COMMUNITY BASED HOME SECURITY SYSTEM USING WIRELESS MESH NETWORK

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ABSTRACT

Home security is refers to crimes prevention such as burglaries and kidnapping. As a preventive measure, a resident may install an ip camera but this method is quite costly because the resident needs to buy a personal computer, router, and software. Furthermore, this method also only benefit to the resident but not to the other neighborhoods. Consequently, the crime prevention in residential area which is the issue of community becomes merely an individual concern. Community based home security system using wireless mesh is a prototype system that promoting on proactive crime prevention through residential neighborhoods involvement. The community based home security system using wireless mesh is suitable to achieve the objective because it offers high scalability, inexpensive, and centralized system. This project objective is to develop a prototype home security system based on wireless mesh network that is scalable, cost effective, and community based application. We applied standard SDLC project development methodology. As a result, a prototype of community based home security system using openmesh wireless mesh routers and pocket size computer raspberry PI is introduced. The system networking can be expanded throughout residential area by deploying additional openmesh wireless mesh router. The cost of the deployment can be shared among house residential. Thus, increases the neighborhood involvements towards achieving the common interest initiative, the home security.

Key words: Community Security, Raspberry PI, PIR, Wireless Mesh Network

1. INTRODUCTION

Internet protocol surveillance cameras based application have drastically increased in recent years by business owner and home residential in seeking to reduce crime. Hence, manufacturers begin to incorporating wireless technology 802.11 to simplify surveillance cameras deployment and maintenance. According to Peizhao Hu et al (2010), at present the feeds from such wireless-enabled cameras can only be wirelessly accessed as far as one hop away. Such limitation prevents the ip camera to be installed at various different places. Peizhao Hu et al (2010) also stated that to setup wireless ip camera, one must have a personal computer and router which is rather expensive, and can be monitored only by the owner. Since effective crime prevention in residential area is the issue of community and not merely an individual initiative, therefore a surveillance system that offers high scalability, inexpensive, and centralized system is required. This is achievable by using wireless mesh network which is a communication network made up of radio nodes organized in a mesh topology. Wireless mesh networks is not only reliable and offers redundancy, but it can be implemented with various wireless technology including 802.11, 802.15, 802.16, cellular technologies or combinations of more than one type. Based on the wireless mesh network, wireless ip cameras and wireless ip motion sensors can be located anywhere within the coverage of wireless mesh network as compared to autonomous home security system. Furthermore, home residential does not need to setup personal computer, router, and software, as well as to monitor the wireless ip camera since it is centralized to a server at a guard post.

Rest of the paper is organized as follow: Section 2 discusses related work. Section 3 introduces the method that is used in this work. Section 4 explains the project set-up. Section 5 present the result, and finally section 6 summarizes the paper.

2. RELATED WORKS

An anti-intruders security system project proposed by Sharifah Fadhilah (2011) employs wireless network to monitor house using wireless ip camera. However, this application only benefits to a single house and very much costly if to implement the similar system into every house. Furthermore, if the wireless network is down, the security system is virtually useless. On the other hand, it would be more robust if the system is deployed using wireless mesh network while taking advantages of its self-healing connectivity to nearby mesh router provided that it is still within coverage of the wireless mesh network. According to S. D. Odabasi and H. Zaim (2008), Wireless Mesh Network (WMNs) important characteristic is to solve Line-of-Sight (Los) problem especially on
central wireless networks. WMNs send packets over multiple nodes; hence packet loss rate can be minimized. S. D. Odabasi and H. Zaim (2008) also mention that addition or subtraction to network can easily be made after network deployment. Stefan Bouckaert (2009) shows that wireless mesh network can be used to provide scalability where he expand and combine the wireless sensor network into wireless mesh network to cover large area. Thus, choosing WMNs for this project is a good option for a home residential security system because it can provide better coverage, redundancy, and easy deployment. Subsequently, a huge cost reduction is achievable by adding one or two wireless mesh routers to expand larger coverage rather than buying a router and a personal computer for each home.

3. METHODOLOGY AND PROTOTYPE DEVELOPMENT

Figure 1 shows the prototyping methodology for this project. The system development life cycle is based on the standard approach in problem solving. In the initial system development, the problem is identified (analysis). Later, find a way to solving it (design), and finally is the implementation of the design (implementation). The advantage of this model is the iterative approach. It emphasizes on analysis, then design, and then some implementation. Based on the approach, we can cycle back to do more analysis and fix what is missing and at the same time it support human learning a lot better.

![Fig. 1. SDLC Project Development Methodology](image)

Figure 2 shows overall system architecture of the community based home security system. The intruder (1) triggers the sensor, then the sensor (2) which is attached to a wireless node (PI Raspberry microcomputer with USB Wi-Fi adapter) requests (3) (4) the ip camera which is also connected to a wireless nodes (PI Raspberry microcomputer with USB Wi-Fi adapter) to capture image. After the ip camera captured (5) the image, the image is stored in the SD card which was inserted in the PI Raspberry microcomputer. The image is then uploaded (6) (7) (8) to server and a graphical user interface displays the image along with an alarm sound (9) (10). Furthermore, at the same time it also sends (7) (8) an alert notification to Twitter on Android device user.

Table 1 and Table 2 briefly describe lists of hardware and software required for the prototype development. The development of the prototype is done in 4 steps. The first step is to setup and install Raspbian operating system on the Raspberry Pi. Second step is to interface PIR sensor with Raspberry Pi. Third step is to connecting webcam with Raspberry Pi. The fourth step is to enable network communication between Raspberry Pi so that when PIR sensor detects movement it triggers the other Raspberry Pi to capture image. Fifth step is setup ftp server on windows, subsequently the Raspberry Pi transfer captured image through ftp. Lastly, the GUI is developed to show captured image on windows.
Fig. 2. Overall system architecture

Table 1. Hardware Lists

<table>
<thead>
<tr>
<th>No</th>
<th>Hardware</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>O2MP Wireless Mesh Router – is a low cost wireless mesh network which is easy to be deployed. The hardware is designed to support a simple and complex mesh network. It also includes a cloud controller that is freely available.</td>
</tr>
<tr>
<td>2</td>
<td>Raspberry Pi (Model B) - The board can be interfaced with PIR sensor using its GPIO port which have 36 pins. USB 2.0 and SD Card interface are also available for the purpose of this project.</td>
</tr>
<tr>
<td>3</td>
<td>SD Card - is used as a hard drive for the board to install Raspbian Linux operating system and the program for the security system.</td>
</tr>
<tr>
<td>4</td>
<td>PIR Sensor (Digital type 5V input) – is use to sense movement of an object; in our case is a human.</td>
</tr>
<tr>
<td>5</td>
<td>Male to Female Jumper Cables - a direct connection is used from PIR sensor to Raspberry Pi board.</td>
</tr>
<tr>
<td>6</td>
<td>USB Logitech Webcam C270 – An inexpensive webcam that capture and feeds its image into a computer upon request. This webcam is connected to Raspberry Pi usb port.</td>
</tr>
<tr>
<td>7</td>
<td>5V 2 Amp Power Adapter - The power adapter is used to supply electrical power to the Raspberry Pi boards. The power adapter supplies 2 Amps, which is sufficient for a board attached PIR sensor and Wi-Fi adapter.</td>
</tr>
</tbody>
</table>

Table 2. Software Lists and descriptions

<table>
<thead>
<tr>
<th>No</th>
<th>Software</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Windows 7 - is used as a server for the Community Based Home Security System. This system is used for storage, storing the captured image of the intruder. The GUI to show captured image is developed on this operating system.</td>
</tr>
<tr>
<td>2</td>
<td>Raspbian OS - is used for the Raspberry Pi board. It is the official image for Raspberry Pi, by using the operating system’s image. Software development for the system already included such as python language.</td>
</tr>
<tr>
<td>3</td>
<td>Python language - is a programming language that integrates our systems. By using Python, an immediate gain in productivity is achieved and a maintenance cost is lower. Python combines remarkable power with very clear syntax. It has modules, classes, exceptions, very high level dynamic data types and dynamic typing.</td>
</tr>
<tr>
<td>4</td>
<td>Twython - is a pure python wrapper for the Twitter API, support Twitter’s main API, Twitter’s search API, and using OAuth with Twitter. It provides easy and up to date way to access Twitter data in python.</td>
</tr>
<tr>
<td>5</td>
<td>Pushnotify - is a package for sending push notification to Android and IOS devices. It supports Notify My Android, Pushover and Prowl. This project use Notify My Android library to send notification to android.</td>
</tr>
<tr>
<td>6</td>
<td>FileZilla - is a server that supports FTP. File transfer protocol is a standard network protocol used to transfer files from one host to another host over a TCP based network. FileZilla used as server to transfer captured image from Raspberry Pi.</td>
</tr>
<tr>
<td>7</td>
<td>Notepad2 &amp; Nano - are used as IDE editing tools for Python source code on windows and Linux platform.</td>
</tr>
</tbody>
</table>

Step 1: Install Raspbian OS

Raspbian OS is the operating system which officially supports Raspberry Pi. The OS can be downloaded from Raspberry Pi website. The operating system is written to SD card which is required to operate the board. After that the SD card can be used to run the Raspbian OS on Raspberry Pi board.

Step 2: Interface with PIR sensor

PIR sensor has 3 wire which is a power supply pin (VCC), a ground pin (GND), and an output pin (OUT). The sensor needs a 5V DC power supply. The power source should be connecting to 5V pin at header number 4. The ground wire should be connecting to ground pin at header number 6, and finally the output wire should be
connecting to GPIO0 which is to header number 11. In the program, it follows the BCM GPIO number which in this case GPIO0 equal to GPIO number 17. When the program starts, the default value is set to false or low, so when there is movement detect, the value changes to high.

**Step 3: Connect webcam to Raspberry Pi**

The Raspberry Pi board can be easily connected to USB port. Kernel in Raspbian OS is up to date, and can successfully detect the Logitech C270 webcam. In Linux it can show if the device supported.

**Step 4: Network communication between Raspberry Pi**

To allow the PIR sensor to communicate with camera through network, the socket programming in python is implemented. Python provide low level access basic socket support in the underlying operating system, which allows implement clients and servers for both connection-oriented and connectionless protocols. By implementing the wireless network communication, the sensor can be located anywhere within coverage. When a human movement is detected, it sends a message to indicate that there is an intruder. At Raspberry Pi camera node, when the message is received, then it run a command to capture the human image.

**Step 5: FileZilla setup**

In FileZilla configuration, user account must be created first, after that destination of folder that are needed to store the captured the images is also required.

**Step 6: Graphical User Interface**

Python built in library include graphic library to make a GUI, it is called tkinter. Tkinter is the standard python interface to the Tk GUI toolkit. This GUI is very simple just to show an image of intruder. The image is show up based on time that was triggered, as it received string of time sent from camera Raspberry Pi through socket programming.

4. TESTING AND RESULT

System and functional testing is done to verify whether the system is able to produce the desired result. The testing is done on wireless network communication between Raspberry Pi nodes through openmesh routers, monitored by the alert notification on android and twitter, and the detected object’s image is saved and pop-up by the graphical user interface.

The result shows that socket programming of the wireless network communication successfully support the communication between Raspberry Pi nodes through the openmesh routers. Figure 3 and 4 shows that when there is a movement, the motion sensor node requests the camera node to capture detected object’s image. Subsequently, figure 5 and 6 shows the alert notification to twitter and android device works when the object is detected.

```
pi@raspberrypi:~ $ sudo python 1.py
movement detect
sent: capture image
movement detect
sent: capture image
movement detect
sent: capture image
movement detect
sent: capture image
```

**Fig. 3.** Raspberry Pi with PIR Sensor

```
pi@raspberrypi:~ $ sudo python 2.py
capture image
--- Opening /dev/video0...
trying source module v4l2...
/dev/video0 opened.
No input was specified, using the first.
Adjusting resolution from 320x240 to 320x240.
--- Capturing frame...
Captured frame in 0.00 seconds.
--- Processing captured image...
Writing JPEG image to '/home/pi/nettest.jpg'.
capture image
--- Opening /dev/video0...
trying source module v4l2...
/dev/video0 opened.
No input was specified, using the first.
Adjusting resolution from 320x240 to 320x240.
```

**Fig. 4.** Raspberry Pi with Webcam
The complete system result is shown in figure 7, 8, and 9. The figures show that the community based home security system using wireless mesh network enable human object detection by the PIR sensor node to wirelessly trigger camera node to capture the detected object’s image. Subsequently, the image is uploaded to the server to be appeared in the GUI (as in figure 7), and then an alert notification is sent to Android and Twitter (figure 8 and 9).
5. CONCLUSION

The prototype system development successfully completed. The results show that it can potentially be used for community based home security system by taking the advantages of wireless mesh network. Furthermore, it can eliminate blind spot, where the sensor and the camera can be placed at hidden places thus produce better detection and human face recognition. Multiple sensors and cameras deployment also can be placed at many locations. In addition, the system networking can be expanded throughout residential area by deploying additional openmesh wireless mesh router, camera nodes, and sensor nodes. The small amount of cost for the deployment can be shared among residential communities. However, an effective social network application that binds the neighborhood involvements towards achieving the common interest in home security is one of the major improvements that needed to be carried out in future.

REFERENCES