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# The Application and Design of QR Code in Scenic Spot's eTicketing System -A Case Study of Shenzhen Happy Valley

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## ABSTRACT

As an integral part of the Chinese tourism industry, the application of information technology in the ticketing system draws close attention from different sectors. The purpose of paper is that it tries to study whether QR code can be applied in Scenic Spot's eTicketing System. Shenzhen Happy Valley was picked by author as the subject of this study to analyze its ticketing system.Then the author designed a cellphone eTicketing model based on QR code application for the Happy Valley and attempted to test the reliability and security of the model with a series of experiments. With the case study method and experimental approach, the conclusion shows that the model is reliable and safe. The result of paper is conducive to providing the new mode for eTicketing System in Shenzhen Happy Valley and also providing the exemplary model to other Scenic Spots.

**Keywords:** *QR code; Cellphone ETicketing; Security; Shenzhen Happy Valley*

## 1. INTRODUCTION

Since the Symbol Technologies applied PDF417 (two dimensional barcode) openly in 1991, the technology has been adopted widely all around the globe for different purposes including national defense, public security, public transportation, medical care, manufacturing, business, finance, customs and government management(Wang Yu 2001). And in recent years, the application of this technology has been broadened to the field of mobile communication by Japan and South Korea. These two countries respectively applied QR code (Quick Response Code), PDF417 as well as Data matrix to the two-dimensional barcode operation for cellphones. Two-dimensional barcode operation has become the major operation for the Japanese and Korean mobile operators with its diversity in format. It has also become the most popular choice for mobile communication users. The two-dimensional barcode operation in China started pretty late and took reference from Japan and Korea to apply QR code and Date matrix in operation standard. China Mobile joined hands with Beijing Research & Technology Co., Ltd in August, 2006 and launched the two-dimensional barcode operation for cellphones. Since QR code has various advantages as the international two-dimensional code, it gains huge competitive edge in technology application standard and intellectual property right protection. QR code has grown to be the preference of China's cellphone two-dimensional barcode operations.

The decoding and verification model is the key technology in the application of two-dimensional barcode for cellphones. The main representations of this technology are eTicketing and e-receipts. Because the application of information technology in China is still at its starting stage, tickets are mostly sold by manpower. Shenzhen Happy Valley belongs to the OCT Group, which is the powerhouse of China's tourism industry. As a theme park tourist attraction, Shenzhen Happy Valley has been selected as one of the top ten theme parks in Asia-pacific for years and has always been the lead in China's theme park industry. Shenzhen Happy Valley has first-class facilities. Yet, its ticketing system is still depended on manpower and paper tickets. It is a great waste of materials and human resources and it lowers tourists' satisfaction and the quality of the tour by wasting their time and energy. In order to promote the development of tourist attraction as well as to improve tourists' satisfaction, cellphone two-dimensional barcode operations should be applied to the scenic spot's eTicketing system reform. And this would serve as an expression of the application of information technology in the tourism industry.

## 2. LITERATURE REVIEW ON QR CODE

QR code is a kind of two-dimensional barcode matrix designed by a Japanese company named Denso Wave in September, 1994(Qi Jinyue 2004). The code consists of black modules arranged in a square pattern with functions such as encoding, image searching, decollating, image allocation and image revision. The advantages of QR code include large capacity for data storage, wide scope for encoding, mini-size printout, hypervelocity reading, strong error correction capability as well as being dirty-resistant, damage-resistant and 360 degrees readable(Zhu Mingli 2006). The Barcode Automatic Identification Techniques Committee created the international standard for QR Automatic identification and data capture techniques – Bar code symbology – QR code. QR code would not arouse any dispute in intellectual property rights and thus has been widely deployed in various fields around the globe. After introducing QR code into China, the Article Numbering Center of China formulated a national standard for QR code known as GB\T18284-2000, the Quick Response Matrix Barcode, to expand the application areas for QR code. When China Mobile launched the cellphone two-dimensional barcode operations in August, 2006, QR code was chosen as one of the cellphone two-dimensional barcodes.

Before 2006, studies on QR code were mostly theoretical. For example, Yang Qiuying performed a theoretical research on encoding and decoding QR code, and tried to apply it to a toll collection system for cars(Yang Qiuying 2003). Tao Tao

testified the realization of QR code's RS encoder arithmetic such as addition and multiplication and their inversion. Tao also used the decomposed non-inversion BM algorithm to achieve decoding algorithm(Tao Tao 2005). Since then, more studies have been carried out in the application area of QR code. For example, Dong Qiang analyzed QR code's intellectual image recognition function, and discussed the feasibility of applying it to videophones. Using actual cases, Dong laid theoretical foundation and preliminary practical foundation for the cellphone barcode recognition system(Dong Qiang 2006). Zhang Zheng discovered that quick response matrix code, with its large data storage capacity, strong error correction capability and mobility, could be the best carrier for e-tickets. Zhang also designed an eTicketing system based on quick response matrix code(Zhang Zheng 2007). Kang Chunying efficiently combined network platform, two-dimensional barcode and Wap technology into a three-tier eTicketing system composed of a browser layer, a web server layer and a database server layer. Kang's study focuses on the screening and generating technology of images during the creation of a two-dimensional barcode(Kang Chunying 2009). Cui Qiang proposed that electronic movie tickets could be better protected against counterfeiting through internally or externally encrypting partial information stored in the two-dimensional barcode(Cui Qiang 2009).

Above researches prove that the previous just constructed the eTicketing System on the two-dimensional barcode. Aiming at the scenic spot ticketing system, the author not only designs the eTicketing System based on QR code application for the Happy Valley, but also test and verify this model through experimental method.

## 3. GENERAL INTRODUCTION TO THE SUBJECT AREA

The theme park, Shenzhen Happy Valley, is located in Overseas Chinese Town, covering 350 thousand square meters. The OCT Group invested 1.7 billion RMB into the construction of this Chinese modern theme park. Shenzhen Happy Valley was the first ones awarded with the title of AAAAA scenic spot and was selected as one of the top ten theme parks in Asia-pacific area.

The current ticketing system of Shenzhen Happy Valley is a combination of manual work and eTicketing. The sector responsible for the selling of tickets is the ticketing office, which works under the direction of financial department. There are two ways to sell tickets. One is to sell tickets through the ticket window outside the park; the other is to sell tickets though the official website of Shenzhen Happy Valley. For the first method, tourists tell the staff at ticket window about their purchase demands and pay the fees, and then the staff input information such as the kind of the ticket, the number of tickets required and the ticket fees into the ticketing management system installed on the computer. After that, the system would transfer these pieces of information to the financial department. Once the financial department confirm with the information received, staff at the ticket window would be authorized to print out paper tickets for the tourists. The tourists should wait in line for their turn to get through the gate and hand their tickets to staff at the entrance point for checking. Only after their tickets are checked can the tourists enter the park. The other way to get a ticket is to buy it through official website of the park. This kind of purchase is the same as shopping from Taobao except that there's no guarantee service. After the tourists confirmed their payment through online banking or Alipay, money would go straight into Happy Valley's account. Tourists can purchase tickets, theme park products and apply for annual membership card of Happy Valley through its official website. After the purchases have been completed online, the tickets can be delivered to a particular address or they can be picked up from the entrance to the theme park directly. In addition, a large proportion of Happy Valley's tickets are sold by travel agency's reservations. However, even if a tourist has booked a ticket through a travel agency, he/she still has to get the paper ticket through the ticket window, which leads to the outcome that 99% of the tickets are sold by manpower through the ticket window. It can be seen that information technology is pretty isolated from Happy Valley's ticketing system.

The computer lab, which is under the direction of the equipment department, takes charge in the maintenance work of Happy Valley's current ticketing system. The function of the system should be constantly ungraded for improve the overall quality of the park and to meet the demands of performance schedules that change. One disadvantage of the current system is the conflict between unadjustable prices and manual ticket sales. And the biggest disadvantage is its low management efficiency, which causes tourists to stagnate at the entrance and in turn causes great inconveniences to the management and lower tourist satisfaction rate.

Happy Valley's main target customers are those from 12 to 40 years old. These people loves new things and thus intend to accept and pursuit freshness. They like the convenient and fast way of life, and therefore are more inclined to buy tickets in advance. Tourists hope that the park can improve its service by reforming its ticketing system. As the leader of Chinese theme parks, Happy Valley's current manual ticketing system can not meet the growing demand of tourist. Considering the disadvantages of Happy Valley's current ticketing system and tourists' demands, a reform to the ticketing system is imminent.

## 4. THE DESIGN OF MODEL SYSTEM

### 4.1Research Conception and Hypothesis

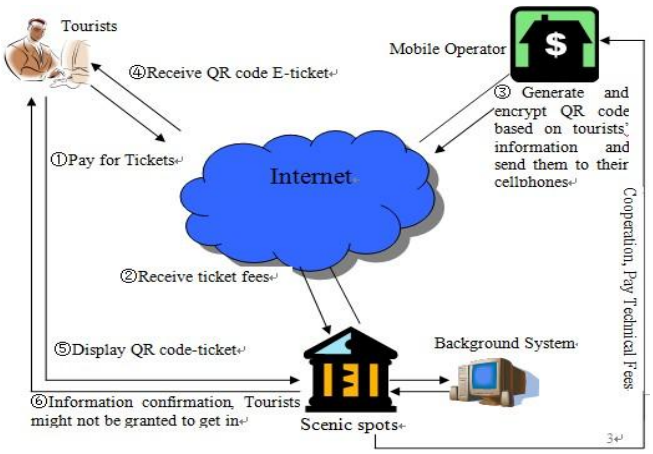
The author combines the previous literature review with the characteristics of QR code, the development trend of eTicketing system and the current level of technology. And a conception of how to combine QR code with scenic spot's eTicketing system was formed. The tourist only needs to click the "buy the ticket" button on the official webpage and fill in some personal information such as name, ID card number,

cellphone number and the number of tickets required and then compete the online payment trough online banking or a third party platform. A selected mobile operator would send information involving a QR code to the tourist's cellphone. (Currently, cellphone two-dimensional barcode adopted by China Mobile are DM code and QR code, both of which are matrix barcodes.) The tourist only need to use a two-dimensional barcode reader at the entrance to scan the QR code stored in the cellphone in order to verify his/her identification to get in.

The conception of the system is based on the following hypothesis: (1) The QR code technology is safe because it can be protected against copy and imitation. (2) QR code can be received and displayed on cellphones. (3) QR code technology is mature in identification of commodity code and movie tickets. The author assumes that QR code can me merged with the scenic spot's current eTicketing system.

### 4.2The Design and Analysis of the Model

The conception of the model system takes reference from McDonald's QR code e-coupon technology application, which was introduced by China Mobile and the McDonald's. The pattern carries large information with security and can store information in Chinese characters and with no disputes in patents. So it is appropriate to be transferred to the application of scenic spot's ticketing system. The author designed a scenic spot cellphone eTicketing system model (see Fig. 1) and hopes to improve the overall quality of scenic spots and customers' satisfaction towards these scenic spots.




**Figure(1)Design of Scenic Spot's E-ticketing Model System Based on QR Code**

#### 1) Generating and sending QR Code

The tourist clicks the "buy the ticket" button on the official webpage and fill in some personal information such as name, ID card number, cellphone number and the number of tickets required and then compete the online payment trough online banking or a third party platform. The website's background system stores all the information in its background database.

Keep to the composition rules of QR code, the encoding algorithm for encoding software, the information storage format as well as the decoding algorithm for code readers, mobile operator ( such as China Mobile) can encrypt the QR code that contains tourist information with QR code encoding software. That is to say, plaintext information is encrypted into ciphertext within the software that generates QR code from information. In this way, part of the matrix of QR code is altered so that no one could use the same information to generate a same QR code. In the end, the QR code is sent to the tourist's cellphone in the form of a text message.

#### 2) Decoding QR Code

The tourist scan the QR code stored in the cellphone with a code reader at the entrance to verify information. The reader has the function of decoding QR code. Information decoded from the QR code is run through the background database for checking. If the information matches, then the tourist can get in. Otherwise, the tourist would not be granted to get in.

## 5. SECURITY TEST FOR CELLPHONE ETICKETING SYSTEM QR CODE

### 5.1 Demand Analysis and Experiment Purposes

Security has always been the biggest concern for the computer and mobile communication technology. High-tech brings us highly efficient ways of life, work and study and yet in the meantime can be served as an instrument for committing a crime by lawbreakers. China's supervision over the computer and mobile communication technology still has loopholes. And many lawbreakers take advantage of computers and cellphones, using technology to cheat and fraud. So when people are enjoying the convenient life that technology has brought to them, they should always stay alert to the computer and cellphone technology. Being on guard could imperceptibly restrict the development of the computer and cellphone technology as well as the improvement of people's living standards and work and study level. Although the application of QR code to the cellphone eTicketing system would greatly improve the overall travelling quality, people are still being skeptical about the security of e-tickets. E-tickets are still in their infant stage. In order to apply e-tickets to more fields, its security concerns should be dealt with as a priority.

E-tickets save the trouble of standing in line to buy a ticket and get the ticket checked for tourists. It has certainly brought convenience to tourists. Yet, the insecure factors of the internet are still making tourists uneasy, and thus hinder the promotion of e-ticket to some extent. The insecure factors about e-ticket nowadays are mainly that the e-tickets are intercepted and distorted. Lawbreakers embezzle e-tickets, hurting tourists' interest and causing huge problems for management. Thus, the security of e-ticket is vital to its development.

To ensure the security of scenic sports QR code eTicketing system, the following experiment is proposed. The purposes of the experiment include:

- Display the operation procedure of QR code cellphone e-tickets and test the feasibility of the eTicketing model.;
- To protect the interest of tourists and to promote the development of QR code cellphone e-tickets. Make sure that Q code would not be intercepted or distorted during the transfer of e-tickets;
- To test the security of cellphone e-tickets.

## 5.2Experiment Design and Content

There are two ways that QR code could be protected against falsification. One is to input data stream, using RSA public key to encrypt it into ciphertext, and then transfer the ciphertext into QR code image. The other is the input data stream to generate QR code image, and then encrypt the image, causing the matrix of QR code change. The author mainly tested the security of the first method.

### 1) Determine the Variables

Include independent variable (QR Code), independent variable (cellphone e-ticket) and irrelevant variable (cellphone hardware devices, transmission lines, etc.).

### 2) The Operation and Control of Experimental Variables

To ensure that the experimenter follows the experimental requirements (independent variable). In other words, the experimenter should follow the two-dimensional barcode image's principles of preprocessing, encoding, error correction algorithms and decoding and control the storage, transfer and security of QR Code on cellphones.

### 3) Observation of the Response Variables

Observation of the response variables: this paper follows the two-dimensional code structure rules, the encoding algorithm of encoding software, information storage formats and the algorithm of code readers. Input information is encrypted by the public key. Then the ciphertext is input into the QR code encoding software. In this way, QR code is generated by ciphertext. Even if QR code is intercepted, the ciphertext could not be deciphered. There are no ways to prove the security of QR code by faking it. So the application of cellphone eTicketing is secure and feasible.

### 4) The Control of ndependent variables

As to the difference in cellphone hardware devices and memory capacity. The measure that the author adopts is to choose cellphones that can receive SMS or MMS containing images and have enough memory capacity for a certain amount of images.

### 5) The Selection of Experiment Subject

The subject is China Mobile cellphone QR Code.

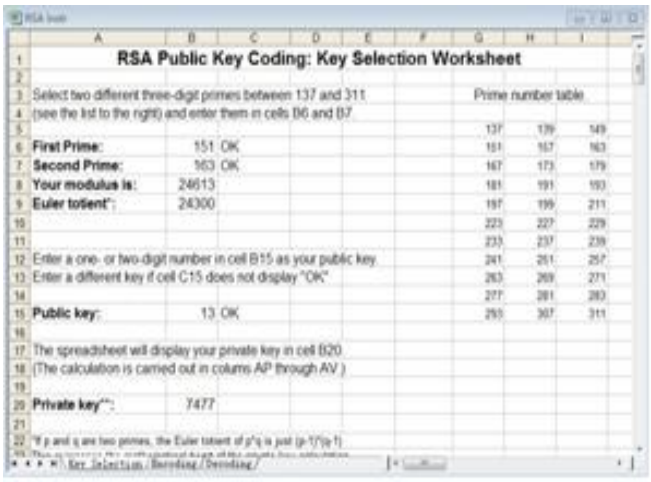
### 6) The Type of Experiment

Contrast experiment. Compare using plaintext to generate QR code with using ciphertext to generate QR code with irrelative variables maintaining unchanged. Observe the change of dependent variables in order to determine the relationship between the independent and dependent variables.

## 5.3 Experiment Content

### 1) Generating Public Key and Private Key

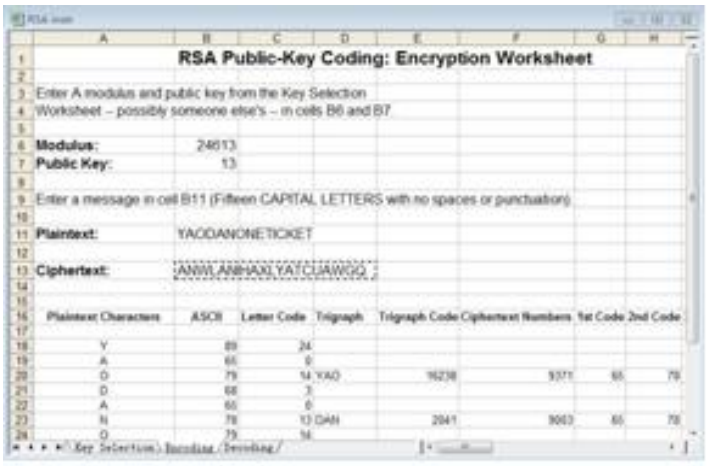
The RSA encryption algorithm selects a prime number p and a prime number q. Their product is then used as encryption and decryption mode n. After that, calculate n's Euler function$\phi$(n). $\phi$(n)represents numbers of integral numbers that are less than n and are coprime with n. The next step is to select e, an integral number that coprimes with $\phi$(n) (The greatest common divisor is for e and$\phi$(n) is 1). At last, calculate d, the multiplicative inverse for e on $\phi$(n). In this way, we have the public key (e, n), the private key (d, n), plaintext M, ciphertext C: C = C=Me（mod n）, M=Cd(mod n) (The RSA keys selection system is shown in Fig.2 ).




**Figure(2) The RSA Key Selection**

### 2) Transferring plaintext M into ciphertext C

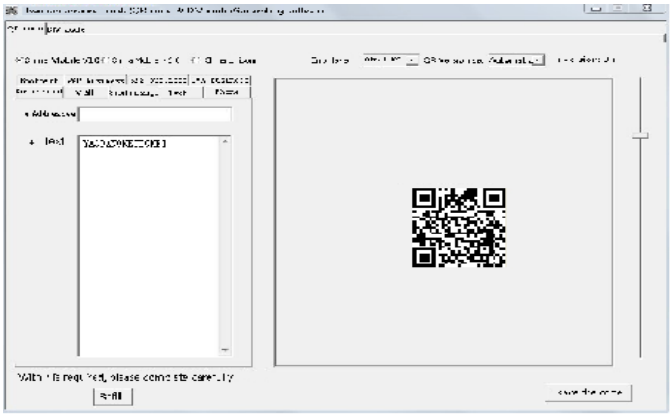
The experiment defines plaintext M as "YAODANONETICKET". Use public key(13，24613)to transfer plaintext M into ciphertext C"ANWLANIHAXLYATCUAWGQ". Shown in Fig. 3.



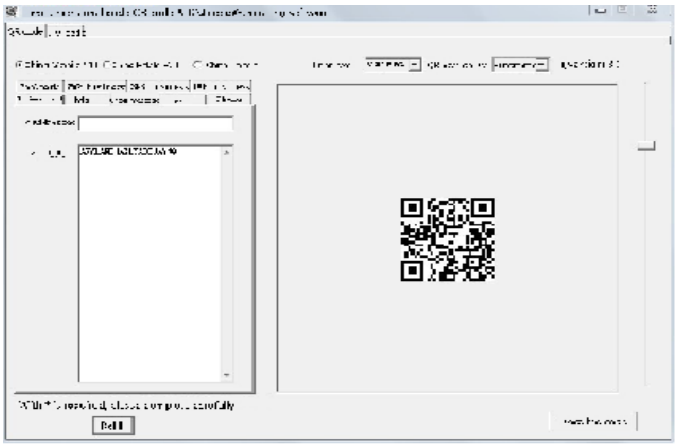

**Figure(3) The Process of Transferring Plaintext into Ciphertext**

## 3) Generating QR code

Use a QR code generator to generate QR code with plaintext and ciphertext respectively. QR code generated by plaintext is shown as ① in Figure 4， QR code generated by ciphertext is shown as ② in Fig. 5.



**Figure(4) QR code generated by Plaintext**



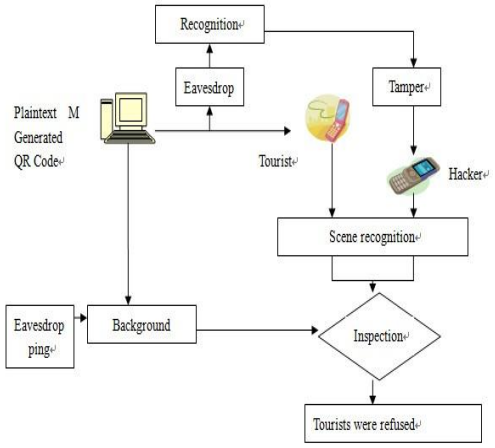
**Figure(5) QR code generated by ciphertext**

## 4) Attempts to intercept, identify and distort

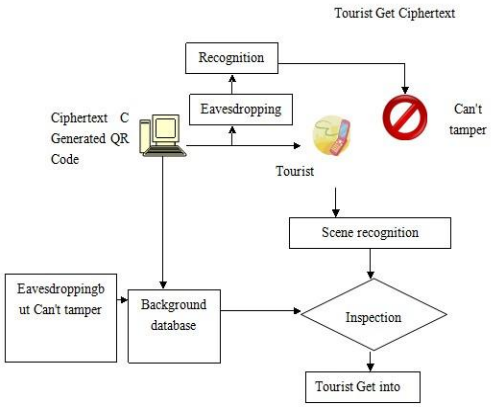
Attempts to intercept, identify and distort: use computers to send QR Code① and QR Code② respectively to cellphones as text messages and attempts to intercept, identify and distort information. QR Code① is not encrypted, and information is transmitted through network in plaintext. A hacker could easily intercept information, and distort information and database system and then transmit the information to his/her own cellphone and be sure that the distorted information matches the information changed in the database. In contrast, QR Code② is encrypted, and information is transmitted through network in ciphertext. Even if the information is intercepted by a hacker, according to the RSA encryption principle, he/she has no ways to decode and distort the information without knowing the private key. For attempts to try decoding, time required would exceed the valid period of the information. What's more, with encryption, QR code generated by the software could be protected against copy and forging. Hackers could not tamper with the information in QR code or its database system. And thus the security of cellphone e-tickets is ensured.

## 5) Contrast the validity of QR Code① and QR Code②

By tampering the information and image intercepted, a hacker could use a QR Code① with distorted information that matches with data in the database system to get into the theme park, while the real tourist could not get into the theme park because information on QR Code① does not matches the one stored in the database. In experiment for QR Code② due to encryption, the hacker could not intercept and tamper with the information sent to the tourist's cellphone or the one stored in database. Moreover, the QR Code② intercepted by the hacker could be generated on the hacker's cellphone, but it could not be identified. So, the real tourist could get into the theme park smoothly with QR Code② cellphone ticket.Contrast Experiment shown as Fig.6 and Fig.7.




**Figure(6) QR code① Experiment**




**Figure(7) QR code②Experiment**

### 5.4 Experiment Results

Through the security test for QR code with RSA encryption algorithm as well as QR code generating software, it is shown that QR code generating software with encryption algorithm could generate QR code that could be protected against falsification and thus enhance the security of cellphone e-tickets. With security as an added element, the application of QR code to scenic spot's cellphone eTicketing system should be better promoted and developed.

## 6. CONCLUSIONS

According to the technical features of the QR Code, the author explores its application in the electronic ticketing system and proposes a designed model for QR code to be applied to scenic spot's eTicketing system. The author also performs security test to the model and comes up with the following conclusions:

- Using a public key to encrypt plaintext and then use a QR code generating software to generate QR code. QR code generated through these procedures could be protected against falsification and thus ensure the security of QR code;
- Based on the current two-dimensional barcode operations carried out by China Mobile, cellphones could receive and display text messages with QR code;
- QR Code is a simple and feasible solution to the problems of scenic spot's cellphone eTicketing system.

In conclusion, the author explores the security issues of QR Code displayed on the cellphones and verifies the feasibility of applying QR Code to scenic spot's cellphone eTicketing system. The technology would promote and benefit the development of e-commerce in tourism with merging information technology better into the management of scenic spots.

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