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BARCODE: THE LANGUAGE OF PRODUCT

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Abstract: Every commercial product is now labelled with a unique code. It appears as a series of parallel black and white lines of increasing widths, followed by the number. Under these lines and patterns, important product information is buried. These distinctive numerical patterns are known as a barcode. As a result, the barcode becomes the language of the product. Barcode technology is currently widely employed in all sectors. Not only that, the global COVID-19 immunisation programme has been running smoothly with this barcode technology. As a result, the barcode is inextricably linked to our modern way of life. It enables us to collect accurate and timely data in real time at any moment. This technology reduces human data entering errors to a minimum. The barcode system offers us transparent, accurate, and automated information about the goods in a short time. The barcode system is evolving from 1D to QR scan as technology advances. The study of barcode technology and decoding is a fascinating topic. This manuscript explains the theory behind the EAN-13 barcode system as well as the decoding mechanism.

Keywords: Barcode, Check digit, EAN-13 barcode, Encoding

I. INTRODUCTION

We love to employ "Emoji"-universally applicable symbols-to show our attitude, expression, and emotions. We are now much more comfortable communicating using symbols, graphics, and doodling. That is, we employ 'code' as a concise, precise, and informative conversational language in our daily lives. To identify a product, almost every product today has a distinctive numerical pattern known as a barcode. A barcode is a code that can be read by an optical scanner. This code can be found on the products themselves. It appears as a series of parallel black and white lines of increasing widths, followed by the number [1]. These lines and patterns include important product information. As a result, the barcode becomes the language of the product.

"Barcode systems have transformed both modern sales management and our way of life [2]. It's a technology for automatic identification. This technology is enormous and assists businesses in tracking products, prices, and stock levels through a centralised management system. The combination of barcode technology with compatible software improves productivity and profitability for the company. E-commerce business almost depends on the barcode system. Barcode technology is currently widely employed in a variety of industries. Now barcode-based machinery has become an essential part of the banking sector as well as courier services. At present, barcodes are mandatory in passports and different types of cards. We take the benefit of the barcode system in the education system also. Furthermore, without a reliable barcode system, the COVID-19 vaccination programme has failed [3]. Thus, the barcode is very much associated with our modern lifestyle. It gives us the freedom to collect real-time data accurately and rapidly at any instant. This system minimises human data entry errors. Within a short period of time, the barcode system provides the seller/consumer/issuing authority with 100% transparent, accurate, automated information about the product. This short manuscript gives you an overview of the EAN-13 barcode system and decoding method.

II. HISTORY OF BARCODE

Norman Joseph Woodland and Bernard Silver were the first to come up with the concept of the barcode. Following a request from a local food chain store owner in the late 1940s, they began developing a system for automatically scanning product information during grocery checkout. The interesting fact is that inventor Joe Woodland designed the first barcode in the sand in Miami Beach. In 1972, a Kroger store in Cincinnati began using a bull's-eye code [4].

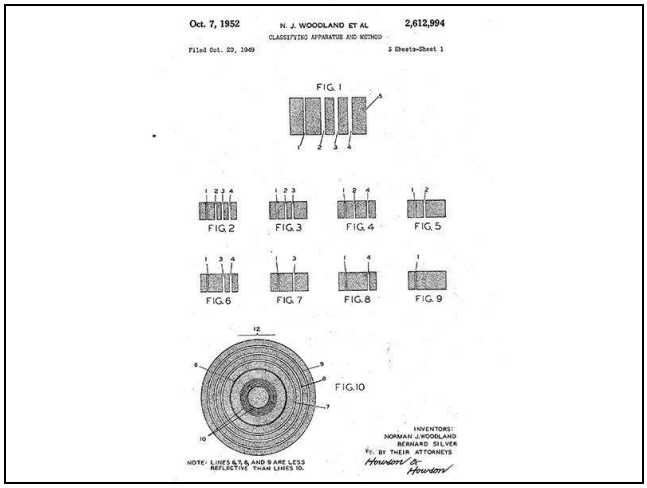

Figure 1. First barcode system [4]

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During that same timeframe, a committee was formed within the grocery industry to select a standard code for industry use. The latter IBM Company proposed a design based upon the UGPIC developed by Logicon Inc., which is very much similar to today's product code. On April 3, 1973, a committee recommended the UPC symbol as the industry standard. The UPC (Universal Product Code) was invented by George J. Laurer [5]. The first UPC scanner was placed in a Marsh's supermarket in Troy, Ohio, in June 1974. Wrigley's Gum was the first product to have a barcode. Tippecanoe Systems, Inc. introduced today's Bars & Stripes to the market in 1991. Since then, Bars & Stripes has relied on one of the most widely used barcode software solutions, allowing small enterprises to implement bar coding at a low cost. Barcodes began as a simple one-dimensional pattern, but they now exist in a variety of forms and sizes, as well as a variety of formats. Its outstanding facility makes barcodes an integral part of the products. Now barcodes come in a 2-dimensional form, which is more useful and popular. Another advantage of this pattern is that it can be scanned simply by smartphones.

III. TYPES OF BARCODE

Depending on the pattern barcode are classified into the two categories. (i) Traditional one dimensional (1D) barcode and recently develop (ii) two dimensional (2D) barcode system [6].

3.1 One dimensional barcode

A one-dimensional (or 1D) barcode represents data by altering the lengths and spacing of parallel lines in a regular manner. One dimensional barcode or linear barcode has two different forms. One is a numeric form that consists only of numbers. On the other hand, another is an alpha-numeric barcode which contains numbers as well as the alphabet.

3.2 Two-dimensional barcode

Two-dimensional (or 2D) barcodes methodically signify data using two-dimensional secret language, shapes and dots etc. A 2D barcode can store more data per unit area than a 1D barcode can. Another advantage of 2D barcodes is to keep data scan-able even after being ripped, scratched or damaged. The development of the 2D barcode substantially broadened the scope of barcode applications.

The following chart (**Chart 1**) shows the most commonly used barcodes types with their pattern and field of application [7].

Chart 1

Name	Barcode	Type	Length	Application
Universal Product Codes (UPC-A)		1-D (Numeric)	12	It is mainly used in retail industry POS (point of sale) round the world—mainly in the United State.
UPC-E		1-D (Numeric)	6	It is used for smaller package.
EAN-13		1-D (Numeric)	13	EAN-13 is used to identify consumer products worldwide and are designed for Point-of-Sale (POS) scanning.
EAN-8		1-D (Numeric)	8	It is used for smaller package; for example on cigarettes, pencils, and chewing gum packets.
Code 39 or Code 3 of 9		1-D (Alpha-Numeric)	variable	Code 39 is widely used in automobile Industry electronic Industries Alliance (EIA) etc.
Code 128		1-D (Alpha-Numeric)	Variable	This barcode is mainly use in supply chain.

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QR Code		2 D	Variable	It is basically use in tracking and marketing like advertisement , magazine and business card
PDF 417		2D	Variable	It has a capability to store huge amounts data of photograph, fingerprint and signature. It is used by Government and logistics.
Aztec		2D	Variable	We see this types of barcode mainly in tickets for transport, airline boarding pass etc.

Out of the many barcode systems, the EAN-13 type barcode is very popular and is seen on almost every product. The ISSN number and ISBN are used as an identification number for journals and books, respectively, and follow the EAN-13 barcode system. So in the next section, we are going to analyse the components of the EAN-13 barcode system.

IV. COMPONENT OF EAN-13 BARCODE

At first glance, anyone can find that the EAN-13 barcode is nothing more than a collection of 13 numbers associated with a black bar and white space. This barcode has mainly four components. The first three numbers of the barcode are the country code allotted by GS 1 (a non-profit organisation). Then five numbers are the manufacturer's identification number. The next four digits represent the item's number. The last digit is known as the check digit, and it allows the scanner to verify whether or not the data is correct.

4.1 GS1 prefixes:

The first three digits of the EAN-13 barcode usually identify the GS1. This number is exclusive to each country as it is allotted GS 1. GS 1 has the only power to fix this globally accepted number for each country. Hence, this number is the "country code" of the product. According to the GS1 prefix chart for a different country, the country code of India is 890 [8]. However, the GS 1 product code of the multinational company depends on which country it applies to. If a China-based mobile company is assembling the parts of a mobile phone in India and applying for a GS-1 code in India, then their product barcode starts with the number 890. In the GS1 prefix-list, the prefix 978 and 979 are preserved for Book-land (ISBN), whereas the prefix 977 indicates International Standard Serial Number (ISSN).

4.2 Manufacturer Code:

The second part of the EAN-13 barcode identifies the origin of the company where the product was made. This manufacturer code is assigned to each company by the numbering authority indicated by the GS1 Prefix. All products produced by the same company will use the same manufacturer code. This manufacturer code has a variable length depending on the profile of the company. In ISBN and ISSN, this component is used to identify the language in which the publication is issued, and it is further subdivided into allocating sub-blocks for publishers.

4.3 Product code:

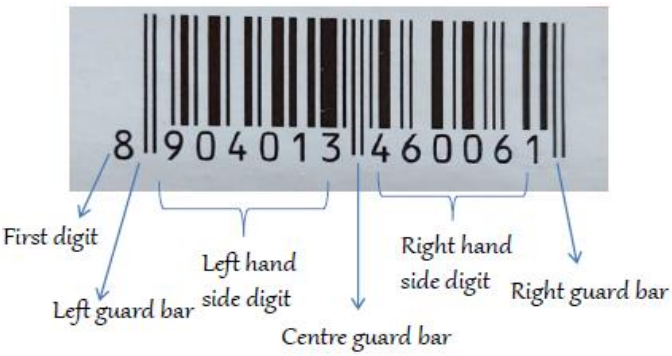
The third component of the EAN-13 barcode is the product code, which is assigned by the manufacturer. The manufacturer's code and product code might be 9 or 10 digits long, depending on the country code (2-3 digits). In ISBN and ISSN, it uniquely identifies publications from the same publisher.

4.4 Check digit:

Any barcode system ends with a check digit and is the most important factor. The 'Check digit' is used to verify whether the barcode was scanned correctly or not. It can detect all single-digit errors.

V. ENCODING OF BARCODE

Encoding the barcode means decoding the hidden information in a barcode into a form that a computer can deal with. One EAN-13 barcode contains 95 areas with equal width. Each area is either white (represented as 0) or black (represented as 1) and each digit takes 7 areas for its bar representation [9].



If we observe the above EAN-13 barcode we can notice the following

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a) The left longer bar known as **left guard bar** takes 3 areas for its bar whose fixed binary representation is101.

b) The middle longer bar known as **centre guard bar** takes 5 areas for its bar whose fixed binary representation is 01010.

c) The right longer bar known as **right guard bar** which also takes 3 areas for its bar with fixed binary representation 101.

Now we try to divide the 13 digits of the barcode and correlate them with the bars. The first digit has no bar representation and is present on the left side of the left guard bar. The remaining twelve numbers can be divided into two groups. The set of 6 digits that lie on the left side of the centre guard bar are called the 'left-hand side digits'. On the other hand, numbers between the centre guard bar and the right guard bar are called 'right-hand side digits'.

Now the encoding rules of different groups are different. To understand the encoding rules of these groups of digits, first we need the following tables.

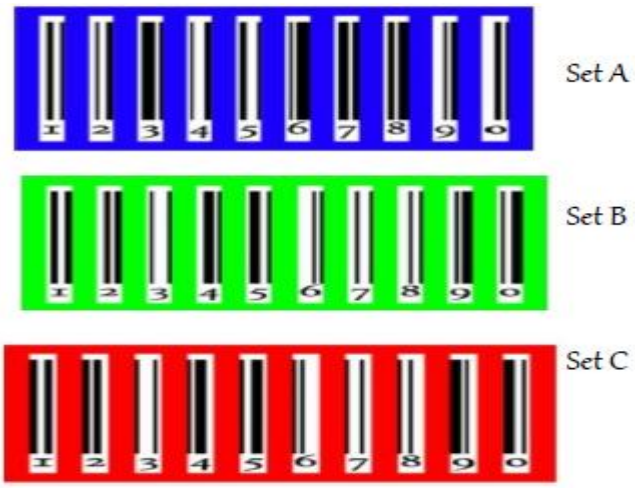
Table 1.

First Digit	Left hand side 6 digit	Right hand side 6 digit
0	AAAAAA	CCCCCC
1	AABABB	CCCCCC
2	AABBAB	CCCCCC
3	AABBBA	CCCCCC
4	ABAABB	CCCCCC
5	ABBAAB	CCCCCC
6	ABBBAA	CCCCCC
7	ABABAB	CCCCCC
8	ABABBA	CCCCCC
9	ABBABA	CCCCCC

Table 2:

Digits	Left Hand		Right-hand
	Set A	Set B	Set C
0	0001101	0100111	1110010
1	0011001	0110011	1100110
3	0111101	0100001	1000010
4	0100011	0011101	1001110
5	0110001	0111001	1001110
6	0101111	0000101	1010000
7	0111011	0010001	1000100
8	0110111	0001001	1001000
9	0001011	0010111	1110100

Table 3:



5.1 First digit encoding rule:

The first digit is not encoded directly as it has no bar representation, but it is encoded indirectly by identifying the pattern of the left-hand side digits according to the rule that follows from Table 1. For example, if left-hand digits follow the pattern ABABBA, then according to the table, the first digit will be 8.

5.2 Left hand side digit encoding rule:

In the case of the left-hand side digits, each digit has two possible bar representations. If the bar representation of one digit comes from set A (or set B) from table 3, the associated binary representation comes from set A (or set B) from table 1. For example, the bar pattern of 9 is similar to the bar pattern of 9 in set A (table 3). Thus, the binary representation of 9 will be 0001011. Again, the bar representation of the next digit 0 matches with the bar representation of 0 in set B, so the binary representation of 0 comes from set B 0100111. In this way, the computer gets the binary representation of the left-hand side digits as well as the pattern of this side. After getting the pattern of this side, the first digit is read.

5.3 Right hand side digit encoding rule:

Encoding rule of this side follows only single pattern rule CCCCCC i.e binary representation of every digit of this side comes from the set C.

VI. CHECK DIGITS CALCULATION

We know that the last digit of the EAN-13 barcode is the check digit. It plays a vital role in barcode representation. After encoding the first 12 digits, the computer calculates the check digits using the following algorithm. If the calculated check digit is different from the encoded check digit, the scanner determines that something went wrong and the data should be rechecked. To understand the algorithm of finding check digit let us take the following barcode:

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6.1 Algorithm:

1. Add the odd number digits: 8+0+0+3+6+0=17
2. Add the even number digits: 9+4+1+4+0+6= 24
3. Multiply the result obtained from the addition of even no. digit by 3: 24 × 3 = 72
4. Add the two results together: 17+72= 89
5. Subtract the result from the nearest higher multiple of 10: 90-89=1 same as the last digit of the above barcode.

6.2 Why we need check digit in barcode system?

People can make various types of mistakes when they enter barcode data into computers. Even barcode scanners can scan a digit wrong. Then the check digit algorithm can detect the error. Common human transcription errors are the following [10]:

getting one digit wrong (substitution)
swapping two digits that are adjacent (transposition)
phonetic errors, such as 60 → 16 ("sixty" to "sixteen")
twin error (22 → 33)
missing a digit
adding a digit

The last two errors will identify by observing the lengths of the barcode. The first four depend on the check digit to be detected. Interestingly, all one-digit errors can be corrected by a check digit.

6.3 Logic behind that:

A number in an odd position always contributes itself to the sum. For example, here the first digit is 8 and no other odd-position digit can contribute to 8 in the sum. In the case of even position digits, one digit that contributes three times to the sum can also contribute once to the sum. The following observation supports the fact.

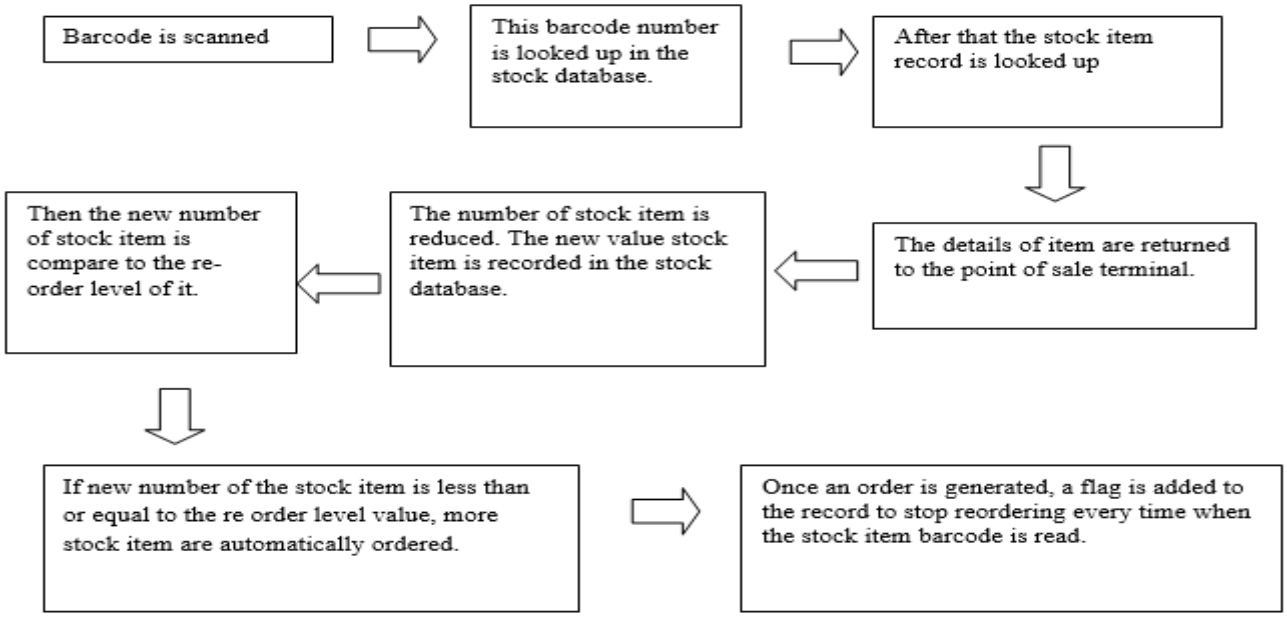
Table 4:

Digits	after multiplication by 3	contribution in sum with respect to 10 modulo		Digits	after multiplication by 3	contribution in sum with respect to 10 modulo
1	3	3		6	18	8
2	6	6		7	21	1
3	9	9		8	24	4
4	12	2		9	27	7
5	15	5		0	0	0

If we look at the above table, we can observe that there is no repetition. This means that there are no longer two different digits which contribute the same amount to the sum with respect to modulo 10 after multiplication by 3. Thus, check digit can detect single digit errors completely.

VII. HOW BARCODE HELPS US?

Now the question arises: what happens after the barcode is scanned? How will it be used for stock control? The following steps will help us to understand this process.



VIII. ADVANTAGE OF BARCODE

8.1 Advantage of barcode to management:

EAN-13 barcode can be found on nearly every item sold in a supermarket, department shop, or mass merchandiser. Although shoplifters can now print their own barcodes, this considerably aids in keeping track of a large number of items in a store and also lowers cases of stealing via price tag switching. This automated barcode-based technology minimises human data entry errors and reduces labour costs. Barcodes make it easy to check the stock [11]. Its ability to track individual and department function

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performance and display individual results with accurate and timely data capture will boost productivity. Barcode Technology also reduce paperwork and training time also.

8.2 Customer Benefits of Barcodes:

Barcodes make the billing part of the product accurate and faster, so consumers are happy to save time.

IX. RESTRICTION

The size of the EAN-13 barcode is fixed. So a size limitation problem may arise. The Ean-13 barcode cannot be read by the scanner if it is damaged or dirty. The procedure of tagging all sites using bar code labels can be time consuming and costly. The cost and effort of implementing technology may not be justified if your business only sells a few things and receives a small number of orders.

X. CONCLUSION

In this world, almost everything is considered a product. Every product is now tagged with a barcode. So, we are surrounded by barcodes and this technology makes our lives faster, no doubt about it. Furthermore, using barcode technology, the global COVID-19 immunisation programme has been working smoothly. Barcodes, particularly the EAN-13, have gradually become an integral component of modern society. This barcode system must be understood not just by management but also by the general public. The various components of the EAN-13 code provide different types of useful information about the goods. The 'Check digit' is used to ensure that the barcode was accurately scanned. By using the barcode encoding rule, we are able to extract this information from the black and white strips of barcode. After obtaining this information, the product can be uniquely identified. This identification aids management in keeping track of the products that are coming in and out within a fraction of a second. One business could miss out on sales or endure product spoiling if you don't have appropriate inventory tracking and control. Manually processing inventory raises operating costs by consuming a lot of time and leaving a lot of room for human error. All of these problems can be solved by putting in place a barcode system.

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