

Performance Comparison of RFID and Barcode Technologies for Library Management System

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Abstract: A Library management system (LMS) plays a key role in students' satisfaction. A good management system of a library must provide effective ways to the library staff in order to save time as well as efforts. In this age of modern technology almost all of the institutes from the globe are trying their level best to facilitate their students from the best technologies. Therefore, most of the institutes are moving to either Radio Frequency Identification (RFID) or Barcode technology to manage their library. The use of these technologies in library can significantly improve the overall service of the library that may eventually lead to a better student's satisfaction. However, it is of great interest to know that which technology works better when we talk about a library management system. This study presents a comparative and conclusive remark for both of these technologies along with their benefits and drawbacks which may help the people in transforming their library management using these technologies. We have performed extensive experiments by setting up necessary hardware equipment. Specifically we have compared the scanning time for RFID and barcode technologies. Experiments reveal that barcode technology works better than RFID technology.

Keywords: RFID, Barcode, Library Management Technologies, Comparison, Security.

1. Introduction

Library is a place which represents a world of various books belong to different categories. Therefore, a library is usually considered as the main building block of any institute. The evolution of various new ideas are also initiated from library because it does not contain only the limited resources or books but also students may get an easy access to the books of their own interest in no time including newspaper as well which allow them to explore their knowledge.

In this modern era, although it is said that computers have replaced the books but it would not be fully correct because still there are lots of books on the internet which are not freely available and if they are made available free then only few pages of the book are allowed to read. This increases the importance of a library where a book may also be provided on demand even if it is not available in the library. Thus, a library does not contain limited data only but also students are allowed to get information from a huge collection of resources made available to students easily.

Management of such vast data in form of books, magazines, newspapers and others is a hectic task and requires lots of efficiency and expertise. Moreover, the maintenance of the membership information of students and updating them with the current record of issuance and retuning of books is time taking. The use of latest technology in managing these tasks may save the time as well as workload of both students and the library staff. In this modern age, humans are frequently replaced by machine in almost all of the institutes. Since, now-a-days

the use of latest technology in right direction in making the system helpful for the user is highly demanded. Therefore, this study specifically focuses on the issue that which technology out of RFID and Barcode works best in managing the library related tasks. RFID comprises of two technologies; radio frequency and microchip, Whereas, Barcode technology scans the objects by making use of machine readable optical device..

2. Related Work

Launched in 2006, twitter has altered the manner in which the business industry and individuals communicate with each other. In 2007, Java et al. [7] discuss the micro blogging phenomena and classified user activities as information seeking, information sharing or social activity. In 2008, Krishnamurthy et al. [9] characterized twitter data from January 12 to February 22[1-6] of that year with respect to the follower/following user relationships, status update influences and growth patterns. Cheong et al. [3] perform text analysis of 1500 tweets on each of the 4 selected trending topics to determine the "collective wisdom" of the twitter community. TURank [16] extends the usefulness of tweets by identifying a twitter user's authority score through a user-tweet.

The use of RFID and barcode technology has been increasing in large industries and is now becoming a trend mark. Whereas, on the other hand, the Barcode technology seems to be popular in small work places and industries specifically in super stores having products with the barcode attached on them. The performance comparison has been carried out in terms of time used for scanning

each book in library whenever a user issues and returns a book.

In this study, all of the important features of RFID and barcode technology are discussed altogether. Moreover, this study also provides a platform where the interested users may analyze the comparative performance of both of these technologies in reference to the library management system without performing experiments by themselves. Other than scanning time, reliability, cost, and efficiency of each technology have also been compared in this study. Fig. 1 and Fig. 2 shows both of these technologies; Barcode and RFID, respectively.

3. Related Work

3.1 System model

A range of identification technologies has been represented by Radio frequency identification (RFID) which evolves speedily and being adopted by various organizations globally, specifically in the region of Asia Pacific [1]. RFID provides recognition from very far away, although it does not identify hundreds of items beyond line of sight but it at least identifies dozens of individual items at fast speed [2].



Figure. 1. Barcode technology and RFID technology



Figure. 2. Barcode technology and RFID technology

In order to provide real time location and environmental knowledge exactly and accurately, the RFID technology is converging with various other technologies including sensors, Global Positioning System (GPS), and cellular telecommunications [1]. For the purpose of identifying lots of items and other data within the libraries, RFID is an alternate option that may replace the conventional bar code technology [3].

With the help of the technologies used within a library, the interaction of the library staff and the other users with that of the library materials may be enhanced and the repeatedly handling of materials may be reduced [4]. With cohesive storage capacities enough to store the item's

identification information, generally equivalent to barcode technology, along with other information needed that include media code or call number and institutional identifier.

The technology of barcode represents a code consisting of dark black color bars having spaces in between them in white color. The code is structured in a way that it contains information. It allows accurate collection of data accurately in real time rapidly. Performance, productivity, and profitability of the system also increase when barcode technology is combined with computer application software. Originally barcode stored data in width and spacing of printed parallel lines. In other words we can say that barcode are series of black and white bars arranged in a pre-defined form to represent known coded information. A linear barcode is a binary code (1s and 0s). The line and space are of various thicknesses and printed in different combinations .A device known as barcode scanner reads this code. The most common is laser barcode scanner .Bars are darker and non –reflective element of barcode. The gaps are white and known as inter character gaps. The space is known as reflective element of barcode. Each barcode represent a number [5].

Similar to RFID technology, barcode technology may also help the staff of library for issuing and returning the items using machine and manually. Also it is found to be helpful in verifying the stock in library [6].

Both of these technologies are being used by various industries. One of the most commonly used applications of RFID and barcode technologies is supply chain. However, a main difference lies in reliability, security, time accuracy and the cost. Libraries had been facing a massive pressure from last decade or so.

Want, Roy have explored the RFID technology from insignificant to conventional applications which help in speeding up the handling of items. The authors also reveal that RFID identifies the material without line of sight unlike earlier bar code technology. The authors have also discussed the principles of RFID along with the applications and also highlighted the challenges faced by the organizations in the deployment of such technologies [7]. Another study has been presented by Dawes, Trevor A. [8] where the authors have discussed about the benefits of RFID technology even when only few libraries have employed this technology due to high cost. The authors have also discussed the pros and cons of the RFID technology in providing the information to librarians which may be beneficial to think whether the technology be employed or not.

Another research study has been presented by Islam, M. S. et al. which is based on the barcode technology. The study carried out a survey in eight different libraries of city Dhaka, in Bangladesh. Survey consists of various questions including Commencement year, which software is being used to barcode, zones in libraries where barcodes are being used, training of staff members, customer (user) satisfaction and information professionals. This study also sheds light in the advantages and disadvantages of the barcode technology [9].

In continuation to the above studies, a comparative study has also been presented by White, G., Gardiner et. al,

[10] where the authors have concluded that although RFID provides enhanced performance but still considered to be less reliable when it comes to implementation. Moreover, in their study emphasize has been given on total number of errors and their nature.

Sinha, Manoj K. [11] has explored this enormous development RFID technology in his work for the purpose of library management system. In their study, they have discussed in detail about the history, evolution, conceptual meaning and different components of RFID technology. Specifically, their work has been focused on the implementation of RFID technology in University and Institutional Libraries of North East India. Since the use of this technology especially in libraries and in other organizations is gaining strength, there is a high need to dig out more possibilities of using this technology for managing the various tasks within library.

In another study conducted by Emad Abu-Shanab et al. [12], a test has been conducted in order to know the perception of employees regarding RFID implementation within libraries. However, their study is limited to the libraries of public universities in Jordan only.

Maryna Marchenko [13] has made a very close analysis of client's will and a web based framework has been presented that also uses the Barcode technology for the management of library related tasks. In another study proposed by Shreenesh Gundeti [14], a hardware based system has been presented that replaces the electromagnetic strips and the Barcode technology and is based on RFID technology. The proposed system seems to be easier in inventorying, book tracking, material handling, and other essential library transactions.

Additionally, various researchers including Makhija et al. [15], Rajput et al. [16], and Xie et al. [17], have discussed the importance of RFID technology with reference to library management system. Similarly, another study has been proposed in the literature [18] where a librarian within a library is replaced by a robotic system to lessen the human burden and time.

3. Methodology

The primary purpose of this study is to compare the two important technologies used for collecting the data in an automatic fashion. The following sub sections describe these technologies in sequence.

3.1 Radio Frequency Identification (RFID)

RFID technology is based on the radio frequency which is used for the identification of a tag given on the product. RFID is an automatic identification technology and its system is described by the electromagnetic waves. RFID device and the card is shown in Fig. 3 which is used for the identification of a specific product



Figure. 3. RFID device and cards

When an object is made closed to the reader, the RFD device uses radio frequency in order to identify that object. There is an electromagnetic chip whose records may comprise of a reader. The contents of the tag memory can be changed by the reader. RFID tags come in various different forms for varying devices used for communication and power supplies.

RFID is a technique which comes under the category of an Automatic Documentation and Statistics Capture technique (ADSC) . This technology is capable of storing a huge amount of data. The low cost of most of the models of RFID tags makes the system more powerful and attentive. Figure 4 shows the architecture of an RFID system.

The technology of RFID has become more popular in the last decade without expectations. The system of RFID comprises of one or more than one tags also known as transponders, interrogators, and antenna. The antenna of RFID exhibits the signal consisting of radio frequency in order to activate the transponder or tag. The activation of the tag allows reading and writing on it.

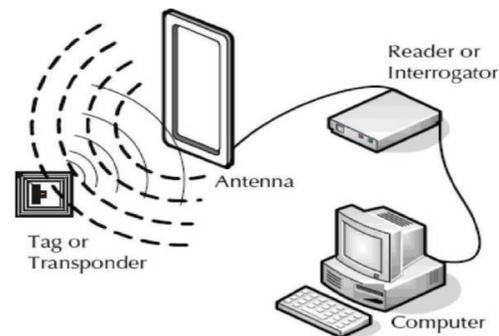


Figure. 4. Architecture of RFID System

The interrogator component of RFID activates the tags which are near to the antenna in order to deliver the battery with fever tags and send command to the tag. The tag of RFID is constructed using a microprocessor chip smaller in size and which is further connected to the antenna. The tag is used for sending the signal to and from the reader. Tag can be of two categories; Active Reader Passive Tag (ARPT) and Active Reader Active Tag (ARAT). The former type of the tag has an active reader that shifts the interrogator signals as well as receives the answers of authentication from the passive tags. The later type of the tag has also an active reader but it makes use of the active tags along with the interrogator signal from the active reader.

3.2 Barcode Reader

A Barcode reader also known as Barcode scanner is a device which reads the tags and the barcodes attached on the product to a machine (computer). The reading device comprises of the source of light that translates the pulses from optical to electrical impulses. The reader/scanner also contains the circuitry for decoding purpose. Basically a barcode is the group of black color vertical lines separated by white spaces in between them as shown by Fig. 1. The vertical lines are arranged in a way that they are parallel to each other.

These tags may appear in different background colors of line, however, the most commonly used practice is black parallel lines on the white background. Interestingly, it should be noted that the size of the barcode may vary as per labeling used for the barcode. The columns of the barcode represent the binary digits (0, 1). The binary digit code is then translated by a machine (computer) to show the digital numbers from 0 to 9. The barcode device and the chip are shown in Fig. 5.

Methodology that is being followed in this study comprises of the detailed analysis of RFID and the Barcode technology. After a detailed analysis is carried out of these technologies, the experimental work is being performed by first setting up the necessary hardware equipment.



Figure. 5. Barcode device and chip

To compare & contrast between the two afore described technologies and to provide a clear view on technology that is most suitable for Library Management Systems, we used the process of scanning a total number of 60-80 books by using these two devices for six days continuously from Monday till Saturday, we recorded the scan timing of both devices and generated graphs on that basis. We also took the minimum scan time and maximum scan time to find out the average scan time of each device.

4. Results and Discussion

In order to compare the two technologies discussed above various experiments have been performed on six different days consecutively. Moreover, in context to the library management system, four hundred (400) books have been used for the experimental work. A computer with 4GB Ram and windows 10 operating system has been used for experimentation. The hardware equipment comprises of a personal computer, RFID device, Barcode reader, Stop watch, RFID chip, a Barcode chip and 400 books having

tag attached on them. After successful experimental scans, a level of consistency can be observed for both of the technologies, RFID and Barcode, over six days. For the purpose of experimentation, almost 60 to 80 books are being used for scanning for both of the technologies up to six days. On day-1, Monday, scanning results of RFID tag are recorded for two hours (9:00 to 11:00) in morning individually for each book. The resulting graph of RFID tagged books is shown in Fig.6. As can be observed from Table 1, on day-1, minimum and maximum scanning time for RFID tagged books is 5 sec and 15.7 sec, respectively. Thus on average the scanning time for RFID tagged books is observed as 9.85 sec.

Similarly, on day-2, Tuesday, scanning results of RFID tag are recorded for two hours (10:00am to 12:00pm) and the experiments are performed on 80 books. The resulting graph is shown in Fig. 8. The minimum, maximum, and average time are recorded as 5.2 sec, 15.8sec, and 9.67, respectively. Likewise, on day-3, Wednesday, scanning results of RFID tagged books are observed from 10:00am to 12:00pm for 60 books. Minimum, maximum, and average scanning time is found to be 5sec, 16.8 sec, and 10.35 sec which are further confirmed by the graph given in Fig. 10.

In the same way, the scanning results of RFID tagged books on 4th day, Thursday, is recorded from 9:30am to 11:00am as follows; minimum time is 5.4 sec, maximum scanning time is 15.4 sec, and average is 10.35 sec. Whereas, on day-5, Friday, experiments are performed on 60 books from 9:15am to 11:15am with minimum, maximum, and average time equivalent to 5.7 sec, 16 sec, and 9.18 sec, respectively. The last day, Saturday, of experimental work on 60 books the scanning time for RFID tagged books is recorded as follow; minimum time: 5.8 sec, maximum time: 16 sec and average time: 9.62 sec and the resulting graphs of day-4 through day-6 are shown in Fig [12,14,16] respectively.

Similar experiments are performed for scanning different books using barcode technology and scanning time of each book is recorded up to six days at varying time. On day-1, Monday, 80 books are scanned using barcode technology for three hours (12:00pm to 3:00pm). The resulting graph of barcode tagged books is shown in Fig. 7. As can be observed from Table 1, on day-1, minimum and maximum scanning time for barcode tagged books is 18.4 sec and 35.4 sec, respectively. Thus on average the scanning time for RFID tagged books is observed as 24.55 sec. Similarly, on day-2, Tuesday, scanning results of barcode tag are recorded for three hours (1:00pm to 4:00pm) and the experiments are performed on 60 books. The resulting graph is shown in Fig. 9. The minimum, maximum, and average time are recorded as 15.3 sec, 31.2 sec, and 24.55 sec, respectively. Likewise, on day-3, Wednesday, scanning results of barcode tagged books are observed from 1.30pm to 4:30pm for 60 books. Minimum, maximum, and average scanning time are found to be 18.5 sec, 32.6 sec, and 24.16 sec which is further confirmed by the graph given in Fig. 11. In the same way, the scanning results of 80 barcode tagged books on 4th day, Thursday, is recorded from 12:30pm to 3:00pm as follows;

minimum time is 18 sec, maximum scanning time is 35 sec, and average is 24.35 sec. Whereas, on day-5, Friday, experiments are performed on 60 books from 4:00pm to 7:00pm with minimum, maximum, and average time equivalent to 19 sec, 32.4 sec, and 24.29 sec, respectively. The last day, Saturday, of experimental work on 60 books the scanning time for barcode tagged books is recorded as follow; minimum time: 15.6 sec, maximum time: 32 sec, and average time: 24.89 sec as can be seen in Table 1. The resulting graphs for barcode tagged scanning books on day-4, day-5, and day-6 are shown in Fig.[13,15,17] respectively.

The summary of all the experiments performed on the six days for both of the technologies discussed above is represented by the Table 1. On average, it is found that the scanning time of the code using RFID technology ranges in between 9.18 sec to 10.35 sec and this range is about 12.8% of the overall RFID reader results. In the similar fashion, it is observed that scanning time of the code using Barcode technology ranges in between 24.16 sec to 24.89 sec and this is 3% of the complete range of Barcode reader results.

From the overall results obtained by the experiment, it is being observed that Barcode technology is more consistent than RFID technology over a particular period of time. Indeed, Barcode provides a wide range if scanning books in a given specified time.

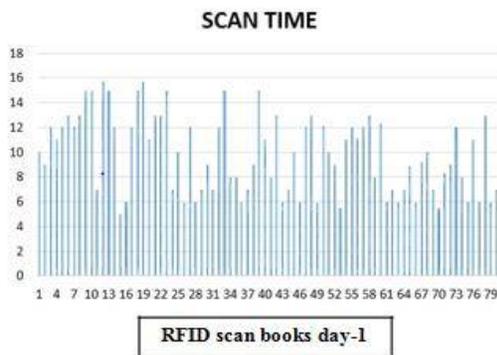


Figure. 6. RFID graph on day-1

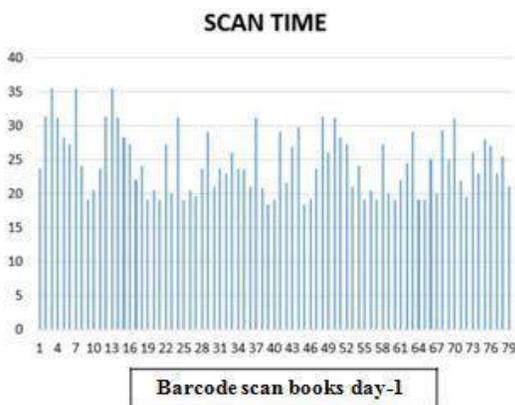


Figure.7. Barcode graph on day-1

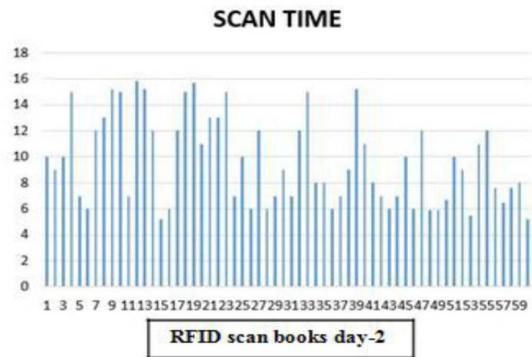


Figure.8. RFID graph on day-2

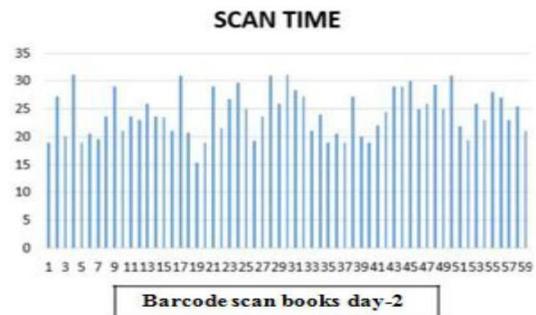


Figure.9. Barcode graph on day-2

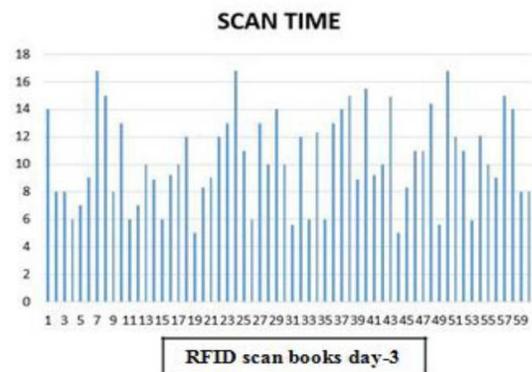


Figure.10. RFID graph on day-3

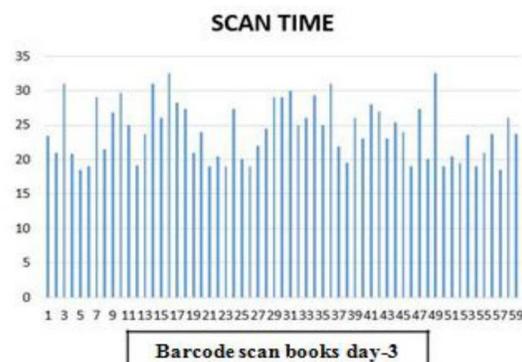


Figure.11. Barcode graph on day-3

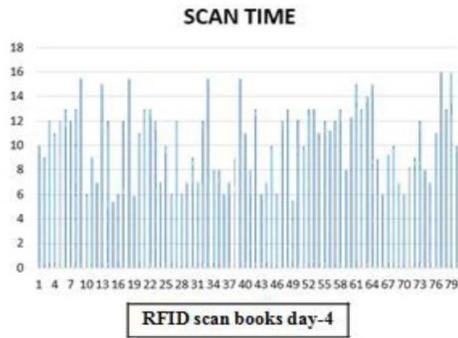


Figure.12. RFID graph on day-4

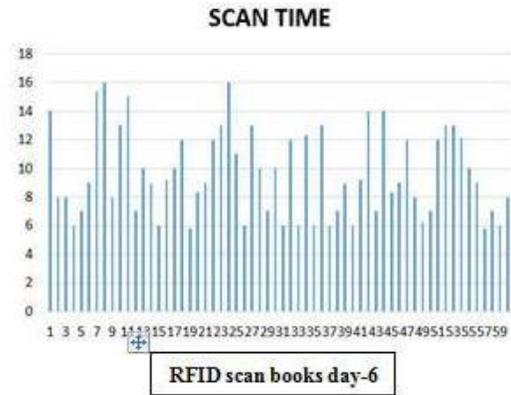


Figure.16. RFID graph on day-5

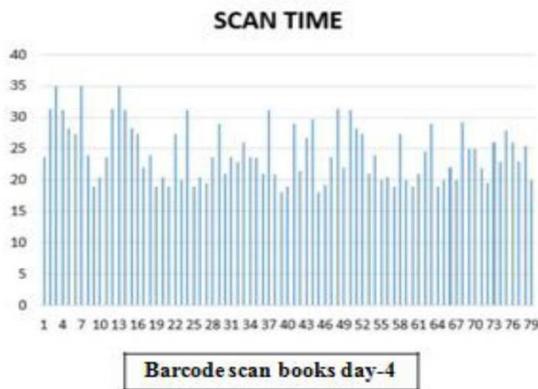


Figure.13. Barcode graph on day-4

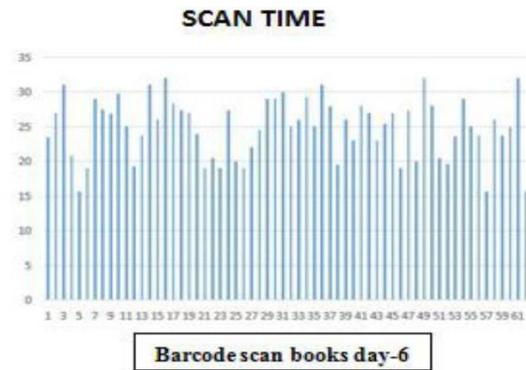


Figure.17. Barcode graph on day-6

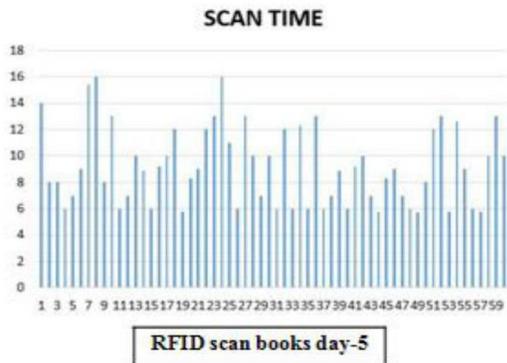


Figure.14. RFID graph on day-4

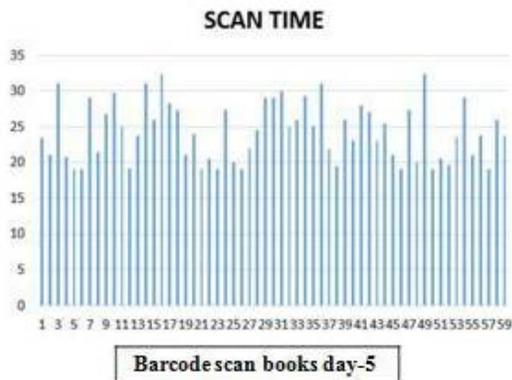


Figure.15. Barcode graph on day-5

TABLE I. STATISTICS FOR SCANNING TIME OF RFID AND BARCODE TECHNOLOGIES

Days	No: of Books	Time in Seconds		
		Min.	Max.	Average
1 st _Day_RFID	80	5.0	15.7	9.85
1 st _Day_BCR	80	18.4	35.4	24.55
2 nd _Day_RFID	60	652	15.8	9.67
2 nd _Day_BCR	60	15.3	31.2	24.25
3 rd _Day_RFID	60	5.0	16.8	10.35
3 rd _Day_BCR	60	18.5	32.6	24.16
4 th _Day_RFID	80	5.4	15.4	10.35
4 th _Day_BCR	80	18	35	24.35
5 th _Day_RFID	60	5.7	16	9.18
5 th _Day_BCR	60	19	32.4	24.29
6 th _Day_RFID	60	5.8	16	9.62
6 th _Day_BCR	60	15.6	32	24.89

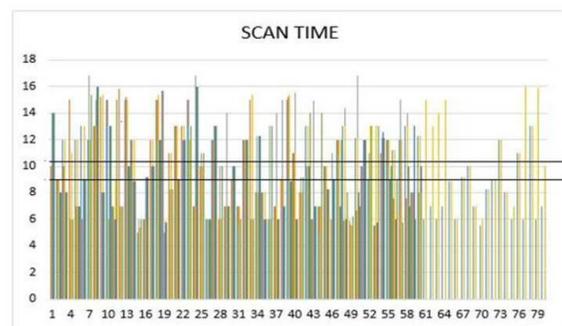


Figure.18. Overall graphs of RFID results

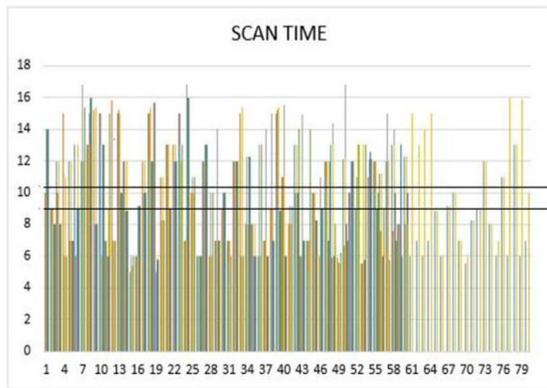


Figure.19. Overall graphs of Barcode results

The status updates influences and growth patterns. From the results it is observed that on average scanning outcomes of books scanning using Barcode technology exhibits less variations over time, Whereas RFID technology indicates more variation in comparison to Barcode technology. Thus, it will be correct to say that average value of RFID varies more in a specific period when compared with Barcode technology. Additionally, analysis shows that during experimental work a high percentage of equipment failure is processed by RFID. The graphs for the scanning time for both RFID and Barcode technologies have been shown by Fig. 18 and Fig. 19, respectively.

5. Conclusion

The conclusive results which we get from comparison of RFID and barcode reader are supporting barcode technology more reliable in the context of library management system because barcode scans one by one so the chances of errors are very less; it is less complex and less expensive. On the other hand RFID readers; a contactless cost effective technology faster and secure and can read multiple tags at a time. One of the most common disadvantages of RFID is that when RFID reader reads multiple tags at a time the collision occurs due to this the information of the particular tag can be lost. The motivation of writing this research paper was to keep the students intention towards reading and importance of the library with the best use of innovative technologies with respect to time, performance and accuracy.

5. Future Work

In future RFID and barcode technologies are to be used frequently almost everywhere and also become very common technologies throughout the business industries of the world because of their automatic scanning capability. Both technologies provide accuracy, consistency, less human errors and labor free solutions.

Acknowledgement

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