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Identification Systems Project

RFID Application

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Chapter 1

Crucial Information about the project

1.1 General Information

1.1.1 Used technology

We characterize RFID as a remote radio frequency identification system, it is a technology that uses radio waves to transmit data, and power the electronic system called RFID ethics by the reader, in order to directly identify the object. The technique makes it possible to read and sometimes also write an RFID chip. Depending on the design, it allows you to read labels from a distance of up to several dozen centimeters or several meters from the reader antenna. The reading system enables the identification of multiple labels simultaneously in the reading field.

1.1.2 RFID working process

RFID is part of a group of technologies known as Automatic Data Identification and Interception (AIDC). In this case, the AIDC process identifies the scanned objects, collects data about them and enters this data directly into the computer system used with the minimum necessary human intervention. As a standard, the RFID system consists of three elements: an RFID tag or a smart tag, an RFID reader in any form and an antenna. The basic RFID TAG contains an integrated circuit and an antenna that are used to transmit data to the RFID reader. The reader then converts these radio waves into a more usable form of data. The information collected by the tags is then sent via a communication interface to the host computer.

1.1.3 Advantages of RFID

Typical advantages of RFID includes:

- RFID tag and reader should not be in LOS to make the system work.
- Unlike barcodes, tags can store more information. Moreover it follows instructions/commands of reader.
- It provides location to the reader along with its ID.
- RFID technology is versatile in nature and hence smaller and larger RFID devices are available as per application.
- It provides location to the reader along with its ID.
- Data on keycards is usually secure because it takes specialised equipment to read it. This maintainsthe lock system security.
- Tags can be read only as well as read/write unlike barcodes.

1.1.4 Disadvantages of RFID

- RFID devices need to be programmed which requires enough amount of time.
- The external electromagnetic interference can limit the RFID remote reading.
- The coverage range of RFID is limited which is about 3 meters.
- An RFID system can be hacked or bypassed by someone who is tech-savvy, so they are not totally foolproof.
- Just like traditional lock and keys, you can also forget or misplace your keycard

1.2 Java code

1.2.1 Application layout

The RFID application layout was created with usage of the Layout Editor enables you to quickly build layouts by dragging UI elements into a visual design editor instead of writing layout XML by hand. The design editor can preview your layout on different Android devices and versions, and you can dynamically resize the layout to be sure it works well on different screen sizes.

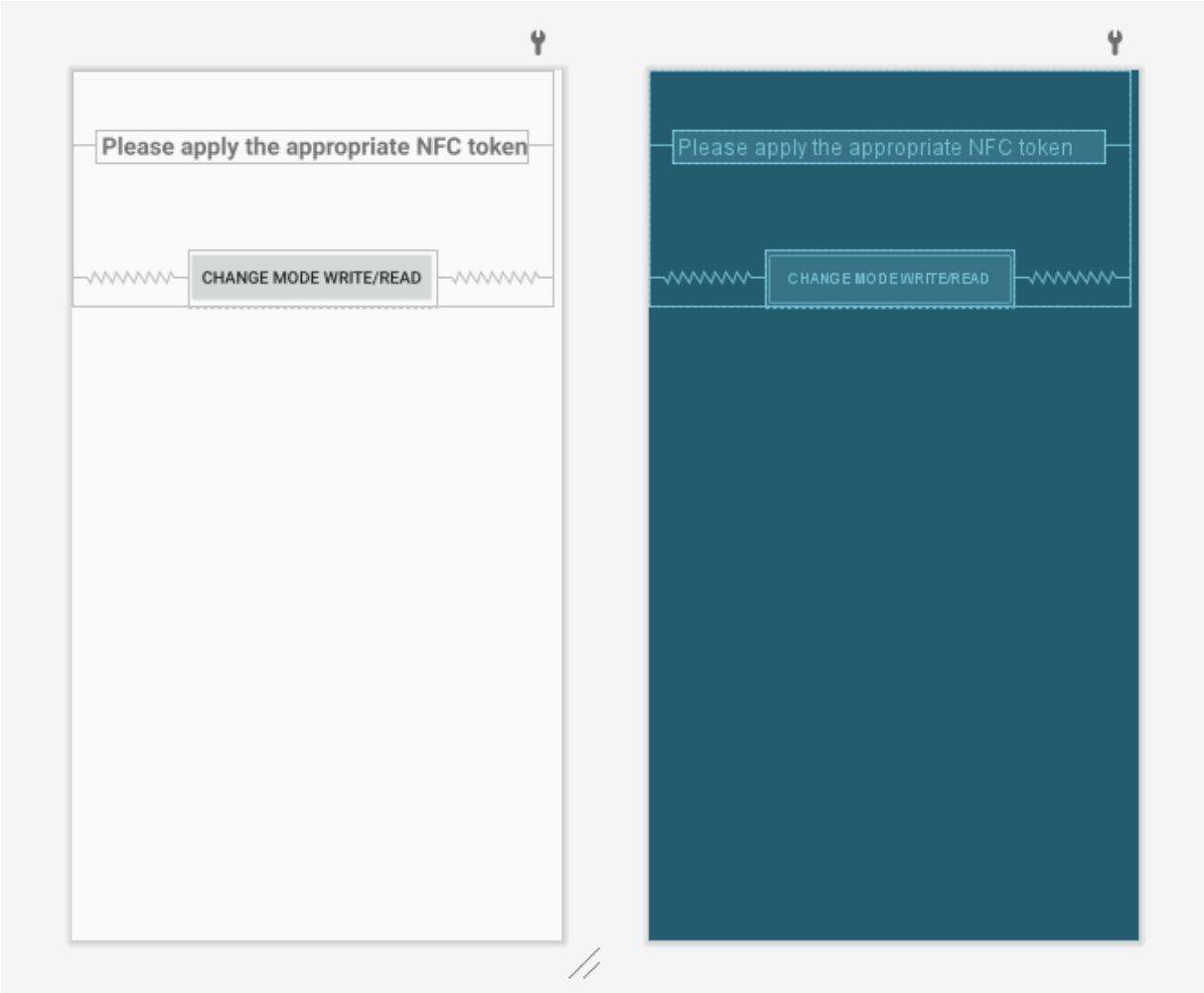

Figure 1.1: Application layout creation

1.2.2 Used Java imports for RFID application

This section describes some of the the Java imports used to create the RFID application.

- android.nfc.NdefMessage constructs an NDEF Message by parsing raw bytes.
- android.nfc.Tag: tag is an immutable object that represents the state of a NFC tag at the time of discovery.
- android.net.Uri: Uniform Resource Identifier (URI) is a string of characters used to identify a resource. A URI identifies a resource either by location, or a name, or both.
- android.nfc.NfcAdapter
  - getDefaultAdapter(android.content.Context) gets the default NFC adapter for this Android device.
  - disableForegroundDispatch() disables foreground dispatch to the given activity.
  - enableForegroundDispatch() enables foreground dispatch to the given activity.

Chapter 2

Main goals

The main goals of the project are to learn about RFID technology and create a user identification system using RFID. It is designed to automate the user verification process, and also allows you to limit access to selected locations and facilities, traffic management, parking systems and register employee activities or control of employee working time. For this purpose, it is necessary to prepare an RFID reader and tags.

Reader

Readers are element of the RFID system. They are stationary or mobile devices, equipped with a radio transmission module, i.e. an antenna that sends and receives a radio signal. In this way, they communicate with RFID tags and write and read data from them. RFID readers can take various forms, from a mobile aplications, through a short-range desktop reader, to long-range UHF readers mounted on masts. The core of the work is to prepare and implement a mobile application for Android, using NFC technology, to work as an RFID tag reader.

Tags

RFID tags, also known as transponders, chips or RFID tags, are another element of the RFID system, they are small data carriers that can take various shapes and sizes. They enable saving, storing and reading information. RFID tags can be placed on objects, devices or be given to individuals in the form of an RFID card (e.g. RFID pendant). For this reason, it is important to select the appropriate tags, depending on: needs, application, price, supported technologies, availability, etc. After buying the appropriate tag, the next step is to prepare the tag to ensure the proper functioning of the system (saving the appropriate data if required).

Tests

The final stage of the project is testing. This is to verify that the system is working properly and to verify the practical aspects of the identification system based on RFID technology. For this purpose, practical tests were carried out.

Chapter 3

Technicals and instructions

The application was created to test solutions based on RFID technology. Especially in the context of the potential safety of solutions used in radio frequency technology. The application was tested and worked on the Pixel 3a emulator available from Android Studio and the Huawei P10 Lite WAS-LX1 smartphone using the android system.

3.1 Main Activity

The main function related to the functionality of the application, it contains all the functions responsible for the application's backend.

3.1.1 Start

The primary calling OnCreate startup function. It displays "No NFC detected" and the PendingIntent function class granting the right to perform the operation specified with the same permissions and identity.

3.1.2 Pause and resume

OnResume function that turns on the activity of the NFC adapter and shows WirelessSettings depending on the operating state of the device. The OnPause function does exactly the same as the state of the device.

3.1.3 Creating new intent

The function responsible for detecting a new action and activating the resolveIntent function.

3.1.4 Resolving intent

The function responsible for the connection, tag detection and recognition of the Mifare Classic technology used. Depending on the parameters, an encoded tag with the information declared in the program code is detected. It also checks the bit value contained in the code and the content of the presented tag. Depending on the obtained value of the information, an appropriate annotation is displayed.

3.1.5 Wireless settings

Check the operation of the options for wireless connections with regard to RFID communication. Depending on the device settings, you will be prompted to unlock the NFC token.

3.1.6 Tag data and verification procedure

In this case, the value of the scanned tag is compared and compared with the value of the declared tag compliant with the application operation requirements. In addition, the function responsible for displaying information about the technology used for the detected tag and the declaration of the tag list are also declared here. Depending on the scanned tag in the Mifare Classic technology, the value is checked using the Hex function in relation to detected value of the information declared in the tag. In case of an incorrect NFC token, the appropriate information will be displayed. The entire value is then converted from a String value to a Hex value and checked against the compatibility of the read token value.

3.1.7 Button Read/Write

The function of the button responsible for switching between writing and reading the content of the scanned tag. Depending on the Write / Read procedure used, a message is displayed that the action has been changed.

3.2 Record and parser

In case of using NFC polling device, it is necessary to use the parser module to interpret the value of the NDEF message read from the NFC tag. This section discusses the libraries used in parsing and recording NDEF messages. And the methods of their practical use in the functionality of the application.

3.2.1 Message parser

A special implementation of the tag dispatch system provided by Android. Used in the application in the sequence of scanning NFC tags, parsing them and searching for processes interested in scanning the contained data.

3.2.2 Text Record

NDEF records are used in the application, they can be characterized as a low-weight binary format intended for encapsulating the saved data. NDEF defines messages and records. An NDEF Record contains typed data, such as MIME-type media, a URI, or a custom application payload. An NDEF Message is a container for one or more NDEF Records. By default, each NDEF record used by the application contains a three-bit TNF allowing a high level of typing for the rest of the content contained in the record. The remaining fields contain the length of the variable's content and are not always present:

- type: detailed typing for the payload
- id: identifier meta-data, not commonly used
- payload: the actual payload

3.3 Design

The basic form of the application's start menu contains an inscription relating to the scanning of the tag. Additionally, each reading or processing process contains complete information about its implementation. In the final form of reading the NFC tag, information related to the tag technology and technologies used in the scanning process is displayed. The design of the application is extremely simple in relation to the NFC functionalities used. Additionally, the design has been extended with NFC and Android graphics.

Figure 3.1: Application logo

3.4 Hardware module

To extend and test RFID based identification issues. The operation of the communication protocol has been additionally checked and verified on the Arduino microcontroller module.

3.4.1 General

In order to have access to tested token in convenient way, testing environment was created. It's main part is RFID-RC522 module.

Figure 3.2: RC-522 board

Is is an integrated circuit that that allows to interact with rfid tags. It is compatible with Arduino, the second component of the testing set. The Arduino platform provides us with a library that makes interactions with tag very easy. Description of basics of the library can be found in [3]. The connection between those two boards is made throught the SPI interface, but we can also use UART and I^2C - RFID-RC522 supports them too. The communication between arduino and PC is made through the UART interface, which allows us to run specific commands. For this purpose we used serial monitor that is build in Arduino IDE.

As we are using Arduino Nano, we used the following pinout (Rc522 - ArduinoNano). Pins RST and SCK can

be connected to any digital pins, but it needs to be included in code.

- 3.3V - 3.3V
- RST - D9
- GND - GND
- MOSI - 11
- MISO - 12
- SDA - 10
- SCL - 13

Connected set looks like this:

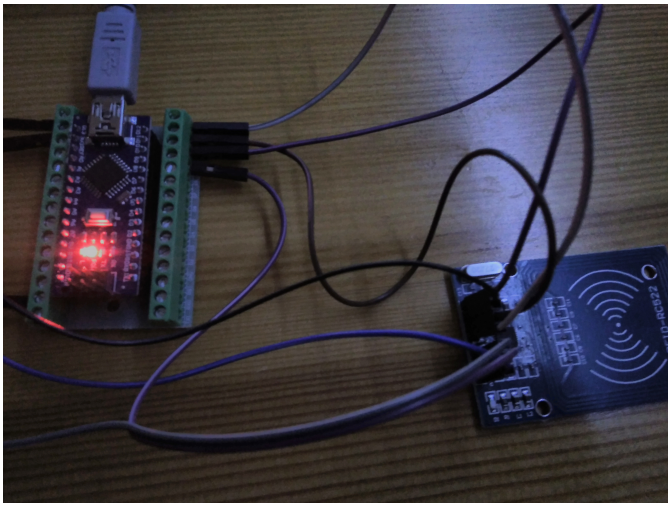

Figure 3.3: Arduino Nano connected to the PC and RC-522

3.4.2 Libraries description

The Arduino platform provides us with library MFRC522. We can install it via libraries manager in Arduino IDE, so it is very convenient way. Then we include it with `#include <MFRC522.h>`. The other big library used, is SPI library, which is required for communication - `#include <SPI.h>`.

The library provides us with some useful, high level functions to interact with tags. We can check if new card is present - `PICC_IsNewCardPresent()` or get type of the card with `PICC_GetType()`. Also, we have access to supporting constats like `uid.size` etc.

Writing to the specific block is possible thanks to the library function `MIFARE_Write(int block_num, bytes[] data, int len)`. Similar one is used for reading. Also, we can authenticate sectors with build in functions in order to get weite access: `PCD_Authenticate`. Those examples of code usage can be found on the same website, but in more advanced article [2].

What is more, in sketch section we have great examples of many operations, together with code that dumps tag's whole memory. We will reuse this code in our testing program.

3.4.3 Communication

The program written performs following steps during the run:

1. initialize all connections and data
2. wait for card/token to be applied
3. print token information
4. dump all data
5. write data to the token
6. dump data again

We define data to be saved in configuration file. We do the same, when specifying the block we will write to. Configuration file look like:

```
byte data_to_write [16] = {"<16bytes string>"};
int block_num_to_write = <int>;
```

Chapter 4

Advantages of the system

4.1 Price

The first advantage of the RFID system is its low price. The application was created on the free Android studio platform. Other elements of the system, such as tags, RC-522 board and Arduino, can be bought in a random electronics store or ordered online at a relatively low price.

4.2 Durability and reuse

RFID tags are able to work in a harsh condition. A durable hardcase protects these RFID tags from impacts, heat, moisture (it can be even completely waterproof is necessary), dirt and changing weather conditions. The data on the tags can be rewritten or modified as needed. They can be reused, what will cut costs.

4.3 Automation of the verification process

Automating certain processes can significantly improve comfort, safety and reduce costs. Automating the process of identifying people translates into saving time, and thus also costs. In addition, it enables automatic collection and processing of data and their digitization, and thus the complete abandonment of all paper documents. Data obtained in this way can be easily used, for example, to record working time. Additionally, thanks to safe access control, we are able to reduce the costs of unnecessary personnel (e.g. some additional guards).

4.4 Fast in usage

RFID tags don't need to be directly in sight of the reader. Because RFID uses radio waves to communicate, RFID tags only need to be within the read range of the reader, which will vary depending on the equipment. They can also work in some kinds of shields like wallets or rubber protectors so don't need to be take out for verification. They are simple and fast in usage.

4.5 Ease of use and reliability of operation

RFID tags are very easy to use because you only need to hold them close to the reader. Thanks to the method of operation and high resistance to external factors (light, dirt, etc.), the RFID technology does not suffer from the ills known from other identification systems, such as face recognition, in which the important factors are lighting, angle of the face, etc. Thanks to this, the system RFID is very reliable in operation.

Chapter 5

Limitations of the system

5.1 Tested hardware description

The tokens that were used during the tests, were RFiD 13.56Mhz tokens and cards. As the output of the function

```
String[] techList = tag.getTechList();
```

On the general tag object in NFC library, we can see, that the technologies are:

- MifareClassic
- NfdA
- NdefFormatable

So, it indicates, that the following token uses the most common standard.

5.2 General

The MifareClassic standard allows the developer to use Android standard library in order to read data from tag and write data to the tag. Unluckily, many phones that have NFC modules, doesn't support that exact standard. As [5] shows, more or less half of phones listed, doesn't support MifareClassic standard, but supports NTAG and MifareUltralight.

This fact means, that the use of this feature is quite limited. Nevertheless, the tokens are easy to buy and doesn't cost much. If supplemented by other standards, can be very accessible and cheap way of authentication in many situation. Also, rc522 modules that are easliy programmable with arduino or other micro controllers and microcomputers, are compatible with this standard. It makes is easy to create (write data) and read (data) from tags on separate platforms.

5.3 Problems occured during work

Code failed to run on two devices during the tests. The first one was Samsung Galaxy A5 2016 SM-A510 - it has NFC module, but doesn't support MifareClassic standard. The phone didn't even detect the nearby tag. In contrast, the second device, Nokia 7.2 detected the tag properly.

It turned out that even if the phone supports the MifareClassic standard, the only data that could be read from the tag were manufacturer's id and some basic information. The libraries, that support other interactions with tag produces an error. The only information that we were able to find about it, was an StackOverflow topic, in which it

turned out, that the same problem is connected with the Cyanogenmod - open source Android modification. As the device uses Android One, which lacks support nowadays, the problem is likely caused by spoiled phone's software that misses some important patch. This problem occurred on software version:

- Kernel 4.4.194
- Android 10
- Google Play 2020-08-01

So, in this case developers can only use `Tag` object. The classes that dervies from it, like:

- android.nfc.tech.NfcA
- android.nfc.tech.NdefFormatable
- android.nfc.tech.MifareClassic
- android.nfc.tech.MifareUltralight

They provide additional interfaces. Unfortunately they all produce an error during initalization from Tag object.

5.4 Accessibility

There is noticeable difference between mifare Classic tag and other standards when it comes to buying some. In local shops, if any tags were accessible, there were Classic ones only. In the internet it is easier to find other technologies, but usually the price difference is noticeable. Also, if item was available, not all the models are available by hand. In many cases, you have to wait few days, so getting tags that are not Mifare Classic ones requires way more effort.

Chapter 6

Summary and future development

6.1 Summary

The RFID application has been fully designed, implemented, installed on the device and tested. All elements of the application are working properly.

It would be good idea to create an API, for example working in the loop, that it based on command would perform specific actions on tag without the need to change config file. Also, it is required to add support for custom sector trailer's.

The hardware device can be also used as a part of the system. Arduino (or any other microcontroller) could communicate with the servers, databases or other apps, and use the rc522 module to authenticate or create specific tags. Hardware can be also treated as and instance, where valid tags are provided to the users of other components - for example electronic tickets encoded in the town hall.

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