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Grouped Classroom Controlling System Using Ethernet Module

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Abstract: This study aims to introduce a building control system which is able to handle a huge number of electrical equipments. The proposed method is named grouping building control systems and was implemented to classroom. The unique point is that a school has a huge number of classrooms which could be grouped in separated buildings. In order to deal with this situations, the idea of grouping controllers might be able to reduce wiring complexity and conform the number of port connections in hardware controlling system. When the system is implemented to classrooms it would be used by a lot of users. Furthermore, maintenance of a huge number of devices should be done regularly. The unique point of the proposed system is that in order to maintain the system a report application could reduce the complexity of maintenance the devices. Considering functionality, the results showed that the system worked as the necessity.

Key words: Building controlling, ethernet, grouping controlling, report application, regularly

INTRODUCTION

Nowadays, power energy saving is considered as a major concern of government planned in the National Energy Conservation Plan (Rencana Induk Konservasi Energi Nasional or RIKEN). One of the targets is to manage electrical usage of buildings and improve the efficiency, since a report showed that public services and residential consume energy higher than the others which grows from 44.1% in 1973-56.9% in 2010 (IEA., 2012).

A home automation is a building which is equipped with a technology to monitor and control the use of electrical energy and electronic devices at home to facilitate the user. Nowadays, this technology emerges as a major application to improve the effectiveness in improving energy efficiency where five parameters were identified, that is cost, user need, simplicity, integrity, stability of service and maintenance. In order to support the RIKEN, developing building controller has been studied in the previous research (Sendari *et al*., 2016; Jivani, 2014).

Here, the developed system is built with a micro controller which is used as the main processor to control the system automatically. Here, light sensor and temperature sensor are used to monitor the operation of electrical equipment. Here, the system can only deal with a small number equipment due to a limit number of micro controller which was used as the controller.

In addressing scalability (Delgado *et al*., 2006), an approach of building controller is proposed it is similar to home automation to monitor and control electrical equipment, however it is advanced by a networking where the whole network is divided into three: data, control and multimedia. It could make the system easier to manage the whole system and allocate them in different areas. Another method to cope a wide area is combination the system with communication media such as GSM (Gupta and Tomar, 2016), Ethernet (Satria *et al*., 2015), Wi-Fi (ElShafee and Hamed, 2012) and smart phone application (Kumar, 2014) so the system can be controlled from a distant.

In order to deal with energy efficiency, there are two meanings of energy efficiency, i.e., better use of energy through energy-efficient technologies (Florax *et al*., 2001) and energy saving through changes of users' awareness and behavior (EEA, 2013). In term of energy efficiency a new technology can be considered as the best technology if it consumes less energy. The problems which could be faced here are as follows. The area could be wide, the system could cover many rooms and many user could monitor and control the situations. Since, the objective of the system is to improve the energy efficiency, the unique point is that some students called class leaders, could also be responsible to maintain the energy efficiency, so, it should be accomplished with plentiful number of users.

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MATERIALS AND METHODS

System analysis

Problem definition: Implementation of a huge number of controlled devices where many users want to access the system, there are four main challenges hat is high-cost development if a wiring system is used, difficulty to achieve security when a lot of users are allowed to access the system; poor manageability of power consumes and inflexibility when changes of classrooms are needed (Florax *et al*., 2011). In order to reduce the complexity of wiring, the use of grouping class system is used. In a class, devices are connected into one group using an existing wiring system while connections between classes and the master control are used a Local Area Network (LAN). Furthermore, the awareness of students in utilizing energy could be an important thing to be obtained so in this system a group class leader should assure that the devices should be switched off when they do not be used.

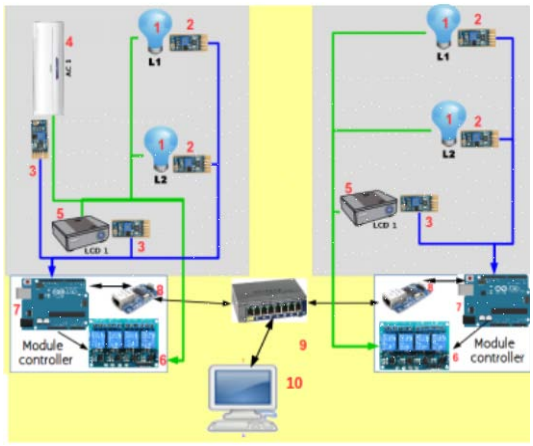

Fig. 1: Layout of the designed system uding group class controlling. 1: LED lamp; 2: Light sensor; 3: Temprature sensor; 4: AC; 5: LCD; 6: Relay; 7: Micro controller; 8: Ethernet modul; 9: Switch/Hub; 10: PC server

System feature and requirements: The proposed system is developed with a master control which delivers control information of group classes. Group classes have function to control local devices placed in each class such as Liquid Crystal Display (LCD) projector, lamps and Air Conditioner (AC). The ON/OFF conditions of those devices are detected using temperature sensor and light sensor. These sensors give a feedback to be processed by micro controller. Indicators will be switched ON/OFF by micro controller regarding the condition of devices called as local control action. This micro controller also send the conditions of the group classes, so users can monitor and control the classroom.

In order to support the mobility of users in campus, a smart phone application based on Android is developed to access the master control. Since, there are many version of Android devices, execution the system should be observed, furthermore. The layout of the designed system using group class controlling is shown in Fig. 1.

System design and implementation: The designed system is presented in this study as follows.

Proposed group class controlling layout: Considering the features and requirements, the system is developed into three parts, i.e., device's interfaces a desktop application, and a mobile application. The devices interfaces have a function to detect whether the device is ON or OFF, return the information to micro controller and get control action from it. Desktop application is an interfacing module, which connects the device's interfaces to PC via. Ethernet. Otherwise, the mobile application is used by user, i.e., students and lecturer to report the problem when the devices could not work properly.

The proposed system is a grouped classroom controlling system which is designed using a star topology to connect each group of classroom to the master control. Here, the group is determined by device interfaces consisting of lamp controller, LCD controller, and AC controller. The device condition whether it is switched ON/OFF is identified using light sensor and temperature sensor.

Hardware design: A micro controller as the main processor in each group should be chosen appropriately considering the controlled-area. When the number of connected-devices is 6-8, Arduino Uno is enough to be used when it is larger, Arduino Mega could be used more appropriately. platform to build interactive electronic controllers (Brush *et al*., 2011).

In order to develop a large controlled-area, connecting a group to others should be used. There are many media could be used to connect a group of controlling system to other. Comparison of those media communication are shown in Table 1.

The ethernet module is selected since the network has been available in campus so the controller can be integrated easily. Ethernet module, ENC28J60 has been

Table 1: Comparison of media communications used Ethernet, Bluetooth and WiFi

Characteristic	Ethernet	Bluethooth	WiFi
Installation	Hard to middle (need cable installation which every PC should connect to the network)	Easy (wireless)	Easy (wireless)
Cost	Low (cable and Switch are cheap)	Low	High (Wireless adapters and accessare expensive enough)
Mobility	Limited (limited to network, indoor only)	Limited (outdoor or indoor)	Wide (can connect anytime and everywhere)
Speed and bandwidth	High (Up to100 Mbps)	Low (25 Mbps)	Low (Up to 54 Mbps on 802.11 g)
Media	Ethernet, coaxial	Radiowave and microwave	Radiowave and microwave
Range	100 m (twisted pair)		
500 m (coaxial)	5-10 m	100 m	
Max user	Unlimited	8	2007
Power consumption	High	Low	Middle

Table 2: Number of controlled-devices

		Number of devices			
Building	Floor	Lamps	AC	LCD projector	Total
G4	G4-1	68	8	6	82
	G4-2	66	9	13	88
	Total	134	17	19	170
H5	H5-2	52	7	9	68
	H5-4	41	0	3	44
	Total	93	7	12	112

Table 3: Network design

Building floor	IP host	No. of host max	No. of available host
G4-1	192.168.11.2-192.168.11.67	65	13
G4-2	192.168.11.68-192.168.11.133	65	13
H5-2	192.168.11.133-192.168.11.198	65	12
H5-4	192.168.11.199-192.168.11.254	59	8

Table 4: Comparison of implementing conventional and grouped classroom method

Character	Conventional	Grouped method
Installation	Middle	Hard to middle (need difficulties PC should connect to the network) cable installation which every
Media	Serial	Ethernet
Cost	Middle	Low
Range	5-10 m	100 m
Max number of devices	Limited to the number of port	Could be extended as computer network controller installed

developed widely as open source application of Arduino. Here, master control works as the main controller where user can access the information using smart phone. The number of devices to be controlled are described in Table 2.

Considering the number of controlled-devices, type of micro controller and position of devices, the system could be grouped into several groups. Here, Arduino UNO is used as the processor while the length of wiring sensors are made as max 15 m. Thus, the number group is designed as 14 group. This number could be appropriate considering the IP host that available as shown in Table 3 and 4.

Detecting the devices whether they are switched ON/OFF is used sensors. Light Dependent Resistor (LDR) sensors are applied to detect lamps while Positive Temperature Coefficient (PTC) sensors are applied to detect LCD projectors and Air Conditioners (ACs).

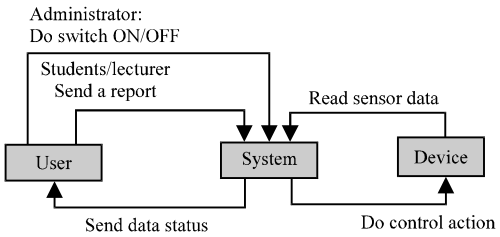

Fig. 2: DFD Level 0 of the proposed system

Software design: Controllers are connected to master control via Ethernet while a user will be able to access the system via master control. The user is divided into two categories, i.e., technician and student. Technician has a privilege to control the devices whilestudents can only monitor and sent report when a trouble is found. This mechanism is designed as Data Flow Diagram (DFD) level 0 as shown in Fig. 2.

The proposed system works involving users, i.e., administration, lecturers and students. While lectures and students can only monitor the device status and send a report if a trouble occur, administrator has a privilege to check the device status and switch them ON/OFF. Here, the system gives a response by sending the device status to the user. Furthermore, system also check the device status continuously and gives action control when user give action to switch ON/OFF.The master control works as explained in the flowchart shown in Fig. 3 which is implemented as a desktop application. On the other hand, the user can access the system using smart phones in order to support their mobility in campus. The application for smart phones is developed, so, the user can monitor the status of devices and send reports when problem were found, however, only admin is the user who can switch ON/OFF the devices.

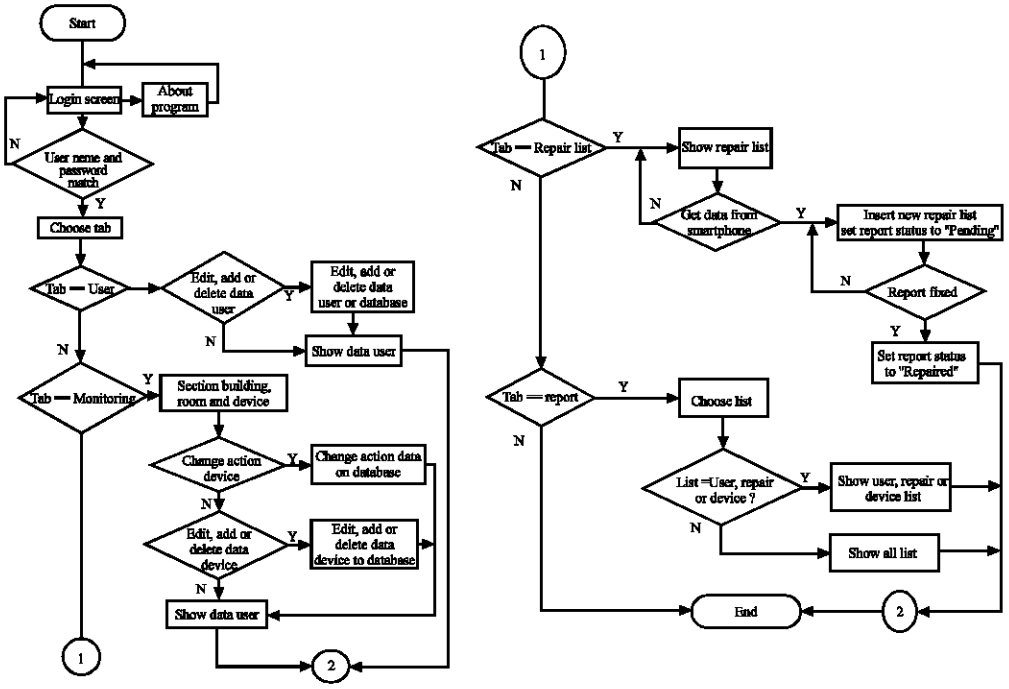

Fig. 3: Flowchart of master control

RESULTS AND DISCUSSION

Implementation was realized by developing a prototype which is named Monitoring System for Learning Equipment (MOSYLE). The desktop application has been developed using Lazarus application (Lazarus, 1993) it has four menus, i.e., user monitoring, report and repairing list.

Implementation this system could be done by extended the conventional method as shown in previous research 6. The grouped classroom method has advantages based on the comparison of conventional and grouped classroom method as shown in Table 4.

Application MOSYLE for smart phone was developed using MIT App. Inventor 16. Here, the user is divided as student/lecturer and admin who are able to monitor and send report while switching ON/OFF devices can be done by admin only. This process is shown in Fig. 4.

Control actions which are done via desktop and smart phone applications are shown in Table 5. Here, the system is checked by executing control action via both of those applications and the results are checked via. sensor feed-backs. From 20 trials, the system shows the sensor feedback give the same respond as the control action given.

This application also has been tested to several smart phone brands to observe whether, the application could be accessed successfully. The result is shown in Table 6 where the average error is 0.36.

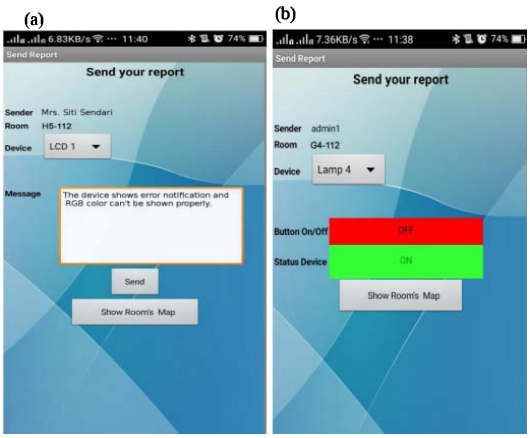

Fig. 4: Smart phone Application of MOSYLE: a) Monitoring and sending report of user lecturer/students and b) Controlling device by admin

Table 5: Controlling device via desktop and smart phone application

	MOSYLE desktop				MOSYLE mobile			
	Control action		Sensor feedback		Control action		Sensor feedback	
Devices	ON	OFF	ON	OFF	ON	OFF	ON	OFF
Lamp 1	ON	OFF	ON	OFF	ON	OFF	ON	OFF
Lamp 2	ON	OFF	ON	OFF	ON	OFF	ON	OFF
LCD 1	ON	OFF	ON	OFF	ON	OFF	ON	OFF
AC1	ON	OFF	ON	OFF	ON	OFF	ON	OFF
Lamp 3	ON	OFF	ON	OFF	ON	OFF	ON	OFF
Lamp 4	ON	OFF	ON	OFF	ON	OFF	ON	OFF
LCD 2	ON	OFF	ON	OFF	ON	OFF	ON	OFF
AC2	ON	OFF	ON	OFF	ON	OFF	ON	OFF

Table 6: Tested result of MOSYLE using several smart phone brand

Brand	Error (%)	Successful (%)
LG L60	0.00	100.0
Samsung Galaxy V Plus	2.53	97.47
Lenovo A516	0.00	100.0
Oppo F1	0.00	100.0
Oppo	0.00	100.0
Sony M Dual	0.00	100.0
Samsung Galaxy Ace	0.00	100.0
Average	0.36	99.68

CONCLUSION

As the result of this study a building control system is used to handle a huge number of electrical equipment with some conditions such as the building could connect with Ethernet or wire connections and the length of wiring sensors max 15 m to reduce data loss. System controller developed into three parts, i.e., micro controller, relay module, sensor module and Ethernet module. System control device's switch power source and read device's conditions which were sent by sensor modules. Device's error report could handle better with developed software system. User could send error message to technicians by using smart phone. Each part of system tested by error handling and functional testing. All parts could work as the necessity with a small error value.

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