2IMP30 Project B –Smart Garbage Collection System (SGCS)

A Smart Garbage Collection System is a waste management system that integrates technology to optimize the collection and disposal of garbage. The system uses sensors and IoT devices to monitor the fill level of garbage bins and containers and provide real-time data on the status of waste disposal. This data can be used to optimize the collection routes and schedules, reducing the cost and environmental impact of garbage collection. The system can also incorporate features such as sorting, recycling, and composting to further improve waste management.
A model serves as a depiction of one or more concepts that can manifest in the real world. It defines a specific area of interest, where a particular field can correspond to an application domain. A model is essentially an abstraction, where it doesn't encompass all the intricacies of the entities being modeled within the area of interest, as well as the characteristics required to fulfill the intended purpose of the model.

The components of a garbage collection system may include:

Garbage Bins: These are the containers where garbage is stored before it is collected for disposal. In a smart collection system, these bins may be equipped with sensors to monitor their fill level, temperature, and other parameters.

Sensors: Sensors are used to detect the fill level of the garbage bin and other parameters, such as temperature and humidity. These sensors can be integrated into the bin or placed on the outside of the bin.

Communication System: A communication system is used to transmit data from the sensors to the central server or database. This system can use wired or wireless communication technologies such as Wi-Fi, Bluetooth, or LoRaWAN.

Data Processing and Analytics: The data collected from the sensors is processed and analyzed to provide insights into the fill level of the bins, the frequency of garbage collection, and other factors that may impact the system's efficiency.

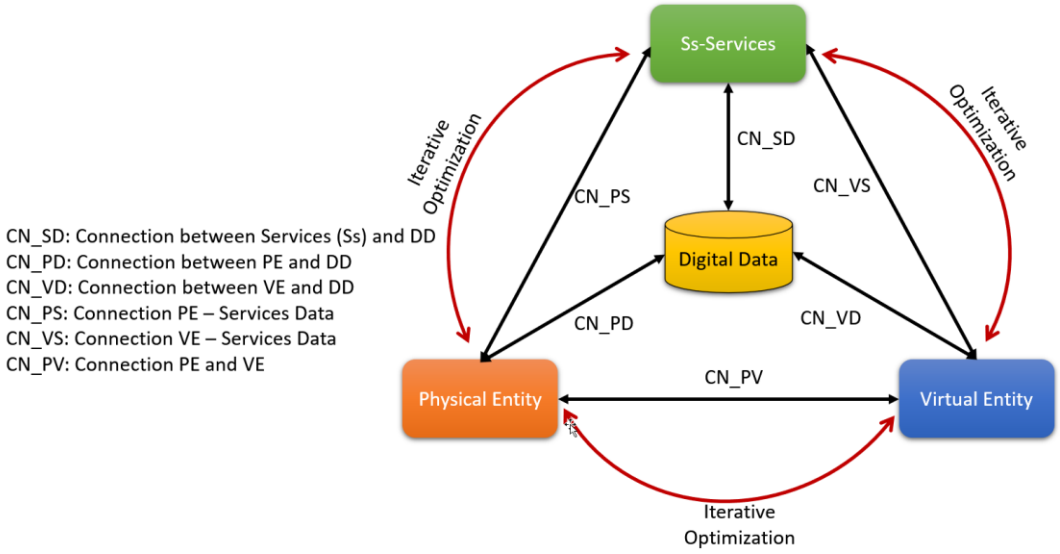
Cloud Platform (Web based): A cloud platform is used to store and process the data collected from the sensors. This platform can be used to monitor and manage the system remotely and to provide real-time alerts and notifications.

Garbage Collection Vehicles: These vehicles are used to collect the garbage from the bins and transport it to the disposal site. In a smart collection system, these vehicles may be equipped with GPS trackers and other sensors to monitor their location and status.

Central Server: The central server is used to manage the entire garbage collection system. It receives and processes data from the sensors, provides real-time alerts and notifications, and generates reports and analytics.

Assignment

Employing the Systems Engineering technique that relies on the Model-Driven methodology (SYSMOD), create, execute, and validate a Smart Garbage Collection System (SGCS) . This SGCS combines the tangible elements of a Garbage Collection System with their virtual counterparts, integrated into the Unity Game Engine. To achieve this objective, utilize the Agile SCRUM framework for project management. A Digital Twin comprises five fundamental elements, which are as follows:



To develop a Digital Twin for a Smart Garbage Collection System using IoT, you need to create a virtual replica of the physical system. This will enable you to simulate the system's behavior and optimize its performance. Here are the components and steps involved in developing a digital twin for a Smart Garbage Collection System using IoT:

IoT Devices: The first step is to install IoT devices on the garbage bins. These devices will collect data on the bin's fill level, location, and temperature. This data will be transmitted to a cloud server for analysis.

Cloud Server: The data collected by the IoT devices will be sent to a cloud server, where it will be analyzed and processed. The cloud server will use machine learning algorithms to predict the fill level of the garbage bin and determine the optimal time for collection.

Dashboard: A dashboard will be created to display the fill level of the garbage bins in real-time. The dashboard will also provide information on the bin's location and temperature.

Mobile App: A mobile app will be created to allow users to view the fill level of the garbage bins in their area. The app will also send notifications when a garbage bin is full and needs to be collected.

Digital Twin: The digital twin will be created to simulate the behavior of the physical system. The digital twin will use data collected by the IoT devices to predict the fill level of the garbage bins and optimize the collection schedule.

Testing: The digital twin will be tested to ensure that it accurately simulates the behavior of the physical system. The testing will involve comparing the performance of the digital twin with the physical system and making any necessary adjustments.

Implementation: Once the digital twin has been tested and optimized, it can be implemented in the Smart Garbage Collection System to improve its performance and efficiency.

Overall, developing a digital twin for a Smart Garbage Collection System using IoT can help optimize the system's performance and improve its efficiency.

For the SGCS we consider the following five components:

DT Components	Consists of
Physical Entity – PE (not given)	*Garbage Bins, Sensors, Communication System, Data Processing Analytics, Cloud Platform, Garbage Collection Vehicles, Central Server*
Virtual Entity – VE (not given)	*3D CAD-CAM models of the PE; models of the software controllers* While not mandatory, incorporating it into your implementation can earn additional points
Digital Data – DT	*The data collected from PE and VE;* *Different Data from specific data source.*
Services - Ss	1. *Develop an algorithm that uses the data collected by the IoT devices to optimize the garbage collection process.* 2. *Use data collected by the IoT devices to predict the fill level of the garbage bins and optimize the collection schedule.* 3. *Implement a sorting mechanism that can separate the waste into recyclable and non-recyclable materials.*

	4. *Develop a method for disposing of the waste in an eco-friendly manner.* 5. *Monitor the* SGCS's *performance, the user has remote access to all the services provided by the* SGCS.
Connections	*Connections between the PE, VE, DT, and Ss: cybersecurity, network communication, network functionality, TCP/IP.*

Develop a SysML model of the SGCS that encompasses its primary structural features and services. Verify and validate the SGCS system, while limiting the focus to the development of the Virtual Entity and its services. The development of the Physical Entity is not within the scope of this project.
You will be working in groups of three students and collaborating to complete the project together. Upon completion, you will also be required to evaluate your peers.

Methodology

To effectively implement the SGCS system, it is necessary to adopt the subsequent approach:

1. Comprehend the problem and the context of the project. Identify the stakeholders of the SGCS and consider how users can interact with and utilize the SGCS. Employ the TRIZ 9 Boxes tool to identify and comprehend the current project and problem 's issues.
2. Create the Project's Context
3. Collect and model the SGCS requirements by utilizing SysML Requirement Diagrams. Categorize the requirements into various packages. Implement TRIZ tools to:
    1. Identify the contradictions that require resolution and utilize the TRIZ contradiction matrix to determine the TRIZ solution for the overall issue.
    2. Employ the suggested solution to solve the contradictions.
4. Create a System Context Diagram for the SGCS, and determine which actors (systems) interact with the SGCS (e.g., electricity, users). Employ a SysML Block Definition Diagram or an Internal Block Diagram to illustrate the system's context.
5. Create the SGCS's Operating Environment using a SysML Block Definition Diagram.
6. Model the services of the SGCS using Use Case Diagrams. Create an essential description for every Use Case.
7. Model the behavior to the SGCS using: Activity Diagrams, Sequence Diagrams, or State Machine Diagrams
8. Construct the architecture of the SGCS by employing a SysML Block Definition Diagram. Populate the block components with values, operations, and relationships.
9. Create the Mission Event Time of the SGCS.
10. Develop a graphical user interface (GUI) in SGCS Rhapsody that simulates a touch panel and demonstrates how a user can interact with the SGCS.

11. Implement and evaluate the model in IBM Rhapsody (utilizing the Visual Studio tool) and incorporate it into the Unity Game Engine Environment that has been provided to you. While not mandatory, incorporating it into your implementation can earn additional points.
12. Generate a concise project report, no longer than 20 pages.
13. Produce a brief video, up to 10 minutes in length, to showcase the functionality of the system and demonstrate your results.
14. Develop a brief PowerPoint presentation outlining your results, including your group number and members, along with their IDs.
15. Upload the IBM Rhapsody project (in a zipped file), along with the video(s), PowerPoint presentation, and Canvas report.