Digital Attendance Recording System

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Abstract

Attendance recording in educational institutions is an imperative task. Most present systems provide database management but still involve laborious manual data entry procedures. The design presented in this paper offers a twofold solution to the problem. It relieves from handling paper records of attendance taken in the class by providing firsthand entry into a portable gadget built around the AVR ATmega8 microcontroller. The attendance entered is firstly stored in the microcontroller's EEPROM from where it is transferred to an application software residing on a computer through the serial port. This application stores the attendance data in a database and also displays requested information extracted from them.

Keywords: attendance recording, remote data entry, data acquisition system, AVR microcontroller, embedded system, PC serial communication

1. Introduction

Recording the attendance of staff in an organization, and of students in an academic institution, are both vital. Based on the organization policy, important measures are taken according to the attendance record of the work force in a company. In educational institutions, students are eligible to appear in examinations only if their accumulated attendance meets the minimum requirement set by the respective institute.

Traditional ways of recording attendance involves manual entering of individual attendance on a sheet of paper. Later, these are fed into either log books or computer database. Even after the computerization of database management, the initial phase involves paper based entry which is very much prone to unauthorized access and thus, the authenticity of the primary data may become doubtful. Other solutions involving the use of e-cards address the problem but require heavy initial investment and may not be cost effective in the long run as it requires issuance of separate e-card to every individual.

Keeping in view the importance of attendance recording, our proposed system provides a cost effective solution for any organization especially academic institutions. Our prototype system has been designed for use in a university class.
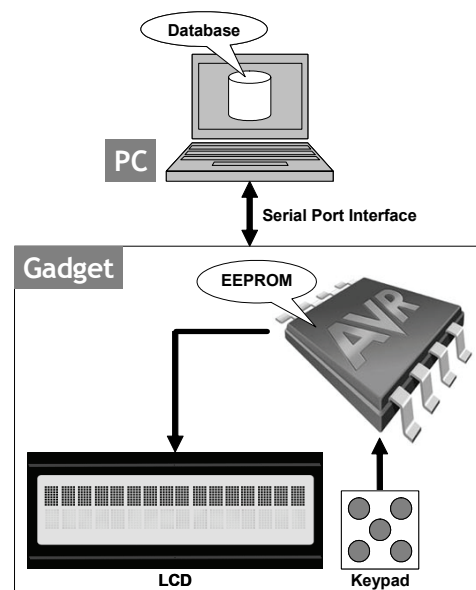
2. System Overview and Features

Figure 1. System plan

2.1. System Plan

The system comprises of a handheld gadget and an application software residing on a computer as shown in Fig. 1. The teacher takes the attendance of students

on the gadget instead of paper. The gadget retains this information indefinitely in its EEPROM. Similarly attendances of several periods can be taken before running out of the capacity of EEPROM. The application software then communicates with the gadget and transfers this stored information from EEPROM to the computer through a data acquisition interface. This software interprets the received data, stores them in a database and generates different types of reports from them.

2.2. Security and Data Integrity

The system is password protected to prevent unauthorized access. Every person designated to use the gadget and enter the attendance of the students, is provided with a unique password. This further helps to identify the user.

2.3. Data Storage and Manipulation

The attendance data are transferred to the computer where it is permanently stored and archived. The application software developed for this system manipulates the data in a number of ways prescribed and required by the user and thus displays the information. Some of the information are:
- Accumulated attendance record of an individual
- Subject-wise attendance distribution
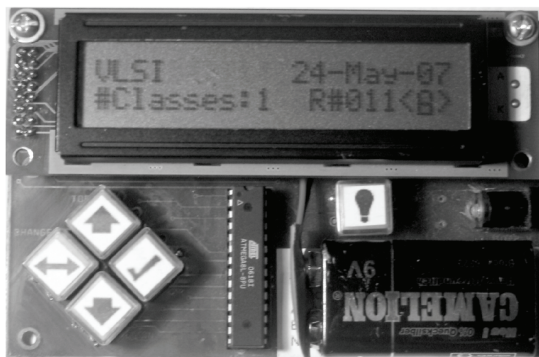- Week or month-wise attendance distribution

3. Hardware

Figure 2. The attendance recorder gadget

3.1. Microcontroller

ATmega8 microcontroller of AVR family is used as the central processing unit for this design. It contains 8 KB of flash memory to store the firmware and also has on-chip 512 bytes of EEPROM which serves to store the runtime generated data. This EEPROM is used to permanently store the attendance data in the gadget. ATmega8 is a 28 pin device, and is selected to keep the size of the gadget small.

3.2. Display

A 20x2 character LCD module is used to interact with the user. It displays all necessary prompts and information for setting various options and shows roll numbers for entering attendance. It also displays EEPROM activity while saving and retrieving data.

3.3. Keypad

A keypad consisting of four keys is provided on the gadget for the user to set various options and enter attendance. The keys are implemented as push buttons and are labelled: UP, DOWN, OK and CHANGE.

3.4. Data Acquisition Interface

The data acquisition interface comprises of the serial port of the ATmega8 on the gadget and the serial port of the computer and a 3 core serial data cable. RS-232 specifies high and low logic levels of -15V and +15V respectively while AVR serial port is at TTL level. So MAX232 level converter IC is used in order to ensure the compatibility between the two.

4. Firmware

4.1. Keypad Scanning and Functions

Poll driven I/O scheme is used for scanning the keypad. The microcontroller polls all the four keys in order to identify which of the keys is pressed. Since there is no CPU intensive task to perform, the microcontroller keeps polling the keys continuously and waits for them to be pressed. This allows to spare external NAND gate which would otherwise be needed to generate the common interrupt signal for interrupt driven I/O scheme. Debouncing is also performed in the firmware to keep the component count to a minimum. All these techniques ensure small sized gadget with less power dissipation.

Each key in the keypad has multiple functions to perform depending on what is prompted to the user at the LCD. A finite state machine (FSM) is realized in the firmware for this purpose. The states correspond to the displayed prompts. Each key press causes a series of operations according to the current state and the FSM progresses to the next state.

4.2. Display

The fixed message segments like prompts to the user, subject and month names etc. are stored in lookup tables (LUT) in the microcontroller's flash (code memory). The variable message segments like day, roll no etc. are generated in RAM at runtime and the fixed segments are also fetched from the flash memory into the RAM where they are combined to form a complete string. Usually a long string is to be written but the LCD module accepts only one character at its input port and displays it on the LCD. So subroutines are written that incorporate loops to display strings on the LCD.

4.3. Number Code Conversions

Numeric data like day, year, roll no's are interpreted and stored as straight binary code by the CPU but for the purpose of display, these must be converted to binary coded decimal (BCD). The LCD module only accepts input characters as ASCII. Therefore, BCD numbers are further converted to ASCII coded decimal (ACD) numbers (see Table 1). Several subroutines are written to perform these conversions.

Table 1. Different codes for number representation

Code	Purpose
$(00011011)_2$	Interpreted and stored by CPU
$(0010 , 0111)_{BCD}$	Converted to BCD to separate each decimal digit
$(00110010 , 00110111)_{ACD}$ $(50 , 55)_{ACD}$	Each digit is then converted to ASCII
" 27 "	Displayed to user on LCD

4.4. Memory Operations

Several repeated memory transfers take place during the execution of the program. These include the transfer of data from flash to RAM, EEPROM to RAM and RAM to EEPROM. Long string of bytes are needed to be copied so respective subroutines are written that employ various indexing and looping techniques to efficiently copy data from one location to the other.

5. Memory Organization

We chose our own class as a target for this prototype which has strength of 70 students. We have 11 subjects and 22 periods every week. The goal is to store maximum possible amount of attendance data in the limited capacity of on-chip EEPROM by prudent memory organization.

The attendance field can only have either 'P' or 'A' so the attendance of each student is recorded by 1 bit totalling to 70 bits for 1 period. We also need to store the date and subject. The subject filed can have 11 different values so it needs 4 bits. The date comprises of three fields viz. day, month and year. 31 days require 5 bits and 12 months require 4 bits. We prudently assigned only 1 bit for the year field because an academic session can't span more than two calendar years (current year and the next) under any circumstances. One quite common feature in university classes is that a single lecture spans 2 or 3 consecutive periods. So we provided the facility of storing the attendance of consecutive periods of a subject while taking the attendance once. This information is stored in the 'number of classes' field. It is 2 bits wide and allows having 1, 2, 3 or 4 consecutive classes of a subject.

Fig. 3 shows all this memory organization. There is a 2 bytes header for each lecture's attendance followed by 9 bytes of attendance data. Since 70 bits equal 2 bits fewer than 9 bytes, so 2 bits are fragmented in each record according to this scheme. Attendance records of subsequent classes immediately follow. Thus in 512 bytes of EEPROM, we can store a total of 512 / 11 = 46 lectures' attendances with 6 bytes remaining unused. This is equivalent to the attendances of more than 2 weeks. One last byte is used to keep track of the number of records currently stored in EEPROM. The user will be asked to transfer the EEPROM contents to the database when the capacity is full.
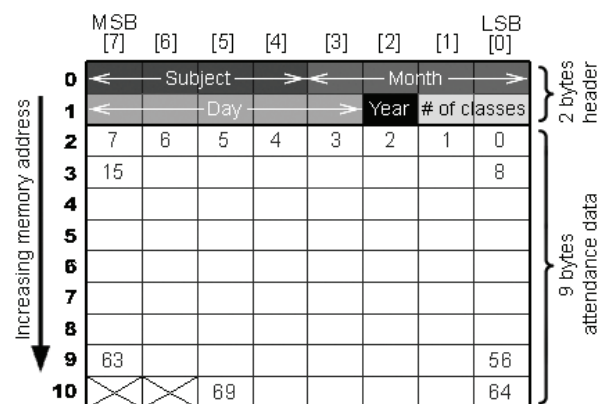

Figure 3. Memory organization

6. Data Acquisition

The attendance data which is retained in the EEPROM must be transferred to a database for archiving and further manipulations. The application software and data acquisition interface described earlier is designed for this purpose. When the gadget is connected to the computer via a serial cable, the software first requests to establish the connection (see Fig. 4). To inhibit unauthorized access, the gadget does not honour the request until it receives correct password. This password is stored not in the software but in the firmware, so it cannot be easily cracked. The user of the software must provide the correct password for authorization. The gadget then tells the software the number of records currently stored in its EEPROM. After that it dispenses with its EEPROM contents by transferring them to the computer followed by termination of the connection.
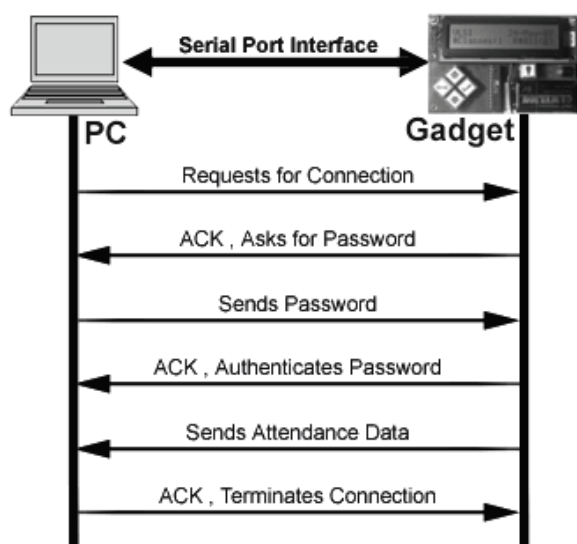

Figure 4. Data Link between the computer and the gadget

7. Application Software

7.1. Front End

At the front end, a GUI (Graphical User Interface) application is designed in Visual Basic that provides an easy way to acquire the data from the gadget. It also provides options to erase the EEPROM contents and to change access passwords. Once the gadget is attached to the computer's serial port, the application software communicates with it and completes the required operations.

The front end application also generates different reports containing the required information extracted from the attendance data. Some of the reports are:

- Summarized attendance of a month
- Detailed attendance of a month
- Cumulative attendance of the session
- Subject-wise attendance distribution
- Week or month-wise attendance distribution

7.2. Back End

The application software after reading the serial bit stream through the serial port interprets and extracts the field values according to the memory organization defined in Fig. 3. The information extracted from this is then fed into a database which serves as the back end for the application software. The database is planned as shown in Table 2. Every subject has its own table. Each record in a table represents the attendance of a lecture of that subject on a particular date. The fields of the table show the date of the lecture and the attendance of each student.

Table 2. Database plan

Table: VLSI								
Date	**R1**	**R2**	**R3**	**R4**	**R5**	**…**	**R69**	**R70**
15/01/2007	P	P	P	P	A	…	P	P
17/01/2007	P	P	A	P	P	…	P	P
22/01/2007	P	P	P	P	P	…	P	A
24/01/2007	A	A	P	P	P	…	P	P
…	…	…	…	…	…	…	…	…

8. Limitations

The present design faces a few limitations. Firstly, the use of on-chip EEPROM of the microcontroller to store the data severely limits the overall capacity. Secondly, there are only four keys in the keypad and their functions are multiple depending upon the state in which the program is at any given time. Thus, effective use of the gadget requires the person using it to have a prior training on it. The LCD used is capable of displaying only 20 characters in the two rows. This puts a limitation on the length of the string to be displayed and hence, shortened pseudonyms are used. The present design incorporates only two types of attendance entries viz. present and absent, but no provision for recording leave.

9. Future Enhancements

External EEPROM can be utilized to increase the memory capacity for storing the attendance record of greater number of students and for a greater period of time. The provisions for recording various status of attendance, such as half-leave, sick-leave etc. can be provided by allotting more bits for this field. Using encryption schemes the storage of data as well as the communication with the computer can be made secure. More sophisticated and efficient memory organization schemes can be utilized to reduce the amount of fragmentation. By employing modifications in the communication link between the gadget and the computer the data transferring can be made more quick and easy. One way is to use the telephone line to perform this function. An IR based serial communication interface can also be set-up and connected to the computer. In this way there would be no need to wire the gadget to the computer.

Other possible modifications include a wireless link on Bluetooth etc. The application software can easily be upgraded to communicate with remote sites over LAN or even WAN which would enable immediate availability of the attendance record to higher authorities and regulatory bodies of institutions located at distant places.

10. References

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