RFID for nurse activity monitoring in the hospital's nurse call system with Internet of Thing (IoT) concept

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Abstract. The hospital nurse call system is a system found around a hospital bed that allows patients in health care to call nurses or other health care staff remotely about their need for assistance. When the button is pressed, the signal tells the staff at the nurse station via a voice signal, and usually the nurse or nurse assistant responds to the call. Today it has created many nurse call systems that are considered efficient both with the concept of wireless and cable. Artifical equipment that has standard facilities and complete facilities. But this tool only emphasizes how patients call nurses, without thinking about how the quality of nursing services responds to each call. The purpose of this study is to develop an RFID-based nurse call system with the internet of things (IoT) concept. The system allowed nurses can respond to every call from the patient without the patient or family the patient comes to the nurse station, also the hospital executive can get a report on the quality of nursing services, in the form of reports on the number of calls, the time is taken by the nurse to respond to each call and report who the nurse responds to each patient's call. Thus, the information can be evaluated how the quality of service in the hospital.

1. Introduction
One of the essential things that patient need is Nurse Call system. It is intended for routine communication between the patient and the nursing staff, nurses immediately attend the patient as soon as they hear the call [1]. It is a must-have tool in the hospital for the patient, especially who are unable to move from their bed and not able to call someone loudly [2]. Nurse call system is needed because of the lack of ratio between the nurse and the number of patients, as well as other duties imposed on the nurse outside of her primary duties. According to the Institute for Healthcare Improvement, Nurses spend only between 20-30% of their time in caring for patients directly, the rest to do another task such as documentation and administration (www.amcomsoftware.com). These conditions resulted in a high workload of nurses that can lead to lower levels of patient satisfaction because nurse care to patients to be less optimal and nurse satisfaction that provides care [3].

The development of nurse call system already a lot in hospitals as an effort to improve nurse services, from wiring devices to wireless devices using xbee and Wi-Fi. Problems arising from existing tools, for nurse callers with cables, each button that is installed must use a cable drawn into the nurse room, so you can imagine the more number of rooms/bed of patients, the more cable that must be in the pairs [4]. Other problems of an existing nurse caller device, both wired and wireless devices, the installed tool only emphasizes how the patient or family of the patient calls the nurse and how the nurse knows which patient is calling, regardless of how the nurse's service quality responds to every call and did not consider how to give more time for nurses to take immediate action against patients because there is no need to
document and administer the patient care process. Nurse's quality respond has been discussed in [5], but only discussed the duration of time spent by nurses in handling each patient's call without knowing who the nurse is handling it. Internet of Thing (IoT) generally refers to a network of interconnections between daily devices which are often equipped with the intelligence to support various kinds of control and monitoring. The ubiquity of the Internet will increase by IoT through integrating every device for interaction on network via an embedded system [5]. Nurse call system with Internet Of Thing (IoT) Concept has been developed by Aswin (2011), Sayekti (2013), Majumder (2016), Mahmud (2017) and Mardjoko (2017) [2, 3, 6-8]. The system Sayekti (2013) and Aswin (2011) not used TCP/IP for IoT Concept, it just used Xbee/ZigBee and Bluetooth. The limitation of the system Majumder (2016) the number of clients is limited to 36 clients per server node while the limitation of the system developed by Aswin (2011), Sayekti (2013), Majumder (2016) and Mardjoko (2017) no archive monitoring for system activity's logging. Another connection used for nurse caller communication uses rs-485 [4, 9]. While other studies emphasize how patients call nurses, such as make use of the patient's eye blink [10] and designing the human interface for patients [1].

Existing research except for Mahmud (2017) only emphasizes how patients call nurses and how to connect a client node to a server node, regardless of how the nurse's service quality looks like how long and who responds to every call[6]. But the limitation of Mahmud the system only monitors the duration of how long the response of the nurse without knowing who the nurse is responding to. By utilizing RFID in this paper the system can find out who the nurse is responding to.

With the Internet of Thing (IoT) technology and RFID is expected to solve installation problems on the nurse caller with the concept of cable. In addition, by using RFID to reset the patient's call, can provide information on how much time is spent from the patient start calling the nurse until the nurse takes direct action on the patient and who the nurse is doing the action. The purpose of this study is to develop an RFID-based nurse call system with the internet of things (IoT) concept.

2. Method

2.1. Block diagram of the system

Block diagram of the nurse call system is shown in figure 1. There are several types of nodes in the system. The server node is a Computer web server, the Web server is a software that provides database services using HTTP or HTTPS protocol from the client using a web browser application for data requests and the server will send data in the form of web pages and generally in the form of HTML documents [11]. It’s stored in the nurse station, any data that the web server receives will be uploaded to the database server. Data received web server can be seen on information systems that can be accessed from the PC Admin. In the implementation web server, db server and PC admin can be one Computer.

The client node is bed node and toilet node in each ward, client nodes are end node. This node is used by each patient. Each client node has a 2.4 GHz wifi module connected to the node server directly using the wifi access point. The limited range and limitations of wifi access point access capability can be helped by increasing the number of access points. Every 1 server node can handle simultaneously 253 client if using IP address class C, 65,533 client if using IP addresses class B and 16,777,213 client if using IP address class A. Network diagram of the nurse call system is show in figure 2. Data from the client node from both the bed node and the toilet node are the same, but the server will distinguish calls from the bed or toilet, whenever a patient presses a button from the toilet node, it indicates an emergency alert. And when the alert is generated from bed node it indicates a normal call for assistance or medication etc. the data that the client node sends to the server node is distinguished from the IP address of each client node. The client node has no time data, to determine when the patient calls and when the respond nurse is determined from the data receiving time by the server node. Each call made by the patient must be reset by tapping the nurse's RFID card to the client node, this process to determine how long and which nurse is responding to. Log data system activity can be seen in the PC admin information system.
2.2. Flowchart of the system
Flow diagram of the system is shown in figure 3. The system starts from patient push the button in client node. Client node will send call data status to the server node (web server). The data received by the node server will be identified from the client node where it came from. The identification is specified from the IP address of the sending node. The identification results determine where the position and type of client node. A call from the bed node will be considered a normal call and from the toilet, node will be considered an emergency call. Once the data is identified, the system will alert the nurse, there is a call from the patient, by displaying the space number, the bed/toilet number and the type of call on the monitor screen and the alarm sound on the pc speakers.
After a warning alert of the patient’s call, the nurse approaches the patient’s room, upon arrival, the nurse taps his RFID card to stop the call alert. Patient activity pressed call button and nurse stuck RFID card in stored on server. Log data can be viewed and analyzed by the executive of the hospital.

![Figure 3. Nurse call system BPMN.](image)

### 3. Results and discussion

#### 3.1. Circuit analysis

Client node consists of several components. Among them, wemos D1 mini board is the heart of the system. Wemos D1 mini board consists of a ESP-8266EX microcontroller, ESP-8266EX is a microcontroller runs at 80MHz/160MHz clock speed. Wemos D1 mini board has 1 analog input, 1 micro USB Connector and 11 digital input/output pins that have interrupt, PWM, i2c and one wire supported in all pins except D0. It also compatible with Arduino, NodeMCU and MicroPython.

Figure 4 show each child node consists of Wemos D1 mini board, one RFID reader RS-522.1 Green LED for Network Status indicator, 1 RED LED for patient call status indicator, 1 momentary switch for patient button and relay module to communicate with room light signal node. Except for toilet node it also has buzzer module to give an audio signal for the patient family if something happens with the patient in toilet, it is shown in figure 5.
3.2. Hardware implementation

The hardware created is a nurse caller tool on the client node. As in figure 6, the hardware is mounted a momentary button that can be in the patient's press if it requires nursing care. To reset the call, the nurse must tap the RFID tag using a 13.56Mhz RFID card with an RS-522 reader connected to the SPI method with the MCU. The MCU used is a Mini D1 wemos. The designed hardware could have added a Shield Battery module so that when the power fails, the system can still function or use a centralized UPS in the nurse's room as a power backup.

3.3. Output analysis

The data stored in the db server is what time the patient calls the nurse and what time and who the nurse responds to the call, figure 7 describes the log data displayed in table form with the content from which the patient is calling (Client Node), the time data the call is made by the patient (Call Time), the time data the nurse's response was done (Response Time) and who the nurse who handles the call (Nurse).

Data stored in the database can be used for executive information systems (EIS) that can display information about how often the patient calls, how long and how much time is needed by the nurse to...
respond to each patient's call, and who the nurse is responds to the call. So it is known how the performance of each nurse in doing treatment to the patient.

![Dashboard](image)

**Figure 7.** Implementation of server node.

Table 1 presents data on the difference in facilities from the nurse call system with the concept of Internet of things (IoT) which uses an IP address to transfer data from client to server.

| No | Author                  | Concept          | Client         | Log Duration | Nurse Log |
|----|-------------------------|------------------|----------------|--------------|-----------|
| 1  | M. A. Majumder [2]      | IoT, IP          | 36 Client      | No           | No        |
| 2  | M. S. Mahmoud [6]       | IoT, IP Based IP Class | Yes         | No           |
| 3  | This paper              | IoT, IP Based IP Class | Yes        | Yes          |

4. Conclusion

The nurse call system is an important tool for every hospital. The nurse call system is designed not only to have a facility to call the nurse but to record when the patient calls the nurse and who the nurse is responding to each call. The data stored on a node server in the form of MYSQL database application can be used to create an executive information system that serves to analyze how the quality of nurse respond to each patient call. Utilization of IoT concept can answer the difficulty of installation of the system if using cable and can add a significant number of client node connected. The system created designed client node can directly store data to the server without using additional hardware, so the data store performance is not interrupted by the data storage hardware capability. There are many improvements that can be made in this system such as adding human interface interface in the form of a menu that lists the types of calls according to the needs of the patient so that nurse services to patients will be faster because it comes with the preparation according to the needs of patients, add blue code warning, warning if node client lose connection etc.

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