Comparative study of Barcode, QR-code and RFID System

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Abstract— **Wireless sensors are standard measurement tools equipped with transmitters to convert signals from process control instruments into a radio transmission. The radio signal is interpreted by a receiver which then converts the wireless signal to a specific, desired output, such as an analog current or data analysis via computer software. The paper gives a brief on wireless sensors and their types like Barcode, QR code, RFID along with their characteristics and working components. The Barcode is an optical machine-readable representation of data relating to the object to which it is attached. On the other hand the Radio-frequency identification (RFID) is the use of a wireless non-contact system that uses radio-frequency electromagnetic fields to transfer data from a tag attached to an object, for the purposes of automatic identification and tracking. Quick response (QR) codes are a very convenient way to display a small bit of information that is easily scanned and processed typically by mobile devices allowing physical items to almost become interactive, by providing information that is easily scanned like a website URL. Finally this paper will compare all the three technologies on various grounds like durability, cost, information capacity, read range etc. to determine best out of it.**

Keywords- Wireless sensors, Barcode, QR-code, RFID

I. INTRODUCTION

Wireless sensors are standard measurement tools equipped with transmitters to convert signals from process control instruments into a radio transmission. The radio signal is interpreted by a receiver which then converts the wireless signal to a specific, desired output, such as an analog current data analysis via computer software. We can make use of these wireless sensors can be used to read the QR code, Barcode and RFID tags.

In case of **RFID** tags it is done as follows:
•   RFID Readers and cameras are mounted in your facility.
• The RFID readers and cameras connect via network with Simply RFID software running on a Windows server. The size and speed of the server depends on how many cameras/RFID readers you will connect.

• When tagged objects move, the network tracks it all. You don't need to read the reports. You just "query" what you want to know and software tells you.
• If something happens that you said you didn't want to happen (like a computer or file folder walks out the door), software sends you a message on your cell phone with a picture of the culprit in high-definition.

On the other hand in case of **Barcode** tags it is done as follows: There are currently four different types of bar code readers available. Each uses a slightly different technology for reading and decoding a bar code. The factors that make a bar code readable are: an adequate print contrast between the light and dark bars and having all bar and space dimensions within the tolerances for the symbology. It is also helpful to have sharp bar edges, few or no spots or voids, a smooth surface and clear margins or "quiet zones" at either end of the printed symbol

There are pen type readers (e.g. bar code wands), laser scanners, CCD readers and camera-based readers.
• Pen Type Readers –
• Laser Scanners –
• CCD Readers –
• Camera-Based Readers –
• Interfacing a bar code reader to a PC –
• Cellphone cameras –
• Smartphones –

Where-as, in case of **QR code** tags it is done as follows:
In the case of QR code scanner, the decoder sends the information to your mobile phone instead of a computer. The app you download for your phone that is a QR code scanner contains the illuminator, which is the red light that runs across the screen when you open the app. The sensor and decoder then work to decode the QR code. Then the decoder sends the information to your phone, and you will be able to see where the QR code was supposed to take you. The way the scanner reads the reflected light it actually a lot more complicated.

The QR (Quick Response) Code is a two-dimensional (2-D) matrix code that belongs to a larger set of machine-readable codes, all of which are often referred to as barcodes, regardless of whether they are made up of bars, squares or other shaped elements.

II. BARCODE

A **barcode** is an optical machine-readable representation of data relating to the object to which it is attached. Originally barcodes systematically represented data by varying the width and spacing of parallel lines, and may be referred to as linear or one-dimensional. Later they evolved into rectangles, dots, hexagons and other geometric patterns in two dimensions (2D). Although 2D systems use a variety of symbols, they are generally referred to as barcodes as well. Barcodes originally were scanned by special optical scanners called **barcode readers** [1]. The different regions of barcode are as follows:

Fig1: Barcode structure

A. Structure of Barcode

Quiet Zone: The minimum required space for bar code scan-ability, preceding the Start Character of a bar code symbol. The quiet zone should be free from any printing and be the same color and reflectance as the background of bar code symbol. The Quiet Zone should be ten times the width of the narrowest element in the bar code, or 0.25 inch minimum, also known as Clear Area.

Start Code: Indicates the start of the barcode. These are special bar code characters & they signify the start of data to the scanner/reader. Start characters are usually stripped-off and not transmitted to the host.

Check Digit: Check digit (not always present) is a mathematical sum that is used to verify the accuracy of the other elements of the barcode. It is the extra digit added at the end of a bar code to allow the scanner to confirm that it read the bar code correctly. It is typically stripped from the data and not transmitted to the host.

Stop Code: Indicates the stopping point of the barcode. These characters signify the end of data to the scanner/reader. They are also stripped-off and not transmitted to the host.

B. Working of Barcode

Laser beam is incident on a mirror/prism which is then directed on the barcode from left to right. The dark bars of barcode absorb the incident light but the light is reflected by light spaces. Photodiode measures the reflected light and gives out electrical signal. The analog electrical signal is then converted into digital one. And corresponding barcode is read.
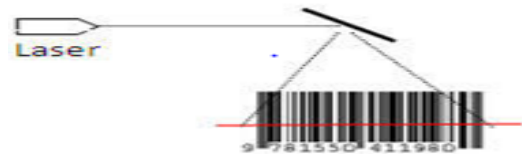

Fig2: Working of Barcode

III. QR CODE

Bar codes have become widely popular because of their reading speed, accuracy, and superior functionality characteristics. As bar codes became popular and their convenience universally recognized, the market began to call for codes capable of storing more information, more character types, and that could be printed in a smaller space. As a result, various efforts were made to increase the amount of information stored by bar codes, such as increasing the number of bar code digits or layout multiple bar codes. However, these improvements also caused problems such as enlarging the bar code area, complicating reading operations, and increasing printing cost.

2D Code emerged in response to these needs and problems. The creator intended the code to allow its contents to be decoded at high speed. Unlike the older one-dimensional barcode that was designed to be mechanically scanned by a narrow beam of light to extract data, the QR code is detected as a 2-dimensional digital image by a semiconductor image sensor and is then digitally analyzed by a programmed processor. The processor locates the three distinctive squares at the corners of the image, and uses a smaller square near the fourth corner to normalize the image for size, orientation, and angle of viewing. The small dots are then converted to binary numbers and their validity checked with an error-correcting code.

The QR (Quick Response) Code is a two-dimensional (2-D) matrix code that belongs to a larger set of machine-readable codes, all of which are often referred to as barcodes, regardless of whether they are made up of bars, squares or other shaped elements. Compared with 1-D codes, 2-D codes can hold a larger amount of data in a smaller space, and compared with other 2-D codes, the QR Code can hold much more data still. In addition, an advanced error-correction method and other unique characteristics allow the QR Code to be read more reliably than other codes.[4]

Fig 3: QR code and Barcode

A. Versions of QR-Code

QR codes are divided in various categories according to information capacity they hold.

Version 1(21*21) content 'version1' 'version2'   Version 2(25*25) content

Version 3(29*29) content :'version3 'version4'   Version 4(33*33) content: QR-code'

QR-code'   QR-code'

. Fig4. Versions of QR Code

B. Error correcting capability

The amount of data that can be stored in the QR code depends on the character set, version and error correction level. The maximum values for version 40 with error correction capacity level L are:

Numeric only Max.   7,089 characters
Alphanumeric Max.   4,296 characters
Binary (8 bits) Max.   2,953 bytes

Higher the error correction level, lesser is the storage capacity. The following table lists the approximate error correction capability at each of the four levels:

Level L (Low)	7% of code words can be restored.
Level M (Medium)	15% of code words can be restored.
Level Q (Quartile)	25% of code words can be restored.
Level H (High)	30% of code words can be restored.

Due to the design of Reed–Solomon codes and the use of 8-bit code words, an individual code block cannot be more than 255 code words in length. Since the larger QR symbols contain much more data than that, it is necessary to break the message up into multiple blocks. The QR specification does not use the largest possible block size, though; instead, it defines the block sizes so that no more than 30 error-correction symbols appear in each block. This means that at most 15 errors per block can be corrected, which limits the complexity of certain steps in the decoding algorithm. The code blocks are then interleaved together, making it less likely that localized damage to a QR symbol will overwhelm the capacity of any single block. Thanks to error correction, it is possible to create artistic QR codes that still scan correctly, but contain intentional errors to make them more readable or

attractive to the human eye, as well as to incorporate colors, logos, and other features into the QR code block. A **QR Code** can also be scanned in any direction. . These 3 **QR Codes** are all the same only they have been rotated 90 Degrees each time.[2]

C. Scannig of QR-Code

Step 1: Launch the application on your device.
Step 2: Use the view finder on screen of device to centre the QR code inside the scanner then hold the device still until the scanner has captured the image.
Step 3: Perform the action indicated on your phone screen to discover what information the QR code contained. For example, a link to a website could appear on screen prompting you to click the link and be directed to the site of the QR code creator.

IV. RFID

Radio-frequency identification (RFID) is the use of a wireless non-contact system that uses radio-frequency electromagnetic fields to transfer data from a tag attached to an object, for the purposes of automatic identification and tracking. The basic premise behind RFID systems is that one mark items with tags. These tags contain transponders that emit messages readable by specialized RFID readers. Most RFID tags store some sort of identification number; for example a customer number or product SKU (stock-keeping unit) code. A reader retrieves information about the ID number from a database, and acts upon it accordingly. RFID tags can also contain writable memory, which can store information for transfer to various RFID readers in different locations use detection requires specific knowledge of intrusive behavior. Collected data before the intrusion could be out of date and yet many times it is hard to detect newer or unknown attacks. This information can track the movement of the tagged item, making that information available to each reader.

RFID tags fall into two general categories, active and passive, depending on their source of electrical power. Active RFID tags contain their own power source, usually an on-board battery. Passive tags obtain power from the signal of an external reader. RFID readers also come in active and passive varieties, depending on the type of tag they read.[5]

A. Types of RFID

1. Active tags

Because they have their own power source, active tags transmit a stronger signal, and readers can access them from further away. The on-board power source makes them larger and more expensive, so active RFID systems typically work best on large items tracked over long distances. Low-power active tags are usually slightly larger than a deck of playing cards. Active tags can remain dormant until they come in range of a receiver or can constantly broadcast a signal. Because of their on-board power source, active tags operate at higher

frequencies—commonly 455 MHz, 2.45 GHz, or 5.8 GHz—depending on the application's read range and memory requirements. Readers can communicate with active RFID tags across 20 to 100 meters.

2. **Passive tags**

Passive tags, on the other hand, are very inexpensive; they can cost as little as 20 cents apiece, and new technologies are constantly making them cheaper to integrate into common materials and products. In addition to their low cost, passive tags can also be quite small. Current antenna technology limits the smallest useful passive tag to about the size of a quarter. The larger the tag, the larger the read range. Currently, passive RFID tags contain about 2 Kbits of memory. This is too small to hold much more complex information than identification and history information. The technology behind RFID is constantly improving, so the amount of information and capabilities of RFID tags will increase over time, allowing RFID tags to eventually contain and transmit much more information.
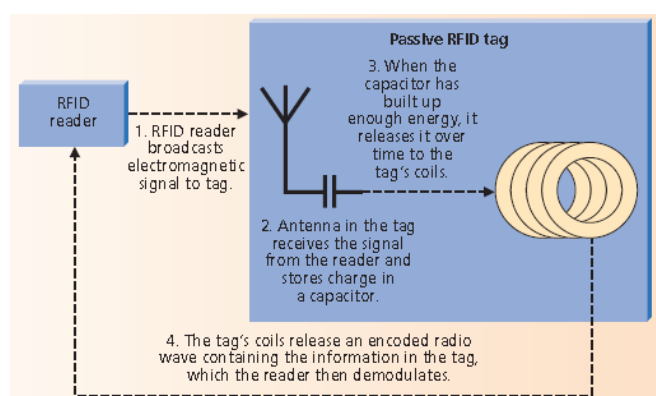
B.   Working of RFID

Fig5. Working of RFID

A passive-tag reader can constantly broadcast its signal or broadcast it on demand. When a tag comes within the reader's range, it receives an electromagnetic signal from the reader through the tag's antenna. The tag then stores the energy from the signal in an on-board capacitor, a process called inductive coupling. When the capacitor has built up enough charge, it can power the RFID tag's circuitry, which transmits a modulated signal to the reader. That return signal contains the information stored in the tag. The communication between the reader and passive tag uses one of two methods to modulate the ID signal.

Low-frequency (less than 100 MHz) tags pass information by releasing energy from the capacitor to the tag coils in varying strengths over time, which affects the radio frequency emitted by the tag. The reader detects these varying waves and can use these variances to demodulate the code. Figure 5 shows this load modulation. In higher-frequency (greater than 100 MHz) tags, the tag transmits

the signal using backscatter, in which the tag's circuit changes the resistance of the tag's antenna. This change in resistance causes a transmission of RF waves, which the reader can pick up and demodulate. Passive tags typically operate at frequencies of 128 KHz, 13.6 MHz, 915 MHz, or 2.45 GHz, and have read ranges of a few inches to 30 feet. Frequency choice depends on the system's environment, what material the signal must travel through, and the system's required read range.

RFID tags can be encased in many materials. Plastics are a very common material for RFID, forming identification cards for building access, credit cards, or bus fares. Tags can also go on the back of labels printed on standard ink jet printers, for placement on inventory.
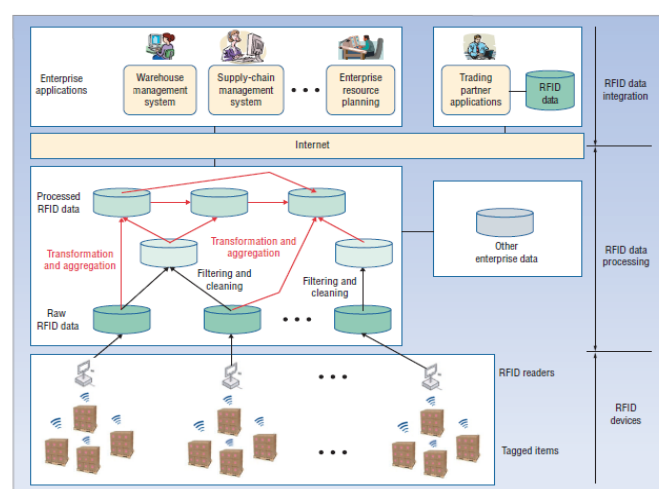

Fig6: Working of RFID

Figure 6 shows a generic RFID framework. Interactions in RFID applications occur at three layers. The devices layer consists of RFID tags and readers as well as RFID protocols. The data processing layer consists of several software components for communicating with RFID readers, filtering and cleaning RFID data, and adapting such data for high-level applications including semantic filtering and automatic data transformation and aggregation. The data integration layer consists of applications that exploit local RFID data as well as RFID data coming from outside business entities.

V.   COMPARISONS BETWEEN BARCODE, QR-CODE, RFID

RFID, Barcodes and QR codes are similar in the fact that they are data collection technologies, meaning they automate the process of collecting data. However they also differ significantly in many areas. Although this comparison mainly focus on the advantage of RFID over barcode and QR codes barcodes also offers some advantages over RFID like their low cost.[3]. QR code and barcode need to be in the line of sight to be read by scanner; but it is not at all required in case of RFID. As

Attribute	Barcode	QR code	RFID
Line of Site	Required	Required	Not required (in most of the cases)
Read Range	Several inches to feet	Several inches to feet	Passive RFID -Up to 30 feet Active RFID -Up to 100s feet
Identification	Most barcode only identify only type of item (not uniquely)	QR code can identify each item uniquely (Limited up to certain value)	It can uniquely identify each item
Read\Write	Only read	Only read	Read Write
Technology used	Optical (laser)	Optical (laser)	RF(Radio frequency)
Automation	Most barcode Scanners need humans to operate	QR scanners need humans to operate	Fixed scanners don't need human labor
Updating	Cannot be Updated	Cannot be Updated	New information can be written on old tag
Tracking	Manual tracking required	Manual tracking Required	No need of tracking
Information Capacity	Very less	Less	More than QR and Barcode
Ruggedness	No	No	Yes
Reliability	Wrinkled and smeared tags won't work	Wrinkled tags may work 30% data recoverable	Nearly flawless read rate
Data capacity	<20 characters with linear	up to 7,089 characters[9]	100s to 1000 characters
Orientation Dependent	Yes	No	No
Marginal Cost	0.01$	0.05$	0.05-1$

the radio signal can penetrate through objects it can be used to read bulk of RFID tagged objects at a time and

Table 1: Comparison among Barcode, QR code and RFID

orientation is also not the issue with them. Accessibility range for barcode and QR code varies from few feet to inches whereas for RFID it is up to few meters. The Most important benefit with the RFID tag is that it is reusable, also the contents on it can be modified any number of times but it is not possible with Barcode and RFID.

Also the RFID tags have better durability over Barcode and QR code; even damaged one can read the information written on it. Barcode stores the least information, followed by QR code and RFID can store considerable amount of information.

VI. CONCLUSION

This report provides a comparable analysis of RFID QR code and barcoding technologies in practice. It gives a clear picture that RFID can deliver more rapid scanning times than barcode QR scanning. The literature suggests this as one of RFID's many benefits since tags can be scanned without being in the user's line of sight. This makes it immediately preferable over barcode technology as well QR code technology in the majority of operational environments where rapid throughput of product is of paramount importance, such as into and out of chilled warehouses. Recent advances in two dimensional barcodes and laser scanning equipment, however, could help improve the time it takes for barcodes to be scanned and further empirical analysis of this particular technology is required.

Therefore RFID proves out to be a promising technology compared to other in use.

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