



Development and Performance Analysis of a Multi-point Radio Frequency Identification File Tracking System

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ABSTRACT

This research discussed the concept of Developing and Carrying out Performance Analysis of a Multi-Point RFID based file tracking system. Locating files is one of the greatest problems in organization nowadays and large volume of data are usually generated in most institutions of learning/ organizations. Time is wasted in searching files, energy is misused, in looking for misplaced files, deadlines are missed and sometimes files are lost. The study used Radio Frequency Identification (RFID) technology as a method of tracking and managing movement of files from one location to another within an organization. Algorithms for tracking of files were developed. This algorithms involve searching the whole database for a file to be tracked and checking for the last time the file was entered into or the time a file moves from one office to another with a view of locating the file. The RFID tracking system can track the location of files within three (3) offices and near field communication (NFC) tags are placed in the file of staff which has a unique identification number. The universal serial Bus (USB) reader will send response to each tag within the reading range of the USB reader. The control units are responsible for receiving the information from the RFID unit and tracking the tagged staff where necessary. The system consists of terminal unit which include xbee s2c module, Reader, Tag, Personnel computer (pc). At end of this research, it was established that all the aim and objectives were achieved. A 3-point RFID Based File Tracking System was successfully implemented, performance of the system based on number of files to be tracked was simultaneously done in which, the design of the system can track up to 256 files at a time.. However, thirty (30) files were simulated and eight (8) were implemented. Thus, increase in number of files is directly proportional to increase in time. Comparison between this research and other previous works was carried out. Part of the caveat of this work is the fact that every staff should carry RFID card and swipe at the door post when going in or closing from office. The file any staff carries will communicate with an RFID reader installed on the door post. The limitation of this work could serve as a good recommendation for future research.

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INTRODUCTION

File Tracking System (FTS) is a system that manages all the files movement when required, that is from one desk to another or from one office to another within a given organization or institutions and help in managing the movement of file efficiently and

knowing the location of all files. Any desk can receive and send request decision at any time. The system follows a procedure of unique numbering and enables file management, file status monitoring, file tracking, etc. It is also a very powerful search system that locates files

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and analyzes their history of movement of that file (Krasnaqi 2016).

Similarly, most of today's data processing is done using manual approaches. Letters are hand-written or are typed manually in most businesses because they are small. For example, an operator of stationeries who buys and supplies equipment to three or four vendors believes that there is no need for accounting system and thereby care less about keeping vital information. It is a system that does not involve the use of machine, almost all the work is done manually (Fagbolu, 2018). When it comes to an effective and smooth running of office, there are certain elements that must be implemented, in any industry one find himself. Firstly, files are the key to your operation and learning how to properly maintain a sufficient paper trail can make a world of difference when it comes to your daily operations (Anne, 2012). One peculiar characteristics of the information age is that companies and organizations have completely depended upon their computer-maintained files for information storage, organization and retrieval. Existing manual system are often replaced with electronic filing system as a result of social changes that have created large, complex political and economic structure (Fagbolu, 2018).

According to Rouse (2017), RFID (Radio Frequency Identification) is a form of wireless communication that incorporates the use electromagnetic or electrostatic coupling in the radio frequency portion of the electromagnetic spectrum to uniquely identify an object, animal or person. This technology comprises of three major components: Scanning antenna, Transceiver (often

combined into one reader, also known as an interrogator) and Transponder (the RFID tag). An RFID tag consists of a microchip, memory and antenna. RFID reader is a network-connected device that can be permanently attached or portable. It uses radio frequency waves to transmit signals that activate tag. Once activated, the tag sends a wave back to the antenna, where it is translated into data.

The data that is transmitted is then interpreted, tracked from the rest of the file and immediate action required is taken by the management. The RFID system consists of tags with antenna, Reader with antenna, middleware and backend or stored database. The tag includes a chip which stores a special series identifier that is utilized to identify the things individually. The tag can be indicating the object from multi meters distance and in front of the RFID reader. RFID tags have three kinds which are active, passive and semi-passive tag. The active tag is that which does not require eternal source, it has battery source built in it, the passive tag is that which is initiated by the reader, it does not have battery source built in it, and the semi passive tags have the properties of both of them (Abdulsada, 2017).

The research analyses the Development and performance of a Multi-Point Radio Frequency Identification (RFID) based file tracking system, however the research area covered three (3) offices, which are as follows; Training & Operation, Administrative duties and Logistics operation. Therefore, the research objectives have been achieved during the Development and Performance Analysis of a Multi-Point RFID Based File Tracking System (Faisal *et al.*, 2019).

MATERIALS AND METHODS

Materials

Table 1: displays the materials used in actualizing this Research.

S/N	Description	Value	Quantity
1	RFID cards	RC522	3
2	RFID Reader	RC522	3
3	Arduino nano Microcontroller	ATMega328p	4
4	Xbee modules	Series s2c	4
5	Infrared Sensors	Short range	6

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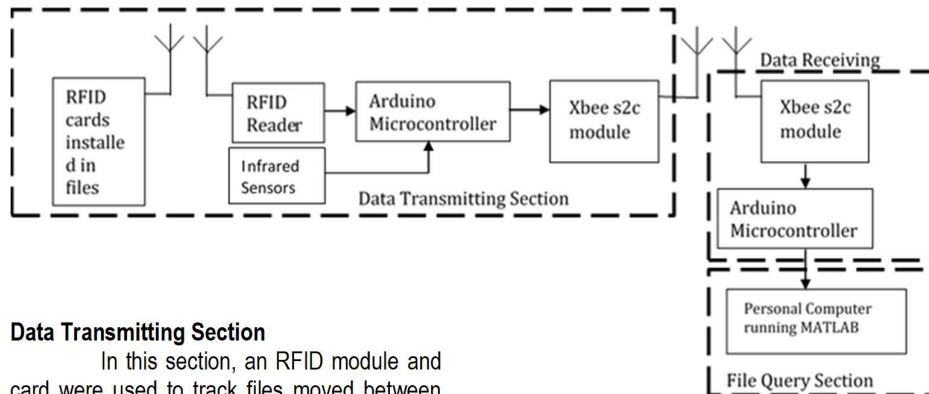
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6	Proteus Software	Professional	Simulating	Version 8.0
7	Arduino Environment	Integrated	Development	Version 1.8.8
8	Virtual Serial Port Emulator			VSPE
9	MATLAB			R2015a

Methods

The design is accomplished by breaking each logical step down into the block diagram of figure1. In this design, it is intended

to track the location of files between three offices, the design is composed of a data transmitting section, a data receiving section and file query section.



Data Transmitting Section

In this section, an RFID module and card were used to track files moved between offices. The RFID module interfaced with a microcontroller, reading card IDs wirelessly. It matched IDs to the files and staff. Infrared sensors aided in distinguishing files entering and leaving offices, with data sent wirelessly via Xbee to the Data receiving station.

RFID Cards or Tags

Radio Frequency Identification (RFID) is a technology that employs electromagnetic fields for automatic identification and tracking of tags affixed to objects (Deviselvam, 2019). These tags, often referred to as RFID cards, store electronic information. This design utilizes passive tags that draw power from the RFID reader. Figure.2 displays an RFID card, which can be affixed to various items such as cash, files, clothing, and more.



Figure 2: RFID card (Source: GITZ Office Supplies, 2019)

RFID Reader and Interfacing with Controller

The RFID reader, an electronic device, is utilized for gathering information from RFID tags to track objects (Anne, 2012). Diverse RFID readers possess varying sensing ranges for RFID tags. These readers generate a high-frequency electromagnetic field, inducing voltage in the tag's antenna coil through electromagnetic induction as the tag approaches. This induced voltage serves as the tag's power source, enabling it to respond to the reader. Figure 3 showcases the RC522 RFID card reader, while Figure 4 illustrates the circuit diagram for interfacing the card with a controller, employing the Serial Peripheral Interface (SPI) communication protocol.



Figure 3: RFID card Reader

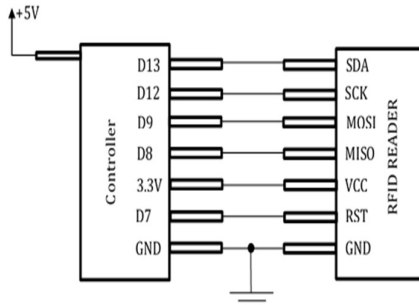


Figure 4: Interfacing RFID reader with

Infrared Sensors and Interfacing with controller

In this setup, six infrared sensors are deployed to detect and distinguish movement direction, with two sensors per office. When movement occurs near a sensor, the connected digital pin (Dout) signals logic one to the controller. The controller's programming discerns which sensor is triggered first, determining whether the movement is "into" or "out of" the office for transmission to the data receiving section. Figure 5 illustrates the infrared sensor, and Figure 6 depicts the circuit diagram for its interface with the controller.



Figure 5: Infrared sensor

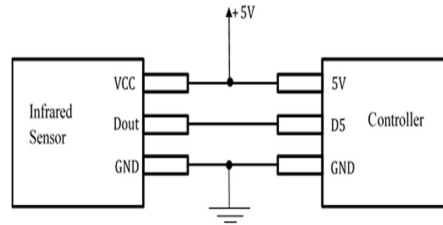


Figure 6: Interfacing infrared sensor with Arduino nano controller

Xbee S2C Radios and Interfacing with Controller

In this design, XBee S2C radios are used for wireless communication, operating on ZigBee mesh communication protocols (IEEE 802.15.4 PHY). These modules enable wireless connectivity within ZigBee mesh networks, including devices from different manufacturers. XBee modules, developed by 'DiGi,' follow the ZigBee protocol for wireless communication. XBee radios were chosen over Bluetooth due to their superior wireless range and the ability to configure multiple XBee radios to send data wirelessly to a single receiver. Figure 7 displays an XBee S2C radio with its adapter (XBee Explorer) for easy computer connection and configuration. Additionally, Figure 8 presents a circuit diagram illustrating how the XBee radio interfaces with a microcontroller, specifically an Arduino Nano.

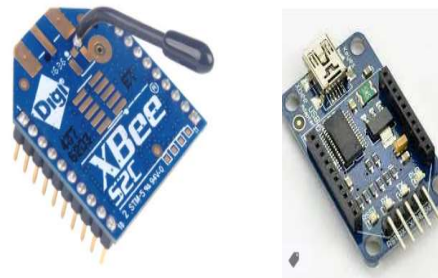


Figure 7: XBEE S2C and XBEE USB

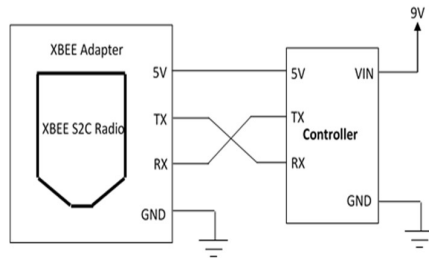


Figure 8: Interfacing XBEE module

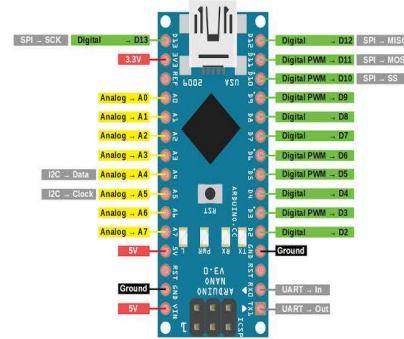


Figure 9: Pinout of Arduino nano (Matt)

Arduino Nano Microcontroller

In this project, the chosen microcontroller is the Arduino Nano, selected for its versatility. This microcontroller houses an ATmega328P chip on a compact board, providing both 5V and 3.3V DC power supplies, a USB interface for programming, and a Vin pin for a wide range of DC power inputs (6V-20V). It was preferred for its 3.3V power supply compatibility, essential for interfacing with the RFID module. The Arduino Nano handles all processing and computing tasks. Figure 9 depicts the pinout and a picture of the Arduino Nano microcontroller.

Power Supply

The power supply employed in this work is essentially a 9v Alkaline battery only connected to the Vin pin of the arduinonano controller. The arduinonano has an on board 5V and 3.3V regulator thereby eliminating the need to build any power supply. All components used in this design run on either 5V or 3.3V dc power supply.

Data Receiving Section (Receiver)

This part of the design comprises of an arduino interfaced to an xbee radio (see section 4.4.4). The arduino is programmed to receive data coming from the transmitting section. This section receives its' power from

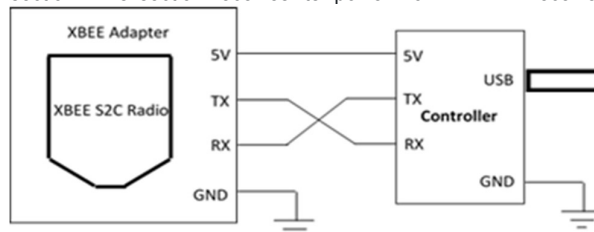


Figure 10: Receiver interfaced to PC

the USB cable connected to the computer. The receiver is connected to the computer and interfaced with a data querying software (file querying section) written in MATLAB. Figure 10 is a diagram of the interface between the receiver and a PC.

File Querying Section

This part of this design comprises of a personal computer and MATLAB program that stores all information regarding files and movement of files in its data base. A database program is written and a Graphics User Interface is also written. The GUI has user interface controls used to not only connect to serial port of a computer but also to query the

location of any file. Figure 11 shows the MATLAB GUI designed for this work.

Simulation

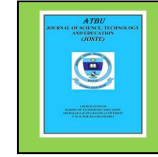
Simulation of this work was achieved using four different software. Also simulation assumes the card ID is already known by the user since there are no RFID simulation libraries available. Therefore, the RFID card reading is

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done by inputting the card ID into a virtual serial terminal. When this happens the user then enter the office name, followed by the file name, followed by the direction of movement of the file (in or out) and the program records everything on another serial terminal and sends all this

information to MATLAB. Time tracking is simulated using a DS1307 virtual RTC.

RESULT AND DISCUSSION

Simulation Results: Results obtained from the simulation are presented in Table 2. Simulation was done using the codes presented in Appendix IV.

Table 2: Simulation Result from file tracking

NO/FILE	EMPLR NAME	OFFICE	FILE	DIR	TT	DATE
1	STEPHEN JOESEPH	LOGISTIC OPERATIONS	STAFF	OUT	1.22	11/1/2023
2	OBINNA VICTOR	ADMINISTRATIVE DUTIES	COMMITTEE	OUT	1.42	11/1/2023
3	AHMED MUSA	TRAINING AND OPERATIONS	BUDGET	OUT	2.24	11/1/2023
4	MARY SAMUEL	LOGISTIC OPERATIONS	AUDIT	OUT	2.43	11/1/2023
5	OBINNA VICTOR	ADMINISTRATIVE DUTIES	PROMOTIONS	OUT	3.20	11/1/2023
6	AHMED IBRAHIM	ADMINISTRATIVE DUTIES	BUDGET	IN	3.37	11/1/2023
7	STEPHEN JOESEPH	TRAINING AND OPERATIONS	STAFF	IN	3.45	11/1/2023
8	OBINNA VICTOR	ADMINISTRATIVE DUTIES	BUDGET	OUT	4.01	11/1/2023
9	ABUBAKAR AMINU	LOGISTICS OPERATION	STAFF	OUT	4.27	11/1/2023
10	OBINNA VICTOR	ADMINISTRATIVE DUTIES	COMMITTEE	OUT	4.32	11/1/2023
11	AHMED MUSA	TRAINING AND OPERATION	BUDGET	IN	4.78	11/1/2023
12	MARRY SAMUEL	LOGISTICS OPERATION	AUDIT	OUT	4.99	11/1/2023
13	OBINNA VICTOR	ADMINISTRATIVE DUTIES	PROMOTION	IN	5.12	11/1/2023
14	AHMED MUSA	ADMINISTRATIVE DUTIES	BUDGET	OUT	5.33	11/1/2023
15	STEPHEN JOESEPH	TRAINING AND OPERATION	STAFF	IN	5.45	11/1/2023
16	OBINNA VICTOR	ADMINISTRATIVE DUTIES	BUDGET	OUT	5.76	11/1/2023
17	STEPHEN JOESEPH	LOGISTICS OPERATION	STAFF	IN	5.98	11/1/2023
18	OBINNA VICTOR	ADMINISTRATIVE DUTIES	COMMITTEE	OUT	6.07	11/1/2023
19	AHMED MUSA	TRAINING AND OPERATION	BUDGET	IN	6.21	11/1/2023
20	MARRY SAMUEL	LOGISTICS OPERATION	AUDIT	OUT	6.44	11/1/2023
21	OBINNA VICTOR	ADMINSTRATIVE DUTIES	PROMOTION	IN	6.57	11/1/2023
22	AHMED MUSA	ADMINISTRATIVE DUTIES	BUDGET	OUT	6.81	11/1/2023
23	STEPHEN JOESEPH	TRAINING AND OPERATION	STAFF	OUT	6.99	11/1/2023
24	OBINNA VICTOR	ADMINISTRATIVE DUTIES	BUDGET	IN	7.05	11/1/2023
25	STHEN JOSEPH	LOGISTICS OPERATION	STAFF	OUT	7.16	11/1/2023
26	OBINNA VICTOR	ADMINISTRATIVE DUTIES	COMMITTEE	IN	7.31	11/1/2023
27	AHMED MUSA	TRAINING AND OPERATION	BUDGET	OUT	7.43	11/1/2023
28	MUHAMMAD ANWAR	LOGISTICS OPERATION	AUDIT	IN	7.60	11/1/2023
29	OBINNA VICTOR	ADMINISTRATIVE DUTIES	PROMOTION	OUT	7.79	11/1/2023
30	NASIR MUHAMMAD	TRAINING AND OPERATION	BUDGET	IN	7.93	11/1/2023

Results of Tracking and Destination Time at Simulation

The following results presented in Table 4.2 explains how long it took the system to the track movement of files (tracking time)

and the time it took the system to document this movement in the database (destination time).Figure 1 is a graphical representation of both tracking and destination time.

Table 3: Simulation Result showing tracking and destination time

S/N	Destination Time (s)	Tracking Time (s)
1	1.27	1.22
2	1.46	1.42
3	2.28	2.24
4	2.48	2.43
5	3.24	3.20
6	3.49	3.27
7	4.06	3.45
8	4.27	4.01
9	4.33	4.27

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S/N	Destination Time (s)	Tracking Time (s)
10	4.88	4.32
11	5.00	4.78
12	5.12	4.99
13	5.44	5.12
14	5.86	5.33
15	5.99	5.45
16	6.09	5.76
17	6.22	5.98
18	6.34	6.07
19	6.53	6.21
20	6.71	6.44
21	6.92	6.57
22	7.03	6.81
23	7.17	6.99
24	7.31	7.05
25	7.42	7.16
26	7.59	7.31
27	7.71	7.43
28	7.92	7.60
29	8.22	7.79
30	8.41	7.93

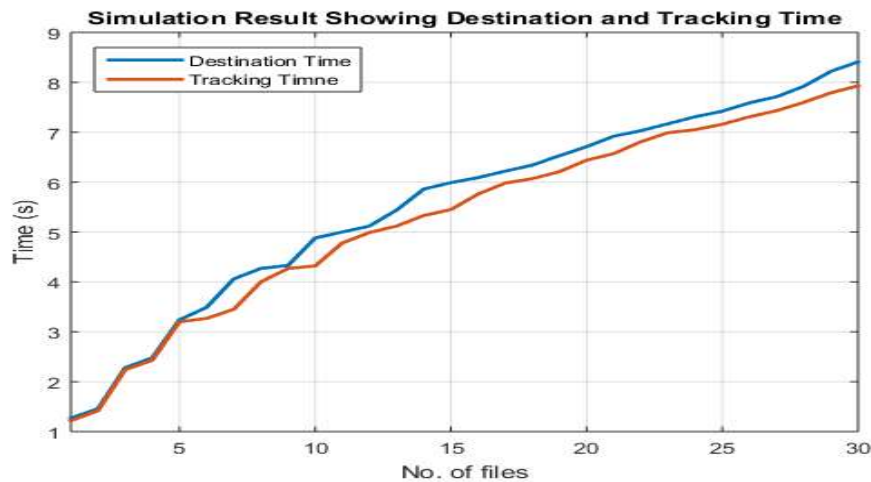


Figure 12: Graph of Tracking / Destination time versus number of files

HARDWARE IMPLEMENTATION

Multi-point File Tracking System; Is a collection of more than one point that allows users to store and track document electronically. File tracking software allows quick and easy access to documents and helps in cutting down dependency on paper. The plate below is the prototype of the implemented

design during the construction of a Multi-Point RFID Based File Tracking before and after coupling. However, plate 1 and 2 is Transmitter and Receiver System before coupling while plate 3 is a complete prototype after coupling. The prototype of the implemented designed during the construction.

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Table 4: Results of file tracking obtained after implementation

NO/FILE EMPLR NAME	OFFICE	FILE	DIR	TT	DATE
1 STEPHEN JOSEPH	LOGISTIC OPERATIONS	STAFF	OUT	01.25	12/1/2023
2 OBINNA VICTOR	ADMINISTRATIVE DUTIES	COMMITTEE	OUT	01.44	12/1/2023
3 AHMED MUSA	TRAINING AND OPERATIONS	BUDGET	OUT	02.29	12/1/2023
4 MARY SAMUEL	LOGISTIC OPERATIONS	AUDIT	OUT	02.46	11/1/2023
5 AHMED IBRAHIM	ADMINISTRATIVE DUTIES	PROMOTIONS	OUT	03.26	12/1/2023
6 ABUBAKAR AMINU	ADMINISTRATIVE DUTIES	BUDGET	IN	03.32	12/1/2023
7 MUHAMMAD ANWAR	TRAINING AND OPERATIONS	STAFF	IN	03.51	12/1/2023
8 NASIR MUTIAMMAD	ADMINISTRATIVE DUTIES	BUDGET	OUT	04.02	12/1/2023

Results of Tracking and Destination Time During and After Implementation

The following results presented in Table 4.3 explains how long it took the system to track movement of files (tracking time) and time it took the system to document this movement in the database (destination time).

Table5: Simulation Result showing tracking and destination time at the Implementation stage

S/N	Destination Time	Tracking Time
1	1.29	1.25
2	1.48	1.44
3	2.28	2.29
4	2.49	2.46
5	3.26	3.26
6	3.48	3.32
7	4.09	3.51
8	4.28	4.02

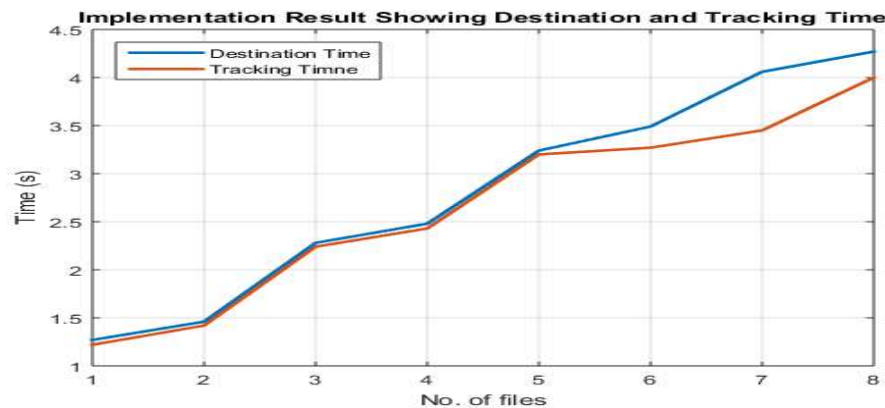


Figure 13: Graph of Tracking / Destination time versus number of files

DISCUSSIONS

During simulation, movement of thirty files was simulated using proteus 8.0 professional simulating software and the results obtained were tabulated and graphed in Table 4.1 and Figure 4.1 respectively. From these

results, the employee moving the files, the name of the file being moved, the direction of the file and the destination of the files were all recorded by the system. The time and date of the movement were also recorded. All this data collection forms the database of the system.

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As data is being collected, it is sent wirelessly and in real-time to a remote computer where it is stored. These stored data become the database of the system. In the simulation stage, proteus was used to simulate the circuit diagram/movement of files of the system while MATLAB was used to simulate or implement the database section of the system. Proteus was interfaced or linked to MATLAB so as the data is being collected in proteus, it is immediately sent to MATLAB for the creation of the database.

After the database has been created, the GUI is then used to query information from the database. Querying this information is done by entering the name of the file to be tracked in the search box of the database GUI and hitting the search button. Also, tracking time and destination time were gathered from the simulation stage using a built-in MATLAB function viz "tic toc" and the results are tabulated in Table 3

At the implementation stage, actual RFID cards were used against the virtual RFID card used during the simulation. Also actual movement of files was carried out and infra-red sensors were used to sense the direction of movement of these files including the employee wielding the file. At this stage, eight files were implemented and the results obtained and tabulated in Table 4.

Table 6: Simulation Result versus Implementation

S/N	Simulation Destination Time	Simulation Tracking Time	Implementation Destination Time	Implementation Tracking Time
1	1.27	1.22	1.34	1.25
2	1.46	1.42	1.51	1.44
3	2.28	2.24	2.38	2.29
4	2.48	2.43	2.55	2.46
5	3.24	3.20	3.29	3.26
6	3.49	3.27	3.53	3.32
7	4.06	3.45	4.19	3.51
8	4.27	4.01	4.38	4.02

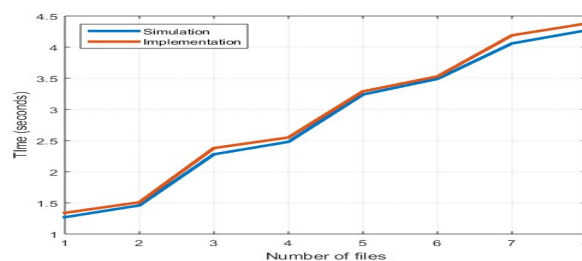


Figure 14: Destination time graph (simulation vs implementation)

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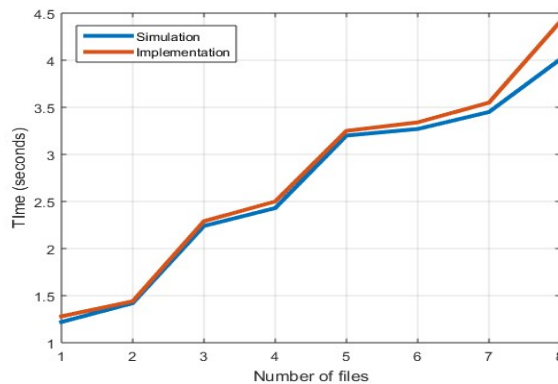


Figure 15: Tracking time graph (simulation vs implementation)

CONCLUSION

In conclusion, the research is a success as the aim and objectives were achieved. A three-point RFID based file tracking system was successfully implemented. Performance of the system, especially based on number of files tracked simultaneously was done in the sense that the system can track up to 256 files, increase in number of files is directly proportional to increase in memory because during the design Arduino nano was used and Arduino nano has a Random Access Memory (RAM) which has a memory of two kilobytes. However, in this research work thirty (30) files were simulated and eight (8) number of files were implemented. The results have revealed that increase in number of files is directly proportional to the time taken and also the memory size, which implies that the threshold (Multipoint RFID Based File Tracking System) would be able to track number of files simultaneously as the number of files increases it affects the tracking time. Finally, the work was compared with other existing works in terms of speed and system performance (i.e. tracking more than one file at a time)

RECOMMENDATIONS

Part of the caveats of this work is the fact that no database software was utilized for querying of files. Therefore, it is recommended that:

1. Database software for querying files should be developed in order to make the simulation very easy.

2. More research should be done to improve the memory size of the system so that it can track more files
3. This work is also recommended to be used in schools, especially higher institutions, to keep attendance of students. Also, this work can be utilized in industries and super market.

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