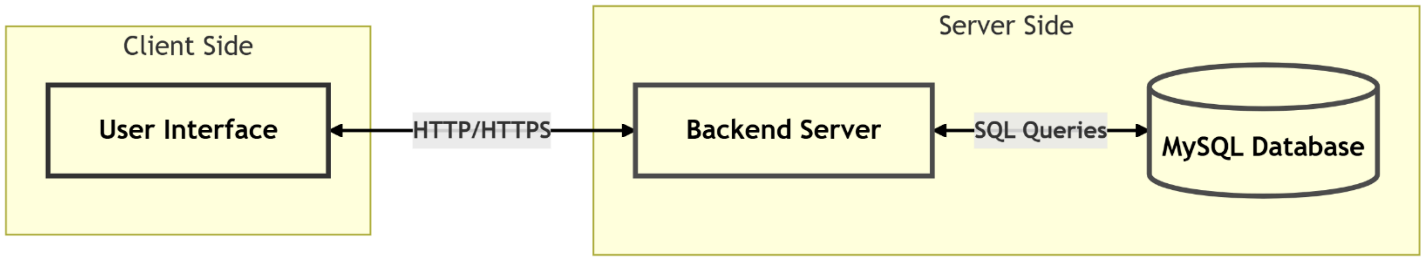
Design Document – Firmware Installer

1. System Architecture Overview

TekMedika Firmware Updater is a comprehensive tool designed to simplify firmware installation for Arduino Mega and NodeMCU boards. The system is divided into three main components:

1. **Installer**: A Python-based Desktop GUI application that provides an intuitive interface for users to install firmware on master and slave boards as well as update or install UID into the system.
2. **Backend Server**: A Node.js/Express-based server that records firmware installation details and provides APIs for interaction.
3. **Database**: A MySQL database that stores firmware installation records, including system UID, firmware version, and timestamps.

High-Level Architecture



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2. Components

2.1 Installer

- **Technology**: Python (Tkinter for GUI)
- **Purpose**: Provides a user-friendly interface for firmware installation, version selection, and board management.
- **Key Features**:
  - Detects connected boards (Master/Slave) via USB.
  - Downloads firmware files dynamically from a GitHub repository.
  - Installs firmware on the boards using arduino-cli and esptool.
  - Displays progress and logs for each step.
  - Registers firmware installation details with the backend server.

2.2 Backend Server

- **Technology**: Node.js with Express.js
- **Purpose**: Handles API requests from the installer and interacts with the database.
- **Key Features**:

    - Records firmware installation details (system UID, firmware version, timestamp).
    - Provides endpoints for retrieving installation history.
    - Secures API interactions using a hashed secret key.

2.3 Database

- **Technology**: MySQL
- **Purpose**: Stores firmware installation records.
- **Schema**:
    - **Table**: firmware_installations

Field	Type	Description
id	INT (PK, AUTO_INCREMENT)	Unique record ID
system_uid	VARCHAR	Unique identifier for the system
firmware_version	VARCHAR	Installed firmware version
installation_timestamp	TIMESTAMP	Timestamp of the installation
verification_status	BOOLEAN	Whether the installation was verified

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3. Firmware Installation Flow

3.1 Home Page – Update Check

1. When the application launches, users are directed to the **Home Page**.
2. The app automatically checks for the latest version using the firmware/appReleases API.
3. If a newer version is available:
    - A notification is shown to the user with a prompt to update.
4. After the update check, users are directed to the **Firmware Selection Page**.

3.2 Admin Login

1. On the **Firmware Selection Page**, an **"Login"** button is available.
2. Clicking the button opens a login prompt with the following credentials:
    - **Email:** admin
    - **Password:** admin
3. On successful login, the user enters **Admin Mode** with access to additional features:
    - Ability to select and install **any** firmware version.
    - Access to **Flash Erase** functionality for both boards.
    - Advanced options become visible in the UI.

3.3 Firmware Selection

1. On the **Firmware Selection Page**, users select the firmware version from a dropdown menu.
    - **Default User Mode:** Can only install the **latest** firmware version.
    - **Admin Mode:** Can select **any available** firmware version.
2. The selected firmware files are dynamically downloaded from the GitHub repository.

3.4 Master Board (Arduino Mega) Installation

1. The application detects the connected **Arduino Mega** board using serial.tools.list_ports.
2. Using arduino-cli, the following actions are performed:
    - **Upload** the compiled firmware to the board.
3. After installation, the app verifies the operation by:
    - Extracting the **System UID** and **Firmware Version** via serial communication.
    - Displaying the verification status to the user.

3.5 Slave Board (NodeMCU) Installation

1. The application detects the connected **NodeMCU** board using serial.tools.list_ports.
2. Using arduino-cli, the following actions are performed:
    - **Flash** the selected firmware file (.bin) to the board.
3. After installation, the app verifies the operation by:
    - Extracting the **System UID** and **Firmware Version** via serial communication.
    - Displaying the verification status to the user.

3.6 Flash Erase (Admin Only)

1. **Admin Mode** users can access the **Flash Erase** feature for both boards.
2. The process includes:
    - Uploading a Empty file to the **Master** and **Slave** boards to clear their flash memory.
    - Receiving confirmation of the **successful erase** operation from each board.

3.7 UID Installation Flow

1. **UID Installation Feature:**
    - Accessed from the Version Selection Page.
    - Requires Admin login.
2. **UID Download Process:**
    - System downloads UID installation firmware from GitHub.
    - Progress is displayed.
3. **Connection Instructions:**
    - Users connect Master board (Arduino Mega) to computer.

- Safety warnings regarding power are displayed.

4. **UID Installation:**
   - Firmware uploads to Arduino Mega.
   - System automatically generates a unique UID during installation.
5. **Barcode Generation:**
   - Upon success, a Code128 barcode is generated for the UID.
   - Barcode can be saved for future reference.
6. **API Integration:**
   - If a previous UID existed, it's deprecated in the database (verification_status set to false).
   - The new UID is registered in the database.
7. **Completion:**
   - Success screen confirms UID installation and displays new UID.
   - Users can return to the main firmware selection screen.

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4. UID & Version Extraction Logic

- **Purpose**: To uniquely identify the system and verify the installed firmware version.
- **Process**:
  - Establish a serial connection with the board.
  - Send specific commands:
    - H: Handshake to ensure communication.
    - U: Retrieve the system UID.
    - V: Retrieve the firmware version.
  - Parse the responses and return the extracted values.
- **Implementation**: The logic is implemented in the get_device_info function in api.py.

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5. API Flow and Database Interaction

5.1 API Endpoints

1. **POST /api/firmware-installation**
   - **Purpose**: Record firmware installation details.
   - **Request Body**:

   -
     ```
     {
       "system_uid": "unique-system-id",
       "firmware_version": "x.x.x",
       "verification_status": true,
     }
     ```

- **Response**: Success or error message.

2. **GET /api/firmware-installation/:system_uid**
   - **Purpose**: Retrieve firmware installation history for a specific system UID.
   - **Response**: List of installation records.
3. **POST /api/deprecate-uid**
   - **Purpose:** Deprecate previous UID records (sets verification_status to false).
   - **Request Body:**

     {
     "old_system_uid": "unique-system-id-to-deprecate",
     "secret": "hashed-secret-key"
     }
   - **Response:** Count of deprecated records
4. **GET /download-excel**
   - **Purpose:** Downloads all firmware installation records in **Excel format**.
   - **Response:** File: firmware_installations.xlsx
   - **Excel Columns:**

ID
System UID
Firmware Versio
Installation Timestamp
Verification Status (shown as **Verified** or **Not Verified**)

5.2 Backend GUI

/view-installations

- **Purpose:** Renders an HTML table view of all firmware installation records.
- **Displayed Columns:**
  - ID
  - System UID
  - Firmware Version
  - Installation Timestamp
  - Verification Status

5.3 Database Interaction

- **Insert Operation**: When a firmware installation is completed, the installer sends a POST request to the backend, which inserts the details into the firmware_installations table.
- **Update Operation**: When a new firmware is installed on an existing system, the backend updates the existing record with the new firmware version.

- **Deprecate Operation**: When a new UID is installed, all previous records for the old UID are marked as deprecated by setting verification_status to false.
- **Query Operation**: The backend retrieves installation history for a given system UID using a SELECT query.

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6. Project Structure

TekMedika-Firmware-Updater/

```
│── main.py                # Main entry point of the application
│── src/
│    ├── arduino/          # Arduino-specific scripts
│    │    ├── arduino.py
│    ├── nodemcu/          # NodeMCU-specific scripts
│    │    ├── nodemcu.py
│    ├── ui/               # UI components
│    │    ├── home_page.py
│    │    ├── login_page.py
│    │    ├── version_selection_page.py
│    │    ├── download_screen.py
│    │    ├── run_installation.py
│    │    ├── erasing_pages.py
│    │    ├── utils.py
│    │    ├── assets/       # UI assets
│    ├── uid_installation/  # UID installation components
│    │    ├── barcode_screen.py
│    │    ├── completion_screen.py
│    │    ├── download_screen.py
│    │    ├── uid_connection_instructions.py
│    │    ├── uid_installation_screen.py
│    ├── backend/          # Backend API logic
│    │    ├── api.py
│    ├── config/           # Configuration files
│    │    ├── config.py
│    │    ├── color.py
│    ├── utils/            # Utility functions
│    │    ├── utils.py
│    │    ├── erasing.py
│    ├── bin/              # Firmware binary files
│    │    ├── InstallSystemUid.ino.mega.hex
│    │    ├── empty/
│    │         ├── empty.ino
│── backend/               # Node.js backend server
│    ├── app.js
│    ├── package.json
│    ├── views/
│    │    ├── home.ejs
│    │    ├── table.ejs
│── requirements.txt       # Python dependencies
│── setup_script.iss       # Setup script for installer
```

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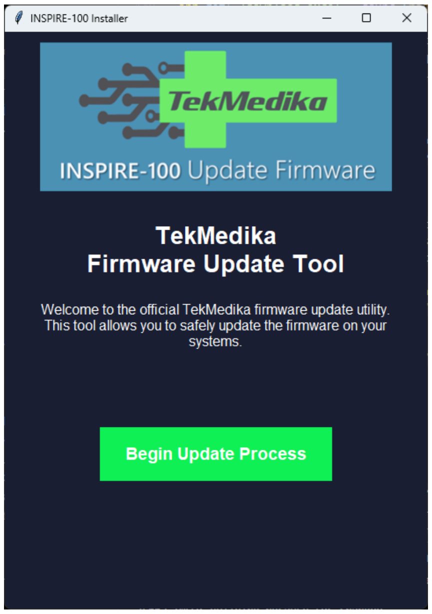
7. UI Flow

7.1 Home Page

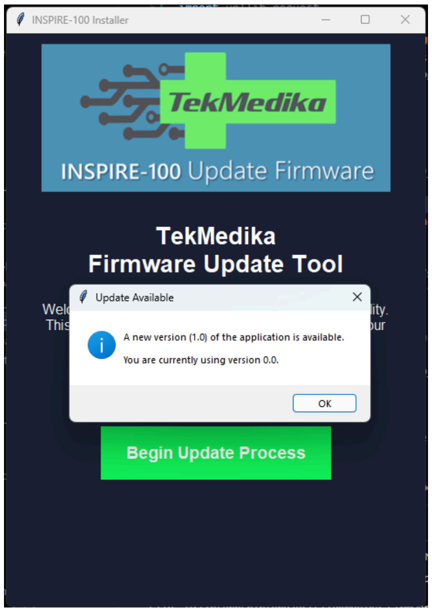
- **Purpose**: Welcome screen with a brief description of the tool.
- **Actions**: Navigate to the login page.

- 

TekMedika
Firmware Update Tool

Welcome to the official TekMedika firmware update utility. This tool allows you to safely update the firmware on your systems.

Home Page when the app is Latest

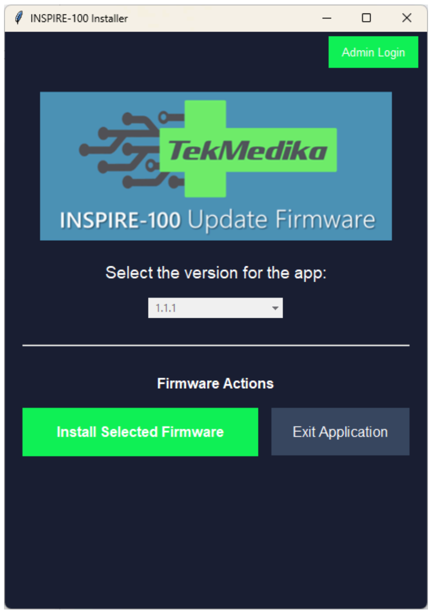
- 

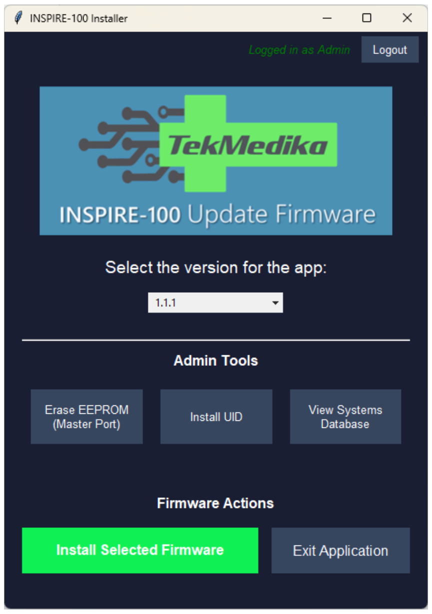
A new version (1.0) of the application is available.
You are currently using version 0.0.

Home Page when the app is not Latest

7.2 Version Selection Page

- **Purpose**: Allow users to select the firmware version to install.
- **Actions**:
  - Admins can access additional erase options.
  - Users can proceed to download the selected firmware.

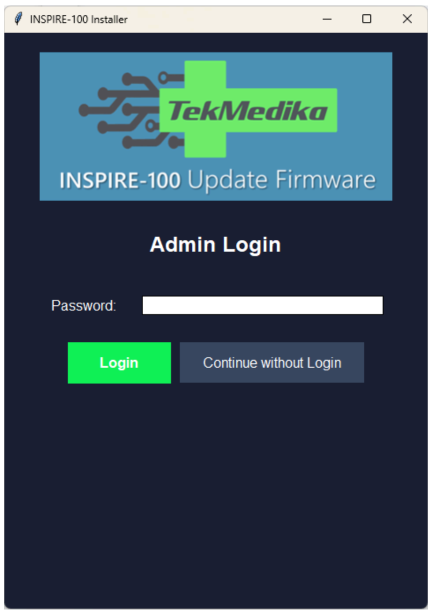
- 
INSPIRE-100 Installer
Admin Login
TekMedika
INSPIRE-100 Update Firmware
Select the version for the app:
1.1.1
Firmware Actions
Install Selected Firmware
Exit Application
Default Version Selection Page

- 

Version Selection Page after admin login

7.3 Login Page

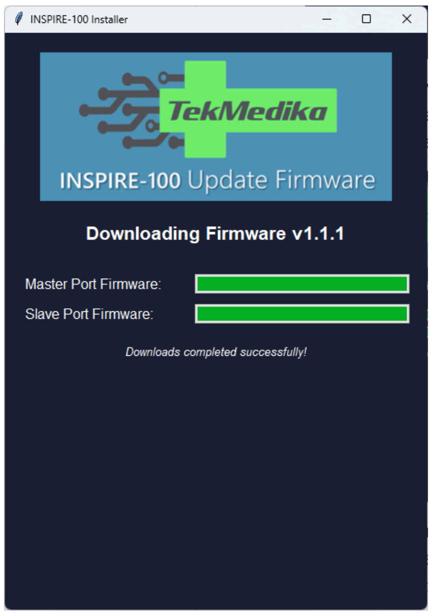
- **Purpose**: Authenticate users (Admin).
- **Actions**: Validate credentials and navigate to the version selection page.

- 

Admin Login

Password:

7.4 Download Screen

- **Purpose**: Display download progress for firmware files.
- **Actions**: Proceed to connection instructions after download completion.
- 

Downloading Firmware v1.1.1

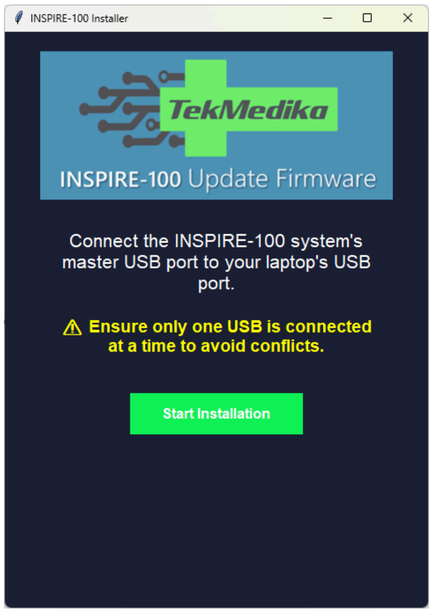
Master Port Firmware:

Slave Port Firmware:

Downloads completed successfully!

7.5 Connection Instructions

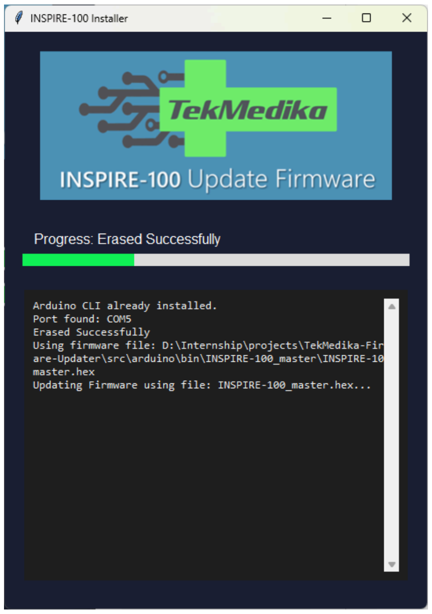
- **Purpose**: Guide users to connect the appropriate board (Master/Slave).
- **Actions**: Start the installation process.

- 

Connect the INSPIRE-100 system's master USB port to your laptop's USB port.

⚠ **Ensure only one USB is connected at a time to avoid conflicts.**

7.6 Installation Progress

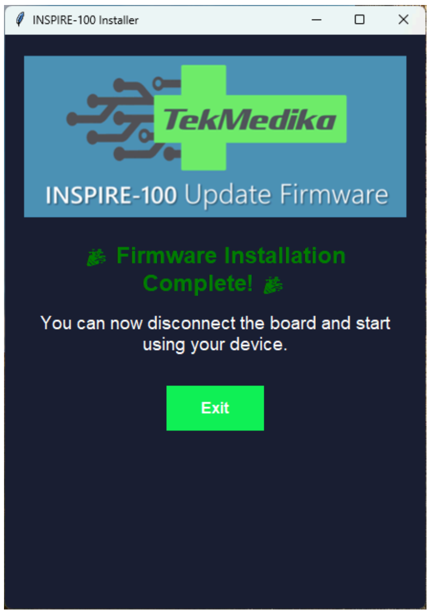
- **Purpose**: Show progress of firmware installation.
- **Actions**: Display logs and progress bar.
- 

Progress: Erased Successfully

```
Arduino CLI already installed.
Port found: COM5
Erased Successfully
Using firmware file: D:\Internship\projects\TekMedika-Fir
are-Updater\src\arduino\bin\INSPIRE-100_master\INSPIRE-10
master.hex
Updating Firmware using file: INSPIRE-100_master.hex...
```

7.7 Completion Screen

- **Purpose**: Confirm successful installation.
- **Actions**: Exit the application or restart the process.

- 

🎉 Firmware Installation Complete! 🎉

You can now disconnect the board and start using your device.

7.8 UID Installation Screens

7.8.1 UID Selection from Version Page

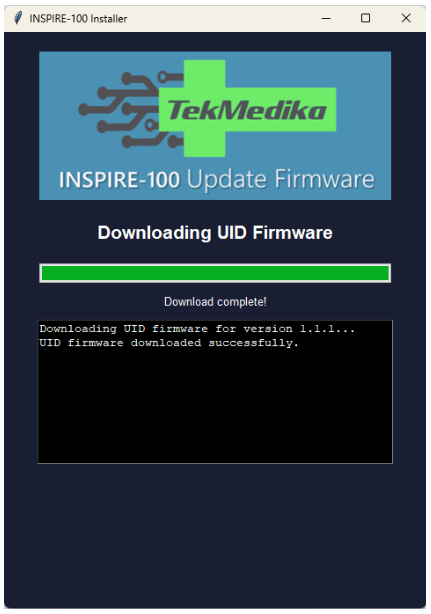
• **Purpose**: Provide access to the UID installation feature.

• **Actions**: Admin users can select the "Install System UID" button and trigger the UID installation flow.

7.8.2 UID Download Screen

• **Purpose**: Download the required UID installation firmware.

• **Actions**: Display progress of the UID firmware download and automatically proceed to the connection instructions upon completion.

- 

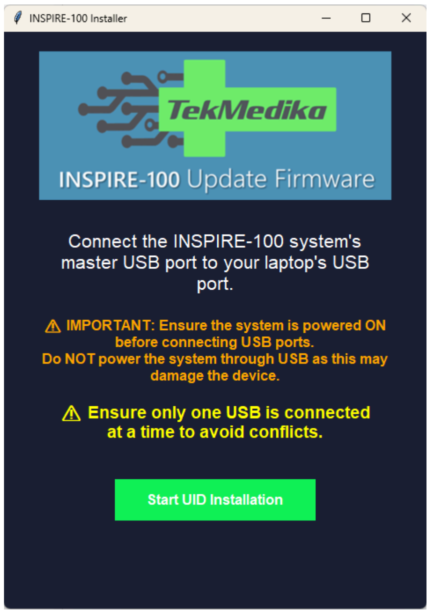
Downloading UID Firmware

Download complete!

```
Downloading UID firmware for version 1.1.1...
UID firmware downloaded successfully.
```

7.8.3 UID Connection Instructions

- **Purpose**: Guide users to connect the Master board properly.
- **Actions**: Provide clear instructions with safety warnings, And Allow users to proceed to installation or go back.

- 

Connect the INSPIRE-100 system's master USB port to your laptop's USB port.

⚠ IMPORTANT: Ensure the system is powered ON before connecting USB ports.
Do NOT power the system through USB as this may damage the device.

⚠ Ensure only one USB is connected at a time to avoid conflicts.

7.8.4 UID Installation Screen

- **Purpose**: Display the UID installation process.
- **Actions**: Show real-time logs of the installation steps and display progress information.

7.8.5 UID Completion Screen

- **Purpose**: Confirm successful UID installation.
- **Actions**: Display confirmation message with the installed UID and allow users to return to the main version selection screen.

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8. Python Dependencies (with Versions)

altgraph==0.17.4
certifi==2025.1.31
charset-normalizer==3.4.1
future==1.0.0
idna==3.10
iso8601==2.1.0
packaging==24.2
pefile==2023.2.7
pillow==11.1.0
psutil==7.0.0
pyinstaller==6.12.0
pyinstaller-hooks-contrib==2025.2
pyserial==3.5
pywin32-ctypes==0.2.3
PyYAML==6.0.2

```
requests==2.32.3
setuptools==78.1.0
urllib3==2.3.0
```