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EMBEDDED SYSTEM FOR DAIRY DATA MANAGEMENT AND RELATED WEB SERVICES

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Abstract: In India, a considerable amount of population is dependent on animal husbandry for the livelihood. As a result, the dairy sector contributes significantly to the economy. However, the milk is produced in small quantities and in scattered manner. This makes the whole collection process tricky and hence it is not well organized. Testing the milk and maintaining the records regularly is a tedious and difficult task if done manually. Additionally bills and registers containing previous records need to be preserved carefully for the future reference. In order to ease the procurement process, many manufacturers have come up with PC-based and microcontroller-based automatic solutions. But many of these solutions are relatively expensive as far as small milk collection centers are concerned. Additionally, these solutions are generally bulky, lacking the portability. Also, they are much complex to be operated by an ordinary person. In this paper, we propose a smart IOT-based embedded system for dairy data collection and the related web services. The aim is to facilitate seamless data collection, data storage, accounting and generation of reports. The major focus is on tunning the system to meet the local requirements by providing user-friendly menus and making it portable and compatible with milk analyzers and weighing machines from various manufacturers.

***Index Terms* - Fat, SNF, CLR, NDDB, AMCS, Rate Chart, SPI, Wi-Fi, Django framework.**

I. INTRODUCTION

India holds around 58 percent 17 percent of the world's buffalo population and cattle population respectively. This makes the dairy industry a major contributor of the economy. In order to maintain and increase the milk supply of the desirable quality, the government of India had promoted Milk and Milk Product Order under the provisions of Essential Commodities Act. It also aims to regulate the production, processing and distribution of milk and its products.

However, since all the milk produced is not handled by the organized dairy sector, the productivity per animal is not up to the mark. The reason is unevenly distributed production of milk in small quantities which make the procurement process effortful. Thus, enhancements in the procurement process are necessary.

Generally, at the village levels, a cooperative society is formed by the farmers. It collects the milk and delivers it to the large milk collection centers. At the milk collection centers, farmers are paid based on the analysis and quantification of the milk. Usually, the pricing is done based on the fat percentage and the solid-not-fat (SNF) in the milk, as suggested by the NDDB. In this process, testing the milk and maintaining regular records both are the tedious and difficult tasks to be done manually. Additionally, the payment receipts and log registers containing collection records need to be preserved carefully for future reference. These challenges act as hurdles for organized milk procurement.

In order to increase the efficiency of milk testing and procurement, Milko testers are being used for measurement of the fat percentage in the milk since 1980's. Recently, PC-based Automatic Milk Collection Stations (AMCS) are being installed in the milk collection centers and the cooperative societies. They are capable of measuring fat contents, weight and generating a slip listing fat, weight and the amount payable to the farmers in a particular shift. These stations also facilitate data storage for 10 days, a month or a year and cumulative summary print of a particular shift. However, these systems are not easily portable and affordable by the small milk collection centers. Also, there is no user access control on the stored data. In order to make the solution affordable, there exist a numerous manufactures providing microcontroller-based automatic milk collection systems. But they have limited storage capability, no accounting facility for report generation and internet connectivity. Additionally, the user interface is not that simple and the menus provided are generally suitable for northern and southern parts of India.

II. Related Work

2.1 Solutions from Everest Instruments

Everest Instruments Private Limited is a key contributor to the Indian dairy sector, having installed more than 7000 milk analysers and milk collection automation solutions.

One of the solutions is the DPU Milk Collection System. It can work on the solar power and is comprised of ultrasonic stirrer, Ekomilk Ultra Pro analyser, electronic weighing machine, data processing unit and digital solar charge controller. It costs around 68,000 INR. The data processing unit is a microcontroller-based embedded system having interfaces for keyboard, RFID reader, GPRS modem and thermal printer. It uses RFID card for member identification. It can store two Rate Charts and the data can be stored up to 12 months and can be transferred to a pen drive. It uses GPRS for wireless data transfer.

Another solution is *e-mandli*. It is comprised of milk analyser, ultrasonic vibrator, electronic weighing scale and an advanced-microcontroller based Data Processing System. The Data Processing System has interfaces for RFID reader, keyboard, big graphic LCD, thermal printer and GPRS modem. It uses RFID card for member identification and can store two Rate Charts. It can import the data using USB or GPRS.

2.2 Solutions from Alfa Tech India

Automatic Milk Collection System designed by Alfa Tech India comprises of electronic weighing scale with maximum capabilities of 150kg, 300kg and 600kg, Milk Testing Equipment, mini-computer named *Dudh-Sachiv*, thermal or dot-matrix printer and RMRD/ERP software. It costs around 65,900 INR. *Dudh-Sachiv* is portable with any milk testing equipment. It supports more than 15 languages. It supports SD cards up to 8GB and can store data up to 20 years using it. The data can be transferred to a USB pen drive and the exported reports are in excel format. Additionally, it is equipped with GPRS for providing wireless administration. Also, there are few revisions of *Dudh-Sachiv* that incorporate advanced features like GPRS, E-mail, GPS, Cloud connectivity maintaining the user-friendliness unaffected.

Besides these solutions, there exists numerous solutions from various manufacturers which are not covered in this paper. The common things amongst many are expensiveness and lack of simplicity of operation. Also, these products are not completely localized. Coming towards the features offered, they lack web connectivity, user-friendly menus, and have limited data storage capacity.

Thus, there is a need for the design and development of a smart and cost-effective embedded system for milk collection centres offering data collection, analysis, and related web services with user-friendly menus.

III. Methodology

3.1 Hardware Interfaces

The hardware peripherals interfaced with the microcontrollers are Milk Analyzer, Weighing Machine, Thermal Printer, Parallel Printer, Indicator LEDs, Buzzer, 20x4 alphanumeric LCD and SD card module.

- Data from the Milk Analyzer and Weighing Machine is read using RS232 interface.
- An 8x6 matrix keyboard is used to input member id and data related to members and system settings. Additionally, is used to switch between the different operating modes.
- A 20x4 alphanumeric LCD is used to guide the operator throughout the operation process.
- Indicator LEDs and Buzzers are used to give indications, warnings and alerts to the operator.
- Thermal Printer and Parallel Printer is used to print the collection receipts and reports.
- SD card is used to store the data for shorter duration. All the data will be pushed to the Web Server for long term storage.

3.2 Block Diagram

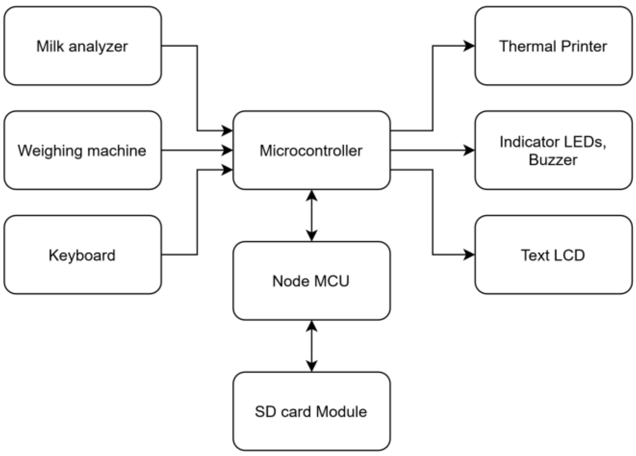

Fig.1. System Block Diagram

3.3 Microcontrollers

PIC24FJ256GB110 is used to connect all the input/output devices. We have chosen PIC24FJ256GB108 for this purpose because its 44 pins out of the 80 are available for GPIO which meets our GPIO requirements. The I/O interfacing board for PIC24FJ256GB108 is designed for connecting all the required devices. It has interfaces for 20x4 LCD, 8x6 matrix keyboard, buzzer, lock switch, parallel printer, thermal printer, two milk analyzers, pulsed fat machine, weighing scale and 2 COM ports.

The main logic of the system is implemented on ESP32 Node MCU. The main reason for using ESP32 development board is the in-built Wi-Fi support which will facilitate the data exchange between system and the web server. The reasons for choosing it as the main controller is its fast-processing capability with 160 MHz crystal frequency and sufficient amount of RAM and Flash memory. It communicates with the PIC using SPI communication at speed of 500 kHz.

In order to handle all the input/output peripherals, we have established an SPI protocol framework. Additionally, an SD card module is interfaced with ESP32 to maintain a local database of members and daily collection on the hardware. The SD card module is connected to the ESP32 directly in order to speed up the communication. Since SPI protocol framework has overhead and introduces some delay, it may affect the data exchange.

3.4 Modes of Operation

There are two modes of operation: Setting mode and Operational mode. By default, the system works in operational mode and it can be switched to setting mode using the escape key.

The setting mode allows the operator to feed member records manually, import member records from SD card, select manufacturer of weighing machine and fat machine, set the date and dairy details, update the Rate Chart etc.

In the operational mode, the system performs a fixed set of operations in a super loop. At the very first, it initializes or tests all the connected peripherals, checks settings and then starts the daily collection process. Each member is assigned a unique by the milk collection centers. The member data is stored in the SD card and is imported during the operation.

After identification of the member, the milk sample and the actual milk quantity is be collected. The microcontroller reads weight and milk analysis data comprising of fat, SNF, CLR, water, temperature from the weighing machine and milk analyzer respectively over the RS232 communication link at the baud rate specified by the manufacturer of Milk Analyzer and Weighing Machine. Based on the weight, fat, and SNF, the rate is calculated using a Rate Chart. The weight, fat, SNF, and rate are displayed on the alphanumeric LCD and the corresponding receipt is printed using a thermal printer. The keyboard allows the operator to choose between different menus and indicator LEDs and Buzzer are used for indications and warnings.

IV. RESULTS AND DISCUSSION

4.1 SPI Protocol Development and Testing

The SPI protocol framework was first developed for ESP32 and Arduino Uno because of ease of development using Arduino IDE. The implemented protocol was tested thoroughly. Fig.2 illustrates request and response packets captured during the development.

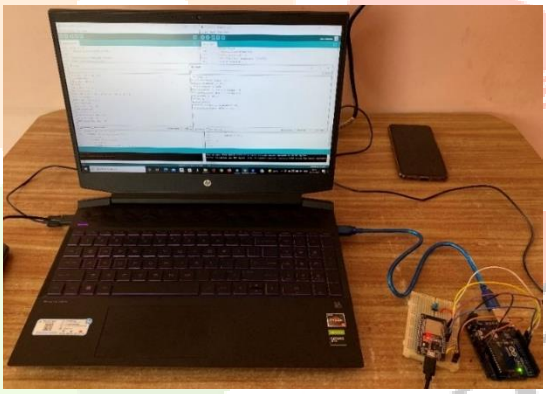

Fig.2. SPI protocol development

4.2 Protocol Testing on the Hardware

After the full-fledged development of protocol and rigorous testing, it was modified to work for PIC24FJ256GB108 and ESP32 Node MCU. Fig.3 shows the image captured during testing of the protocol.

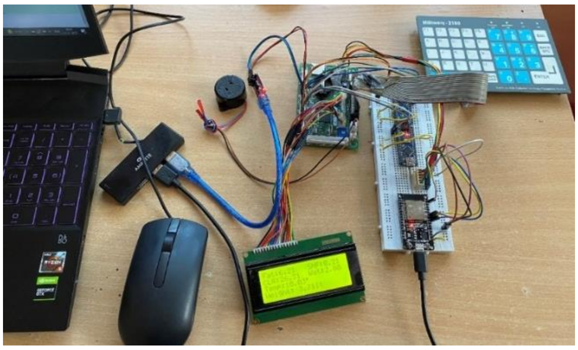

Fig.3. SPI protocol testing

4.3 PCB Design and Manufacturing

Two printed circuit boards are designed for the system. First PCB is associated with all the interface circuitry for PIC microcontroller and the second PCB is for ESP32 Node MCU and SD card module. The manufactured and assembled PCBs are shown in Fig.4 and Fig.5.

4.3.1 PIC24FJ256GB I/O Interfacing Board:

Fig.4. PIC24FJ256GB108 I/O interfacing board

4.3.2 ESP32 Master Circuit Board

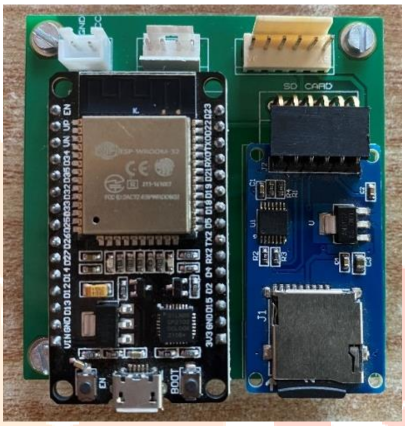

Fig.5. Master Circuit Board

4.4 System Testing in Data Entry Mode

After the hardware design, assembly and writing drivers for all connected peripherals, logic for the Data Entry Mode was written and was tested for checking the accuracy and the performance.

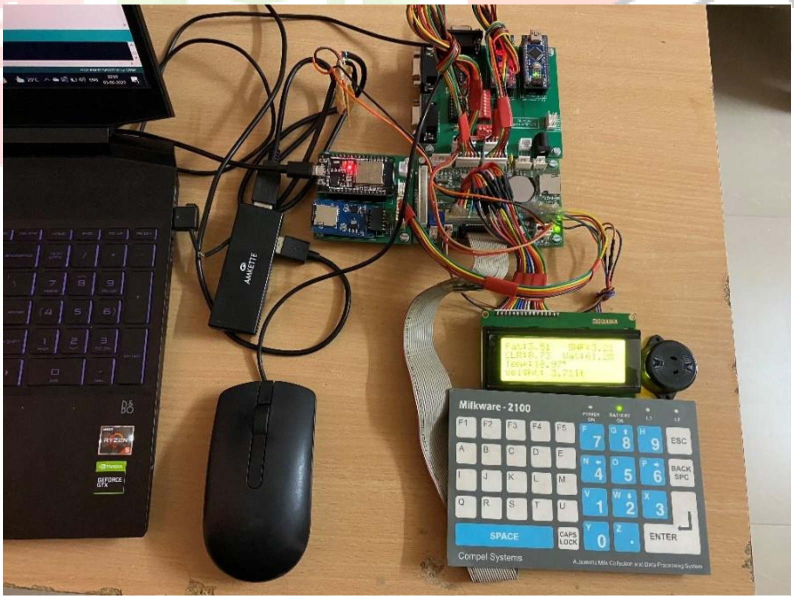

Fig.6. System Testing in Data Entry Mode

4.5 Web Design

We have designed a website using Python's Django Framework for managing the web services. The website is hosted using Heroku PaaS.

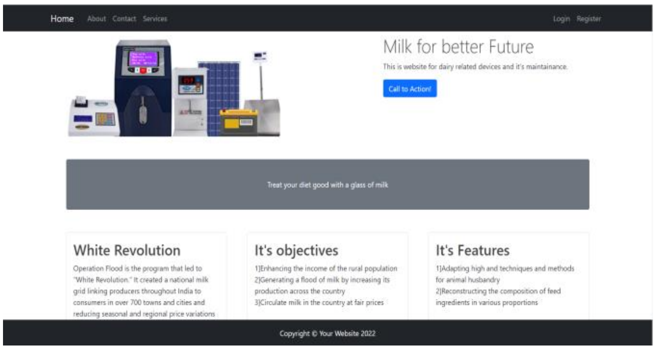

Fig.7. Website Landing Page

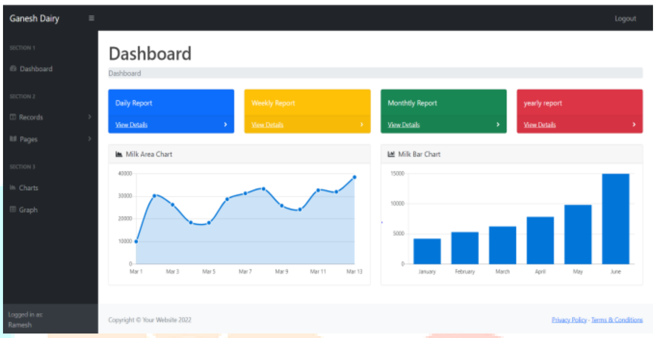

Fig.8. Dashboard

V. Conclusion

The objective of this paper is to describe the need for the design and development of a smart and cost-effective embedded system for milk collection centers offering data collection, analysis, and related web services with user-friendly menus, and then its actual design and implementation.

We have designed a prototype which is capable of storing and accessing the member data, analyzing and quantifying the milk samples, calculating the payable amount, maintaining the daily milk collection records on the SD card and updating the records on the Web Server.

The estimated cost is 7500 INR. If taken to the product level, it will be very useful for local Milk Collection Centers and Cooperative Societies since it is compact, affordable, compatible with Milk Analyzers and Weighing Machines from any manufacturers and most importantly, user-friendly.

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