Design and Installation of Security System for the Data Center of Cavite State University - Main Campus

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ABSTRACT

A paper presents the construction of a microcontroller unit together with the development of its software that can secure the files and equipment at the CvSU Data Center, 3rd floor of Information Technology Building of the College of Engineering and Information Technology. It also aimed to install the system and transmit the alarm signal to the desired locations and person. Through beam, glass break and magnetic sensors serve as the triggering device that will send the alarm signal through Zigbee and Global System Mobile (GSM) module, while the motion sensor serves as a trapping device that will send the solenoid lock a high signal to activate. The transmission range of the Zigbee for the alarm signal is 2,000 meters, having a strong anti-jamming capability, flexible network and stable performance, enough for the receivers to take the alarm signal. Cameras as well as the Digital Video Recorder were also installed to record detected motions inside the room. Based on the data gathered, security measures, data transmission and the overall performance of the system were proven to be successful with a total cost of PhP22,329.00.

Keywords: Information security, microcontroller, sensors, Zigbee, Data Center

INTRODUCTION

This modern data center, along with the Information and Communications Technology (ICT) infrastructure, is the nerve center of an enterprise and universities. The data center serves as a connecting nerve of an institution or enterprise to outside digital world and vice versa. Its key importance is not its physical size but its capability to provide high speed availability and peak performance. Data center services encompass all of the technology and facility-related environment that provides processing, storage, networking, management and the distribution of data within an enterprise. Services from a data center can encompass any service that data centers deliver, such as data backup and archiving, managing e-mail or cloud computing.

Information security is the confidentiality, integrity, and availability of information (von Solms & van Niekerk, 2013). While confidentiality is the prevention of unauthorized disclosure of information, integrity aims at ensuring that information is protected from unauthorized or unintentional alteration, modification, or deletion. Availability, on the other hand aims to ensure that information is readily accessible to authorized users (Boiko & Shendryk, 2017; Mahfuth et al., 2017; Sari, 2015). Information security includes those measures necessary to detect, document, and counter such threats (Boiko & Shendryk, 2017).

Security systems are designed to detect attacks and counter attacks from intruders. These are composed of specialized hardware and software, such as a microcontroller interfaced with different kinds of components like sensors and communication modules. These systems are also called anti-theft systems (Bykovyy et al., 2012; Huang, et al., 2010; Sabeel & Chandra, 2013; Xu, 2013). The applications of microcontroller-based devices continue to rise because of their greater processing speed and flexible control, reduced cost and low power consumption (Ahmed et al., 2012; Arboleda et al., 2015; Cero, Ala, & Arboleda, 2018; Paulite, Carandang, & Arboleda, 2018).

The Security System for the Data Center of the Cavite State University is a microcontroller-based anti-theft system that can prevent or deter unauthorized appropriation of items considered valuable. Having this for the Data Center, the equipment such as databases, routers, modems and others will be protected. Those who have malicious intents of connecting their gadgets and hardware to copy and duplicate the stored files can be easily monitored. Using the developed security system, the person-in-charge does not need to worry whenever he leaves his assigned premises. The person-in-charge of the center, as well as the guards on duty, could respond faster to reports when there is an intrusion or even night time attack in the data center with the help of its monitoring and wireless data transmission features.

MATERIALS AND METHODS

The Security System was developed using the following set of methods:

Construction of the Microcontroller Unit

The Gizduino microcontroller board is the local version of the world famous open source microcontroller known as the Arduino (Ausilio, 2012; Badamasi, 2014; Younker & Ribaric, 2013). It was used in the system together with other components for proper interfacing. Figure 1 shows the block diagram of the system with the microcontroller as the main processing unit.

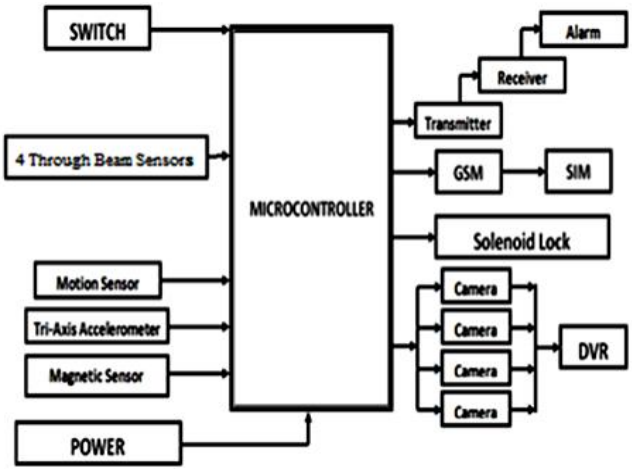

Figure 1. System block diagram

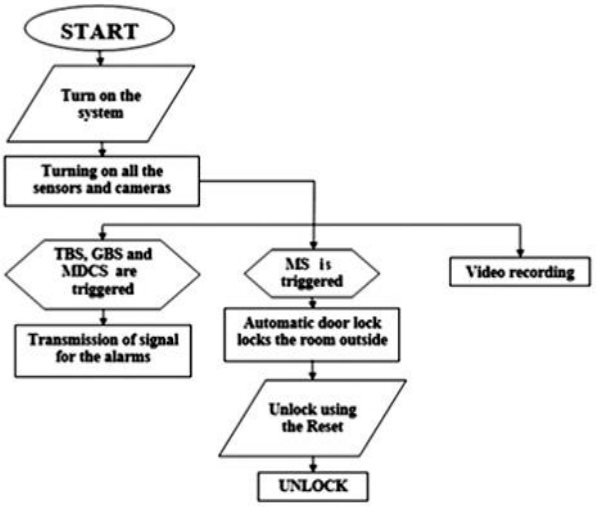

Figure 2. The system flow chart

The switch turns the whole security system on and could only be unlocked using the reset button. The sensors are connected as input to the microcontroller. The four through beam sensors, two tri-axis sensors, and the magnetic sensor were connected in "or" condition, meaning, any of the sensors that would be triggered would generate the microcontroller then command the transmitter to send signal to the receiver to turn the alarm on. Also, it would send a command to the Global System Mobile (GSM) module (Yoannan et al., 2013; Afridi et al., 2012) to send a Simple Mail Services (SMS) message to the authorized person.

The passive infrared (PIR) motion sensor (Frankiewicz & Cupek, 2013; Morshed et al., 2015; Sravani et al., 2014) was connected as input to the microcontroller that when it senses an intruder inside the room, it would send a HIGH signal that would turn the solenoid lock (Poirier & Vishnubhotla, 1990) on to trap the intruder inside.

System Development

The development of the system is shown in Figure 2. At first, the authorized person would turn the system on before he/she leaves the room. All the sensors and cameras would be turned on to start the operation. The single photoelectric beam, glass break (Chang &

Chang, 2013; Teng et al., 2016) and door contact or magnetic sensor would detect the entry of the intruder then send the alarm signal. The motion sensor (Erden et al., 2015) would sense the motion of the intruder then locks the room as well as turns the light indicator on. The light indicator would be placed outside that indicates that there is an intruder inside. Also, the automatic door lock would lock the room outside to trap the person inside.

Design of the Installation

Softwares like AutoCAD and Google Sketch Up application were used to design the actual installation of the sensors, cameras and Digital Video Recorder (DVR), and the solenoid lock.

Figure 3 shows the outside front view of the CvSU Data Center where the sensors cabinet, magnetic sensor, solenoid lock, and the tri-axis accelerometer were placed.

Figure 4 shows the outside back view of the CvSU Data Center where the through beam sensors were installed with equal spaces in between.

Figure 5 shows the inside view of the room where the cameras, PIR motion sensor and DVR cabinet were installed.

Figure 6 shows the application used in the strategic placing of cameras using the IP Video System Design Tool 7. The specifications of the camera and the floor plan of the Data Center were entered as well.

Figure 7 shows the drawing of camera installation that includes the height of the camera from the ground, its tilt and viewing angle.

Figure 8 shows the outside transmission and reception view of the system. Zigbee (Safaric & Malaric, 2006; Chen & Wang, 2006) was used to send the alarm from the Data Center to the Gate 1 and Gate 2 of CvSU.

The installation of the security system was based on the design shown in Figures 3, 4 and 5. The cameras were strategically installed on the four corners of the room that would catch the intruder's physical appearance. The DVR was

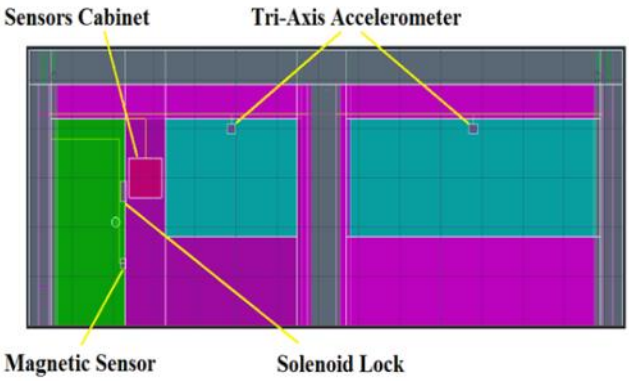

Figure 3. Outside front view of the CvSU Data Center

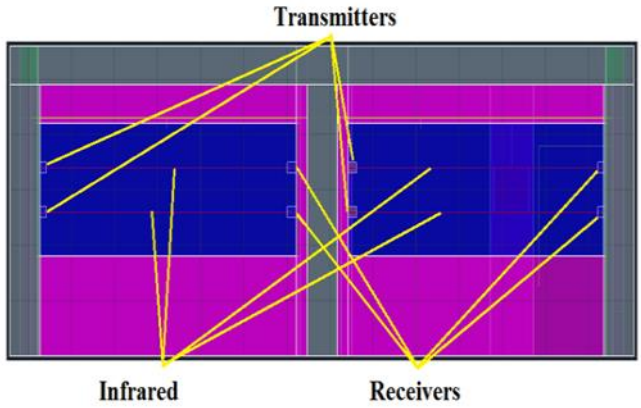

Figure 4. Outside back view of the CvSU Data Center

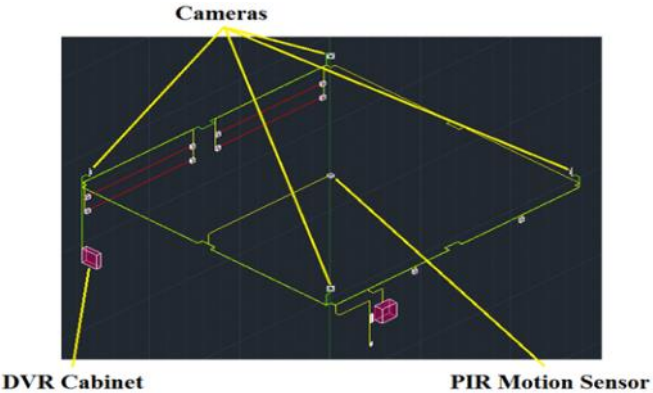

Figure 5. Inside view of the CvSU Data Center

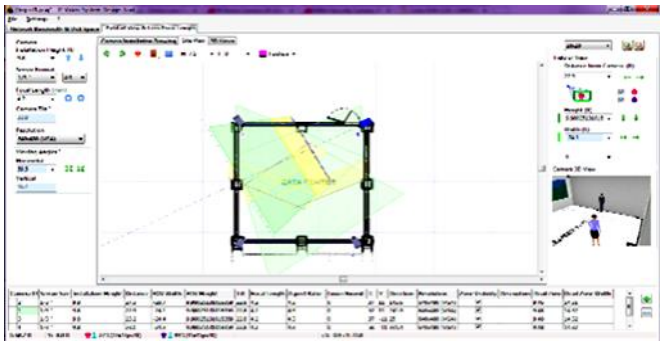

Figure 6. IP Video System Design Tool Application

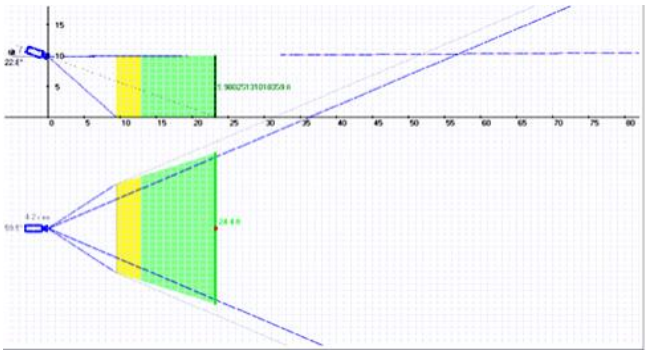

Figure 7. Camera height installation, tilt and viewing angle

placed in a cabinet with lock to avoid stealing of the recorded video.

The four through-beam sensors were placed strategically. There were equal distances between the two sensors (on two windows) that ensure the detection of the intruder. The passive infrared (PIR) motion, tri-axis, magnetic sensors and the solenoid lock were placed according to the proposed design.

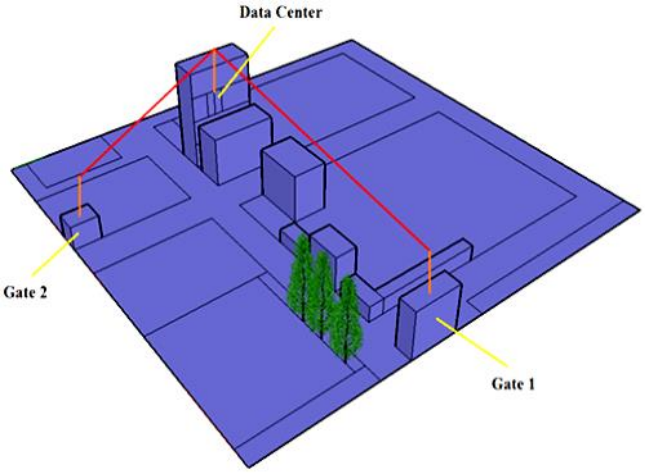

Figure 8. Transmission and reception view from the Data Center to the Gates 1 and 2 of CvSU

Developing the Software of the System

The study used a Gizduino microcontroller which is the brain where the program for the operation of the security system is located. It has the capability to control all the sensors that were used. The software used in programming the security system is C programming language which is the language of Arduino.

RESULTS AND DISCUSSION

Presentation of the Design and Installation

The height of the room is 3.33 meters and the width and length is 7 meters (Table 1). The sensors that were installed are the light dependent resistor and laser, tri-axis accelerometer, mini PIR motion sensor and

Table 1. Dimensions of the installed Security System for the Data Center, in meters

DIMENSION OF ROOM, FIXTURE AND CABINET	HEIGHT	LENGTH	WIDTH
Data Center	3.33	7.00	7.00
Sensors Cabinet	0.27	0.27	0.13
DVR Cabinet	0.33	0.28	0.13
Back Windows	1.20	3.00	---
Front Glass Window (1)	1.24	1.60	---
Front Glass Window (2)	1.24	3.07	---
Door	2.07	0.90	---

magnetic door contact detector. The light dependent resistor and laser were installed on the back windows. The laser served as the transmitter and the LDR serve as the receiver. It has a length of 2.96 meters and a height of 1.2 meter and each window has two pairs of it. The tri-axis accelerometer was installed on the front glass windows that have a height of 1.24 meters and length of 1.6 and 3.07 meters. The mini PIR motion sensor was installed on the center ceiling of the room with a height of 2.39 meters. The magnetic door contact detector was installed on the door that has a height of 2.07 meters and a width of 0.90 meter. The sensors cabinet has a height of 0.27, width of 0.13 and length of 0.27 meter. The cameras were installed on four corners of the room with a distance of 6.5 meters. Its DVR was installed on the left side of the room with a cabinet that has a height of 0.33, width of 0.13 and length of 0.28 meter.

The Zigbee transmitter was installed on the rooftop of the building with a height of 15 meters from the ground. It will transmit the signal to the receivers on Gate 1, that was installed with a height of 5 meters and a total distance from the transmitter of 352.05 meters, and in Gate 2 that was installed with a height of 5 meters and a total distance from the transmitter of 107.14 meters.

System Flow

The Security System aims to protect the Data Center from intruders using different sensors and modules that are connected to the Gizduino microcontroller. Figure 9 shows the interconnection of modules and sensors to the microcontroller.

The through beam sensors, tri-axis accelerometer and magnetic door contact detector detect the intrusion. Any of these when interrupted would send the signal immediately to the Zigbee Transmitter then sends it to the receivers in Gates 1 and 2. The Global System Mobile (GSM) module would send the alarming message to the authorized person through text.

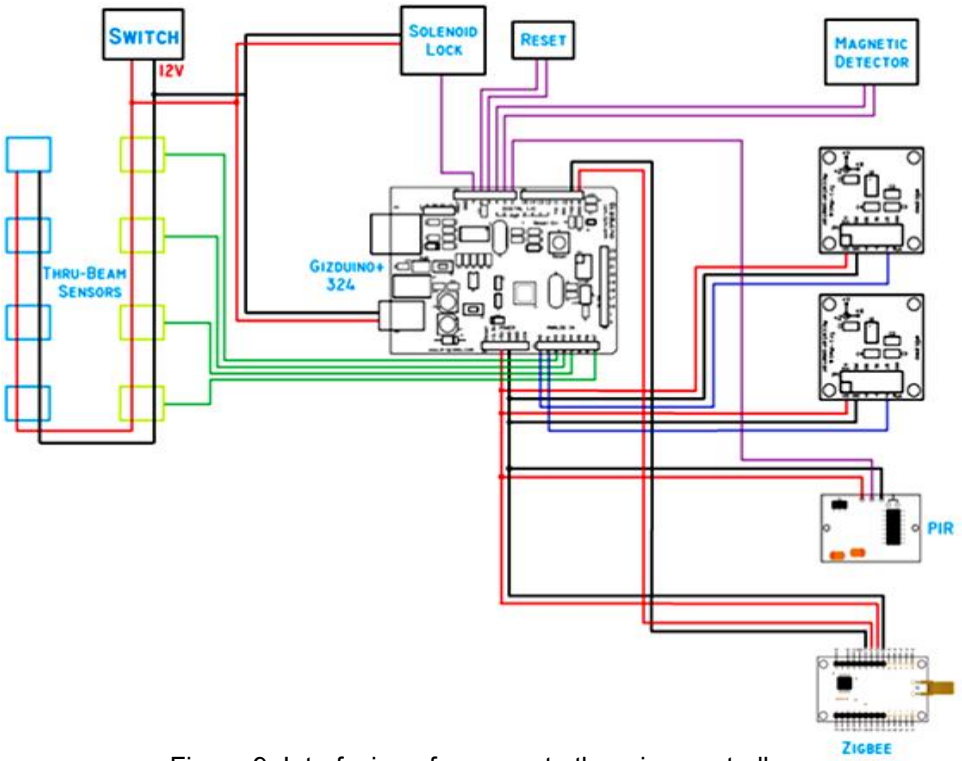

Figure 9. Interfacing of sensors to the microcontroller

The mini PIR motion sensor would trap the intruder inside by sending the signal to the solenoid lock installed on the door. This entrapment is only possible if and only if the intruder enters the room using the door.

The infrared (IR) dome cameras have their own sensing ability that when they sense an intruder inside, the recording of the DVR would turn on. The screenshots of the cameras are shown in Figure 10.

The locking mechanism of the system is composed of a conventional solenoid - a wire coil that is magnetized when paired with an electric current made to lock the door. The coil is small enough to fit into a lock, where it keeps the locking mechanism from moving unless an electromagnetic force is used to gain access. The solenoid would lock automatically when the microcontroller detects the movement of the intruder inside the Data Center using the motion sensor. The door would be unlocked by pushing the reset button. A reset button is used to reset the whole system. The guards on duty or the authorized person can push the reset button to activate and deactivate the alarm once the intruder is already trapped inside the Data

Figure 10. Sample screen shots from the cameras

Center. The reset button located in a secure cabinet would unlock the solenoid door for the authorized person to get inside the Data Center and get the intruder. Only authorized persons that hold the key to the secure cabinet are capable of turning the system on or off.

Software Development

Since Gizduino was used as the microcontroller, Arduino application was utilized to program the operation of the security system. This has the capability to control all the sensors used. It used C language to input codes.

All the sensors, namely: the glass breaking sensors, through beam sensors, motion sensor and magnetic door lock sensor were interfaced on the microcontroller. These input sensors were calibrated to obtain the desired output by different means. For the calibration of the glass breaking sensor, it was set having a threshold value pf 819 counts/g which came from its test specification. The through beam was assigned to have a set point of 250 depending on the receiver's sensitivity requirement and its distance to the transmitter.

The glass breaking sensors, magnetic door lock sensor and the thru beam sensors were set to send the alarm signal to the GSM and Zigbee while the motion sensor was set to send a high signal to the solenoid lock.

Performance of the Security System

To evaluate the performance of the system, 30 participants were chosen. The evaluators were composed of faculty members, security personnel, Data Center personnel and students. It was evaluated using three parameters that include security measures, data transmission and security system or overall performance. The results of testing and evaluation of the design were as follows:

Tables 2 and 3 show the perception of the participants on the system based on security measures and data transmission, respectively.

Table 2. Assessment of the participants on the security measures of the system

SECURITY MEASURE		PARTICIPANT N= 30	PERCENTAGE (%)
1. Do through beam sensors send alarm when interrupted?	Yes	30	100
2. Does the solenoid lock function when the motion sensor senses an intruder?	Yes	30	100
3. Do the glass break sensors send alarm when interrupted?	Yes	30	100
4. Does magnetic sensor send alarm when the door opened?	Yes	30	100
5. Does the camera capture the whole room?	Yes	30	100

Table 3. Assessment of the participants on the data transmission of the system

SECURITY MEASURE		PARTICIPANT N=30	PERCENTAGE (%)
1. Is the alarm signal successfully transmitted to gate 1?	Yes	30	100
2. Is the alarm signal successfully transmitted to gate 2?	Yes	30	100
3. Does the GSM successfully send an SMS?	Yes	30	100

The Likert scale was used as reference in interpreting evaluation as follows: 4.5 - 5.0 for Excellent, 3.50 - 4.49 for Very Good, 2.50 - 3.49 for Good, 1.50 - 2.49 for Fair, and 1.00 - 1.49 for Poor.

Table 4 shows the average perception of the respondents on the system based on its overall performance. The table shows that the total calculated mean was 4.547 with standard deviation of 0.558.

Based on the results, the technicality and performance of the device was approved and accepted by participants by giving an overall rating of "Excellent". The Security System received a positive feedback from the evaluators thus making it applicable for the Data Center.

Total Cost Computation

Table 5 shows the list of all materials used with their quantity, description, unit price and total price incurred. The total cost of the system is PhP22,329.00.

Table 4. Assessment of the participants on the overall performance of the system

SECURITY SYSTEM	MEAN	SD	INTERPRETATION
1. Is the data center efficiently secured?	4.6	0.626	Excellent
2. Does the security system function well?	4.4	0.498	Very Good
3. Are the cameras installed strategically?	4.7	0.466	Excellent
4. Are the sensors installed properly?	4.5	0.629	Excellent
5. Are the sensors interfaced properly in the microcontroller?	4.5	0.571	Excellent
AVERAGE	**4.547**	**0.558**	**Excellent**

Table 5. Price list of the materials used

DESCRIPTION	QUANTITY (pc)	UNIT PRICE (PhP)	TOTAL PRICE (PhP)
A. Main Components and Power Supply			
Gizduino+ (ATMega324)	1	735.00	735.00
GSM module	1	2,225.00	2,225.00
Zigbee	3	1,550.00	4,650.00
Buzzer	2	50.00	100.00
AC/DC adapter (12V/2A)	1	180.00	180.00
AC/DC adapter (12V/500mA)	2	150.00	300.00
Switch	1	30.00	30.00
Reset button	1	15.00	15.00
B. Sensors			
Tri-Axis accelerometer	2	485.00	970.00
PIR motion sensor	1	378.00	378.00
Magnetic door contact	1	80.00	80.00
Solenoid lock	1	1,500.00	1,500.00
Light dependant resistor	4	10.00	40.00
Laser	4	25.00	100.00

Table 5. Price list ... *cont'd*

DESCRIPTION	QUANTITY (pc)	UNIT PRICE (PhP)	TOTAL PRICE (PhP)
C. CCTV AND DVR			
4-channel DVR with cameras	1	3,990.00	3,990.00
1TB hard disk drive	1	3,600.00	3,600.00
D. Other materials			
**INSTALLATION*			
200 m telephone cable	1	940.00	940.00
5 m connecting wire	1	20.00	20.00
Electric stool	6	110.00	660.00
Cable ties	10	1.00	10.00
**CARPENTRY*			
Drawer lock with keys	2	85.00	170.00
48x48 in. 3/4 Plywood	1	200.00	200.00
1/2x2x10 in. wood	2	34.00	68.00
1/2 kg. finishing nails	1	40.00	40.00
3/4 nails	1	5.00	5.00
Screw	5	3.00	15.00
Sand paper	2	20.00	40.00
Stikwell	1	40.00	40.00
**MISCELLANEOUS*			
SIM card	1	30.00	30.00
Resistors 10 ohms	4	1.00	4.00
Resistors 10k ohms	4	1.00	4.00
Resistors 1k ohms	4	1.00	4.00
7805 voltage regulator	2	15.00	30.00
ULN2802 relay driver	1	23.00	23.00
DC jack	2	5.00	10.00
RJ22	8	12.00	96.00
RJ25	8	15.00	120.00
PC101 PCB	1	10.00	10.00
Glue stick	1	5.00	5.00
Shoes glue	6	15.00	90.00
Double sided tape	1	35.00	35.00
Sintra board	1	350.00	350.00
Cutter	1	20.00	20.00
Scissor	1	15.00	15.00
Soldering lead	1	350.00	350.00
Electrical tape	2	16.00	32.00
TOTAL			**PhP22,329.00**

CONCLUSION AND RECOMMENDATION

The developed security system was successfully designed and installed. The microcontroller circuit of the project was successfully developed and the expected design of the security system was properly installed and constructed. With the help of IP Video System Design Tool Application, the cameras were installed according to the desired placement where the whole room can be captured. The Zigbee transmitter was placed properly at the rooftop of the DIT building where the Data Center is located. It can successfully send alarms to both receivers which are placed at the guard houses of Gates 1 and 2 of the campus. The messages were also sending successfully via the GSM module. Likewise, the input modules such as tri-axis accelerometer, through-beam sensors, PIR motion sensor, solenoid lock, and magnetic door contact were installed on their desired position and successfully interfaced on the microcontroller unit. The program necessary for the security system was developed using Arduino programming with C language.

The 4-Channel DVR has a recording capacity of 1 terabyte. An hour recording consumes 200 megabytes. Therefore, it can record up to 208 days (continuous recording).

Thirty respondents rated the security system excellent based on its overall performance. Further studies in order to improve the system is recommended; that is, there should be a password mechanism in turning on or off the system. Instead of a locked cabinet wherein anyone with access to the key can reset the system, a password that proves the identity of the authorized person would significantly improve the security of the system. Likewise, an evaluation of the recording of the DVR when the sensors are triggered should be added in the evaluation questionnaire. Recording of DVR when the system is triggered was evaluated technically by multiple simulation of a burglary event but this was not included in the questionnaires.

The total cost of PhP22,329.00 is lower compared to commercially available systems. The developed system has wireless sending of alert signal which makes it more technologically advanced than its commercially available counterpart.

LITERATURE CITED

Afridi, M. I., Faisal, S., Ud, H., Bangash, D., Qazi, E., & Ali, W. (2012). GSM based smart distribution system. *International Journal of Electrical and Computer Engineering (IJECE)*, *2*(5), 589-596.

Arboleda, E. R., Alegre, M. C. T., & Idica, K. F. (2015). Development of a low-cost electronic wheelchair with obstacle avoidance feature. *Journal of Mechatronics, Electrical Power, and Vehicular Technology*, *6*(2), 89. doi:10.14203/j.mev.2015.v6.89-96

Ausilio, A. D. (2012). Arduino: A low-cost multipurpose lab equipment. *Behavioral Research*, (October 2011), 305-313. doi:10.3758/s13428-011-0163-z

Badamasi, Y. A. (2014). The working principle of an Arduino. In *Electronics, Computer and Computation (ICECCO), 2014 11th International Conference*.

Boiko, A., & Shendryk, V. (2017). System integration and security of information systems. *Procedia Computer Science*, *104* (December 2016), 35-42. doi:10.1016/ j.procs.2017.01.053

Bykovyy, P., Kochan, V., Sachenko, A., Aksoy, S. & Markowsky, G. (2012). Security network interface for alarm systems. *Computer Standards and Interfaces*, *34*(6), 468-475. doi:10.1016/j.csi.2011.10.013

Cero, C. D. L., Ala, K. J. L., & Arboleda, E. R. (2018). Android application for microcontroller -based reservoir water level monitoring. *Indonesian Journal of Electrical Engineering and Informatics (IJEEI)*, *6*(1), 79-85. doi:10.11591/ijeei.v6i1.338

Chang, C., & Chang, Y. (2013). Application of abnormal sound recognition system for indoor environment. In *2013 9th International Conference on Information, Communications & Signal Processing*. doi:10.1109/ICICS.2013.6782772

Chen, D. & Wang, M. (2006). A home security zigbee network for remote monitoring application. In *ICWMMN2006 Proceedings* (pp. 1-4).

Erden, F., Ziya, A. & Enis, A. (2015). A robust system for counting people using an infrared sensor and a camera. *Infrared Physics & Technology*, *72*, 127-134. doi:10.1016/j.infrared.2015.07.019

Frankiewicz, A. & Cupek, R. (2013). Smart passive infrared sensor - Hardware platform. In *Industrial Electronics Society, IECON 2013 - 39th Annual Conference of the IEEE* (pp. 7543-7547).

Huang, H., Xiao, S., Meng, X. & Xiong, Y. (2010). A remote home security system based on wireless sensor network and GSM technology. In *2010 Second International Conference on Networks Security, Wireless Communications and Trusted Computing*. doi:10.1109/NSWCTC.2010.132

Mahfuth, A., Yussof, S., Baker, A. A., & Ali, N. A. (2017). A systematic literature review: Information security culture. In *5th International Conference on Research and Innovation in Information Systems: Social Transformation through Data Science, ICRIIS 2017* (pp. 1-6). doi.org/10.1109/ICRIIS.2017.8002442

Morshed, N. M., Muid-Ur-Rahman, G. M., Karim, M. R. & Zaman, H. U. (2015). Microcontroller based home automation system. In *Proceedings of 2015 3rd International Conference on Advances in Electrical Engineering* (pp. 101-104).

Paulite, Y. V. P., Carandang, N. J. C., & Arboleda, E. R. (2018). Smart wheelchair with dual control using touchpad and android mobile device. *Indonesian Journal of Electrical Engineering and Informatics (IJEEI)*, *6*(1), 86-96. doi:10.11591/ijeei.v6i1.342

Poirier, D. C., & Vishnubhotla, S. R. (1990). A microprocessor-controlled door lock system. *IEEE Transactions on Consumer Electronics*, 129-136.

Sabeel, U., & Chandra, N. (2013). An ingenious wireless home security system standard, magnetic contact and PIR sensor. *International Journal of Modern Education and Computer Science*, (September), 50-59.

Safaric, S., & Malaric, K. (2006). ZigBee wireless standard. In *48th International Symposium ELMAR-2006* (pp. 7-9).

Sari, P. K. (2015). Measuring information security awareness of Indonesian smartphone users. *Telecommunication, Computing, Electronics and Control TELKOMNIKA*, *12*(2), 493-500. doi:10.12928/TELKOMNIKA.v12i2.2015

Teng, T. T., Sze, L. T., & Yeng, O. L. (2016). Abnormal sound analytical surveillance system using microcontroller. In *2016 IEEE 12th International Colloquium on Signal Processing & Its Applications (CSPA)*.

von Solms, R., & van Niekerk, J. (2013). From information security to cyber security. *Computers & Security*, 2-7. doi:10.1016/j.cose.2013.04.004

Xu, S. Q. (2013). Design of intelligent alarm system based on GSM network Shun Qing XU. *Applied Mechanics and Materials*, *373-375*, 1578-1582.

Yoannan, S. N., Vaipicherry, V. T., Thankachan, D. K., & Tripathy, R. P. (2013). Security system based on ultrasonic sensor technology. *IOSR Journal of Electronics and Communication Engineering (IOSR-JECE)*, *7* (6), 27-30.

Younker, J. T., & Ribaric, T. (2013). Beyond open source software: Solving common library problems using the open source hardware Arduino platform. What is Arduino? *Partnership: The Canadian Journal of Library and Information Practice and Research*, *8*(1), 1-16.