Industrial Internship Report on

”Smart Home Locking System”

Prepared by

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Executive Summary
This report provides details of the Industrial Internship provided by upskill Campus and The IoT Academy in collaboration with Industrial Partner UniConverge Technologies Pvt Ltd (UCT). This internship was focused on a project/problem statement provided by UCT. We had to finish the project including the report in 6 weeks’ time. My project was ”**Smart Home Locking System**”**,** and it aimed at creating a multi-factor authentication system combining Face Recognition (via ESP32-CAM MB)**,** OTP Verification (via Firebase and NodeMCU)**,** and Manual Code Entry (through MIT App)**.)** This internship gave me a very good opportunity to get exposure to Industrial problems and design/implement solution for that. It was an overall great experience to have this internship.

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1 Preface

Over the course of six weeks, I had the opportunity to work on the project titled " Smart Home Locking System using ESP32-CAM MB and NodeMCU" under the guidance **of** Upskill Campus (USC) and The IoT Academy, in collaboration with **(**UniConverge Technologies Pvt. Ltd. UCT)**.** This internship gave me an excellent platform to explore and implement an end-to-end IoT solution aimed at solving real-world security problems in an affordable and user-friendly manner.

The project was focused on developing a multi-factor authentication smart lock system incorporating Face Recognition**,** OTP-based unlocking**,** and Manual Code Entry through a mobile application. This required hands-on work in embedded system programming, and mobile app development through MIT App Inventor. The project was carried out in incremental stages: project understanding, hardware setup, Firebase integration, app development, and full-system testing.

This internship emphasized the importance of relevant practical experience in career development. It not only enhanced my technical skills in IoT and embedded systems but also improved my ability to troubleshoot real-time issues, work with cloud platforms, and communicate technical outcomes effectively.

The opportunity given by USC and UCT was instrumental in shaping this experience. The program was well-structured with weekly goals, mentor interactions, technical documentation, and continuous evaluation, which made the learning process seamless and impactful.

1.1.1 Key Learnings & Experience:

- Gained strong understanding of ESP32-CAM**,** NodeMCU**,** and Firebase Realtime Database
- Developed a fully functional IoT smart lock system with cross-platform integration
- Learned to handle hardware-software synchronization and multi-modal authentication
- Improved debugging**,** problem-solving**,** and documentation skills
- Understood the full product lifecycle from idea to working prototype

1.1.2 Acknowledgements:

I would like to express my sincere gratitude to:

- **Team at UCT** – for technical guidance and real-world feedback
- **Faculty at Upskill Campus & The IoT Academy** – for providing this valuable learning platform

1.1.3 Message to Juniors & Peers:

To all my juniors and peers — take every project opportunity seriously. Even small projects can evolve into innovative solutions when you focus on real-world problems. Introduction

2 Introduction

1.1 About UniConverge Technologies Pvt Ltd

A company established in 2013 and working in Digital Transformation domain and providing Industrial solutions with prime focus on sustainability and RoI.

For developing its products and solutions it is leveraging various **Cutting Edge Technologies e.g. Internet of Things (IoT), Cyber Security, Cloud computing (AWS, Azure), Machine Learning, Communication Technologies (4G/5G/LoRaWAN), Java Full Stack, Python, Front end** etc.

i. UCT IoT Platform(UCT Insight)

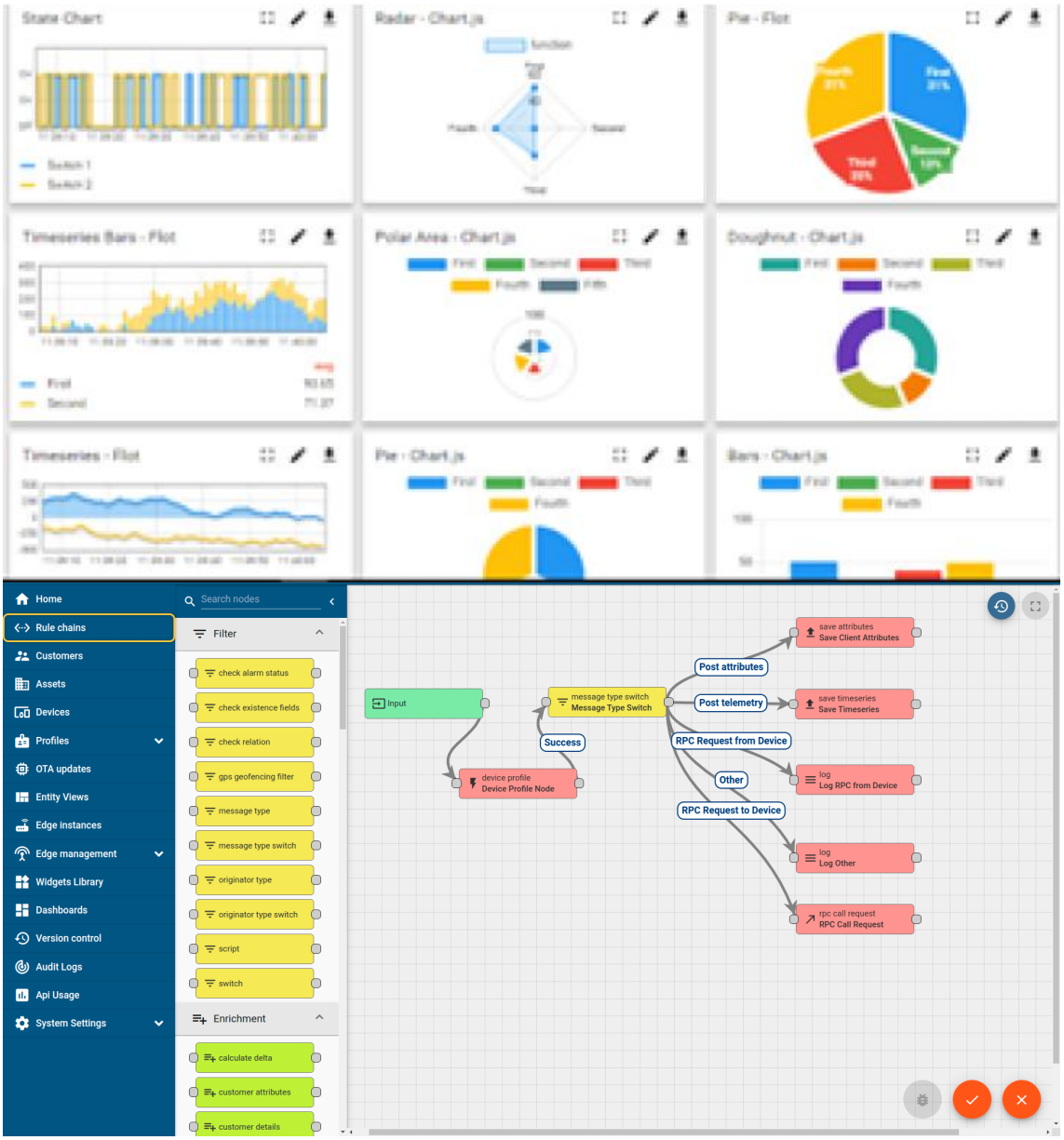
UCT Insight is an IOT platform designed for quick deployment of IOT applications on the same time providing valuable "insight" for your process/business. It has been built in Java for backend and ReactJS for Front end. It has support for MySQL and various NoSql Databases.

- It enables device connectivity via industry standard IoT protocols - MQTT, CoAP, HTTP, Modbus TCP, OPC UA

- It supports both cloud and on-premises deployments.

It has features to

- Build Your own dashboard
- Analytics and Reporting
- Alert and Notification
- Integration with third party application(Power BI, SAP, ERP)
- Rule Engine



ii. Smart Factory Platform (FACTORY WATCH)

Factory watch is a platform for smart factory needs.

It provides Users/ Factory

- with a scalable solution for their Production and asset monitoring
- OEE and predictive maintenance solution scaling up to digital twin for your assets.
- to unleased the true potential of the data that their machines are generating and helps to identify the KPIs and also improve them.
- A modular architecture that allows users to choose the service that they what to start and then can scale to more complex solutions as per their demands.

Its unique SaaS model helps users to save time, cost and money.

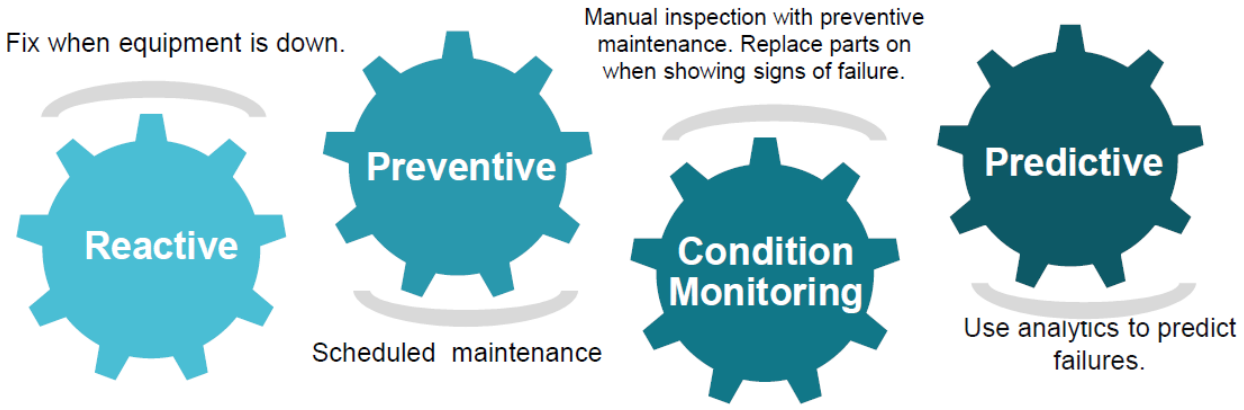
Machine	Operator	Work Order ID	Job ID	Job Performance	Job Progress		Output		Rejection	Time (mins)				Job Status	End Customer
					Start Time	End Time	Planned	Actual		Setup	Pred	Downtime	Idle		
CNC_S7_81	Operator 1	WO0405200001	4168	58%	10:30 AM		55	41	0	80	215	0	45	In Progress	i
CNC_S7_81	Operator 1	WO0405200001	4168	58%	10:30 AM		55	41	0	80	215	0	45	In Progress	i

iii. LoRaWAN based Solution

UCT is one of the early adopters of LoRAWAN teschnology and providing solution in Agritech, Smart cities, Industrial Monitoring, Smart Street Light, Smart Water/ Gas/ Electricity metering solutions etc.

iv. Predictive Maintenance

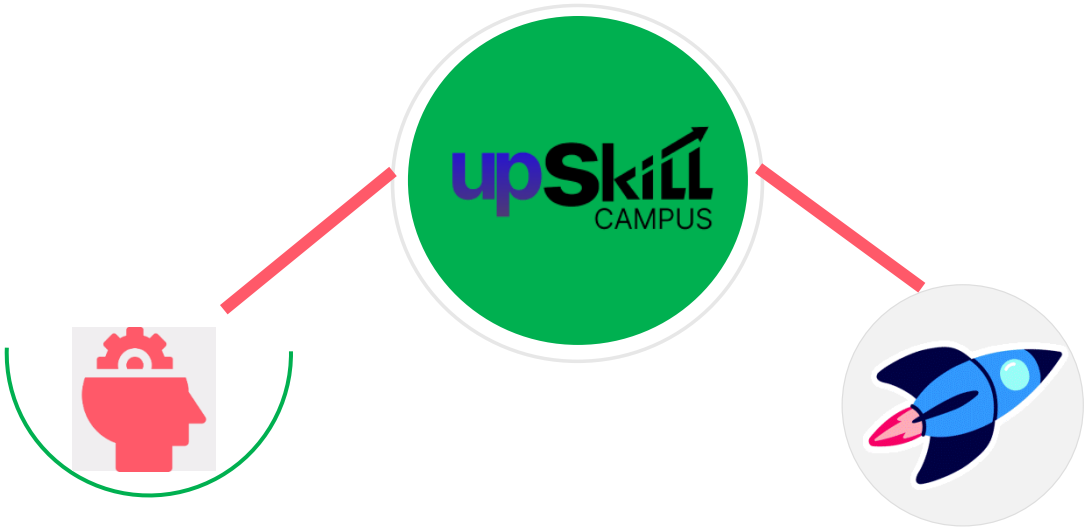
UCT isproviding Industrial Machine health monitoring and Predictive maintenance solution leveraging Embedded system, Industrial IoT and Machine Learning Technologies by finding Remaining useful life time of various Machines used in production process.



1.2 About upskill Campus (USC)

upskill Campus along with The IoT Academy and in association with Uniconverge technologies has facilitated the smooth execution of the complete internship process.

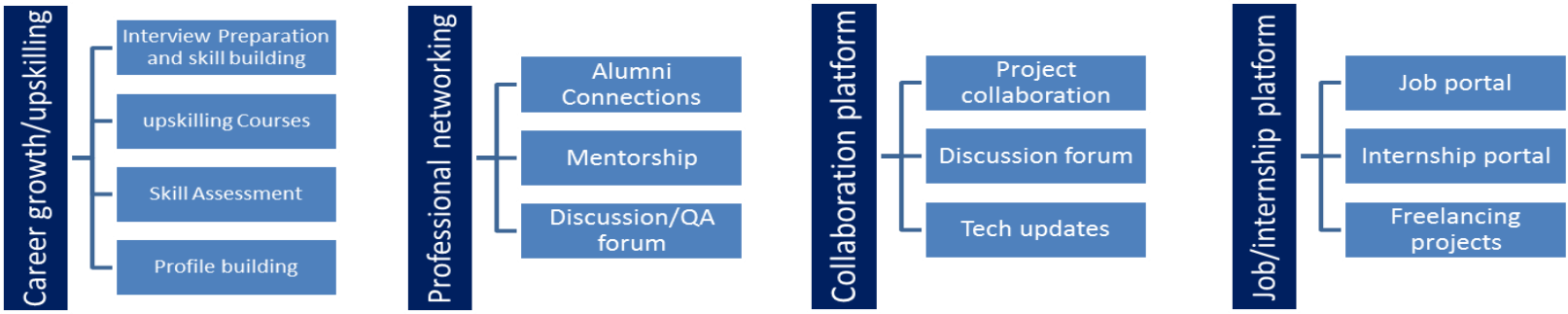
USC is a career development platform that delivers **personalized executive coaching** in a more affordable, scalable and measurable way.



Seeing need of upskilling in self paced manner along-with additional support services e.g. Internship, projects, interaction with Industry experts, Career growth Services

upSkill Campus aiming to upskill 1 million learners in next 5 year

https://www.upskillcampus.com/



1.3 The IoT Academy

The IoT academy is EdTech Division of UCT that is running long executive certification programs in collaboration with EICT Academy, IITK, IITR and IITG in multiple domains.

1.4 Objectives of this Internship program

The objective for this internship program was to

☛ get practical experience of working in the industry.

☛ to solve real world problems.

☛ to have improved job prospects.

☛to have Improved understanding of our field and its applications.

☛to have Personal growth like better communication and problem solving.

1.5 Reference

[1] https://firebase.google.com/docs

[2] https://github.com/espressif/esp-who

[3] https://github.com/mobizt/Firebase-ESP32

1.6 Glossary

Terms	Acronym
ESP32-CAM	A microcontroller with built-in WiFi, Bluetooth, and a camera module.
NodeMCU	An ESP8266-based development board used for IoT projects.
MIT App Invento	A web-based platform for building Android apps using visual programming.
Firebase	A cloud platform by Google for databases, authentication, and more.
OTP	One-Time Password – A temporary code used for user authentication.

3 Problem Statement

In today's fast-paced and security-conscious world, protecting homes and small offices has become increasingly critical. Traditional lock-and-key mechanisms are often vulnerable to theft, duplication, or misplacement. Moreover, most commercially available smart locks in the market are either too expensive**,** lack multi-factor authentication, or require complex installation and maintenance**,** making them unsuitable for the average Indian household.

There is a need for a cost-effective, secure, and user-friendly smart lock system that:

- Eliminates dependency on physical keys
- Offers multiple authentication methods to enhance reliability
- Works efficiently even in low-light or low-network environments
- Uses commonly available hardware components and open-source platforms
- Provides remote access and monitoring via mobile app

Hence, this project aims to develop a multi-factor IoT-based Smart Home Lock that:

- Integrates **Face Recognition** (using ESP32-CAM MB),
- Includes **OTP-based unlocking** (using Firebase and NodeMCU), and
- Offers **Manual Code Entry** (via a custom mobile app),

all while ensuring secure, real-time communication using Firebase Realtime Database and providing status feedback to users.

The ultimate goal is to create a **secure, scalable, and affordable smart lock** solution tailored for Indian homes, rental properties, and small businesses — combining the power of IoT, cloud computing, and mobile technology.

4 Existing and Proposed solution

4.1 Many smart lock systems are available today, such as:

August Smart Lock:

- **Key Features:** Mobile app, Wi-Fi, door sensor
- **Limitations:** Expensive, requires proprietary hub, not beginner-friendly

Yale Smart Lock:

- **Key Features:** Keyless access, app control, Alexa integration
- **Limitations:** Complex setup, high cost, less accessible in India

Biometric Door Locks:

- **Key Features:** Fingerprint-based access
- **Limitations:** Expensive sensors, not reliable in dusty environments

4.2 Proposed Solution

My project, Smart Home Locking System using ESP32-CAM MB + NodeMCU**,** addresses the above limitations through:

Multi-Mode Unlocking:

- Face Recognition (ESP32-CAM with OpenCV-based sketch)
- OTP-based Unlock (via Firebase & MIT App)
- Manual Code Entry (from app UI)

Smart Hardware Integration:

- Replaced **solenoid lock** with a **servo motor** for better efficiency and control.
- Used **ESP32-CAM MB** for easy programming (built-in USB).
- Added **NodeMCU** for Firebase and OTP logic management.

Mobile App:

- Built in **MIT App Inventor**
- Allows OTP entry, manual code unlock, and real-time lock status display

Firebase Integration:

- Used **Firebase Realtime Database** for secure cloud communication.
- Enabled data validation, expiry timers, and path-based security rules.

4.3 Code submission: https://github.com/Anushka-Dhakad-2006/upskillcampus

4.4 Report submission: https://github.com/Anushka-Dhakad-2006/upskillcampus

5 Proposed Design/ Model

The development of the IoT-Based Smart Home Lock system followed a systematic engineering approach**,** progressing through hardware selection, software integration, and system testing, culminating in a robust multi-factor unlocking solution.

5.1 Problem Understanding & Component Selection

- **Objective**: Develop a smart lock for Indian users that is cost-effective, secure, and easy to use.
- **Key Initial Decisions**:
    - Replace expensive solenoid with a **servo motor** for locking mechanism.
    - Use **ESP32-CAM MB** for camera and face recognition (with USB for programming ease).
    - Add **NodeMCU** for handling Firebase-based logic and OTP management.
    - Select **Firebase Realtime Database** for cloud communication.
    - Design a **mobile app** using MIT App Inventor to handle UI and trigger events.

5.2 Intermediate Stages: Development & Integration

Stage 1: Hardware Setup

- Interfaced **ESP32-CAM MB** with servo motor and tested camera functionality.
- Used an **external 5V supply** for servo to prevent current drops.
- Connected **NodeMCU** via UART to Firebase for real-time updates.

Stage 2: Face Recognition Module

- Programmed ESP32-CAM to capture and recognize faces using trained images.
- Linked the output to **servo motor control** to unlock upon match.
- Calibrated face detection under **different lighting conditions**.

Stage 3: OTP Authentication System

- Generated OTP in the mobile app using a simple algorithm.
- Stored the OTP in Firebase.
- ESP32/NodeMCU fetched the OTP and matched it with input before unlocking.
- Added **OTP expiration timer** for improved security.

Stage 4: Manual Code Entry System

- Developed a secure **manual code input screen** in the app.
- Verified codes from Firebase and triggered unlock via Firebase write event.

Stage 5: Firebase & Mobile App Integration

- App connected via Web component to Firebase to read/write these values.
- Real-time feedback implemented using **Firebase listeners**

- Errors and status messages shown in app UI.

5.3 Final Outcome: Complete Working Prototype

- **All 3 unlocking modes integrated**: Face Recognition, OTP, and Manual Code.
- Mobile app fully functional with user interface, error handling, and unlock options.
- Firebase integration complete with encrypted data and TTL for OTP.
- Servo lock enclosed in a 3D-printed/DIY housing box.
- System tested in various conditions: lighting variation, slow internet, and multi-user trials.
- Future scalability features identified (fingerprint, role-based access, Android Studio migration).

6 Performance Test

Testing the smart home lock system under real-world conditions is essential to validate its feasibility for **industry use**, beyond just an academic prototype. The goal was to analyze how the system performs under **practical constraints** such as memory, accuracy, responsiveness, power, and reliability — and how the design decisions accounted for them.

- Low-light camera performance
- Firebase response time under poor network
- Servo motor delay compensation
- Authentication conflicts across multiple modes

6.1 Test Plan/ Test Cases

- Tested each mode separately
- Tested failover logic (what happens when one mode fails)
- Tested under weak WiFi signals
- Checked Firebase sync across app and device

6.2 Test Procedure

- **Tested each mode separately**: Face, OTP, and Manual Code modes were tested independently for proper unlock/deny actions.
- **Tested failover logic**: When one mode failed (e.g., face not recognized), alternate modes (OTP or code) were able to unlock successfully.
- **Tested under weak Wi-Fi**: Simulated poor network conditions; system experienced slight delays but remained functional with retry handling.
- **Checked Firebase sync**: Verified real-time communication between app, Firebase, and ESP32. Data synced correctly in both directions.

6.3 Performance Outcome

- Face unlock works reliably with good lighting
- OTP unlock completes within 3 seconds of input
- Manual code functions as expected
- Servo responds consistently with <1s delay
- UI shows real-time status from Firebase

7 My Learnings

I gained hands-on experience in real-world IoT and embedded systems development through the design and implementation of a multi-mode smart home lock system. Working with components like ESP32-CAM MB, NodeMCU, Firebase, and MIT App Inventor, I developed technical skills in microcontroller programming, cloud-based data exchange, and mobile app integration.

- Understanding of multi-factor authentication systems (Face, OTP, Code Entry).
- Confidence in using tools like Firebase Realtime Database, and Arduino IDE.
- Ability to design a complete working prototype from concept to testing.
- Exposure to real-world constraints like connectivity, response delays, and system failover handling.

This experience has significantly boosted my problem-solving, debugging, and system integration abilities, making me industry-ready for roles in IoT development, embedded systems, and smart automation projects. The project reflects not just academic knowledge, but practical application, and has prepared me to contribute confidently to future tech-driven roles.

8 Future work scope

While the current system achieved its goal of integrating three secure unlocking modes (Face Recognition, OTP, and Manual Code), several enhancements were identified for future implementation:

1. **Biometric Fingerprint Sensor Integration**
   - Adding a fingerprint module will offer an additional secure, fast, and contact-based unlock method.
2. **Migration to Android Studio (from MIT App Inventor)**
   - A professionally developed app using Android Studio will allow greater customization, better UI/UX, background services, and improved Firebase efficiency.
3. **Role-Based Multi-User Access Control**
   - Implementing admin/user-level roles can allow different levels of access for different users (e.g., owner vs. guest).
4. **Remote Monitoring & Notifications**
   - Adding features to receive **SMS or app alerts** in case of unauthorized access attempts or system malfunctions.
5. **Battery Monitoring & Low-Power Optimization**
   - Including a battery level monitor and sleep modes for ESP32 can improve real-world deployment, especially in power-sensitive areas.
6. **Offline Fallback Mechanism**
   - Developing an offline mode (e.g., local storage of codes) for unlocking when the internet is unavailable.
7. **Logging & Analytics Dashboard**
   - A web/app dashboard to review unlock logs, access history, and device status in real-time.