# DYNAMIC PATTERN GENERATION AND ENHANCING AUTHENTICATION USING TWO-LEVEL QR CODE

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***Abstract : This paper illustrates about a new Quick Response (QR) code to enhance data security with importance given to its wide use in information storage and authentication. The Bi-Level QR code add new capacities to standard QR code which include supplementary reading level, which does not disrupt the standard QR code reading process and increase in privacy of initial QR code. The standard QR code used as first level of our Bi – Level QR code stays fully functional. It can be read by all standard application, without any restriction. Bi – Level QR code ensures privacy of data stored in the second level by a physical separation, between levels and reader application abilities.***

***IndexTerms-Bi-level, QR code, public level, private level, P& S process***

## 1.INTRODUCTION

During recent years, there are major developments in the adoption of 2D Codes such as :

I. The directive by International Air Transport Association (IATA) for airports worldwide to adopt 2D bar code for passenger boarding passes by2010.

II. The adoption of QR Code for patient identification by two leading hospitals in Singapore and all hospitals in Hong Kong.

III. The use of 2D bar codes/micro codes for various applications in other sectors.

IV. The use of QR code with mobile phones in Japan and Korea.

With the advent of Bi- level QR code the authentication and message sharing capacity has been enhanced when compared to standard QR codes. The Bi- Level QR code has a unique Print-and –Scan(P&S) process which eliminates duplication of the code. The attack method used in the QR code was that when a user scans the code he/she is directed towards a website and then a malicious file downloads in the user's device without the knowledge of the user. In this paper, the authentication is done through the scanning of Bi-level QR code via the mobile scanner application to retrieve public details and through the unique scanner to retrieve the private details.By this method the attack method used in the standard QR code is minimized to a great extent. Here the real time implementation of the Bi – Level QR code is explained by means of an android application to book tickets in metro trains.

## 2.RELATED WORK

This section is split into two sub-sections (2.1,2,2). Section 2.1 deals with the description of the most commonly used Quick Response (QR) code. Section 2.2 deals with the proposed work Bi – Level QR code.

## 2.1. QUICK RESPONSE (QR)CODE

Unlike the older, one-dimensional bar codes that were designed to be mechanically scanned by a narrow beam of light, a QR code is detected by a 2-dimensional digital image sensor and then digitally analyzed by a programmed processor. The processor locates the three distinctive squares at the corners of the QR code image, using a smaller square (or multiple squares) near the fourth corner to normalize the image for size, orientation, and angle of viewing. The small dots throughout the QR code are then converted to binary numbers and validated with an error-correcting algorithm. The amount of data that can be stored in the QR code symbol depends on the data type (*mode*, or input character set), version (1, …, 40, indicating the overall dimensions of the symbol), and error correction level. The maximum storage capacities occur for 40-L symbols (version 40, error correction levelL).

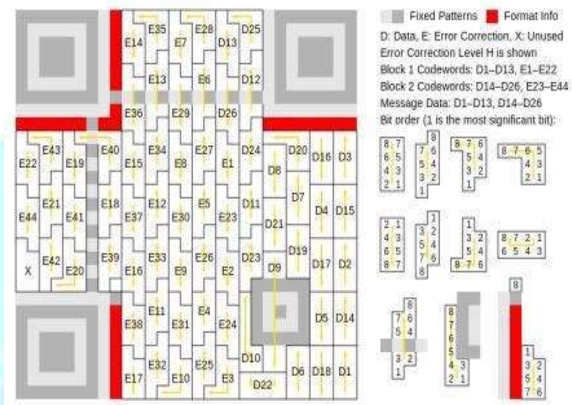


Fig 1. Fixed patterns and format info in QR code

Data is stored in a QR in words that are 8 bits long and use the Reed-Solomon error correction algorithm with four configurable error correction levels. The higher the error correction level, the less storage capacity. QR Code has error correction capability to restore data if the code is dirty or damaged.


Fig 2. Efficiency of Quick Response code with respect to error correction

Four error correction levels are available for users to choose according to the operating environment. The following figure illustrates the fixed patterns and the formatting.Raising this level improves error correction capability but also increases the amount of data QR Code size. To select error correction level, various factors such as the operating environment and QR Code size need to be considered.Level Q or H may be selected for factory environment where QR Code get dirty, whereas Level L may be selected for clean environment with the large amount of data. Typically, Level M (15%) is most frequently selected. The above image lists the approximate error correction capability at each of the four levels.

### 2.2. BI - LEVEL QRCODE:

The Bi – Level Quick Response code add new capacities to standard QR code:

1. Supplementary reading level, which does not disrupt the standard QR code reading process.
2. Increasing storage capacity of initial QR code.

The standard QR code used as first level of our Bi- Level QR code stays fully functional. It can be read by all standard application, without any restriction.Our Bi-Level QR code ensures privacy of data stored in the second level not only by applying a classic numeric ciphering, but also by a physical separation, between levels and reader application abilities.

The Bi-Level QR code has two information levels:

1. The first level contains public information and can be read by any QR code application, i.e. iOS, Android and scanner applications. That is why the proposed Bi-Level QR code satisfies all standard QR code features.
2. The second level contains supplementary information and is realized by replacing black modules in QR code with two specific textured patterns. The combination of these textured patterns allows to encode and afterwards, to reconstruct the supplementary information.

## 3. TWO LEVEL QUICK RESPONSE CODE WITH PUBLIC AND PRIVATE LEVELS

Bi level QR code is that standard QR code with both public and private levels. Standard QR code usually contains public level alone that is it shows all the information that has been stored in it. The main purpose of bi level QR code is the invisible storage and transmission of private information in to QR code .This sub section explains about the QR code generation steps, storage capacity of bi level QR code and pattern recognition method.

### 3.1 BI LEVEL QR CODEGENERATION:

The overview of Bi level QR code generation steps are illustrated in the following figure

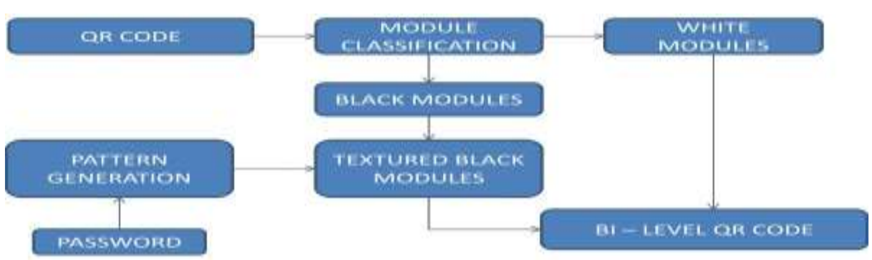


Fig 3. Bi-level QR code generation architecture diagram

This section describes the structure of standard QR code with private level. After generating a standard QR code, private information is added to make it as a bi level QR code. Generation of standard

QR code includes 7 steps, they are Data analysis, Data encoding, Error correction coding, Structure final message, Module placement in matrix, Data masking, Format and version information.

In first step, a QR code encodes a string of text. The standard QR code has four modes for text encoding, they are numeric, alphanumeric, byte and kanji. Each mode encodes the text as a string of bits and each mode uses a different method for converting the text into bits and each encoding method is optimized to encode the data with the shortest possible string of bits. Therefore, first perform data analysis to determine whether your text can be encoded in numeric, alpha numeric, byte or kanji. Then select the most optimal mode for your text.

In data encoding stage, first step is to choose error correction level. QR code uses Reed Solomon error correction code. This process creates a error correction code word based on the encoded data. If the QR code reader did not read the data correctly, then error correction bytes are used . And also error correction code words can be used to correct those errors. There are four levels of error correction, they are L, M, Q, H. The next step is to determine the version of the data. Then mode indicator is added to it. Each encoding mode has a four-bit mode indicator that identifies it. After that, encode using selected mode by breaking up into 8-bit codeword and pay bytes if necessary.

Next step is error correction coding which means that after creating the string of data bits, error correction codewords are generated using those data bits. This process is called reed-solomon error correction. QR code scanner reads both the data codewords and error correction code words. By comparing these two codewords, QR code reader determine if it read the data correctly or not . If not, it can correct error using those error correction code words. The data and error correction code words generated in the previous step should be arranged in a proper order which is called structure final message. For smaller codes, data and error correction code words are used as it is and also interleaving is not necessary. For large QR codes, the data and error correction code words are generated in blocks and these blocks must be interleaved according to the QR code specification.

After data are arranged properly in the previous step, module placement in matrix is done in this step. The code words are arranged in the matrix in a specific way. This step includes function patterns. Function pattern includes finder pattern, separator, alignment pattern, timing pattern, dark module. The finder pattern are three blocks in the corner of QR code at the top left, top right and bottom left. The separators are the areas of white spaces beside the finder pattern. The alignment pattern are similar to finder pattern, but smaller and are placed throughout the code. The timing pattern are dotted line that connects the finder pattern. The dark module is a single black module that is always placed beside the bottom left finder pattern.

Certain patterns in the QR code matrix are difficult to read correctly by QR code scanners. To counteract this, the QR code specification defines eight mask patterns, each of which alters the QR code according to particular pattern. Then masked matrix is evaluated based on four penalty rules in order to determine which of these mask patterns result in the QR code with the fewest undesirable traits. The first penalty rule gives the QR code a penalty for each group of five or more same colored modules in a row or column. The second penalty rule gives the QR code a penalty for each 2*2 area of a same colored modules in a matrix. The third penalty rule gives the QR code a large penalty if there are patterns that look similar to finder patterns. The fourth penalty rule gives the QR code a penalty if more than half of the modules are dark or light, with a larger penalty for a large difference. Finally, QR code must use the mask pattern that resulted in lowest penalty score.

The final step in standard QR code is to add format and version information to the QR code by adding pixels in particular area of the code that were left blank in previous step. The format pixel identifies the error correction level and mask pattern being used in this QR code. The version pixels encode the size of the QR code matrix and are only used in larger QR codes. The format information string encodes which error correction level and which mask pattern is use in the current QR code. Since there are four possible error correction levels and seven possible mask pattern, therefore there are 28 possible format information string. After generating format string and version information, output will be the standard QR code.

After generating a standard QR code, private information is added to that standard QR code in order to make it as a bi -level QR code. The first step in bi level QR code is to separate black modules from the output of the standard QR code. And a pattern should be generated using the unique password which is given by the user. Then the generated pattern should be replaced in the particular place of the QR code in which place where the private information is encoded in it. After processing all these steps, the resultant will be the bi level QRcode.

### 3.2. STORAGE CAPACITY OF BI LEVEL QR CODE:

The storage capacity of QR code is calculated based on the version of the QR code. The formula to calculate the size of the QR code is (((v-1)*4)+21), where v is the version of the QR code. For example, if version of the QR code is 10, then the resultant of this formula for this example (((10-1)*4)+21) will be 57 modules by 57 modules. The data are stored in the finder pattern of the QR code and the position of the finder pattern can be generalized as the top-left finder pattern's top left corner is always placed at (0, 0), the top-right finder pattern's top left corner is always placed at ([(((v-1)*4)+21)-7], 0) and the bottom left finder pattern's top left corner is always placed at (0, [(((v-1)*4)+21)-7]).

For a particular version, character capacity vary based on error correction level and text encoding modes. For example, in version 10, for error correction level L, the capacity is 652 for numeric mode, 395 for alpha numeric mode, 271 for byte mode, 167 for kanji mode. Let N2 be the number of modules in QR code. Since there are equal number of black and white modules in QR code, N2/2 is approximately the number of black modules in the QR code. An further there are three position tags and each tag has 33 modules, there are approximately (N2/2 - 3*33) black modules in QR code that could be replaced by textured patterns.

Let n be the total number of digits in a codeword and k be the number of message bits and n-k be the number of error correction bits in the codeword. Therefore, the number of code words could be inserted in the private level of Bi-level QR code which is approximately equal to Np≈ (N2 / 2 - 3* 33) / n.And the number of message bits is approximately equal to Np * k.

### 3.3. RECOGNITION METHOD

The overview of Bi-level QR code reading process is illustrated in the fig. no. . First the bi-level QR code has to be corrected during image processing step. The position tags are localized to determine the position coordinates. The linear interpolation is applied in order to re-sample bi level QR code. After this step, the Bi-level QR code has the correct orientation and original size.

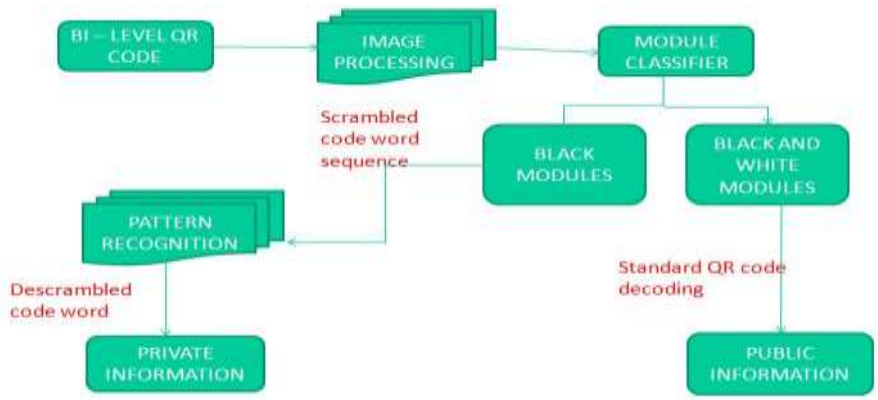


Fig 4. Bi-level qr code scanner architecture diagram

## 4. RESULTS

This section illustrates the improved authentication and how the dynamically generated pattern is included in the Bi-level QR code. However the storage capacity remains the same as proposed by the authors in [1]. The application scenario encompasses the ticket ID, the source, the destination,booking date and time, number of tickets and the amount as the public details. The private detail will include the payment ID which is encoded as the secret information.

The QR code version used here is the version 7 with the lower error correction level. This version has 45 x 45 modules and can encode bits of length 154. The error correction is done by Golay correction code with the encoding [11, 6, 5] with the digit length n=11, and where k=6 and the number of parity bits is 11-5=6 [1].

### a. Bi-level QR code generation

This pattern includes three steps- the standard QR code generation, pattern generation and the replacement of black modules in the QR code. i. Generation of standard QR code: With the help of android studio IDE a standard QR code of version 7 is generated with the public message as Mpub"Ash, code, source, destination, booking time, ticket count". The conversion or encoding of data in to QR code is done in the alphanumeric mode.

Step1: This mode involves splitting of the string into pairs. For example, HELLO WORLD is splitted as HE, LL,O ,WO,RL,D.

Step2: For each pair of characters, get the number representation of the first character and multiply it by 45. Then add that number to the number representation of the second character.

For example, the first pair in HELLO WORLD is HE.

$H \rightarrow 17$ $E \rightarrow 14$

Following the steps in the previous paragraph, multiply the first number by 45, then add that to the second number:

$$(45 * 17) + 14 = 779$$

Now convert that number into an 11-bit binary string, padding on the left with 0s if necessary.

$$779 \rightarrow 01100001011$$

If you are encoding an odd number of characters, as we are here, take the numeric representation of the final character and convert it into a 6-bit binary string.

Step3: Break Up into 8-bit Codewords and Add Pad Bytes if Necessary

Step4: Encode these bits with the error correction code.

The following figure shows the generated QR code as a metro train ticket.

Fig 5. QR code version 7 (as generated)

**b.The pattern generation:**

Patterns are generated from the passwords given by the users. The passwords as texts are first converted in to bits of length 16. For the converted bits patterns are generated using the pixilation tool. The generated patterns are then embedded in the QR code that will match the correlation values [1]. The patterns are binary and have 16 x 16 pixel size.

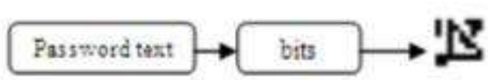


Fig 6. Text to pattern conversion

One important feature of the textured patterns used is their sensitivity to the P&S process. To take advantage of this sensitivity, we use a pattern recognition method based on maximization of correlation values among the P&S degraded versions and characterization patterns. We have tried three different types of characterization patterns: mean patterns, median patterns (for the private message sharing scenario) and original patterns (for the document authentication scenario). The mean and median characterization patterns give almost the same results of pattern detection. Therefore, either of them can be used in the private message sharing scenario. The best pattern recognition results were obtained, when the original patterns are used as characterization patterns. The original patterns can be also used for the private message sharing scenario, but in this case the blind method for pattern detection cannot be performed. The suggested textured patterns can be distinguished only after one P&S process. Therefore, we can use the detection method with original patterns in order to ensure good document authentication results.

**c.Replacement of black modules in the QR code:**

The black modules in the QR code are replaced with the textured patterns. There is no change in the black modules of the position tags. The public level of the bi-level QR code can be read by and ordinary scanner. The private level needs a unique scanner which is application specific. b. Information retrieval: The public level of the bilevel QR code has been scanned by various scanners available in the Google play store. The following figure shows the scanned bi-level QR code which is scanned by the application "QR Scanner".

For each P&S Bi Level QR code, the proposed detection method is applied with characterization patterns (mean and median) for the message sharing scenario and with the original patterns for the authentication scenario. We apply the unscrambling operation using key K to the sequence of numbers, which corresponds to detection patterns. Since our private message was encoded using ternary Golay ECC, the error correction and decoding algorithm is applied to get the private message Mpriv.


Fig 7. public level information retrieved using QR code scanner

We conclude that all errors caused by incorrect pattern detection are corrected by Golay error correction algorithm: the 100% of the message digits are decoded [1].

The private message is retrieved using an application specific scanner which will identify the patterns and decode the pattern. The private message as the payment details is scanned using the unique scanner. The following figure illustrates the retrieval of the public information. Only two (including the proposed Bi Level QR code) of the mentioned graphical codes are sensitive to copying process, as well as this, only two have the private storage level capability. The maximum storage capacity of QR code with hidden message [2] is equal only to 9720 bits using QR code V40.

The sensitivity to copying has been improved in this paper by dynamically generating the patterns which can be changed by the user as and when they require. The early works includes incorporating the already designed textured patterns from the pattern database into the black modules of the QR code. The experiment results have shown that the authentication property has been enhanced by dynamically generating the patterns and impeding into the QR code. Also, when the QR code is shared via any medium like Bluetooth or any sharing means this authentication will help to store the private information only with the shared user if the QR code has been shared with any unauthorized user.

The proposed bi-level QR code can be used for any QR code tamper proofing. In addition, due to the specific characteristics of the used textured patterns, the original bi-level QR code can be distinguished from one of its copies to ensure authentication. This functionality has been performed due to the impact of the P&S process where the patterns cannot be duplicated because of both the deficiencies of the physical process and the stochastic nature of the matter. Any P&S process adds specific changes in each image. These modifications can be provided by ink dispersion (in the paper or onto the device output), non-homogeneous luminosity conditions during the scanning process, inherent re-sampling of the P&S process or variable speed during the acquisition process. Due to the P&S impact, it is difficult to model the P&S degraded versions of proposed textured patterns.

## 5. CONCLUSION

Thus, we say that there are two levels in bi-level QR code, the first level can be read by any QR code reading application. On the contrary, the second level needs a specific application. The second level is created by using specific binary textured patterns, which are distinguishable from one another after P&S process and are considered as black modules by standard QR code reading applications. In future we plan to study the capacities of Bi – Level QR code, depending on both QR version and pattern size, as well as, to propose other pattern recognition algorithms, that will be less sensitive to P&S impact.

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