

Usage and Application Prospects QR Codes

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Abstract—The paper considers 6 types of QR codes and real examples of their application, as a result, diagram visualizing the general statistics of the use of QR codes in 4 most promising areas is presented. This article is an overview of QR codes with their characteristics and versions. The article briefly presents applications for Android and devices for access control with ability to read barcodes, analyzing their functions and formats.

Keywords—overview; information encoding; barcode; QR code; reader.

1. INTRODUCTION

The QR code is most widely used 2D barcode in world and it has been successfully applied in many applications [1].

In era of informatization and high technologies, information is becoming more and more every day, while relevance of threats to integrity and confidentiality of information requires careful attention to task of protecting it.

The main prerequisite for widespread use of QR codes is that they are quickly and easily read using scanning equipment. Three corner anchor squares, which have become distinctive feature of code, allow it to be correctly deployed in scanner program's memory.

The convenience of QR code is that it can contain large amount of information.

The amount of capacity depends on form in which information is to be encoded into it. The main task for companies that develop QR codes is that code should be easy to “read”.

Today, QR codes are used in many industries, both for storing data (links to websites, phone numbers or texts), as well as for providing access to Wi-Fi, sending and receiving payment information, and other purposes.

Every day, applications of QR codes are expanding, and especially popularity of QR code is rapidly increasing due to growth of smartphone users, and thus QR code quickly reaches high level of acceptance around world, so topic is actual. At the same time, to develop a QR code, you can use various methods and approaches that are used in other areas of scientific activity [2]-[9].

2. RELATED WORK

To date, problem of QR codes has been subject of numerous studies that reveal two-dimensional codes in terms of coding against threats, authentication, payments, and other processes, but still need additional analysis.

In [10], we are talking about QR codes in education, some examples of QR codes are given in form of separate figures, which allows you to better understand the material presented.

Reference [11] describes an Android application that provides real-time bus information in Malaysia. It uses public feature on any modern Android device such as Global Positioning System (GPS).

In [12], authors use QR code as carrier for information transfer. QR code has digital watermark.

Application of QR code and mobile payments: in trade are presented in works [13]-[15].

Features of QR code in retail trade in [13], [14].

In [15], an alternative method is proposed that use of electronic payments and transactions using QR codes to combat debit or credit card fraud; security of personal information.

The effectiveness of electronic ticket system using QR codes for intelligent transport systems is considered in [16].

An intelligent library management system using QR code was presented by the authors in [17]. Through QR code feature, users can use app to issue, return, and manage books with little or no staff assistance. The authors propose management system that simplifies library processes, keeps track of all records.

In [18], smart packaging is proposed using QR codes to provide information to consumers and influence their demand.

3. OVERVIEW OF QR CODES: THEIR CHARACTERISTICS AND VERSIONS

Quick Response (QR) stores information as series of pixels in square grid that looks like black and white pattern.

QR is read by digital device.

QR code, unlike barcode, is read in two directions – horizontally and vertically. This allows you to store more data in it.

When scanning QR code, user gets access to this data instantly.

Versions of QR code symbols range from version 1 to version 40 (Fig. 1 [19]).

Each version has its own module configuration or number of modules.

The module refers to black and white dots that make up QR code.

Each higher version number contains 4 add-on modules per side.

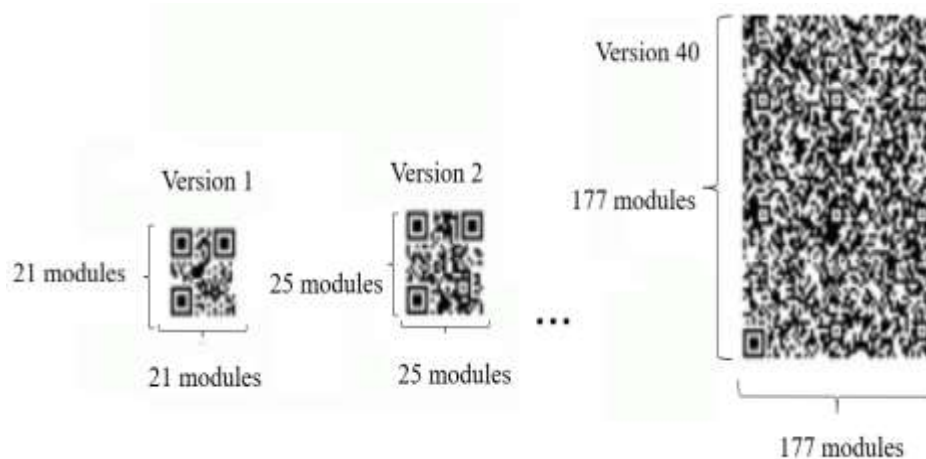


Figure 1: Versions of QR codes

Each version corresponds to certain capacity, taking into account level of error correction. The more information that needs to be encoded and greater level of redundancy used, larger version of code we will need.

Modern QR generators automatically select version of QR code based on these points. The maximum number of characters that can be entered in QR code (in largest version 40 – 177×177) [20]:

- numbers – 7089;
- numbers and letters of Latin alphabet – 4296;
- hieroglyphs – 1817;
- binary code – 2953 bytes (hence, about 2953 Cyrillic letters in windows-1251 encoding or 1450 Cyrillic letters in utf-8).

In table. 1: L, M, Q and H – 4 levels of error correction, which differ in amount of information to recover and, accordingly, amount of useful information that can be restored if code is damaged:

- L – correction level. When using it, you can recover 7 % of information;
- M – correction level; recovery 15 % of information;
- Q – correction level; recovery 25% of information;
- H – correction level; recovery 30% of information.

Table 1: Characteristics of QR codes different versions

Version	Number of modules	Error correction level	Maximum number of characters considering error correction level and character type		
			Number: 0 – 9	Number and symbols of the Latin alphabet*, space,, \$ % * + — . / :	Binary data
1	21×21	L	41	25	17
		M	34	20	14
		Q	27	16	11
		H	17	10	7
2	25×25	L	77	47	32
		M	63	38	26
		Q	48	29	20
		H	34	20	14
3	29×29	L	127	77	53
		M	101	61	42
		Q	77	47	32
		H	58	35	24
4	33×33	L	187	114	78
		M	149	90	62
		Q	111	67	46
		H	82	50	34
10	57×57	L	652	395	271
		M	513	311	213
		Q	364	221	151
		H	288	174	119
40	177×177	L	7,089	4,296	2,953
		M	5,596	3,391	2,331
		Q	3,993	2,420	1,663
		H	3,057	1,852	1,273

Now consider types of QR-code.

1. Standard QR code (models 1 and 2). Today, term QR code usually refers to this type.

Model 1 is original QR code. The largest version of this code is 14 (73 x 73 modules), which is capable of storing up to 1,167 digits.

Model 2 is improved version of Model 1 where largest version is 40 (177 x 177 modules) which is capable of storing up to 7,089 digits (Fig. 1).

2. Micro QR-code, which can contain up to 35 digits and 21 alphanumeric characters (Fig. 2, a). There are no fields in this code. Such a QR code contains only one positioning mark, which allows it to be printed in smaller size (a standard QR code has three positioning points).

This code can still work even if its field width is 2 modules. The largest version of this code is M4 (17 x 17 modules) which can store up to 35 digits.

3. Rectangular Micro QR Code (rMQR-code) – code is used for printing in narrow spaces where regular QR cannot be printed (Fig. 2, b). This is code with wide range of module configurations. Code capacity: minimum 12 digits in 7 vertical modules on 43 horizontal modules; maximum is approximately 361 symbols in 17 on 139 modules [20]-[26]. Such code to store more information than is possible with Micro QR Code.

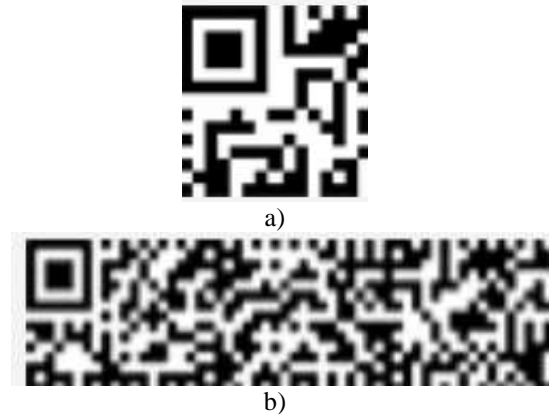


Figure 2: QR-code: a) micro QR-code;
b) rMQR-code

4. Frame QR code – QR code with "label area", which is flexible, since in such code letters and custom images can be added inside label area (Fig. 3). Frame QR capacity depends on size and ranges from 13 digits and 12 letters to 3832 digits and 3067 letters [25], [26].



Figure 3: Frame QR-code

5. Security QR Code (SQRC-code) is one of safest types of encoding information using QR codes [27]. Such code contains confidential information and stores it perfectly – only devices with appropriate cryptographic key can read this data. SQRC-code has read restriction feature and can be used to store personal information or manage internal company information. Its appearance is no different from regular QR code.

6. IQR-code – appearance of QR-codes can be square, rectangle or even bitmap. Capacity up to 40,000 digits. In total, there are 61 formats of such code. The peculiarity of IQR codes is that it is readable even with 50 % damage. An iQR code can contain more information than traditional QR code.

IQR code that is same size as existing QR code can contain 80 % more information than last one. Another classification of QR codes (depending on field of application):

- static QR codes – contain information that cannot be edited after code is created.
- dynamic QR codes – information can be updated, edited and type of such code itself can be changed after its creation.

4. USE OF QR CODES

The scope of QR codes is expanding every day (table 2).

QR code is used everywhere, mainly to optimize various business processes.

Previously, QR codes were used in industry, but today they are ubiquitous.

QR code has received greatest distribution among subscribers of mobile communication. The user can instantly enter text information into his mobile phone (netbook), contacts into address book, follow web link, send SMS message, etc.

Table 2: Scope of QR codes

Scope	Application
Authentication / Identification	Patient identification; information about medical history and analyzes in medical institutions.
	In enterprises or firms.
	Identification of goods by QR-code.
	On tickets in field of air and rail transportation.
	COVID PASSES
	Electronic digital signature.
Protection of information (accounts)	Restrict access to certain premises or to certain documentation.
	Access to individual folders and files.
	Protection of photographic images from falsification and unauthorized access.
Informing	The code can replace invitation cards for large event. In it, you can register all details of event and send it to invitees.
	PDFs can encode voluminous articles in which organization will share data on latest research or statistics.
	Directly on billboards QR-codes with links to company's website; information about discounts and coupons.
	Schedule in universities by code.
	The code is like link to background information about museum exhibit.
	In road transport for truckers, to receive information about their movements and time spent in flight and in parking lots.
Geolocation designation	After scanning code, map app opens.
Link recognition	QR codes are often used to design links to download content: music, movies, pictures, videos, etc. In addition, referral links are very popular.
	Links to social networks, as well as videos, photo galleries, museums, etc.
Sharing data	In QR code, you can put link to profile in social network, thanks to which you do not need to remember unique identifier of user. The code will allow friends, colleagues, relatives to instantly add to friends.
	Business cards – you can encode your phone number, name, email and other information for quick transfer to the device.
Payments	The ability to pay for purchases without use of bank cards and their readers.
Feedback	Users can scan such code and fill out form with reviews and wishes, write to company's mail, and also rate company. QR code with SMS support makes it possible to send feedback to corporate phone number even without Internet connection.

Having analyzed the literature [20]-[24], it is determined that most common areas of QR codes application are presented in diagram of Fig. 4.

QR codes have now become commonplace. Thanks to increase in global smartphone penetration, which grew from 59,01 % in 2017 to 78,05 % in 2020. Access to high-speed mobile Internet increased from 48,8 % in 2014 to 62,5 % in January 2022, which increased use of QR codes.

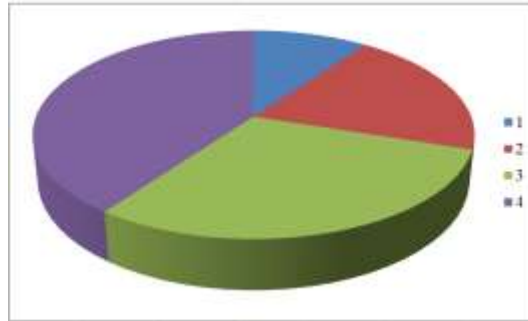


Figure 4: Diagram of the application of QR codes:
1 – data sharing, 2 – payments;
3 – informing; 4 – Authentication

Thus, we will draw conclusions about prospects for use of QR codes, which are caused by:

- since now is age of digital technology and there are many applications that store passwords in database, but these programs specify password in form of text and you need to enter it with your hands, QR codes can successfully display saved passwords;
- ease of use, as QR code can be printed on sheet of paper, plastic or attached as key fob;
- QR code can be generated when registering in any free application and save it;
- need to generate sometimes quite complex one-time passwords and encode them in QR.

5. READING QR CODES

When QR code is formed you need to understand that it consists of certain set of labels and directly pixels, which are encoded messages stored in QR code.








Any QR code must have following labels (Fig. 5):

- positioning, that is, area is necessary for detecting code;
- version number that determines which version of code is used (from 1 to 40);
- synchronization. It is duplicated in two directions, and reduce likelihood of errors in reading, system information (for example, version, data type, etc.);
- format. The data types required for definition are encoded in code;
- alignment. They are used for better positioning of code during processing (with QR code version above 1);
- error correction level. Allows you to determine what level of protection against interference was used during coding phase to correctly select method of detecting possible errors in code.



Figure 5: Tags and data on QR code

 – version code;

-  – mask or correction level code;
-  – data with correction codes;
-  – immutable parts of code;
-  – search part;
-  – leveling part;
-  – synchronization lines;
-  – white field.

We will consider readers for: systems with Android; systems for access control and management (ACS).

To begin with, consider programs for reading QR codes for Android devices:

1. Gamma Play reader is considered one of most popular. The software recognizes all types of two-dimensional codes, allows you to change capture scale if, for example, scanned object is far away, as well as decode images stored in device's memory. The user can create business card to share his contact information at any time through QR code, or generate QR code based on text, contacts, email addresses, phone numbers, geographical coordinates, etc.

Features (readable codes): site links (URLs); reading smartphone contacts; Recognizes calendar events. reads e-mail and messages; geolocation data; reading data about Wi-Fi; product codes in stores; ISBN.

2. Droid Team for weather, forecast, radar, widget.

Droid Team – free QR code reader app, this Droid Team reader app can scan and read all types of QR codes including text, URL, ISBN, contact, calendar, email, location, Wi-Fi and many other formats. QR code, QR code generator and barcode scanner.

3. QR-code reader – for scanning and reading QR and barcodes for mobile based on Android.

No Internet connection required for scanning. Features: reads all types of 1D and 2D codes, texts, QR, barcodes; reads location data. reads the URL; reads product codes; reads phone contacts. reads calendar events; decrypts information for connecting to Wi-Fi; reads information about calls, SMS and e-mail; reads ISBN.

Readers for ACS.

Consider novelties – gate brand readers appeared attractive novelties in form of two new modifications of popular QR code reader. They were named: Gate-Reader-QR mod2-EM (Fig. 6, a) and Gate-Reader-QR mod2-MF (Fig. 6, b).

By last letters in name, it is easy to guess that they differ in format of readable cards: EM-Marin or Mifare.

These readers are fully adapted to work as part of ACS Gate – Gate ACS software provides special tool for generating QR code, printing it on badges and sending it to specified e-mail of user.

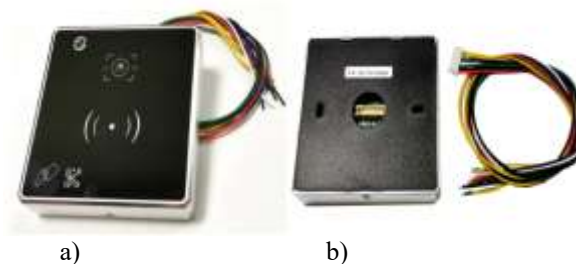


Figure 6: Cr-code readers for ACS:

- (a) Gate reader- QR mod2-EM;
- b) gate-reader- QR mod2-MF

The devices provide reading only digital QR codes (printed or displayed on screen of mobile devices) and codes of contactless identifiers EM-Marin or Mifare (UID 4 bytes).

When using identifiers in form of QR codes in ACS, it is necessary to take into account their insecurity from copying. Therefore, in most cases, this type of identifier is used only to provide temporary guest access to object.

6. CONCLUSION

The paper reviews versions of QR codes from which it is determined that as amount of data increases, more modules are required to include QR code, which leads to increase in symbols of QR code.

Each QR code has timing bars so that they can be read even on uneven surfaces.

Each QR code is separated from outside space by white space or "quiet zone", which is needed for scanner to recognize code.

6 types of QR codes and real examples of their application are considered, as result, diagram is given that visualizes general statistics of use of QR codes in 4 most promising areas.

Thus, this article is overview of QR codes with their characteristics and versions.

The article briefly presents applications for Android and devices for ACS with ability to read barcodes, analyzing their functions and formats.

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