Integrated application design to facilitate effective and safe student pick-up process by utilizing microcontrollers, socket TCP, and client-server database

D Suprianto¹*, D W Wibowo¹, A Setiawan¹ and R Agustina²

¹ Information Engineering Department, State Polytechnic of Malang, Malang, Indonesia
² Science & Technology Department, Universitas Kanjuruhan Malang, Malang, Indonesia

*dodit.suprianto@polinema.ac.id

Abstract. Long queues during student pick-up are a major problem in some elementary schools and kindergartens. Sometimes parents don't find their children in school because they may be buying food, being in class or playing in a large school area, so their parents have to wait for a long time for their children to go out to the gate. Conversely, sometimes parents are late in picking up their children, which causes the school to keep students from leaving school without the permission of the teacher or officer, and they also have to ensure that all students have returned to their homes. Parents' complaints about this pick-up problem are a serious concern for the school. Moreover, the news of the kidnapping of children aged 4-12 years (the crime of trafficking) will worry all parties. This study aims to design integrated applications by utilizing RFID, Microcontroller, Socket TCP, Text to Speech, Client Server and Database as a student pickup model by parents as registered RFID cardholders. Based on the identification of the parent RFID card that is read by the RFID reader sensor and matched with the data in the database, then the application will automatically call the name of the student according to his RFID through the technique of text to the speech voice synthesizer. The method of developing applications using Waterfall. The results of implementing this application system show that the performance accuracy of 90% can be used properly.

1. Introduction
This study aims to design an integrated application for picking up students by parents in school safely and effectively by combining hardware and software technology, including the Arduino Microcontroller, RFID, Socket TCP as a communication protocol and a client-server database programmed with language C# .NET.

1.1. Microcontroller Arduino
The Arduino concept of open source hardware was developed by the visionary Arduino team. The team’s goal was to develop a line of easy-to-use microcontroller hardware and software such that processing power would be readily available to everyone (Examples of Arduino Microcontrollers are UNO, Nano, Mega 2560 and others) [1,2].
Arduino microcontroller takes ID / TAG stored in each RFID card through reading the RFID reader sensor module (MFRC522), then sends it to the server for further processing via the ENC28J60 Ethernet module. Data transmission uses the Socket TCP protocol. The Arduino microcontroller also produces an output string to the I2C LCD1602 module when it gets feedback from the server.

Figure 1. Flow of the main task of the Arduino microcontroller.

1.2. RFID card & RFID card reader
RFID is generally characterized by use of simple devices on one end of the link and more complex devices on the other end of the link. The simple devices (often called tags or transponders) are small and inexpensive, can be deployed economically in very large numbers, are attached to the objects to be managed, and operate automatically. In general, RFID TAGs are in the form of cards or key chains [3]. While the TAG RFID reader can be an RFID module that is connected to an Arduino Microcontroller or a USB RFID Reader that is connected to a computer. Therefore, RFID technology has been adopted to facilitate the collection and sharing of data in a warehouse environment. However, an essential decision should be made on the type of RFID tags the warehouse managers should adopt, because it is very important to implement RFID tags that work in warehouse environment [4].

Figure 2. RFID keychain.  Figure 3. RFID card

Figure 4. RFID reader module.  Figure 5. USB RFID reader.

There are two different pairs of RFID TAGs that will be registered into the database, each will be held by parents and students. The two RFID TAGs will be corresponded to each other as proof of the validity of the relationship between students and parents.
1.3. Socket TCP protocol
A socket is an abstraction through which an application may send and receive data, in much the same way as an open file allows an application to read and write data to stable storage. A socket allows an application to “plug in” to the network and communicate with other applications that are also plugged in to the same network. Information written to the socket by an application on one machine can be read by an application on a different machine, and vice versa [5,6].

Data transmission that occurs between the Arduino Microcontroller and the Server uses Socket TCP. Both types of devices are connected based on IP addresses, provided all IP devices must have the same IP network, for example 192.168.1.1/24.

2. Method
To develop this product, we use R&D method. This section is a brief explanation of system design, interface design and program code snippets in client-side and server-side.

2.1. System architecture
The system architecture that is built is shown in figure 9, which is divided into 3 parts:

- **RFID Cards** (figure 5 and figure 6), 2 RFID cards held by students and parents, the two RFID TAGs correspond to each other as a pickup legality requirement. RFID TAG data will be stored in the database.

- **Device Controller**, consists of an RFID Reader sensor (figure 6. RFC522) to read RFID TAG, the Arduino Microcontroller as the main controller, Ethernet (Fig 10. ENC28J60) to transmit data to the server or vice versa, and an I2C LCD module to display messages from server applications automatically.

- **Server**, as a process controller, communicates data between server-side (computer) and client-side (microcontroller) or vice versa, RFID card registration application with USB RFID Reader (figure 7), manages a database, and automatically calls to students by converting text to voice calls (text to speech) according to TAG / ID RFID cards received from the microcontroller when pickup occurs.
Figure 9. System architecture.

Figure 10 is the flow of the RFID card registration process to be stored in the database, this activity is ideally done once. Figure 11 is the process of picking up students by parents using an RFID card.

2.2. Client side
In this section we will explain briefly about system design and interface design on the client side.

2.2.1. Design system. Data communication between Arduino Microcontroller with Ethernet module (ENC28J60) and RFID module (MFRC522) using the SPI interface (Serial Peripheral Interface), which is Arduino as the SPI master and the other two modules as SPI slave [7].
Figure 12. Sketching an Arduino microcontroller, RFID and Ethernet module.

Table 1. Wiring between Arduino and others modules (MFRC522 and ENC28J60 module).

| Arduino UNO Board | MFRC522 Module | ENC28J60 Module |
|------------------|----------------|-----------------|
| D9               | RST            | NC              |
| D10              | SS/SDA/RX      | CS/SS           |
| D11 - MOSI       | MOSI           | SI/ST/MOSI      |
| D12 - MISO       | MISO/SCL/TX    | SO/MISO         |
| D13 - SCK        | SCK            | SCK             |
| VCC 3.3V         | VCC            | VCC             |
| GND              | GND            | GNX             |

2.2.2. Microcontroller programming. The Arduino microcontroller contains a program code for reading RFID TAG cards when an RFID card is brought close to an RFID sensor (module MFRC522), then sends the TAG data to the server via Ethernet (module ENC28J60) using TCP sockets. On the TCP socket microcontroller works two directions, including sending TAG data to the server and receiving text responses from the server to display to the LCD. This means that the microcontroller acts as the sender and recipient of data.

2.3. Server side
In this section we will explain briefly about system design and interface design on the server side.

2.3.1. Design interface register RFID. The student registration application is responsible for managing student data, parent data and TAG RFID Card data. The application interface appears in figure 13.

Figure 13. Interface of register RFID card for students and parents.
2.3.2. **Database programming.** On the basis of simple data manipulation considerations, this database application uses a Microsoft Access database with Jet OLEDB access database that is implemented with the C# programming language.

2.3.3. **Socket server.** The server also handles data communication between the microcontroller and the server via socket protocol. The server computer acts as a socket-server set to "Listening" condition. This term ‘socket’ has come from an electricity/phone socket metaphor where sockets acts as interfaces that plug into each other over a network [8].

### 3. Result and discussion

The application was tested using the UAT method involving 50 respondents, divided into 25 parents and 25 students [9]. The following are the results of the scores obtained:

#### Table 2. Testing applications using the UAT (user acceptance test) method.

| Question Task                                      | Score | Sum  | Sum/Resp. | %   |
|----------------------------------------------------|-------|------|-----------|-----|
| 1. Is the application operation responsive?        |       | 182  | 3.64      | 91% |
| 2. Does the RFID card read well?                   |       | 185  | 3.70      | 93% |
| 3. Is the calling of the student's name correct?   |       | 178  | 3.56      | 89% |
| 4. Does the application often experience errors?   |       | 185  | 3.70      | 93% |
| 5. Are Parents/Student assisted by this application? |     | 185  | 3.70      | 93% |
| 6. Are Parents/Student bothered by the system's calling process? | | 180  | 3.60      | 90% |
| 7. Do Parents/Students feel that the system respond quickly? | | 175  | 3.50      | 88% |
| 8. Do Parents/Students need more help to use this system? | | 181  | 3.62      | 91% |
| 9. Do Parents/Students feel safer and more comfortable in the pickup process? | | 181  | 3.62      | 91% |
| 10. Do Parents / Students satisfied with this system? | | 181  | 3.62      | 91% |
| 11. Do Parents/Students feel easy use the RFID system? | | 174  | 3.48      | 87% |
| **Total average**                                  |       | **90%** |

Based on UAT testing on the system that has been applied shows that the performance accuracy of 90% can be used correctly. The results of this study are the same as those carried out by al-naima, that said the system using RFID is efficient, flexible, comprehensive and can be adapted as an attendance system for any institution [10]. Parkash also identified the same result that RFID technology will open new doors to make organizations, companies more secure, reliable, and accurate [11].

### 4. Conclusion

In this study it can be concluded that the application makes it easy for parents or people who have the authority to pick up students (proven by registered RFID cards) effectively, efficiently so as to provide a sense of security and comfort for parents and students in the school pick-up process. Further research on this paper includes: a) The process of picking up parents to students does not use an RFID card but uses the Instagram bot, so the application becomes more practical in its operation; b) RFID cards can be developed into student attendance applications, where attendance reports will automatically be sent to each parent's Instagram.

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References

[1] Herger L M and Bodarky M 2015 Engaging students with open source technologies and Arduino
   *IEEE Integrated STEM Education Conference*

[2] Mukhopadhaya S 2016 Low cost Sensor usability with Arduino UNO

[3] Chetouane F 2015 An Overview on RFID Technology Instruction and Application *IFAC-PapersOnLine* 48(3) 382–387

[4] Hassan M, Ali M and Aktas E 2012 Radio frequency identification (RFID) technologies for
   locating warehouse resources: A conceptual framework *Smart Objects, Systems and
   Technologies (SmartSysTech), Proceedings of 2012 European Conference On 1–20

[5] Xue M and Zhu C 2009 The Socket Programming and Software Design for Communication Based
   on Client/Server *Pacific-Asia Conference on Circuits, Communications and Systems*

[6] Chaudhari R P and Chopade M K 2016 Ethernet based field control module for industrial process
   monitor and control using ATmega328 *International Conference on Communication and
   Signal Processing (ICCSP)*

[7] Maemunah M, Mardhani R 2018 The Architecture of Device Communication in Internet of
   Things Using Inter-Integrated Circuit and Serial Peripheral Interface Method *4th International
   Conference on Science and Technology (ICST)*

[8] Kalita L 2014 Socket programming. *International Journal of Computer Science and Information
   Technologies* 5(3) 4802–4807

[9] Agustina R, Suprianto D 2018 Analysis of Results of Use of Interactive Learning Media Algebra
   Logic with User Acceptance Test (UAT) *SMATIKA Journal* 8 67-73

[10] Al-naima F M and Ameen H A 2016 Design of an RFID-based Students / Employee Attendance
    System Design of an RFID based Students / Employee Attendance System *Majlesi Journal of
    Electrical Engineering* 10(1) 23–33

[11] Parkash D, Kundu T and Kaur P 2012 The Rfid Technology And Its Applications : A Review
    *International Journal of Electronics, Communication & Instrumentation Engineering Research
    and Development (IJECIERD)* 2(3) 109–120