Intelligent Water Dispensing System Model Utilizing AAA Framework

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Abstract: ***Clean Water is one of the most precious resources which mankind cannot do without. However through lack of water conservation techniques our future might have scarce clean water. This paper proposes a demand side approach to water conservation. This involves an intelligent water dispensing system model which utilizes the AAA framework. This provides for authentication, authorization and accounting. Two Solenoid valves are used to mimick two flow rates. All the intelligence is build in a PIC18F4520 micro controller. This interfaces with a 4x4 keypad and 2x16 LCD display. The system uses users with different privilege levels. The system was tested and required levels of access and restrictions to the water usage were demonstrated successfully. With the current shortages of water in many parts of the world such a system proves to be of great value and also versatile, where it can find use in a variety of applications were access to resources needs to be restricted to a selected number of people and were the resources available needs to be used sparingly.***

Keywords: Microcontroller, LCD, Relay, Solenoid valve

1. Introduction

Clean Water is a precious resource which mankind cannot do without. Domestic water uses include drinking (2-5%), cleaning (4-35%), flushing toilets (15-40%), outside use (20-60%) [1]. In urban areas the supply of water for domestic use is mostly from treated water. Due to rural to urban migration, the population in cities is increasing [2]. This has resulted in treated water supply failing to meet the demand. In countries like Zimbabwe, in the city of Harare, people can go for days without access to treated water. It can be seen from the domestic use profile that there can be substantial reduction in water consumption if cleaning; flushing toilets and outside use is managed through effective demand side management strategies. These strategies can provide a virtual water supply source which will allow everyone to have access to the scarce water resource. Currently there is no incentive for one to conserve water as it is almost for free [3] .Demand side Management has been a success story in the Electricity industry [4]. This has seen the creation of virtual power stations which can even supply a city. Utilising embedded systems a demand side management strategy is proposed. As the Water supply industry wakes up to the technological revolution we forsee an uptake of prepaid water meters in residential households. The demand side management strategy involves intelligent water dispensing model which provides authentication, authorisation and accounting (AAA) services. This provides for every user of water to be responsible, account for water use and provides limited access to a user depending with the privilege level of that user. AAA framework is a way to control who is permitted to access a resource (authenticate), what they can do while they are there (authorize), and to audit what actions they performed while accessing the resource (accounting) [5].

2. Design Concept of the System

The intelligent water dispensing system model proposed utilises the AAA framework [6].A simple local database in non-volatile memory is created. Each non-volatile memory location signifies a user ID. There can be as many user IDs as the memory size of the non-volatile memory. The user IDs has privilege levels: The super user level and the general user level. Just as a proof of concept the system model in this paper uses 7 user IDs. If one enters a user ID the system queries the local database and checks whether the credentials are correct. If the credentials are authenticated the system will allow the user to access the water resource with authorisation for the particular user ID. In this system model the authorisation includes the maximum amount of water that can be used and the flow rate. In the second phase of the project the Accounting part of the AAA framework will be developed. It is envisaged that the accounting will include tracking the amount of water used by a particular user and the details are logged to non-volatile memory like SD storage. The super user account will have the highest privileged level which includes maximum flow rate, unlimited access to the water resource and ability to perform system wide configuration set up which include passwords, flow rates for users, amount of water limits per user.

2.1 System Block Diagram

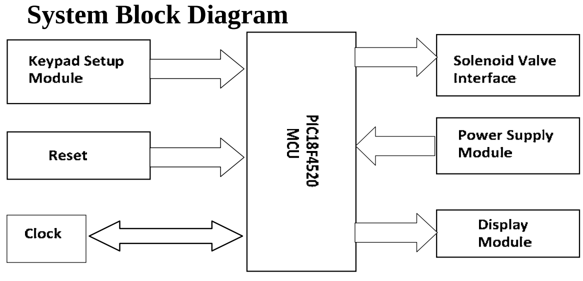

Figure 1: System block diagram

2.2 System Hardware Design

2.2.1 Keypad setup Module

A 4x4 keypad is used to provide the interface between the user and the system. The user enters the password to start the system. Once the water is flowing if one enters any key the flow of water is stopped**.**

2.2.2 Relay circuit

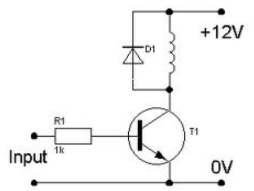

Figure 2: Relay circuit

The above circuit drives the solenoid valve. The relay can switch the solenoid valves on or off. The above circuit is employed as the PIC18F4520 cannot source the current greater than 30A that is needed to operate a 12V solenoid valve. The driver circuit also provides the required voltage of 12V to the solenoid valve.

2.2.3 Display Module

A 16 x 2 LCD display is selected. The characters entered on the keypad can be easily displayed as opposed to use of a seven segment display. Most embedded compilers do have library routines for this type of LCD.

2.2.4 PIC18F4520 MCU

The microcontroller unit chosen for this model is from microchip and is shown in the Fig 3. The PIC18F microcontroller family was chosen. Specifically the PIC18F4520 was chosen because it is cheap and readily available from most electronics shops. It is with this chip that the whole project depends on. The chip has 32K program memory and 256 bytes of EEPROM. The large memory makes the development of the embedded code in high level language a lot easier.

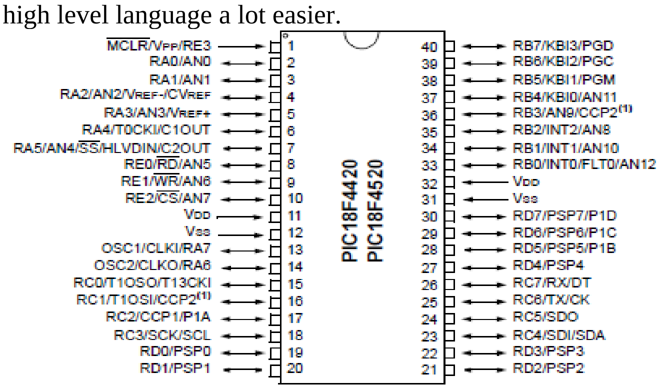

Figure 3: PIC18F4520 [7]

2.2.5 Solenoid valve

Figure 4: Solenoid valve

To provide the minimum and maximum flow rate this system employs two solenoid valves that are being operated by the micro controller. For minimum flow only one valve is opened and for maximum flow both valves are opened. To have a much more variant output the number of valves could be increased or a special valve could be employed. The valves used in the project are threaded solenoid valves that are operated electrically to control supply of water with pressure ranging from 0.2 – 10 bars [8]. The valve is opened or closed by a voltage signal from the relay circuit

2.2.6 Power Supply Module

The power supply provides the required 12V and 5V for the system. The 7805 voltage regulator provides the 5V DC voltage for the PIC18F4520 MCU. The 12V is provided via a 220/12V transformer.

2.2.7 Clock

The PIC18F4520 is clocked using the 8MHz crystal.

2.2.8 Real-Time Clock (RTC)

For the purpose of the accounting component of the AAA framework the RTC will be used in the second phase of the project to perform the auditing function of water usage and the time of the day and for how long the water resource is used.

3. System Software Design

Mikro Basic Compiler was used to develop the software routines required in this project. Testing of the software routines were initially performed on the Easy PIC v7 development system from Mikro Electronika [9]

3.1 System Wide Initial Configuration Setup

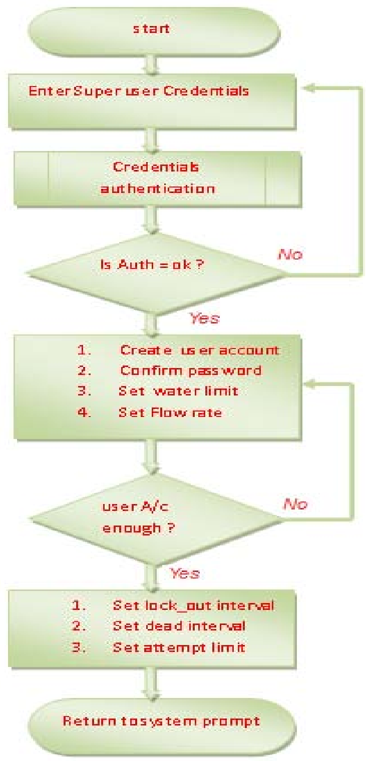

Figure 4: Initial Configuration Setup

The super user ID has administrative privileges on the system. For the first time, the system requires initial configuration. This involves the steps shown in the flowchart in figure 4.Once the super user ID is authenticated. Accounts for ordinary users can be created. Each account profile should indicate the password, the amount of water limit allocated to the user and also the flow rate. The system has been modeled using seven as the maximum number of ordinary users. Also the super user will have to set the lockout interval which defines the amount of time one have to wait before entering the password after the system has blocked a user. This happens when one makes maximum number of login attempts. This is set with the attempt limit parameter. The super user can be able to reset password for any ordinary user should one forget a password.

3.2 Menu Prompt

The system prompt shows the options available on the system. The options are available are:

Select Option: 1=Water, 2=Admin

Figure 5: System prompt

If one enters the "1" key the user will have to enter his credentials to have access to the water resource. A "2" will only work for the super user account to perform administrative tasks which include resetting passwords for any user

3.3 Main System Software

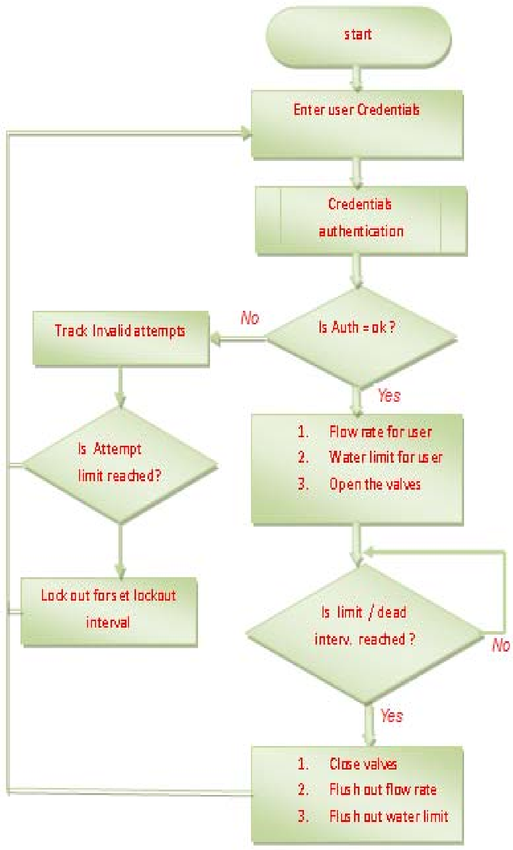

Figure 6: Main System software

Fig 5 shows the main system flow chart. During the operation of this system any user can login with their credentials and be authenticated and have access to water resource with a particular flow rate. The laboratory model which was developed used two valves to come come up with two flow rates. The user can stop the flow of water at any time by presing any key. In case a user leaves the water flowing the systems uses an idle timer which works with a set dead interval. Once the dead interval is reached the system can automatically close the valves .

4. Results and Discussion of Results

In order to validate the concept discussed in this paper a laboratory model was build and tested in the lab. Fig 7 shows the circuit on a veroboard.

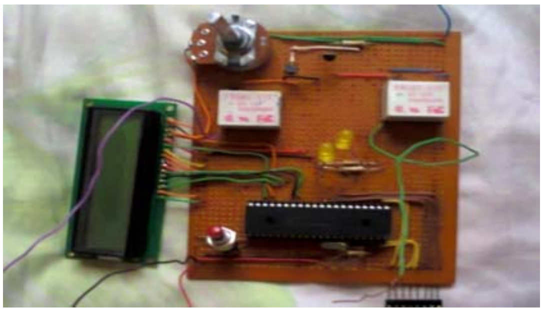

Figure 7: Designed circuit on Vero board

Figure 8 shows the fabricated solenoid valves which were used to simulate the two flow rates. A general user account will have the minimum flow rate which activates one valve. The super user would be able to have maximum flow rate using the two valvles.

Figure 8: Fabricated solenoid valves

Figure 9 shows a picture of the system under test. The output is a result of the login by the super user account.

Figure 9: Picture of the system output under test

5. Conclusion and Further Work

The lab model developed produced satisfactory results. The system could be activated upon entering a correct password. The flow rates were controlled. In terms of the AAA framework the authentication and authorization was tested. In the second phase of the project the Accounting component will be developed further and tested .This will incorporated an RTC for audit purposes. To improve the design a single valve could be employed that has various stages of opening. With this design for further flexibility more valves could be employed to have a bit more different flow rates. Further work includes development of an industrial prototype with rugged construction. In the future the controller unit will be separated using technologies like Zig-bee. This will enable the controller unit to be located within the premises as opposed to outside.

References

[1] Siebel, M.A., Gijzen, H.J., 2002. Application of cleaner production concepts in urban water management. Paper presented at the Environmental Technology and Management Seminar 2002, Bandug, Indonesia, 9–10 January 2002

[2] http://www.irinnews.org/report/97615/zimbabwe-s-urban-housing-crisis [accessed 10 July 2013]

[3] Nhapi, Z. Hoko "A cleaner production approach to urban water management: potential for application in Harare, Zimbabwe ", Physics and Chemistry of the Earth, 2004, pp 1281–1289.

[4] Emanuel Rashayi , Mphil Thesis , " Simulation and Optimization of Utility Interactive Photovoltaic Power Generation in Zimbabwe", University of Zimbabwe, 2006

[5] Metz,C "AAA protocols: authentication, authorization and accounting for the internet", Internet Computing, IEEE, vol 3,pp 75-79,2002

[6] J.W Jinhuang Huang, Jun Xie et al. "Intelligent Water Dispenser System Based on Embedded Systems", International conference on Mechatronics and Embedded Systems and Applications (MESA), 2010, 15-17 July

[7] http://www.microchip.com/TechDoc.aspx?type=datasheet&product=18F4520 [accessed 10 July 2013]

[8] http://www.pacontrol.com "Technical Information – Solenoid valve Basics" [accessed 10 July 2013].

[9] http://www.mikroe.com/easypic/ [accessed 10 July 2013]

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