REMOTE DESKTOP POWER MANAGEMENT SYSTEM USING SINGLE-BOARD COMPUTER

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Abstract

In this paper, remote desktop power management system is proposed for remote power management of multiple desktop computers. This system will enable desktop computer to be restarted, switch on or off in the event of computer freeze or based on user input by controlling the power to the desktop computer. The system has the ability to monitor the environment parameters such as the temperature, humidity, and air quality surrounding the desktop computer. This remote desktop power management system can be accessed primarily using website interface. This system will save time and cost as less on-site maintenance and monitoring is needed.

1 Introduction

Home automation is one of the key areas with high demand as Internet of Things (IoT) become more prevalent among consumer and business user. Home automation usually refer to automation of home appliances such as light bulbs, coffee maker, and other possible home appliances by means of connecting the home appliances device to the Internet, which enables the appliances to be controlled using mobile devices such as smart phone and tablet. However, this paper will focus from different angle, by showing application of IoT for the purpose of remote desktop power management (RPDM) system.

RPDM system is analogous to home automation system in one aspect, but instead of connecting home appliances to the Internet, this RPDM system will connect desktop computer to the Internet, which also record relevant data regarding environmental data of the desktop computer location. In this paper, it would expound this RPDM system, which enable for the user to know the status of the desktop computer and the environment data. This RPDM system can be controlled using website application.

2 Literature Review

There exist a lot of consumer products and platform with focus on home automation such as Amazon Alexa, Mozilla Things Gateway, Google Home and many more. There are lot of academic papers regarding the usage of IoT in the home environment; more of it is focused in the area of energy monitoring, home control and helping the disable and elderly, and even monitoring pets and children. However, all of these academic paper will focus on the application of Raspberry Pi in the field of home automation, as it is similar in some aspect of the RDPM system, which inherently both system use single-board computer as the main controller.

In [1], the smart home automation is done mainly for helping the elderly, using open source software such as Python, OpenCV, Android and Raspberry Pi. The system is built for enabling face detection and recognition integrated with door monitoring system, controlling fan and intensity of light, all by using Android phone applications. It also able to take command from voice. In [2], the paper also explain home automation with the focus on the elderly and disabled, however it is much simpler compared to [1]. This home automation system is used to control fans and lights by using Wi-Fi capable handheld device such as smartphone and tablet. This system also equipped with web camera, which can enable video monitoring of the home environment. Simple GUI application act as the interfacing of the home automation system.

In [3], Raspberry Pi is controlled by using command send from email, which then can be used to control home appliances using you email. Email notifications also Meanwhile in [4], home automation is also focused, which used 3 main sensor, Infra-Red (IR) sensor for controlling lights, Passive Infra-Red (PIR) for controlling Fans and Light dependent resistor(LDR) as the fire detection sensor. Again, this system used Wi-Fi as the main communication, and Raspberry Pi as the microcomputer. The interface to control the system is by using web portal. From [5], the paper explain a home automation system based on the controlling the home
electronic appliances by using website interfaces. The system is based on using web services from weaved and webopi. This two web services will enable the home automation to be globally accessible, not just from the local network.

In [6], Raspberry Pi is presented as a wireless sensor node (WSN) capable of gathering and processing sensor data, and act as a web server to communicate and transfer the data to other party. This paper presents low cost design and applications using Raspberry Pi, which will enhanced and secure home automation system.

Based on the literature, it seems that home automation can be developed using a single-board computer, which all the reviewed paper use Raspberry Pi as their main choice. There are a lot of advantages by using Raspberry Pi although it also has its own constraints [7], however using Raspberry Pi should fulfilled most of the requirement needed by the literature reviewed here. One of the important component in all of these reviewed papers is all the home automation system is connected to the internet, whether it can be accessed locally or globally. Through the Internet connection, the home automation system would be able to communicate, sending data from the sensor input, and the user input, which will in effect will control the home automation system.

3 System Overview

This RDPM system is based on intelligent power management system which are mainly used in the fields of server farm, where server can be turn on or off by using intelligent Power Distribution Unit (PDU). PDU will control the power to the server computer, by having intelligent plug, which can connect and disconnect the power from the main power supply.

In this RDPM system, the power management is controlled from the motherboard using relay, which it is equivalent to pressing power button on the desktop computer, whereas in the PDU, it is equivalent to plug and unplug the power cord. The RDPM system will be better in remote power management due to safe shutting down process compared to PDU system, with an addition of knowing the environmental data of the desktop computer.

4 System Design

This RDPM system is designed to stand on three main architectures, which are the hardware, software and network architecture. These three architectures is what make this RDPM acts seamlessly as one system.

4.1 Hardware Architecture

Basic control system require three hardware components, which are sensors, controller, and actuators [8]. Hence, this RDPM system is developed based on this paradigm. Apart from that, this system also need a power source and a connection to the Internet.
• Temperature Sensor

Temperature sensor is used to detect the temperature in the room where the desktop computer is placed. Electronics hardware such as desktop computer can last longer and operates better if the environment is maintained at optimum level for the desktop computer performance.

In this RDPM setup, LM35 is chosen as it convenient to be interfaced with RDPM, low cost and widely available. LM35 will output higher analog voltage signal corresponding to higher temperature, and vice versa.

Based on the temperature sensor reading, the suitability of running desktop computer in the office can be inferred, hence adjusted if needed. Some of the adjustment that can be done is to design a better airflow and ventilation system for the office to make the desktop computer last longer.

• Dust Sensor

Dust sensor is used to measure the dust particle concentration in the air. High dust particle concentration in the air can be bad for the operation of desktop computer, which can block the fan of the desktop computer; hence, the heat dissipation by the fan will be less than optimum. The results is the desktop computer can be running at higher temperature as it should and reduce the lifetime of the desktop computer.

In this RPDM system, GP2Y1010AU0F optical dust sensor is used. This dust sensor operate by having an infrared emitter and phototransistor to detect the reflected light of dust in air. As more dust density is detected, higher voltage reading will be produced. Again, as the other type of sensor, this dust sensor need to be calibrated to ensure better and accurate detection of dust.

If the dust particle density in the air is too high, cleaning operation must be done to ensure the desktop computer is running in optimum condition. The level tolerable for the

• Gas sensor

Gas sensor is used to detect for gas particles in the air. In this RDPM system, gas sensor is intended to detect for smoke. In using gas sensor, there are numerous type of gas sensors that can be chosen from.

For this RDPM system, MQ2 gas sensor is chosen and interfaced with it, as it is widely available for low cost. This sensor use electrochemical sensor, which changes its resistance based on gasses concentration and type of gases. This changed in resistance is then feed into the RDPM in form of analog voltage signal.

As MQ2 gas sensor is usable with various type of gas detection, a calibration is done using the gases that need to be detected. Hence, this gas sensor is calibrated using smoke, and then the resulting analog voltage reading is used as indicator for smoke detection.

At a certain voltage value reading from the MQ2 gas sensor, it will trigger the RDPM system to send notification to the users.

These three combination of sensor is adequate for a simple RDPM system. However, more sensor can be added or removed, depending on the needs and requirements.

b) Controller

Controller is a device that monitors a system, by reading the input from the sensor instrumentations, and alter the environment based on the input reading, using actuators. In the current time, the controller usually is a microcontroller or computer. In this RDPM system, a single-board computer (SBC) is used as the controller.

• BeagleBone Black

BeagleBone Black (BBB) is a single-board computer (SBC) which can run Embedded Linux [9]. The two main advantages of using this SBC in designing this RDPM system is that this SBC has more GPIO pins compared to Raspberry Pi 3[9][10], and it also has ADC pin which is useful for easier interfacing with sensors compared to Raspberry Pi 3 [9][10].

From the aspect of processing capability and energy consumption, there is not much different between these two SBC, although there are some who argued that BBB consumed much less energy compared to Raspberry Pi 3 during idle[9][10].

Main task of this SBC is to read the data from the sensors, and control the output to the relay. This SBC incorporates some signals conditioning to smoothen the data reading, and some conversion is done to make it easier for next step in processing. This SBC also control the actuator through GPIO pins on the SBC. Another main use of this SBC is for it to act as a website server, which will be explained in depth in the ensuing software and network architecture section.

c) Actuators

Actuator is the device which responsible for moving and controlling mechanism or system. In this RDPM system, it is responsible for switching on and off, or rebooting desktop computer. The source for the actuators action is from the signals generated by the sensors. Hence the

• Relay

This RDPM system used HL-52S relay module, which is widely available for purchases. The function of this relay is to control the switching on, off and rebooting of the controlled desktop computer. The output of this relay is connected to the on/off pins on the motherboard of desktop computer.
d) Internet Connection

The BBB is connected to the Internet by using an Ethernet cable. There exist BBB with built in WiFi, however BBB with Ethernet cable is chosen as the Internet connection will be more reliable, secure and faster compared to WiFi.

e) Power Source

This RDPM system hardware is powered by 5V wall plug. Although BBB can be powered through USB, it is more convenient to supply power to BBB using wall plug.

4.2 Software Architecture

This RDPM system is developed using Embedded Linux operating system. The main advantage of using Linux is it is free. Another advantage there is a large community who maintained and developed applications and softwares using Embedded Linux.

Application software for controlling this RDPM system is developed using Python programming language. Python is a high-level language, which is highly readable and accessible for both beginner in programming and advanced developer. Development of application software using C programming language theoretically will provide better efficiency and speed, however in this case, Python is chosen as to reduce application software development time.

Model-View-Controller (MVC) paradigm is used for designing the user interaction with this RDPM system. MVC is praised for its ability to separate information that is presented and accepted from the user. MVC also promote code reusability and parallel development, which will enable different section to be developed independently.

User of this RDPM system will interact using the View and Controller, which are based on website application. Website application shows the user the temperature, dust level, smoke level and the desktop computer status. The user can control the switching on, off and resetting the desktop computer using the website application.

4.3 Network Architecture

SBC acts as website server by using Apache Server and utilising MySQL database for storing sensor data and desktop computer status. Using combination of static Internet Protocol (IP) address, Domain Name System (DNS) and port forwarding, this RDPM system can be accessed globally using website browser.

In the SBC, the local IP address must be set for the port forwarding to be executed. Next, from the modem, port forwarding of the SBC is enabled so that the SBC can be accessed externally. However the modem must have static IP address, so that the IP address is not changed over time. Then, use DNS for providing your IP address a name that is memorable. Now, by typing the name of the chosen DNS, the SBC should be accessible to the user. Also, make sure the security and authentication process is taken care of to prevent unauthorized user from accessing this SBC, hence using your RDPM system without permission.

Figure 3: Software Block Diagram.

Apart from the user control, this system always run to check the status of the desktop computer every 10 minutes from external website API. This external website API is the source for the desktop computer status, whether a reboot is required. This will enable the user to let this system operate in fully autonomous fashion, without needing the intervention of the user.

In addition to the MVC paradigm interaction with the RDPM system, this software application also use concurrent program execution instead of sequential program execution. This is to maximise the resources used for the processing and enable faster response. Website applications is written using Python Flask web framework for easy linking between website applications and electronics hardware on the BBB.

Figure 4: Network Block Diagram.
5. Results, Analysis and Discussion

As mentioned in part 3 Systems Overview, this system is to replicate a commercial intelligent PDU, which is known to be high in cost (which is justified as it has advanced features) which can cost up to thousands of dollars depending on the specifications of the intelligent PDU. In contrast, this RPDM system is made from SBC hence the cost is lower compared to commercial intelligent PDU, as the RPDM system is being built using open source software and widely available electronic hardware. This RPDM setup can be built as low as USD 150 for basic RPDM system.

This RPDM system achieve the main intention of using commercial intelligent PDU, as it reduces the time, labour and cost of sending technician to manually turn on, off and restart desktop computers. In the authors’ situation, most of the cost in monitoring the desktops computer before using the RPDM system involve the cost of fuel as the technician is required to travel and fixed the problem of the desktop computers, apart from the cost of labour and time of traveling. With minimal cost by using RPDM system, there is significant cost saving, and even reducing carbon footprint in monitoring the desktop computers, which will be better for the environment.

In term of functionality, this RDPM system has less functionality compared to commercial intelligent PDU. This is understandable, as commercial intelligent PDU system has specialized hardware and software to interact with their commercial intelligent PDU. This in turn enable commercial intelligent PDU to have complex operation in monitoring computers, especially in server farms at they have stringent requirement. However, for the authors’ purposes, this RDPM system is adequate.

Another facet of this RPDM system is that it is not user friendly, and intermediate knowledge in programming and hardware is needed to use this system effectively. This is a huge drawback for the purpose of commercialization; however it has the ability to be customized depending on the exact needs for the users. Meanwhile for the commercial intelligent PDU, they are designed mainly with the purpose of plug-and-play system, with minimal customization and configuration hence they are better for large majority of users.

- Performance

During the operation of this RPDM system, it is able to monitor 10 desktop computers, which automatic monitoring is enabled. RPDM Automatic monitoring will check all the status of the desktop computer every five minutes, which then will send the required action for the desktop computer. For example, if the desktop computer freeze or does not send a live signal to the network, a reboot signal or turn on signal is send to the desktop computer. This can be run reliably except for 2 issues which are needed to be solved in case it happen.

- Optimization and Improvement

First, if there is a power supply cutoff, there need to be a backup power supply, to power the RPDM system, the desktop computer, and the networking system. This may be solved by using uninterruptible power supply (UPS) for the setup. UPS is electrical power system whereby it will supply power from batteries if the main power supply fails.

Second issue is about the problem of Internet connectivity lost. If this happen the monitoring cannot be done and the status of desktop computer will be unknown in the duration of network connectivity lost. A commercial 3G/4G backup modem system could be used in case of Internet connectivity fail.

When testing the RPDM website application using local and remote network, negligible performances differences is noticed in term of speed and responsiveness.

- Optimization and Improvement

Apart from the performance of RPDM, there is few issues, which can be optimized and improved. One is the optimization of website interface to control the desktop computer. Speed is the bottleneck of the websites for now as the time taken to execute the command to control the turning on, off and resetting the desktop computers can take as much as 20 seconds. This could be contributed to the factor such that processing and communication of the website application is not being optimized, hence reducing the responsiveness of the RPDM system.

Another big improvement required for this RPDM is the website application User Interface and User Interaction (UI/UX). Improving the design of UI/UX, making it easier to change and customize the operation of the RPDM system by the user without much of programming and hardware knowledge will be a value added to this system by means of easing the users for using this RPDM system.

These two improvements of this current operational RPDM system will enable better user experience for the user who needed means to monitor their desktop computer remotely.

6. Conclusion and Future Applications

This RPDM system will contribute in a small way for the thriving of IoT industry, by saving energy consumption, reducing cost of monitoring and maintenance, and hence optimizing the operation of desktop computer, whether a single or multiple desktop computers, up to a level of server farm.

For future applications, this RPDM system could be integrated with modules, such as camera, motion sensor, email alert and SMS alert to this system. Addition of multiples modules will greatly enhanced the ability of RPDM systems, hence enabling smarter automation and betterment of the RPDM system operational efficiency.
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