Ministry of Higher Education and Scientific Research, Tunisia

Institute of Technological Studies of Bizerte

License in Electrical Engineering

Web-Based IIoT Monitoring System with Integrated Maintenance Management

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To my dear father and mother, this graduation report is dedicated to you.
Thank you for your endless love, guidance, and support.
Every step I took in my education was made possible by the strength and care you both have always given me.
Your encouragement helped me overcome challenges and reach new heights.
I am grateful for the lessons you taught me about hard work, honesty, and kindness.
I hope this work makes you as proud of me as I am proud to be your child.
Thank you for always believing in me.
This achievement is as much yours as it is mine.
I love you both .

Acknowledgements

I would like to express my heartfelt gratitude to everyone who supported me throughout this project. I am deeply thankful to my supervisor, , for their invaluable guidance, insightful feedback, and encouragement. Your expertise and support were essential to my progress and learning.

I would also like to thank my professors and classmates at ISET Bizerte for their continuous motivation and collaboration. To my family and friends, your encouragement and understanding during this journey have meant everything to me. This project is a reflection of our shared dedication and hard work.

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General Introduction

Background

While Industry 4.0 is developing at a fast pace, industrial systems are increasingly connected by the Industrial Internet of Things (IIoT). The technologies are designed to digitalize production environments in order to enable real-time monitoring, predictive maintenance, and data-driven decision-making.

In most small to medium-sized manufacturing plants, machine monitoring is mostly reactive in nature, thus resulting in delays in fault detection and manual recording of maintenance procedures. Although conventional SCADA systems provide extensive monitoring functionality, they usually have a high cost, are beset by complexity in deployment, and may not be adequately customized to meet the unique requirements of each and every plant.

This project is motivated by the necessity to create an economical and versatile IIoT system capable of real-time monitoring and integration with a maintenance platform (CMMS/GMAO) for better responsiveness and efficiency.

Motivation

At Lear Corporation's Menzel Bourguiba factory, one use case stood out as being especially important and highly relevant: it was a sorting machine that had a number of faults and malfunctions. In addition, and arguably even more importantly, the production data of this machine were not being tracked in real time. This lack of immediate and granular trend data on the performance of the machine gave rise to a host of issues and challenges. Among these issues were the following:

- The fault-finding process and instituting required interventions have been greatly postponed.
- The manual process of logging faults and scheduling maintenance activities
- There has been a total lack of any analysis of historical data when it comes to predictive or preventive maintenance.

To properly address and overcome these current limitations, it became clear that a new, web-enabled platform was imperative one that would have the ability to interface natively with the Siemens S7-1200 PLC, which operates the sorting machine. Further, this platform would need to have the ability to report and visualize key operational data and any faults that occur, all in a highly accessible format on an all-encompassing web dashboard.

Chapter 1 This chapter introduces the company, outlines the project context, identifies the problem, and specifies the project requirements.

Chapter 2 An overview of the system architecture, key elements, workflow, and technology is given in this chapter

Chapter 3 This chapter discusses how to develop and assemble the IIoT-based monitoring and maintenance system.

1. Project Context

Introduction

in this chapter, we will present the company first, then we will present the project context,problem and the requirements of the project.

1.1. Lear company

Lear Corporation is a world leader in the automotive technology industry, specializing in the complex design and lean manufacturing of seating solutions and electrical distribution systems. Lear has a massive employee base of over 170,000 committed workers, who are dispersed in a whopping total of 38 countries worldwide. Lear proudly services almost every major automaker in the world.

Figure 1: LEAR Corporation logo

1.2. History of Lear Corporation

Lear Corporation was founded in 1917 as the American Metal Products Company in Detroit, Michigan. Initially, the company specialized in manufacturing tubular, welded, and stamped assemblies for the automotive and aircraft industries. Over the decades, Lear underwent several transformations, expanding its capabilities and diversifying its product portfolio.

Key milestones in Lear's history include:

Table 1: Lear's history timeline

1960s-1970s	Expansion into automotive seating and interior systems.
1988	Renamed Lear Corporation after a series of acquisitions and restructuring.
1994	Became a publicly traded company, listed on the New York Stock Exchange.
2000s	Strategic acquisitions, including United Technologies' Automotive unit, strengthened its position in electrical systems.
2010s-Present	Focused on innovation, sustainability, and intelligent seating technologies, with significant investments in research and development.

1.3. Products and Services

Lear Corporation operates under two major business segments: Seating and E-Systems.

1.3.1. Seating

Figure 2: Seat made by lear

Lear is one of the world's leading manufacturers of complete automotive seat systems and related components. The seating division focuses on:

- Seat Structures & Mechanisms: Development of durable and lightweight seat frames.
- Foam & Comfort Solutions: Advanced foam technologies for enhanced comfort.
- Trim & Surface Materials: High-quality leather, fabric, and synthetic materials.
- Seating Electronics: Integration of climate control, massage functions, and safety features.

1.3.2. E-System

Figure 3: E-system fo lear corporation

Lear's E-Systems division specializes in electrical and electronic components for vehicles, including:

- Wiring Harnesses: Advanced connectivity solutions for automotive electrical systems.
- Power Distribution Units: Smart distribution of electrical power within vehicles.
- Connectivity Solutions: Infotainment, communication modules, and cybersecurity systems.
- Battery Management Systems: Technology supporting electric and hybrid vehicle batteries.

1.4. Global Presence

Lear Corporation operates in 39 countries with more than 257 locations worldwide. Major production and engineering facilities are located in North America, Europe, and Asia, ensuring close collaboration with leading automakers.

Figure 4: LEAR implantation in the world

- United States: Headquarters in Southfield, Michigan, and several manufacturing plants.
- Mexico: A major production center for automotive seating and wiring systems.
- Germany & UK: European R&D and innovation centers.
- China & India: Growing markets for electric and connected vehicle technologies.

1.5. Lear Corporation in Tunisia

Over the last few years, Tunisia has increasingly become an important and strategically located production base for Lear, mainly due to the availability of a highly qualified and skilled workforce, competitively low and affordable costs of production, and its geographical location in very close proximity to Europe. Due to these favorable factors, the company has been able to set up and is now running several plants in the country.

1.5.1. Tunisian Facilities

Lear Corporation has several facilities in Tunisia, including:

- Bir El Bey Facility: Specializes in electronic component production for automotive applications.
- Menzel Bourguiba Plant: Involved in assembly, wiring systems, and quality control.
- Bizerte Industrial Complex: Opened in 2023, this facility is expected to employ over 7,000 workers by 2027, focusing on advanced automotive technologies.

1.6. Problem Statement

The Menzel Bourguiba facility, which shows growth and modernization,experiences standard beginning challenges in its new manufacturing operations.

Plant visits alongside worker interviews confirmed that the facility's maintenance management systems remained paper-based without any digital transformation. The maintenance teams received machine fault reports exclusively through paper documentation while the operators provided verbal fault information.

The operational difficulties result in decreased production efficiency and longer response times and worsened equipment durability throughout the lifecycle.

1.7. Proposed Solution

The proposed solution to the problems listed above would address them through the use of a Web-Based IIoT Monitoring System with an in-house tailored GMAO (CMMS) module. The proposed system is to be deployed on one prototype sorting machine, with simulation of the real-world factory environment in the Menzel Bourguiba factory.

By showing the integration of Siemens S7-1200 PLC, edge communication using Python, and maintenance portal using Django, the project has immediate applicability to Lear's broader Industry 4.0 vision:

- Improve fault visibility and response time,
- Reduce machine downtime,
- Enable data-driven maintenance planning,
- Provide a low-cost, scalable alternative to SCADA systems.

By implementing this system at Lear Corporation, the factory can significantly enhance its maintenance efficiency, reduce unplanned downtime, and improve overall operational performance.

Conclusion

This chapter provides the context to the project by tracing the history of Lear Corporation, identification of the major maintenance issues, and offering the suggested Webapp solution.

The Later chapters provide further details regarding the design, execution, and evaluation of the combined system, its merits, and how it can benefit Lear's business.

2. System Design and Architecture

Introduction

The main goal of this project's design is to create an organized and effective system that guarantees the smooth operation and integration of different parts. An overview of the system architecture, key elements, workflow, and technology is given in this chapter. In line with the project's goals, the design strategy seeks to achieve dependability, scalability, and usability.

2.1. Technologies Used

- Frontend: HTML, CSS, JavaScript for an interactive user experience.
- Backend: Django (Python) for handling data logic and system processes.
- Database: PostgreSQL for structured and efficient data storage.
- Industrial Communication:Node-RED and Snap7 to read PLC values and send updates to the web app.
- HMI: WinCC Runtime Advanced for real-time machine monitoring and operator interaction.

Technologies used in the Project

2.2. Hardware Architecture

2.2.1. Sorting Machine Prototype

The system is built around a functional prototype of a sorting machine that classifies parts based on physical characteristics such as color and height. The machine includes:

- Sensors:
    - Color sensor
    - Height detection sensor
    - Position or presence sensors
- Actuators:
    - Pneumatic or motorized sorters
    - Conveyor motor
    - Indicator lights (LEDs)
- Controller:
    - Siemens S7-1200 PLC

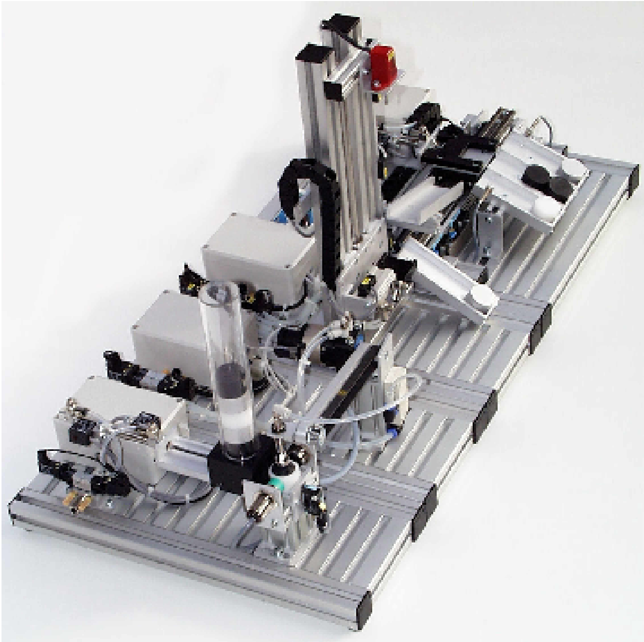

Figure 5: The Sorting Machine Prototype

mention the schema in the annex of the report.

2.2.2. PLC I/O Setup

table of input and output of the PLC

2.2.3. HMI

Hmi panel

2.2.4. Pc

pc A,B and C

2.2.5. Communucation

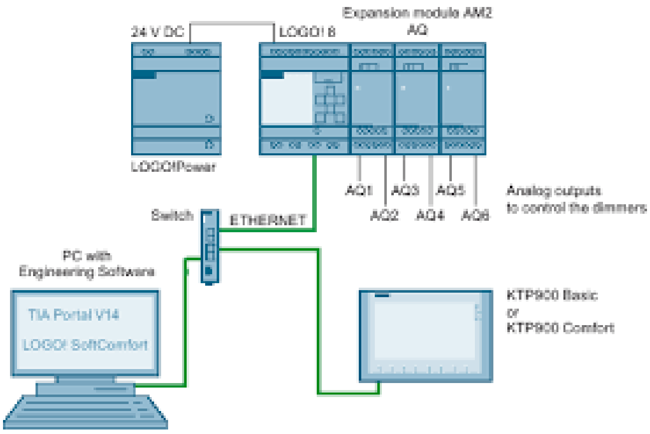

Figure 6: The interaction between the different modules

2.3. Software Architecture

The software system is split into three main layers:

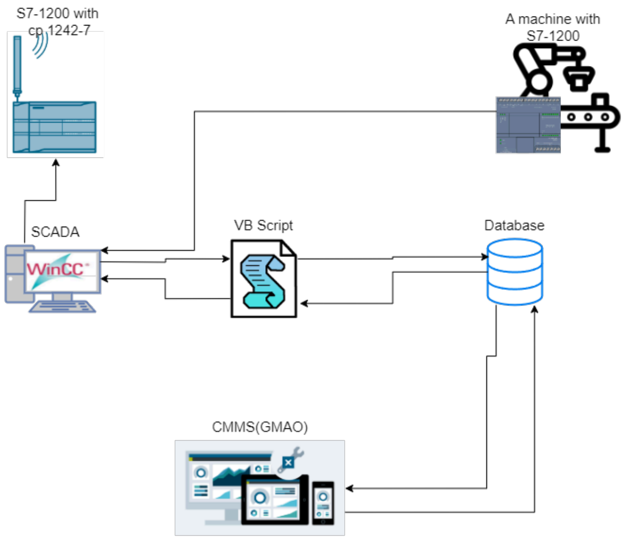

Figure 7: The interaction between the different modules

2.3.1. Plc Layer

- Controls sorting logic (e.g., sensor detection → sorting action)
- Stores runtime variables (e.g., part count, status codes) in a Data Block (DB)
- Assigns fault codes based on operating conditions (e.g., sensor errors, jammed parts)

2.3.2. Edge Communication Layer

This component bridges the PLC and web application using:

- Python + Snap7 library
    - Periodically reads data from DB1 in the PLC
    - Formats the data as JSON
    - Sends it to the web app via a REST API
- Node-RED (alternative visual programming tool)
    - Uses the s7 node to read PLC values
    - Sends updates to the web app

2.3.3. Web Application Layer (Django)

The Django app provides:

- Frontend: A user-friendly interface developed using HTML, CSS, JavaScript, and Bootstrap, allowing operators to interact with the system.
- Backend: Implemented using Django to handle business logic, data processing, and authentication.
- Database: PostgreSQL is used to store user information, work orders, fault logs, and intervention records.
- PLC Integration: The S7-1200 PLC monitors machine states and detects faults in real time. These faults trigger data transmission via a Python script.

- Fault Notification System: Once fault data is recorded in the database, the Django backend processes it and updates the web interface. This allows maintenance teams to respond promptly and resolve issues efficiently.

PostgreSQL Database

The PostgreSQL database is structured to store various data types, including user information, work orders, fault logs, and intervention records. The database schema is designed to ensure data integrity and efficient querying.

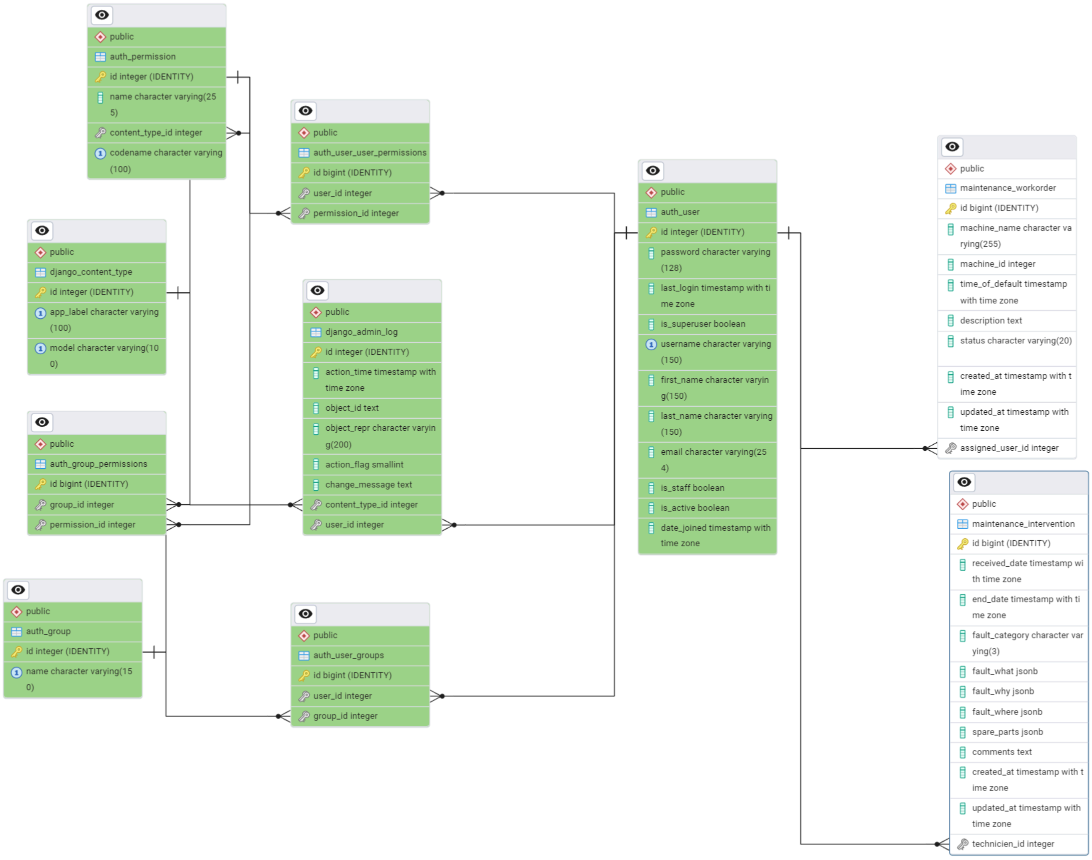

Figure 8: The ERD of the database

2.4. Data Flow Diagram

The system is designed to enable seamless and responsive machine-to-machine, HMI interface, and maintenance platform communication. The workflow is structured as follows:

- Machine Monitoring: The S7-1200 PLC continuously monitors machine conditions, detecting faults or abnormal conditions when the machine is running.
- Local Fault Handling: When a fault occurs, a python Script in the Pc captures the machine-specific information regarding the event.
- Database Update: Such information is directly uploaded to the PostgreSQL database to be stored and accessed by the maintenance management system (GMAO).
- Backend Processing: The received fault data are processed by the Django backend, tagged with their respective machine and time, and updated in respective work order or intervention record.

- User Access via HMI & Web Interface: Fault reporting can be done by operators via the HMI or interact with the web interface for real-time machine status viewing, intervention requests, and monitoring work order status.
- Maintenance Workflow Management: With the GMAO interface, maintenance teams have all of these related tasks to take care of—posting interventions, monitoring response time, noting completed tasks, and analyzing repeat faults.
- Reporting and Traceability: Reports on maintenance and performance are made available from a centralized perspective, giving visibility into downtime, intervention history, and machine reliability information.

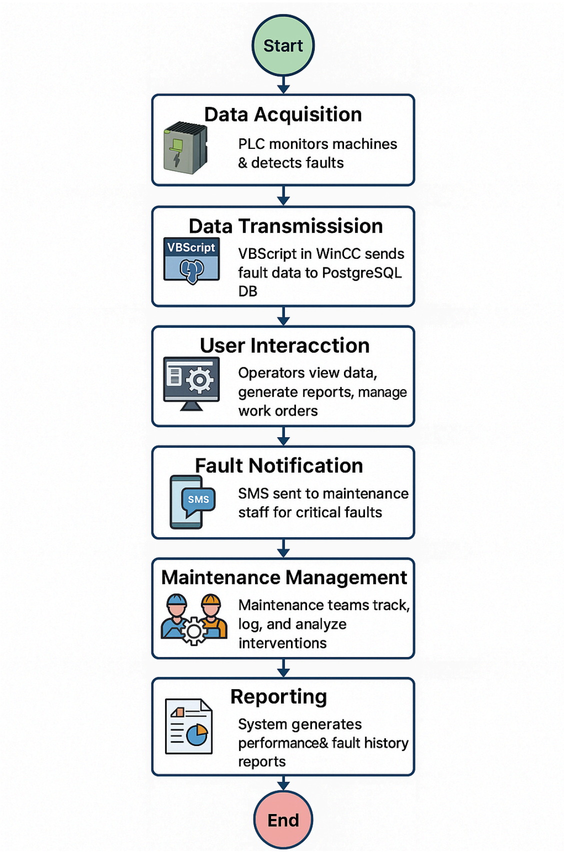

Figure 9: The interaction between the different modules

Conclusion

This chapter provided a comprehensive analysis of the system's design, covering its architecture, components, data flow, and constraints. Figures such as the system architecture diagram, database schema, and fault detection workflow illustrate the working mechanisms in detail. The next chapter will delve into the implementation phase, explaining the technical aspects of development and integration.

3. Implementation

Introduction

This chapter explains the actual development and integration of the proposed IIoT-based monitoring and maintenance system. The development was divided into three main layers: PLC programming, edge data acquisition, and the Django-based web application. All components have a core role in enabling real-time monitoring, fault reporting, and maintenance management.

3.1. PLC Programming (TIA Portal)

The Siemens S7-1200 PLC was programmed using TIA Portal to monitor and control a prototype sorting machine. The machine identifies and classifies parts based on height and color using sensors. The PLC also manages actuators (e.g., conveyors, reject mechanisms) and tracks machine status.

Key elements:

- Input signals from sensors detect part presence and type.
- Output signals drive actuators based on classification logic.
- Memory addresses (in Data Blocks) store:
  - Total part count
  - Number of parts by type
  - Current machine status (e.g., idle, sorting, error)
  - Error flags for specific faults (e.g., jammed part, sensor failure)

These values are continuously updated and made available for external read access by the edge device.

3.2. Web Application

3.3. Edge Communication

3.3.1. Python Script

A Python script running on an edge device was developed to:

- Connect to the S7-1200 via Ethernet using the Snap7 library.
- Read critical data points from the PLC.
- Convert binary/byte data into human-readable values (integers, strings).
- Send the data to the Django web server using HTTP POST requests.

3.3.2. Script Snippet:

```python
import snap7
import requests

plc = snap7.client.Client()
```

```python
plc.connect('192.168.0.1', 0, 1)  # Adjust IP, rack, and slot

while True:
    part_count = plc.db_read(1, 0, 2)
    status = plc.db_read(1, 2, 2)

    data = {
        "machine_id": "sorter01",
        "part_count": int.from_bytes(part_count, 'big'),
        "status_code": int.from_bytes(status, 'big')
    }

    requests.post("http://your_web_app/api/machine-data/", json=data)
```

3.3.3. Node-RED

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3.3.4. REST API Structure

Table 2: API structure

Endpoint	Method	Description
/api/machine-data/	POST	Receives machine data from PLC

3.3.5. Subsection 2.2

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typst

Figure 10: Typst logo

Figure 10 shows the `Typst` logo.

Conclusion

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General Conclusion

Discussion

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Future Work

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