

## SYSTEMATIC REVIEW


 OPEN ACCESS

Received: 27-03-2020

Accepted: 01-05-2020

Published: 04-06-2020

Editor: Dr. Natarajan Gajendran

**Citation:** Abbas I, Iqbal H, Ahmad M, Naveed A, Qudoos B (2020) Comparative study of technologies and intelligent train ticketing system. Indian Journal of Science and Technology 13(15): 1570-1579. <https://doi.org/10.17485/IJST/v13i15.13>

## \*Corresponding author.

Irfan Abbas

Lecturer, Department of Computer Science, University of Central Punjab, Natt Road, 50700, Gujrat, Pakistan. Tel.: +92-306-647-3003

Department of Computer Science and IT, Minhaj University Lahore, Hamdard Road, Pakistan  
[abbasirfan440@gmail.com](mailto:abbasirfan440@gmail.com)

Funding: None

Competing Interests: None

**Copyright:** © 2020 Abbas, Iqbal, Ahmad, Naveed, Qudoos. This is an open access article distributed under the terms of the [Creative Commons Attribution License](https://creativecommons.org/licenses/by/4.0/), which permits unrestricted use, distribution, and reproduction in any medium, provided the original author and source are credited.

Published By Indian Society for Education and Environment (iSee)

# Comparative study of technologies and intelligent train ticketing system

Irfan Abbas<sup>1,2\*</sup>, Hamza Iqbal<sup>2</sup>, Munib Ahmad<sup>2</sup>, Amir Naveed<sup>2</sup>, Bilal Qudoos<sup>2</sup>

<sup>1</sup> Lecturer, Department of Computer Science, University of Central Punjab, Natt Road, 50700, Gujrat, Pakistan. Tel.: +92-306-647-3003

<sup>2</sup> Department of Computer Science and IT, Minhaj University Lahore, Hamdard Road, Pakistan

## Abstract

**Objectives:** To compare the services and technologies of automatic train ticketing systems. **Methods:** The Internet of Things (IoT), Radio Frequency Identification Technology (RFID), Quick Response Code (QR Code) and Near Field Communication (NFC) are used for automatic ticketing in the trains as well as in buses. A comparison of different machines is also done that are used for tickets-generation, ticket checking, punching machines like QR scanner, BT Services, RFID. **Findings:** Results are compared with manually checking (by the person) for the validity of the ticket. After the comparison of different technologies and services to find the advantages and disadvantages of each in terms of time and cost, a new method/ technology is introduced for local train ticketing system that is better and more robust than previously used technologies and services.

**Keywords:** Automatic Train Ticketing System (ATTS); RFID train system; NFC train system; QR train system; Tickets Generation Machines (TGM); Tickets Punching Machines (TPM); Near Filed Communication (NFC); Automatic Tickets Checking Method (ATCM)

## 1 Introduction

The automatic train ticketing, generation, and verification are important technological outcome to provide better service in local railways (Pakistan railway). Multiple services like wireless services are used for the automatic train ticketing generation and verification system, i.e. Bluetooth service, RFID service, QR Code service and Web-based<sup>(1)</sup>.

Modern technologies i.e. Bluetooth services (BTS)<sup>(1)</sup>, Radio Frequency Identification Technology (RFID)<sup>(2)</sup>, Quick Response code (QR code)<sup>(3)</sup>, Near Field Communication (NFC)<sup>(3)</sup> and Web-based are being introduced and used for different purposes in the world.

Technologies applied in the automatic train ticketing system (ATTS) are using Tickets Generation Machines (TGM) to generate tickets, tickets are verified by using ticket checking and punching machines, and train ticket distances are measured by using various features. In ATTS, tickets are automatically generated by the machines and verified by the checking and punching machines which are used to measure the distance of the tickets<sup>(1)</sup>. These features and technologies are used in trains, buses and underground

train ticketing<sup>(2,3)</sup>.

BTS is a limited-range radio wave wireless technology, used to simplify communication among internet devices and between devices and the internet. It aims to simplify data synchronization between Internet-connected devices and other devices and IoT. RFID is wireless connections of wireless communication that integrates the use of electromagnetic or electrostatic connection in the radio frequency portion of the electromagnetic spectrum uniquely identifies an object and data. It is used to automate the train ticketing process. A QR code is a matrix barcode. It was introduced in Japan. Barcode is a machine-readable optical label that contains information about the selected object. The NFC is a wireless technology that is used to allow a user device to collect information from near NFC devices. In a web-based system, the website is used to perform different tasks by the passenger using websites<sup>(1,4)</sup>.

In the ATTS, different machines are used for ticket generation. In Bluetooth services, service is used to connect passenger's device with train's connection to buy tickets by selecting different railway station from their device. After the selection of the destination, the ticket is automatically generated by the machine and the amount deducted from their bank card. In RFID generator machine, the card is provided by the railway management that is used for purchasing the ticket. QR code generator machine uses a code to scan passenger's code using machines for purchasing tickets and submitting the amount of the ticket to travel<sup>(1,3-5)</sup>.

Ticket checking is a very difficult and time-consuming process in train and bus systems as ticket checker goes to person to person for verification and validation of tickets; whereas, ATTS uses different scanners and applications for the same purpose. In a Bluetooth service, a ticket is automatically checked via ticket generator application. Train system checks BTS connection of passenger's device with the train system before ticket checking. If a connection exists then the ticket is verified by passenger's connection and the amount is paid via bank account.

In RFID systems, a railway card is provided by the railway ticket counter and passengers buy their card for the first time to use and then recharge from the counter again. When passengers reach their destination, they scan their card at leaving the gate and if the transaction is successful then the door opens, otherwise, the alarm starts ringing. In a QR code scanner is used to scan at the destination when a passenger wants to exit the door then they scan their code to pay the amount.<sup>(6)</sup>

Charges of the tickets depend on the source and the destination of the ticket. In a previous technology, the ticket was generated and checked by machines but distance measuring is very difficult, whereas in BTS when passenger connects his/her Bluetooth, distance is measured automatically using the map. In RFID, the ticket is saved on the RFID card. When the card is scanned by the machine, the place of boarding the station and leaving the station is used to measure distance. In QR code, distance is measured using the ticket. When passengers buy their ticket to generate QR they must select the source and the destination<sup>(7,8)</sup>.

## 1.1 Problem statement

This study aims to compare different services, methods, and technologies used in auto train ticketing (ATT) as well as bus ticketing system and proposed a new system for local train and buses. It explains the advantages and disadvantages of these technologies, methods, and services. It proposes the best methods for using these technologies, which make it possible to predict the best railway train ticketing system. Thus, we aim to reduce the human efforts, increase the sufficiency of ATTS, provides the benefits and efficiency to the passengers, with studying and comparing different train technologies regarding different features. Paper attempts to overcome the passenger efforts, increase efficiencies of the different railway to improve their auto ticket checking security and facilities to their passengers<sup>(2)</sup>.

## 2 Previous Methodologies

ATTS is used to provide benefits to the passengers and in different railway systems so the cost can be deducted. Data from different research papers, regarding the automatic ticketing system, is collected to evaluate it according to manual and wireless technologies. Raw data is transformed into the proper format using excel sheets and tables so data analysis can be performed systematically. Data is analyzed to spot the best ATTS. To better understand the dynamics of the automatic ticketing system, at first useful data is extracted.

In the second step, data is organized according to various features so technologies can be differentiated. These features include TGM, tickets verification, distance measurements, TGM and other information. Data is filtered to get more accurate systems that is more beneficial for passengers<sup>(8)</sup>. Lots of ATTS are currently being used by various countries in the world. These ATTS are different from one another based on features, procedures, services, and technologies being used. Still, many issues need to be addressed so profit can be maximized and passengers can be facilitated as well for the tickets acquiring process. Different ATTS are discussed and compared in this study to find which system is best according to technologies, procedures and passengers'

benefits<sup>(9)</sup>.

### 3 Auto Train Ticketing Procedures

Multiple technologies and procedures are used for ATTS. Some of the procedures are as follows (figure 2):

#### 3.1 Ticket generation machines (TGM)

In Auto ticket generation, different technologies are used in TGM to benefit the passengers and to minimize their efforts Figure 2 (figure 2).

##### 3.1.1 Bluetooth services and based on mobile application

It is a method in which mobile applications and Bluetooth services are used for ticket generation. When a passenger comes into the train he connects his mobile Bluetooth to the train service and opens the ticket generation application to generate the ticket by selecting his/her destination. The current location is automatically selected by the application using Bluetooth services connection with train and seats are shown on the application. Seats are selected by the passenger and confirmed by clicking on the confirm button<sup>(4,8)</sup>. ( Figure 1)

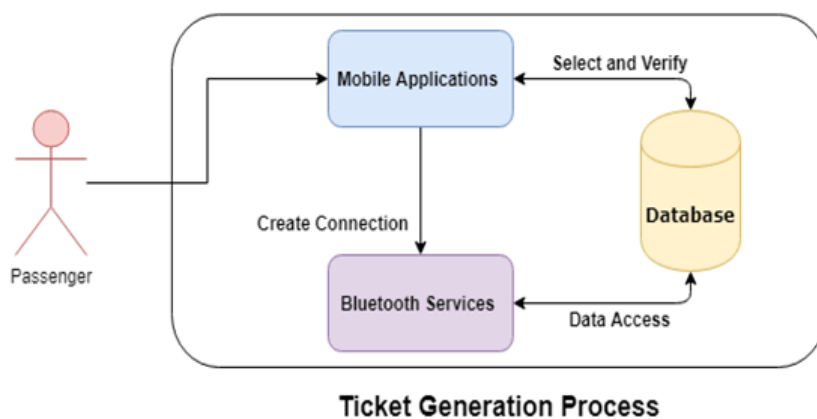


Fig 1. GM Using BTS and MPS

##### 3.1.2 RFID based ticket generation machines

RFID is a technology-based TGM, used to automatically generate passengers’ tickets. Machines are connected with the railway database to select and confirm the passenger seat. When a passenger wants to buy RFID based ticket then the passenger must go to the ticket shop, buy an RFID card and load some amount into the card. Another method is to put the money into the machines and generate RFID based ticket. When passengers want to travel then they go and scan their RFID into the machine. After reaching the destination the passengers again, scan their RFID into the machines for the confirmation of exit and ticket price then go out of the station<sup>(2,5,8)</sup>.

##### 3.1.3 QR code based ticket generation machine

QR is a technology-based TGM used to automatically generate passenger tickets. The passenger goes to the ticket shop and buys a card. Another method is to put the money into the machines and generate QR based ticket. When a passenger wants to travel then they go and scan their QR Code into the machine. The machine accepts and opens the gate for a passenger. When passengers reach their destination, then again scan their ticket into the machine to open the gate for exit from the train. The machine must check the amount within a QR Code and route ticket price to take the exact amount of the ticket<sup>(3,10)</sup>.

### 3.1.4 Paper ticket

Most of the countries including, Pakistan and India, use manual methods to generate tickets for the passengers of the bus as well as for train. They use paper and stamp to generate a ticket. Paper is stamped to make tickets for the passengers. Passengers use this ticket to travel from one place to the other<sup>(7)</sup>.

## 3.2 Ticket checking methods

TCM's is a procedure in which different machines and technologies are used to check the accuracy of the tickets. Different machines are used to check the correctness of the tickets

### 3.2.1 Mobile application and Bluetooth services

Bluetooth is a service that is used to pair different devices with others. In this system, BTS is used to generate as well as check and verify the passenger's tickets. When a passenger buys his/her ticket, the device must confirm his/her ticket. The amount of tickets is paid using a visa card or special train card. If they have no money in their account, then they cannot leave the station. Passengers load the amount into the card from the ticket counter and then pay. After all, the mechanism allows leaving the station<sup>(1,4,9)</sup>.

### 3.2.2 RFID reader

RFID is used to store all the information regarding passengers. When a passenger buys a ticket using RFID then all the data of the passenger is stored into the RFID. After completing the distance successfully, the passengers must verify their tickets using machines. RFID reader is used to checking the tickets of the passengers. When passengers want to leave the station then they scan their tickets using machines. The machine checks the detail and then allows or restricts the passenger to leave the station<sup>(11)</sup>.

### 3.2.3 QR code scanner

QR Code Scanner stores all required information about the passengers. When a passenger buys a ticket QR ticket then all the data of the passenger is stored into the card. When the passengers want to travel then they scan their QR Code and start their journey. After completing the distance, the passengers must verify their ticket's price using the QR Code Scanner. If the ticket price is according to the distance then the machine opens the door and allows the passenger to leave the station<sup>(10,12)</sup>.

## 3.3 Distance measuring methods

Distance measurements are a technique in which distance of the different routes and tickets are measured. Every passenger pays the amount of the tickets according to the route and distance of the tour. Different methods are used for distance measurements using different technologies. Multiple ways are used to measure ticket distance. Some of the ways are described here.

### 3.3.1 Automatically measured by the mobile application

It is a method, in which mobile application is used to measure the distance automatically using a map, Geolocation services, and the current location of the train. In this technology, when the passengers connect their Bluetooth with the train service to buy the ticket then the distance is counted, stored in the application and when passengers disconnect their Bluetooth or reach the destination then the total distance is measured<sup>(4,13)</sup>.

### 3.3.2 Manually

It is a method, in which distance of the passengers' tours is measured when they come for tickets in a ticket counter or purchases their tickets using machines. When the passengers buy their tickets, they must choose the route, source, and destination. The distance of the tickets is counted using the destination and source point.

## 4 Technologies of Auto rain Ticketing Systems

Different countries use different ticketing methods, machines for ticket generation, ticket testing and distance measuring [Table 1](#).

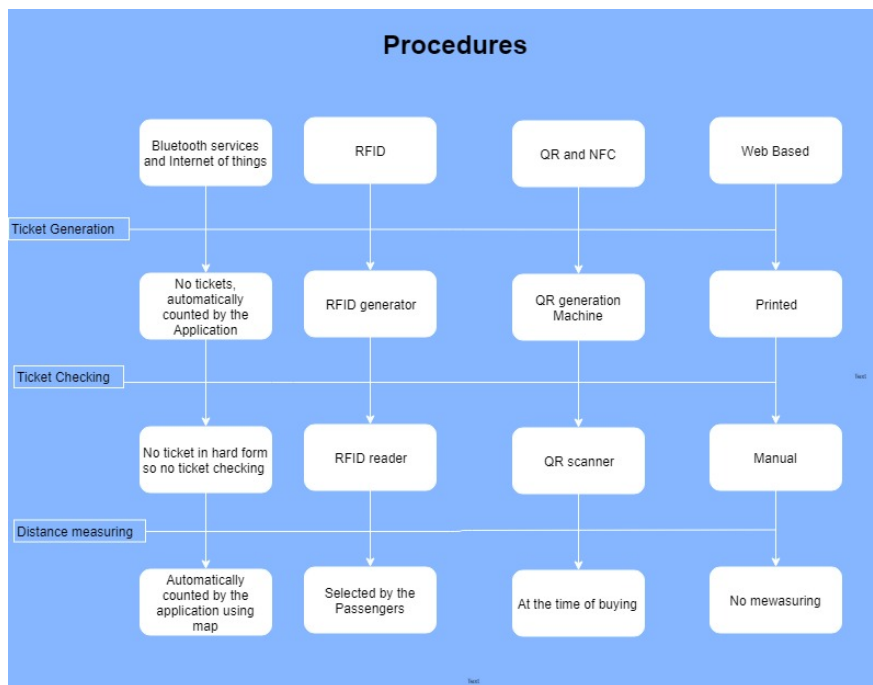


Fig 2. Procedures of automatic train ticketing system

Table 1. Features of different Train Ticketing System

Wireless Technologies/ Technologies	Technologies/ Platform	Platform	Ticket Machine	Generation	Ticket Machines	Checking	Ticket Distance Measuring Methods
Geolocation, IoT and BTS <sup>(4)</sup>		United Kingdom	No ticket counted <sup>(4)</sup>	Automatically	No Ticket		Automatically counted using source and destination by Map
RFID <sup>(8)</sup>		United Kingdom	RFID Machine <sup>(8)</sup>	Generator	RFID Reader <sup>(5)</sup>		The machine takes input from the passengers when they buy their ticket
QR and NFC <sup>(3)</sup>		Australia	Mobile QR Scanner and Mobile Application for QR Reader <sup>(9)</sup>		Manually by Ticket Checker		The mobile application count automatically
RFID <sup>(13)</sup>		China	RFID Card Generator <sup>(8)</sup>		RFID Reader and Scanner <sup>(5)</sup>		Machine check the destination of the passengers when they checkout
Manual based <sup>(14)</sup>	and Web-	Pakistan	Manual		Manually check one by one Railway Employs <sup>(14)</sup>		Different tickets for different routes

### Wireless technologies

In a wireless connection, a specific key or code is used to connect different devices with the other devices. Countries listed the Table 1 use a wireless connection for communication, ticket generation, ticket checking, ticket verification for communication with railway employees, for trail location and online trail scheduling<sup>(15)</sup>.

#### 4.1.1 BTS and IOT

BTS (Bluetooth service) is a limited-range radio wave wireless technology used to simplify communication among internet devices and between devices and the internet. It aims to simplify data synchronization between Internet-connected devices



and other devices and IOT (Internet of Things) is a technology in which different devices communicate with each other using internet connection or internet devices<sup>(16)</sup>.

**United Kingdom** railway uses wireless technology of automatic train system based on the Internet of things (IoT) and Bluetooth using geolocation or Google map to generate the online ticket when the passengers connect their Bluetooth with the train system. When the passenger establishes their Bluetooth connection with the train system then route seat, route map is confirmed by the Bluetooth, internet source selected by the train station location and destination selected by the passenger by choosing destination station from the options given in mobile Ticket cost charged by their bank card or railway card and automatically deducted<sup>(1)</sup>.

#### 4.1.2 RFID

RFID is the wireless connection of wireless communication that integrates the use of electromagnetic or electrostatic connection in the radio frequency portion of the electromagnetic spectrum uniquely identifies an object and data<sup>(11)</sup>.

**The United Kingdom and China** railway use RFID technology, in the Chinese RFID technology every passenger, uses the mobile application to generate RFID code and buy their tickets online but in United Kingdom technology every passenger must go to the station and buy their RFID card. After this passenger loads money into the card and use card to generate their tickets online. They put their card into the machines and use their card to move from one place to the other. When the passengers go out from the station then the passengers must scan their card to exit and when the card is scanned by the RFID scanner then machines automatically count the traveling distance and charges the amount from the card. If the amount is not enough according to the distance then machines cannot accept their transaction and show the amount error “please recharge your card”. The passenger goes to the ticket counter to recharge the card then again puts into the machine and exits the station<sup>(8)</sup>. (Figure 3)



Fig 3. FID in auto train ticketing system<sup>(17)</sup>

#### 4.1.3 QR code

A QR code is a matrix barcode (or two-dimensional barcode). It's developed in the Japanese automotive industry in 1994. A barcode is a machine-readable optical label that contains information about the object to which it is attached chip.

It contains all the information related to the passenger's detail and amount into the account. The NFC (Near Field Communication) is a wireless technology that is used to allow a user, devices to collect information from the near NFC devices<sup>(10,12)</sup>

**Australian** railway uses QR and NFC. In this, technology passengers buy their tickets using QR generator machines after

reaching the station. They scan their QR using the scanner for the ticket confirmation.

#### 4.1.4 Manual and web-based

In this system everything is manual, but a little bit of technology is used for the long routes. Web-Based technology is used for the ticket generation by the employees of the railway train system. All other procedure is manual for every purpose, like ticket generating, ticket checking and entry and the exit of the station. If the passengers want to buy a ticket when they go to the station and buy tickets from the ticket counter and pay the amount of their ticket manually or use Pakistan railway website to buy their ticket and pay ticket amount using a bank account, visa card or master card<sup>(14)</sup>.

### 5 Comparison

In this study, the comparison is done among the different technologies and features of the automatic train ticketing system. Technologies compared together are BTS, RFID, QR Code, NFC, and Web-based. RFID is much better than the BTS with the help of Geolocation because if the passengers face the difficulty of BTS connectivity issues, I-phone device does not accept the local Bluetooth connection, but the other devices do accept. Therefore, it is the cause of the device portability issue. It has many flaws but when passenger use RFID as compare to the BTS then passenger takes many benefits and minimize the issue ( Table 2).

On comparing BTS with QR, the result of QR is better than the BTS. BTS provides many facilities but has some disadvantages as compared to the QR Code. QR Code provides the full authentic passenger information and no need to require any portable or another device for the ticket. Moreover, if a passenger generates a ticket, one ticket is used only one time because the machine validates the ticket<sup>(18)</sup>.

**Table 2. Comparison between BTS and Manual**

Technologies	Advantages	Disadvantages
BTS <sup>(1,4,19)</sup>	<ul style="list-style-type: none"> <li>• Fast working</li> <li>• No extra charges</li> <li>• Require devices generally avail for every-one</li> <li>• No need to go to the ticket shop or in queue.</li> </ul>	<ul style="list-style-type: none"> <li>• Bluetooth connecting issue</li> <li>• Bluetooth portability issue</li> <li>• Intentionally do not connect the Bluetooth with the train.</li> <li>• The initial procedure should be done before entering the train.</li> </ul>
RFID <sup>(2,9,11)</sup>	<ul style="list-style-type: none"> <li>• Authentication</li> <li>• No Queue and Time-saving</li> </ul>	<ul style="list-style-type: none"> <li>• Heavy cost on RFID chip</li> </ul>
QR Code <sup>(3,6,10)</sup>	<ul style="list-style-type: none"> <li>• Full Authenticate • No device required • Time-saving</li> <li>• After using one QR at one time</li> <li>• QR has to expire.</li> </ul>	<ul style="list-style-type: none"> <li>• The passenger could in a queue and Necessary for the passenger to in a ticket counter</li> </ul>
Manual and Web-based <sup>(14)</sup>	<ul style="list-style-type: none"> <li>• Tickets with specify seat number can only be limited to total seats</li> <li>• Advance booking</li> <li>• Online booking and Limited time-saving.</li> </ul>	<ul style="list-style-type: none"> <li>• The passenger could be heavily fined if found with no purchased validated ticket and The passenger could be in Queue</li> </ul>

Comparison between BTS and Manual, web-based technology is that both are the same because both have many flaws. In a manual system, passengers stand in a queue for the tickets but the advantage is to distribute only the number of seat tickets but no way for ticket checking. On the other hand, in a BTS, no need to wait for the ticket, one can use one’s mobile to buy the ticket but passengers cannot buy tickets in advance. But passengers face the connectivity issue for Bluetooth connection. According to this study, BTS is better than the manual<sup>(20)</sup>.

QR Code is better than RFID. RFID is more costly than the QR code. When a passenger buys an RFID chip card from the ticket counter then pay a heavy amount against the card. So, it is difficult for the passengers to pay an amount of the RFID chip every time. The availability of the QR Code is much easier than RFID. Every passenger uses QR code easily than the RFID chip because passengers use paper and different devices for the QR code and did not require to buy a special chip use this QR Code as a ticket<sup>(2,11,21)</sup>.

Manual or Web-based is better than the RFID because of chip cost. There are many advantages of the Web-based ticketing system but the QR Code is more batter the web-based. The process of ticket generation using the web is very easy but there is no way to confirm their tickets<sup>(1,2,5,6,8,22)</sup>.

## 6 Recommended Technology and Proposed Model

Multiple technologies are being used for the ticket generation, ticket checking and ticket verification in local as well as metro train systems. After the study of different technologies of auto train ticketing systems, it is concluded in this research study that the QR Code with the Web-based system is perfect for the auto local train ticketing as well as a bus system. In the proposed system, QR Code and app are used for the train ATTS. An app is used for the ticket generation online, when a ticket generated by the passenger online then a ticket is confirmed and a QR code automatically created for the ticket in the form of QR Code generated and all the data saved on the QR Code. Passenger can download their QR ticket from the online website and save into the device. Take a print of this QR ticket and scan into the machine for traveling

### 6.1 Proposed QR and App-based technology

QR and App based technology is a QR code, message and notification based ticket that is generated by the passengers using train websites and machines. Passenger goes into the website and generates their ticket by selecting the source and the destination. Passenger puts the data into the fields and pays their amount online using a bank card, visa card or special train card to generate a ticket. After completing the ticket generation process then a QR code generated. This QR code is a passenger ticket. Passenger can download and take a print and scan their ticket into the machine. But on the other hand, passengers can use a ticket generation machine. Passenger uses both Website and the machines are connected with the database, where all seats of the train automatically are assigned to the passengers or manually selected by the passengers.

In our proposed method, a passenger uses the train website and login to their account. If the passenger does not have an account then he registers himself using personal information. After logging into the website, the passenger clicks on the ticket button to generate the ticket. If all seats are filled then the ticket generating button is disabled.

The passenger selects the date, source, and destination. After selecting the route, the website loads some data and displays the different ticket types and prices of the selected route. The passenger selects the ticket type and pays their ticket amount using a train card code or bank account and download the QR code ticket. The passengers scan their QR Codes in a machine and travel according to the route. After reaching the destination, the passengers again scan their Code to verify the ticket route. If ticket price does not match with actual price then the machine rejects it and the passengers face a heavy fine. On the other hand, passengers can use machines to generate their ticket. The proposed method provides the facility of both, app application and machine. Both machines and app are connected into the database and after a second database updated and load data into the machines interface as well as apps [Figure 4](#).

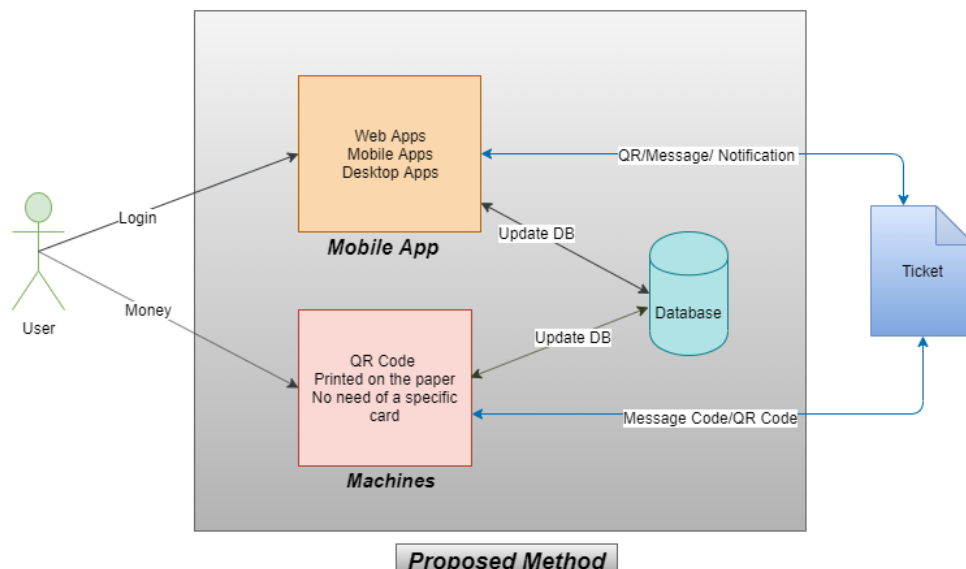


Fig 4. QRT process



## 7 Results

After the evaluation of all given technologies and proposed method shows the advantages and disadvantages as given in Table 3

**Table 3. Comparison with proposed method**

Tech-nologies	Advantages	Disadvantages
BTS (1,4,19)	<ul style="list-style-type: none"> <li>• Fast Working.</li> <li>• No extra charges.</li> <li>• Require devices generally avail for everyone.</li> <li>• No need to go to the ticket shop or in Queue</li> </ul>	<ul style="list-style-type: none"> <li>• Bluetooth connecting issue</li> <li>• Bluetooth portability issue</li> <li>• Intentionally do not connect the Bluetooth with the train.</li> </ul>
RFID (2,9,11)	<ul style="list-style-type: none"> <li>• Authentic</li> <li>• No Queue.</li> <li>• Time-saving</li> </ul>	<ul style="list-style-type: none"> <li>• The initial procedure should be done before entering the train</li> <li>• Heavy cost on RFID chip</li> </ul>
QR Code (3,6,10)	<ul style="list-style-type: none"> <li>• Full Authenticate</li> <li>• No device required</li> <li>• Time-saving.</li> <li>• After using one QR at one time, QR has to expire.</li> </ul>	<ul style="list-style-type: none"> <li>• The passenger could in a queue.</li> <li>• Necessary for the passenger to in a ticket counter</li> </ul>
Manual and Web-based (14)	<ul style="list-style-type: none"> <li>• Tickets with specific seat numbers can only be limited to total seats.</li> <li>• Advance booking</li> <li>• Online booking.</li> <li>• Limited time-saving</li> </ul>	<ul style="list-style-type: none"> <li>• The passenger could be heavily fined if found with no purchased validated ticket.</li> <li>• The passenger could be in Queue</li> </ul>
Proposed method	<ul style="list-style-type: none"> <li>• Fastest working</li> <li>• No expansive</li> <li>• Time saving</li> <li>• Both apps and QR based</li> <li>• Easy to measure distance</li> <li>• Advance and online booking</li> <li>• Use a machine to generate tickets</li> <li>• Use a web app to generate tickets</li> <li>• Simply tickets printed on the paper</li> <li>• Card is not necessary • Pay money online using bank card, visa card, special card</li> <li>• For every tickets, QR is different</li> <li>• Easy to control tickets free traveler</li> <li>• Easy to check passengers tickets</li> </ul>	

## References

- 1) Boden R. Rail passengers pilot Bluetooth and geolocation service for ticket-free travel. 2017. Available from: <https://www.nfcworld.com/2017/01/23/349578/rail-passengers-pilot-bluetooth-geolocation-service-ticket-free-travel/>.
- 2) Ganapathi S, Kumar S, Kumar SP, Madhusdhanan P, Kumar SR, Ganesan M. SMART RAIL RESERVATION AND VERIFICATION SYSTEM WITH UNIQUE IDENTIFICATION IN IoT USING CLOUD DATABASE. *International Journal of Pure and Applied Mathematics*. 2018;p. 279–283.
- 3) D&apos;silva G, Michael. Smart ticketing system for railways in smart cities using software as a service architecture. *2017 International Conference on I-SMAC (IoT in Social, Mobile)*. 2017.
- 4) Finžgar L, Trebar M. Use of NFC and QR code identification in an electronic ticket system for public transport. *SofiCOM 2011, 19th International Conference on Software, Telecommunications, and Computer Networks*. 2011.
- 5) Wang C. . Available from: [http://en.cnki.com.cn/Article\\_en/CJFDTTotal-TLJS200805013.htm](http://en.cnki.com.cn/Article_en/CJFDTTotal-TLJS200805013.htm).
- 6) Cost of Train Travel In Holland.. 2018.
- 7) Wang G, Shi TY. Design, and Realization of Automatic Ticket Checking System. *China Railway Science*. 2005;(5).
- 8) Fraga-Lamas P, Fernández-Caramés T, Castedo L. Towards the Internet of Smart Trains: A Review on Industrial IoT-Connected Railways. *Sensors*. 2017;17(6):1457–1457. doi:10.3390/s17061457.
- 9) Soon TJ. QR Code. *Synthesis Journal*. 2018;p. 59–78.
- 10) Brate G. Price Competition within and between Airlines and High-Speed Trains: The Case of the Milan-Rome Route. *Tourism Economics*. 2016;22(2):311–323.
- 11) Shenzhen Metro Transport. 2018. Available from: <https://shenzhenshopper.com/transport/shenzhen-metro>.

- 12) Zhai X, Zhao J, Chen Q. Optimization of the assignment of tickets for railway networks with large passenger flows. *Proceedings of the Institution of Mechanical Engineers, Part F: Journal of Rail and Rapid Transit*. 2018;232:632–642.
- 13) Finkenzeller K. John Wiley & Sons. 2010.
- 14) Want R, Denso-Wave. QR Code features. IEEE. 2011;p. 1. Available from: [https://repo.zenk-security.com/Magazine%20E-book/RFID\\_handbook.pdf](https://repo.zenk-security.com/Magazine%20E-book/RFID_handbook.pdf).
- 15) Savior R. . Available from: <https://patents.google.com/patent/US20070116185A1/en>.
- 16) Abbas I. Serway on Automatic train ticketing system. 2019.
- 17) Hak-Sun Y, Key-Seo L. A study on the development of the train control system data transmission technology using a wireless mesh. *Third International Conference on Multimedia Information Networking and Security*. 2011.
- 18) Abbas I, Muneer U. The Prediction of death causes using regression models and moving averages. *International Journal of Data Science and Advanced Analytics*. 2019;1:39–46.
- 19) Terán M, IEEE. IoT-based system for an indoor location using Bluetooth low energy. In: and others, editor. In IEEE Colombian Conference on Communications and Computing (COLCOM). IEEE. 2017.
- 20) Sharp S. 2017. Available from: <https://urbanize.la/post/new-optic-readers-ease-metrolink-metro-transfers>.
- 21) Grogan A. Driverless trains: It's the automatic choice. *Engineering & Technology*. 2012;7(5):54–57. doi:10.1049/et.2012.0514.
- 22) Elhamshary M. TransitLabel: A crowd-sensing system for automatic labeling of transit stations semantics. *Proceedings of the 14th Annual International Conference on Mobile Systems, Applications, and Services*. 2016.