and techniques for developing digital twins, but also to intervene in the actual process to collect the data which is send to the digital twin. Digital twins provide an opportunity to transform business strategy in the development, sale, and management of existing products or services [11] and are among the most important components of the recent Industry 4.0 revolution [12]. The digital twin of the business process consists of the following components: the real business process, the digital twin model and the business process data [13], [14], which connect these two elements. According to the literature [9], there are two basic steps in the development of a digital twin: 1. The design of a digital twin prototype, which contains the information required for the description and creation of the digital twin model;

2. The creation of a digital twin instance. The development activities of the digital twin are usually motivated by business requirements, resulting, for example, from digital transformation, business process management or product innovation, i.e., changes in the market. The motivation for the creation of the digital twin can change over time, which can have an impact on the design of the digital twin. In addition, observations during operations performed by the digital twin may imply changes in the design of the digital twin or reveal new business opportunities that may influence business motivation [11]. The primary goal is not to implement the digital twin of the business process *per se*, but to optimize the business process using the digital twin model in which artificial intelligence is embedded [11], [5]. A digital twin of a business process offers many advantages as it records all events of the real business system as well as operational and financial data about the system and device configuration [13].

In the paper [15], a case study of internal transportation in an industrial company was conducted to show the differences between traditional enterprise information systems and digital twins. As part of the case study results, the authors have developed an IIoT (Industrial Internet of Things) architecture that includes a data transformation service layer, a digital twin platform, data aggregation services, analytics services and a control panel that manages the entire architecture. IIoT solutions are built solutions that replace existing operational management (OM) technologies by transforming IT (Information technology) and OT (Operations technology) into cyber-physical systems [15]. The results of the comparison between the traditional information systems of companies and the digital twins in the case study show, among other things, that the traditional information systems are transaction-driven and aim to support business processes by storing information, while the digital twins are geared towards the interaction of real entities and rapid intervention in business processes, which increases organizational resilience and agility.

When driven by a combination of artificial intelligence (such as data mining and deep learning), the digital twin can replicate the physical counterpart and identify issues before they arise [16], relying on an array of sensors embedded in the physical world to transmit real-time data on the operational process and environment [13], [10], [17].

The data gathered from the connected sensors is subsequently analyzed in the cloud and made available via the control panel of the tool in which the digital twin was developed. In the case study in [13], machine learning was integrated into the digital twin model and pattern recognition algorithms which can assist in identifying shifting trends in supply and demand. In the articles [17], [18], the authors assert that neural networks have demonstrated effectiveness in addressing complex data processing challenges and recommend their use in creating digital twins. The goal of using neural networks to create a digital twin of a business process is to optimize and model real business systems more realistically [19]. Neural networks can be adapted to different business requirements and they are considered useful for automating, optimizing and improving the management of business processes. A comparison of the effects of machine learning methods in [18] led to the conclusion that neural networks are suitable for the creation of a digital twin. In [19], the development of a digital twin in the pharmaceutical industry is described, that includes neural networks, experimental data sets for model training and the adaptation and validation of digital twin models. By creating a digital twin of the business process, the automation of the process is achieved, resulting in the modernization of the pharmaceutical industry. Vaskovsky *et al.* discuss the development of a digital twin and the application of neural network technology to customize food products for individuals with a genetic predisposition to diabetes [20]. Park and Van Der Aalst propose a digital twin model as a representation of a real business process and as support for an organization's information system [21].

3. Methodology

There are several ways to collect business process data from external devices to develop a process digital twin. One of these is through a PLC (Programmable Logic Controller) device. PLC systems are generally used in industry to automate processes and control machines. Data acquisition via PLCs can be carried out in various ways, depending on the specific requirements of the application. Data can be acquired via PLCs using input modules, whereby the PLCs are connected to various sensors, switches and other input devices via input modules.

These input modules convert physical signals (e.g. voltage, current, resistance) from the field devices into digital signals that the PLC can understand. Another way, PLCs contain a program written in a programming language such as ladder logic, function block diagram or structured text. This program defines the logic to control the process based on the input signals received from the field devices. The third way is data logging, where PLCs can be programmed to log data at specific intervals or based on specific events. This data logging feature allows PLCs to record key process parameters such as temperature, pressure, flow rate, etc. over an extended period of time. Other possibility is the use of communication interfaces that enable PLCs to communicate with other devices such as HMI (Human-Machine Interface) systems, SCADA (Supervisory Control and Data Acquisition) systems, MES (Manufacturing Execution Systems) or even directly with higher-level IT systems. With the advent of IoT technologies, PLCs can also be equipped with connectivity features that enable remote monitoring and control. This allows operators and engineers to access real-time data from PLCs via web-based interfaces or dedicated applications over the internet.

This chapter describes the method of data collection in this research and the Internet of Things (IoT) devices used in the study.

The process digital twin in this study is developed in Camunda platform. The version of Camunda Modeler in which the process digital twin was developed was 7.18. Camunda's "process orchestration platform allows developers to design, automate and improve processes" [22]. Camunda Modeler is a free tool that enables the development of a business process model. When a created process communicates in real time with IoT devices and adapts its execution based on the information received in real time, it refers to a process digital twin. In this study, process digital twin sends a message to the actuator telling it how many degrees to turn based on the data it receives about the measured temperature. A temperature sensor was used to record the idle temperature in the room.

The IoT devices used to conduct this study were: Small Servo, Dasduino Connectplus and DHT11 Humidity & Temperature Sensor. Some of the features of Small Servo were: Speed: 0.15/0.10 sec/60° (4.8/6.0V), Voltage: 4.8-6.0 Volts, 3-Pole Ferrite Motor, Single Top Ball Bearing, Nylon Gears, etc.

This servo is rated for 180° rotation, but in actuality it only hits ~160°.

The Dasduino Connectplus microcontroller features integrated Wi-Fi and Bluetooth 4.2, utilizing an ESP32 controller with 4 MB of integrated flash memory and 8 MB of integrated PSRAM. In this study, the board was connected to the computer with the standard USB Type-C cable and it was programed with Arduino IDE.

The DHT11 Temperature & Humidity Sensor includes a humidity and temperature sensor module with a calibrated digital signal output, using advanced digital signal acquisition methods and sensor technology. Other DHT11 technical specifications were: Temperature Accuracy: ±2℃; Measurement Range: 20-90%RH, 0-50 ℃; Humidity Accuracy: ±5%RH; Package: 4 Pin Single Row [23].

Two Python services (REST-API) were developed to collect data from the temperature sensor and send data to the actuator about the activities it should perform.

The first Python service is subscribed to the Mosquitto topic (MQ) and loads messages about the measured temperature from the sensor in real time. The second Python service is also subscribed to the Mosquitto topic, through which it sends information to the actuator to adjust performance.

4. Results and Discussion

This chapter describes the results explaining how the sensor transmits data to the Camunda platform and how Camunda platform sends the data back to the actuator.

The temperature sensor measures the temperature and the temperature data is sent to the MQ. The Python service is subscribed to this topic. This service receives a message about the measured temperature in real time and calls the Camunda API, so Camunda Modeler is familiar with the course of the process based on the parameters of the message.

Depending on the measured temperature, Camunda platform sends information on how many degrees the actuator should be moved. If the measured temperature is higher than 25 degrees, the actuator moves at an angle of 135 degrees. If the measured temperature is less than 24 degrees, the actuator moves at an angle of 45 degrees. The default output of the process is that the actuator moves at an angle of 90 degrees (e.g., if no data is received from the sensor).

To enable Camunda to send the information to the actuator, a Python service (REST-API) was developed that represents a Web service. This Web service starts the Web server and sends a message to MQ, whose topic is subscribed to. Dasduino listens to this MQ topic and when it receives a message, this message is sent to the actuator to move at a certain angle. It is important to note that although Dasduino has access to MQ, it does not communicate directly with the Python services and Camunda. In other words, Dasduino is subscribed to the MQ topic and thus receives data.

The process digital twin model together with the settings in Camunda depending on the data received from the temperature sensor is presented in Figures 1, 2 and 3.

Figure 4 depicts how it looks like to receive a message from the temperature sensor and send a message to the actuator to move it at a certain angle.

According to the results of study, it can be concluded that the Camunda platform successfully communicates with IoT devices, but technological basis must be established so that these two parties can communicate. To enable Camunda to communicate with IoT devices like temperature sensors and actuators, Python services were developed to subscribe to the Mosquitto topic. This setup allows Camunda to react to real-time data updates and trigger appropriate actions within the workflow, ensuring seamless integration and responsiveness in IoT-driven processes.

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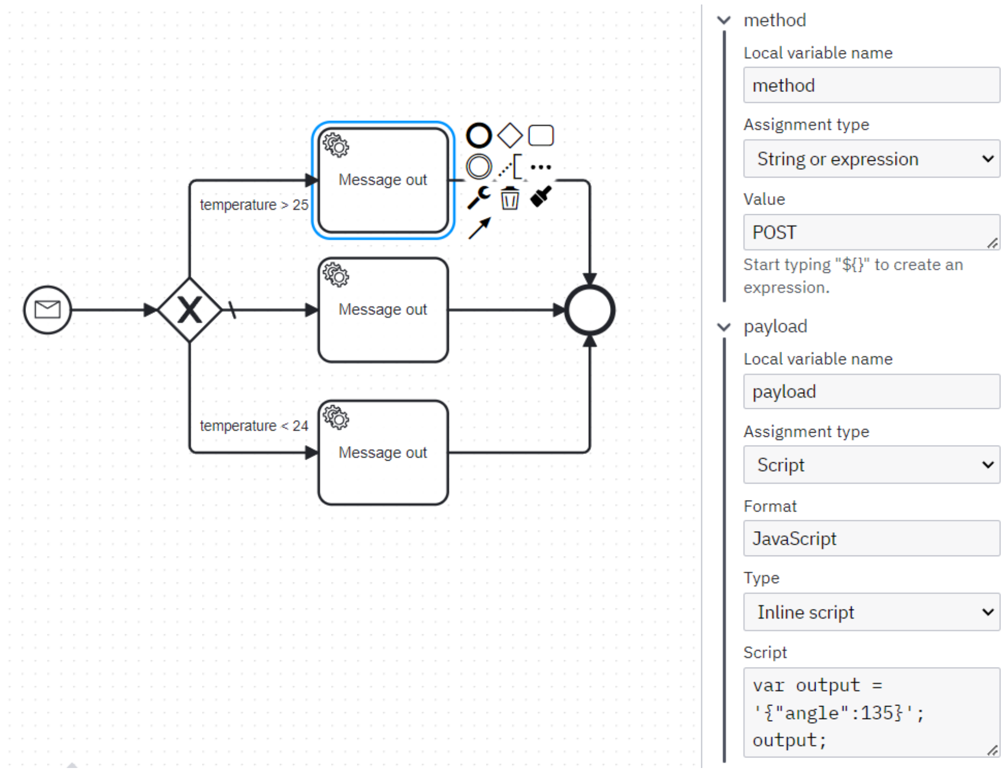

Figure 1. Settings in Camunda if temperature > 25

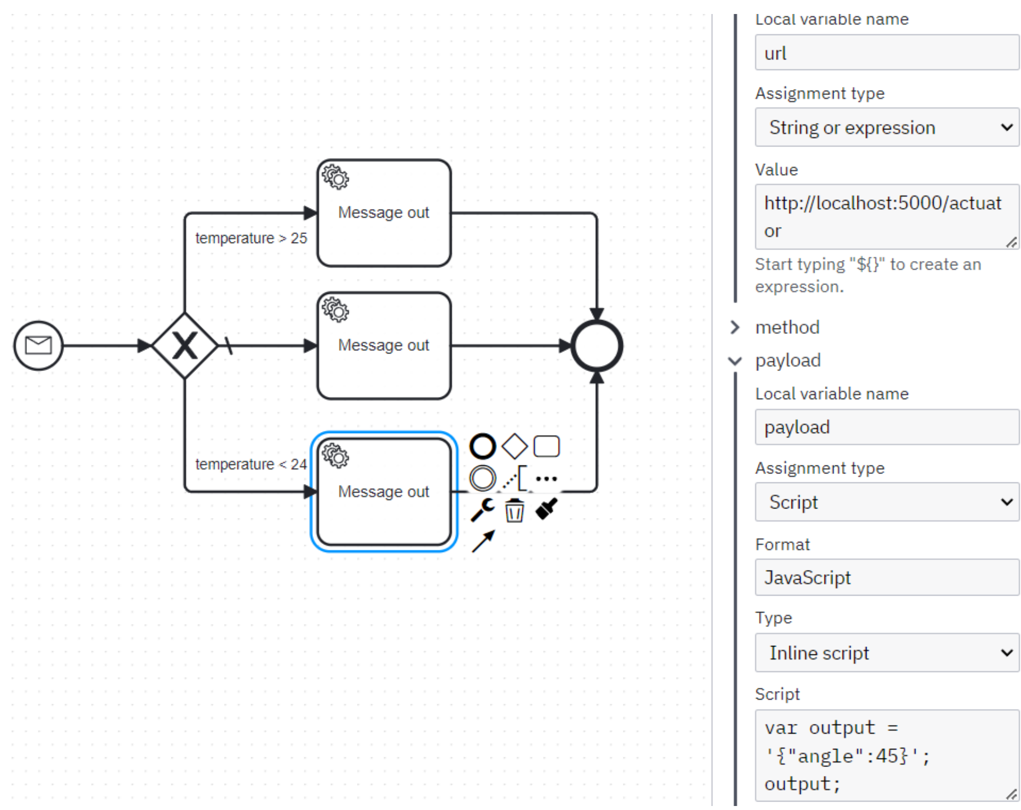

Figure 2. Settings in Camunda if temperature < 24

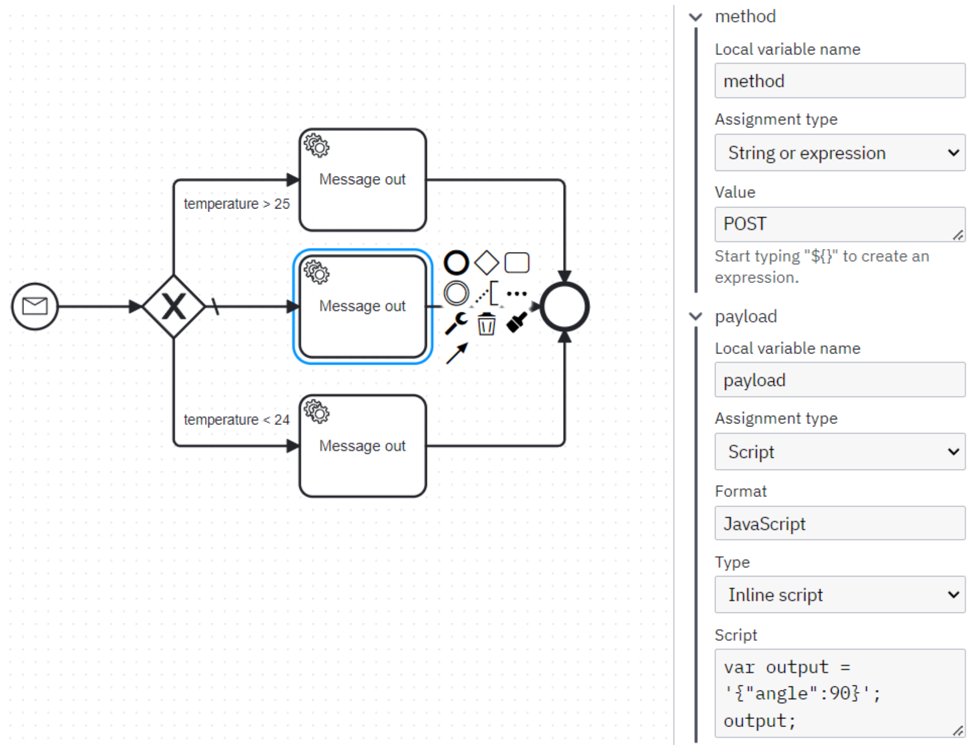

Figure 3. Default process flow, settings in Camunda

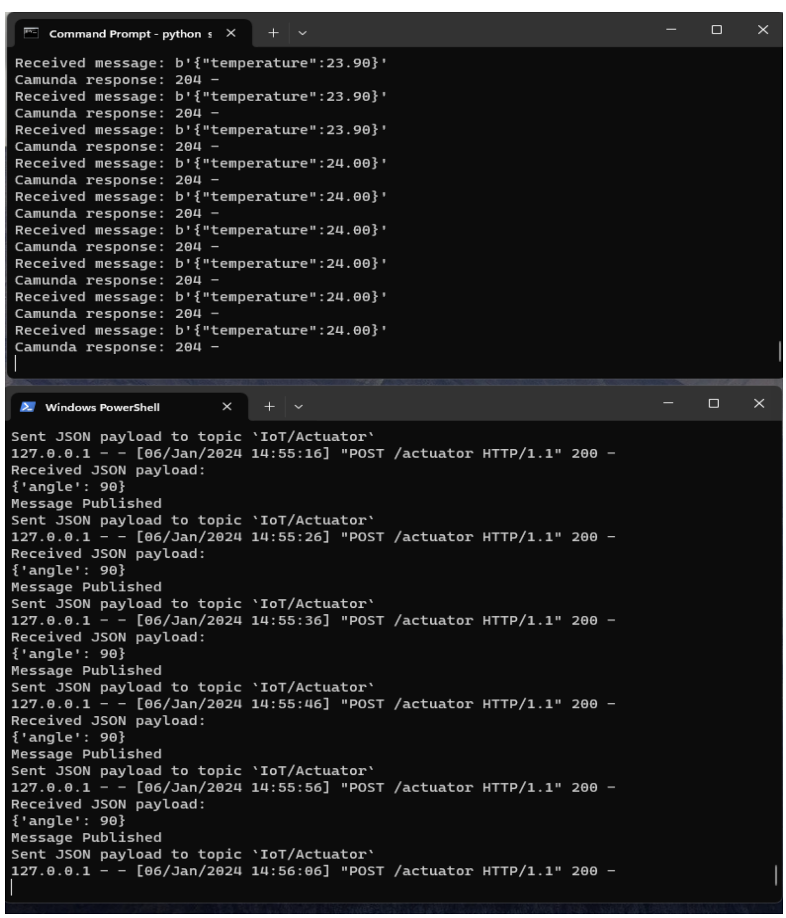

Figure 4. Receiving a message from the sensor and sending a message to the actuator

In Figures 1, 2 and 3, it can be seen how the process digital twin in Camunda has been set up to communicate simultaneously with IoT devices. Precisely, because of the transmission of data in real time and the adjustment of the performance of an actuator, it can be said that the process model presented in this research is a digital twin.

The research strives to show how the layer between the Camunda platform and the real world evolves by adapting to the information and communication technology through which Camunda is connected with the real physical entity, with the aim of two-way communication. The goal of this layer is to make the model of the process digital twin in Camunda independent of how the data from the real world is collected: via a simple IoT device, like temperature sensor or a PLC device. The process digital twin focuses on real-time communication in both directions: receiving data from the sensor and sending data to the actuator.

In the context of this research on process digital twins, the incorporation of both a sequence diagram and a class diagram serve distinct and complementary purposes to elucidate the system's functionality and structure. The sequence diagram is used to illustrate the dynamic interactions and real-time communication flow between the process digital twin and IoT devices. On the other hand, the class diagram is used to depict the static structure of the system, focusing on the architectural organization and relationships among different classes involved in the process digital twin. Figures 5 and 6 are representing the sequence diagram and the class diagram of the process.

The sequence diagram presented in Figure 5 depicts the communication flow. The system comprises an IoT device, an MQTT broker, Python services functioning as an MQTT subscriber and publisher, and a Camunda Process orchestrating the workflow. The diagram elucidates the sequence of interactions among these components during the execution of a task or process. The class diagram depicted in Figure 6 delineates the key classes and their relationships within the system architecture. The diagram encompasses classes representing the IoT/PLC device, the messaging protocol utilized for communication, and the service responsible for exposing functionality through a Representational State Transfer (REST) API.

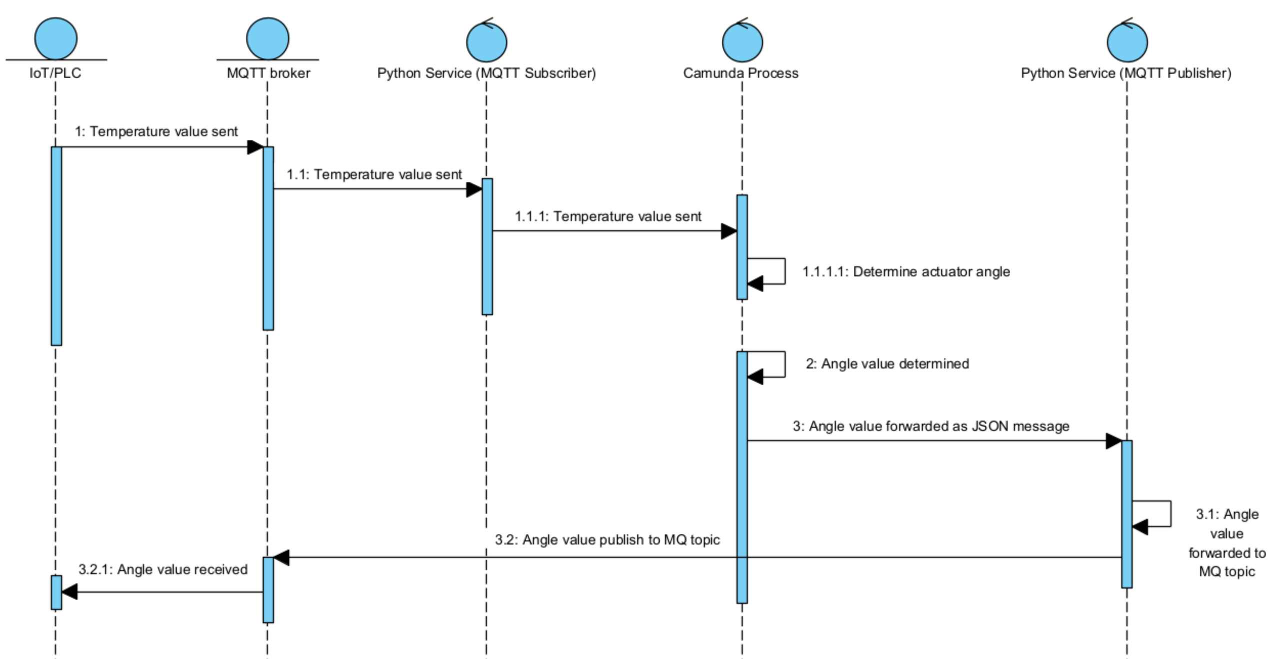

Figure 5. Sequence diagram

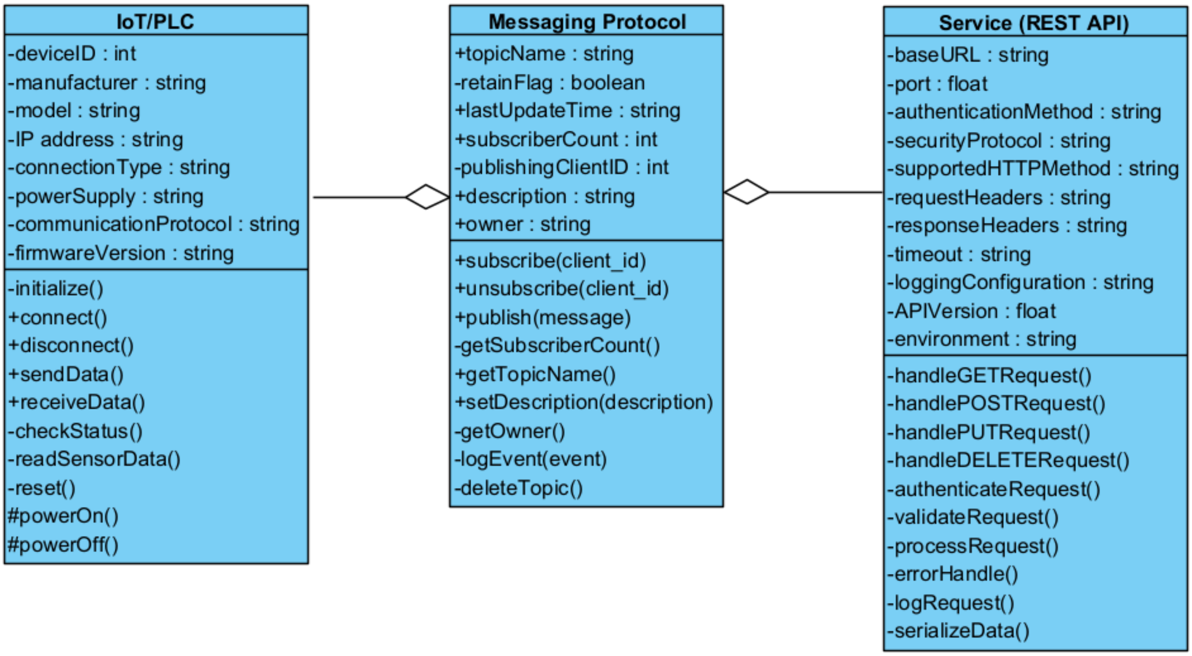

Figure 6. Class diagram

The class diagram illustrates the relationships and interactions among the depicted classes. For instance, the "IoT/PLC" class may utilize the services offered by the "Messaging Protocol" class to transmit sensor data to remote servers or to receive control commands from centralized controllers. Similarly, the "Service (REST API)" class may consume data from IoT devices via the messaging protocol, process the received data, and expose it to client applications through RESTful endpoints. This class diagram serves as a visual aid for understanding the structural components and interactions within an architecture for process digital twin. By delineating the classes representing IoT devices, messaging protocols, and backend services, the diagram elucidates the foundational elements underpinning the design and implementation of solutions for developing process digital twin.

5. Conclusion

Digital twins have become a crucial technology framework in the fast-changing digital landscape, driving substantial business value and facilitating large-scale digital transformation.

The importance of the process digital twin is in analyzing potential weaknesses that may occur in the process and in operational decision-making, in real time, before unpredictable circumstances occur.

In this research, the aim was to investigate how a process digital twin can be developed in Camunda Modeler so that it can communicate with IoT devices in real time. The research questions tried to answer how a process digital twin created in Camunda Modeler retrieves data from a temperature sensor and how the process digital twin communicates with an actuator in real time. In this research, the process digital twin was developed in Camunda Modeler, a free tool that is ideal for modeling business processes and developing process-oriented applications in general. One of the benefits of creating a process digital twin in Camunda is that Camunda is adaptable and can communicate in real- time with IoT devices via services and the MQ protocol. Recently, the demand for digital twins has increased in various industries and it is predicted that the market for digital twins will grow. It is, therefore, time to continue research in this field and develop new projects involving the application of digital twins in various business domains.

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