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# APPLICATION OF SMART COMPUTING IN INDIAN RAILWAY SYSTEMS

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***ABSTRACT***
*Almost all the countries across the globe strive to meet the demand for safe, fast, and reliable rail services. Lack of operational efficiency and reliability, safety and security issues, besides aging railway systems and practices are haunting various countries to bring about a change in their existing rail infrastructure. The global rail industry struggles to meet the increasing demand for freight and passenger transportation due to lack of optimized use of rail network and inefficient use of rail assets. Often they suffer from the lack in smart technologies and latest technological updates to provide the most efficient passenger services. This is expected to induce rail executives to build rail systems that are smarter and more efficient. The passenger reservation system of Indian Railways is one of the world's largest reservation models. Daily about one million passengers travel in reserved accommodation with Indian Railways. Another sixteen million travel with unreserved tickets in Indian Railways. In this vast system, it is a herculean task to efficiently handle the passenger data, which is a key point of consideration now-a-days. But the implementation of the latest technological updates in this system gradually turns inevitable due to increasing demand for providing the most efficient passenger services. Handling the passenger data efficiently backed by intelligent processing and timely retrieval would help backing up the security breaches. In this paper, the authors have explored different issues of implementing smart computing in railway systems pertaining to reservation models besides pointing out some future scopes of advancement.*

***KEYWORDS—*** *operational efficiency ; global rail industry; Indian Railways ; smart computing ; passenger reservation system ; unique identification ; inter-database query processing ; automatic ticket vending machine ; ubiquitous computing ; Aadhaar ; online reservation ; e-ticket ; one-time password*

## I. INTRODUCTION

Railway services are available in most of the countries in the world. However, a fast, reliable, and a passenger-friendly service was always in need. As the volume of passengers and freight loads started increasing day by day, more effective mechanisms are found needful to handle this increasing demand. But it is not the sole capability of man-power to meet this growing need. Hence the implementation of smart technologies turns inevitable in this connection.

Smart Computing is a comparatively infant sector of technology which can be efficiently implemented in Railway systems for up gradation to a more efficient and smart model. Most of the railway services serving as public transport have to consider passenger data as an important key factor. To provide fast and efficient passenger services, a major role lies on handling this passenger data in an efficient manner besides processing and storing it fast and seamlessly. In the case of Indian

Railways, this passenger data is primarily collected from the passengers in reservation/cancellation Requisition Forms and fed into the system in the form of manual entry. However in case of online ticketing system, the manual entry of passenger data still exists. To bypass the huge overhead of manual entry of this passenger data and to update the existing system to a more efficient one, a new model based on linkage through unique identity is proposed. Besides, the passenger identities would also undergo efficient verification process, which would be comprehensive and secure further. The introduction of a more efficient reservation system based on unique identification would facilitate handling the passenger data more efficiently with the help of inter-database interaction. Moreover this will be a step ahead in wiping out different sectors in the existing system, susceptible to corruption and other problems, thereby providing an excellent and efficient passenger service as addressed in Vision 2020.

## II. IMPACT ON GLOBAL MARKETS

Segmenting the global railway market in terms of the following attributes, the key areas are identified.

- **Solutions:** Passenger Information System (PIS), Freight Information System (FIS), railway traffic management system, rail operations management system, advance security monitoring system, rail communication and networking system, smart ticketing system, and railway analytics system
- **Components and Devices:** Video surveillance, rail sensors, networking and connectivity devices, smart cards, biometric input devices and multimedia displays
- **Services:** Professional services, integration services, cloud services and ubiquitous services.

Basically, the concept smart railways imply a set of new-generation solutions, services, and modern transportation with the help of Information and Communication Technology (ICT). It combines software products to make more intelligent use of all rail assets, from tracks to trains, so companies can meet the increasing consumer demand for more efficient and safer services. Trends such as regulation, sustainability, demographics (growing traffic and aging population), economics (limited public funding and price sensitivity), mobility, and Information Technology (IT) innovations are impacting the rail industry. As a result, every aspect of the value chain — from passenger service to the back-end organization — is changing. The main long-term drivers of the railway market are linked with economic and demographic growth in the emerging markets. In mature markets, they are related to the renewal and upgrading of existing infrastructures, as well as increased environmental and sustainability awareness. In spite of the recent global economic downturn with slower growth and governments' mounting deficits, the long-term outlook for the railway industry remains positive, with investments in rail and urban transport projects not being significantly impacted. The future rail industry is expected to rely upon smarter transportation systems that leverage technologies over larger rail network infrastructure. New technologies include integrated service management solutions, asset management software, and predictive analytic tools which are expected to help rail management companies to manage optimal routes, schedules, and capacities in near real-time. With the increasing presence of smart technologies in the rail transportation, the associated solutions and services market will grow at higher growth rates globally. The emerging technologies such as smart ticketing, rail analytics, cloud adoption, smart traffic, and operation solutions will enable efficient and better rail infrastructure. It will also improve timely decision-making for issues such as asset deployment, utilization, and maintenance. The high growth rate in the overall rail spending worldwide, with major boom from regional economies such as Asia Pacific including Japan (APAC), Europe (EU), and Middle East and Africa (MEA) and the large number of ongoing and upcoming smart rail transportation projects worldwide are expected to create room for the smart rail systems. The global smart railways market is estimated to grow from $12.30 billion in 2013 to $39.20 billion in 2018, at a Compound Annual Growth Rate (CAGR) of 26.1% during the forecast period. Markets and Markets outline the key trends that will shape the evolution of the passenger and freight rail industry. Smart railway infrastructure services and solutions are balanced to catalyze the next phase of growth in the rail transportation industry. Smart railway transportation can drive the transformation of rail networks from a basic means of transport to complex systems that are indispensable to society. Rail executives

must strive to meet the demand for rail systems that are integrated into the global economy, competitive with other transportation systems, and flexible enough to meet global trade and passenger demands. Smart rail infrastructure is expected to lead to an expanded rail ecosystem, asset optimization, new revenue model opportunities, and new ways to serve customers.

Smart Computing is a relatively infant technique which can be efficiently used in Indian Railways Passenger Reservation System. Basically, the distributed and implicit approach of Smart Computing can be employed to link different stakeholders of the reservation mechanism, without vividly opening up the underlying mechanisms. The computing and distributed structure would lie entirely subtle, and the passengers need not to interact with this underlying computing system explicitly. Exploiting the basic concept of ubiquitous computing that numerous computers would serve for a single user entity, a huge interconnected structure is needed to be designed, which will provide necessary interfaces. But this is always to be maintained, that the overhead of users explicitly interacting with computers and its accessories is to be minimized as much as possible. To be very clear, mechanisms are to be embedded within the throughout systems, such that the user-entered data automatically gets fetched to the computers and will be ready for processing. In this context, the Unique Identification Number (example: Aadhaar number as in case of India) or UID would serve as the key factor of the system and employing an inter-database query and transaction processing, and the system so designed would be very fast and robust compared to the existing one. Also the inter-database linkage would be beneficial in providing different services to the passengers linked with the same UID.

## III. SMART PASSENGER RESERVATION SYSTEM BACKED BY UNIQUE ID

The Unique Identity (E.g. Aadhaar Number in India) would serve as the chief pillar for this entire smart Passenger Reservation System model. The Unique Identity (UID) would be considered as the key for primary identification in the services offered by the Passenger Reservation System. Countries having UID registration in a comprehensive status can easily implement this UID-based reservation model to get a very efficient and smart approach in ticketing system. As in case of India, since the UID registration is not fully completed country-wide, the model would be initially implemented on selected domain, parallel to the existing one, which in turn would gradually eat up the existing Passenger Reservation System with incremental coverage.

## IV. THE EXISTING PASSENGER RESERVATION MODEL --- AN OVERVIEW AND SHORTFALLS

The existing Passenger Reservation System comprises of two broad reservation outlets, one at the railway reservation counters, another being the online reservation system. Considering the existing system at the reservation counters, a person seeking a ticket needs to submit the duly filled Reservation/cancellation Requisition form to the railway personnel at the counter. The railway personnel in turn manually enter the passenger data and journey details into the system, and on receipt of fare, issue a ticket. Passengers while travelling, shows the ticket and Identity card when asked for, which are verified by the concerned railway personnel (ticket examiner, for example). Only in case of Tatkal ticket reservation, Identity cards are verified in the reservation counters itself.

In case of online reservation system, the passenger needs to create an account manually entering all personal information (Name, Address, Age, Sex, Contacts etc.), thereby entering journey details and making necessary payment. On the payment confirmation, the ticket details are received by the passenger (in SMS/E-mail etc.). The passenger produces this SMS/Printout of E-ticket along with Identity card to the Ticket Examiner during journey.

Basically, the existing Passenger Reservation system is not comprehensive in the field of identity verification of all the passengers, travelling in train. Also a large overhead is handled every time in feeding the personal details (for example: Name, Age, Sex) of all passengers and details of applicant (for example: Name and Address of applicant, Phone Numbers) to the system. This overhead gets multiplied further, even when the same passenger is booking another ticket just after the previous one with just the journey details as different (as in the case of frequent travellers). Also these data are not linked to each other. Due to huge time consumption in data processing and entry, long queues are often noticed in reservation counters of Indian Railways.

Regarding the identity verification of passengers travelling in the train, passengers are required to produce their Identity cards with tickets, when asked for. But as seen practically in most cases, only one passenger per ticket (consisting of maximum 6 passengers) shows the Identity card on demand and is allowed to travel successfully by the Ticket Examiner. The identity verification of the remaining passengers travelling in the same ticket is not properly taken care of. This is a serious breach of security in terms of passenger identity, since throughout the ticketing process and even during the journey, there is no comprehensive verification mechanism employed for verifying the passenger identity. This makes tracking in case of a suspected person very difficult and makes it easy for unscrupulous persons to carefully utilize this security loophole.

## V. PROPOSED SMART MODEL FOR PASSENGER RESERVATION SYSTEM

The preliminary implementation of smart Passenger Reservation System model is proposed in terms of two separate areas, one for the railway reservation counters, and another for the online reservation system (E-tickets).

### A. Railway Reservation Counters

To illustrate the working of Smart Passenger Reservation System model in terms of ticketing, a schematic algorithm is discussed.

- Passenger seeking a journey ticket approaches to a Reservation counter
- He produces Identity Card (E.g. Aadhaar Card) to the railway personnel, bearing the UID Number (or simply quotes the UID Number)
- The passenger inputs Finger-print in the Finger-print Reader installed in the counter (or some other biometric information or face detection).
- The system matches the finger-print and the UID Number and retrieves the details like "Name, Age, Sex, Phone Number, Address" from the UIDAI (Unique Identification Authority of India) database.
- The railway personnel enter the required Train Number, Journey details (like date, source, destination etc.), Class of travel, Concession etc.
- The ticket comes out and the booking clerk hands over the ticket to the passenger on receipt of requisite fare.
- Also an auto-generated SMS reaches to the registered mobile numbers of all the passengers along with the ticket information (PNR NO., Journey details etc.)

The complete working of the proposed Smart Reservation system at the ticketing phase is now illustrated broadly:-

The database maintained by Railways for storing passenger data and journey information and that maintained by UIDAI (Unique Identification Authority of India) for storing person-information are basically different completely. Since it is not practically feasible and efficient to fuse these two databases, an alternative is improvised, which could maintain a Query-exchange service between the two. This implies queries from the railway database would be served by the UIDAI database and vice versa. As soon as the UID and the biometric information (E.g. fingerprint) are fed into the system, a query is sent from the railway database system to the UIDAI database asking whether the UID and the fingerprint satisfy each other. If both of them correspond to the same person, some information related to that UID is fetched from the UIDAI database to the Railways database. This information may include Name, Age, Sex, Address etc. (all those needed for the railways system to issue a reservation ticket). All this information gets fed into the Passenger Reservation System database and no manual entry of the passenger data is needed. Only the journey data (Date of journey, Train number, Class of travel etc.) is to be manually entered into the system. And then with receipt of the fare, the ticket can be handed over to the passenger.

***Case 1*:** Total passengers travelling in a single ticket is six. But only one person has come to procure the ticket. In that case, that person has to bring the Aadhaar cards or simply the UID numbers of other passengers with him. In this case, only the UIDs are fed to the system, and using the inter-database query service the passenger information is fetched from the UIDAI database (without finger-print

verification). This implies at least one of the passengers travelling is present physically. The other passengers are to carry their Aadhaar cards with them while travelling (to be verified by the ticket examiner).

***Case 2*:** A senior citizen is seeking concession in railway tickets. This can be instantly verified from the query result obtained from UIDAI database, which also returns the Age corresponding to a UID. While travelling, the ticket examiner will verify the Aadhaar card of the passenger (senior citizen) whether it bears the same details as in the railway records. Other concessions may also be applied by choosing suitable options in the interface.

***Case 3*:** An authorized representative of the passenger has come to the booking counter to get tickets. In this case, that authorized representative of the passenger has to present the UIDs of all the passengers. Also he should have to present his own UID (or Aadhaar Card) and input his finger-print which should be recorded by the railways database. In that case, along with the passengers, the details of the authorized representative of the passengers are also recorded in the system for the purpose of future reference. In this case also the passengers are to carry their Aadhaar cards with them while travelling.

## B. Online Reservation System

Now this new model is to be discussed with respect to E-ticketing system. In this model, the passenger seeking reservation will enter the portal of Indian Railways. In the user interface, the passenger needs only to enter the UID. As soon as the UID is entered, the UID itself feeds the railway database with all personal information obtained from the UIDAI database by virtue of inter-database query services. Then a One Time Password (OTP) is generated and is sent to the mobile number registered against the UID. That OTP is to be entered into the system within a stipulated time, after which the OTP expires. With this OTP from the registered mobile number, the identity of the passenger is verified. After this verification, the passenger can enter the journey details and proceed for payment and receipt of ticket.

Also, once a passenger books a ticket using E-ticketing system, the corresponding UID and registered mobile number information is saved in the portal. Next time the user needs to book a ticket, he can simply send SMS from his registered mobile number. In reply, the portal sends the necessary connected information already saved in the system (name, UID etc.) which can be verified by the user. If satisfied, the user can proceed further with interactive SMS and the ticket gets booked. Provisions would be there where the ticket charges are directly debited from a Bank Account connected to the particular UID.

***Case 1:*** Total 6 passengers are seeking reservation on a single ticket. In this case, at least one passenger should enter his UID at first, on which OTP will be verified. After verification of one passenger is done, he can proceed to reserve tickets for other passengers in the same ticket with himself, just by entering their UIDs. As soon as the booking is proceeded for payment, automatically an SMS is to be sent to all the passengers (whose UIDs are entered but are not verified with OTP) informing that a ticket is purchased with their name as passenger. Any discrepancy of purchase of false/fake personified tickets would be sorted out at this stage only.

***Case 2:*** A senior citizen is seeking concession for fare. He has to select the type of concession. As he selects the concession type as “senior citizen”, the system checks the age and sex, and applies the respective concession (“Senior Citizen Male” or ”Senior Citizen Female”).

***Case 3:*** An authorized representative of the passenger is booking a ticket. In this case, his UID is input into the system. Also the UIDs of all the passengers who will be travelling are also entered into the system. In this case, the OTP will be sent to the first passenger. With correct response of OTP, the system will proceed further for booking, payment, and ticket generation.

# VI. IMPLEMENTATION AND ADVANTAGES OF THE SMART PASSENGER RESERVATION SYSTEM MODEL – A ROBUST STRUCTURE

Since the existing PRS model is a wide-spread existing structure, it is practically impossible to usher in a new model, completely flushing away the old one. But this smart PRS model can be implemented just by introducing some modifications into the existing system. Just as in case, presently the data entry in the system during the time of reservation is done manually. When the new model introduces the UID-based entry and verification, an overlying interface is to be designed, which will handle this portion of data entry and will feed the same data to the system, but the data will be supplied based on the UID.

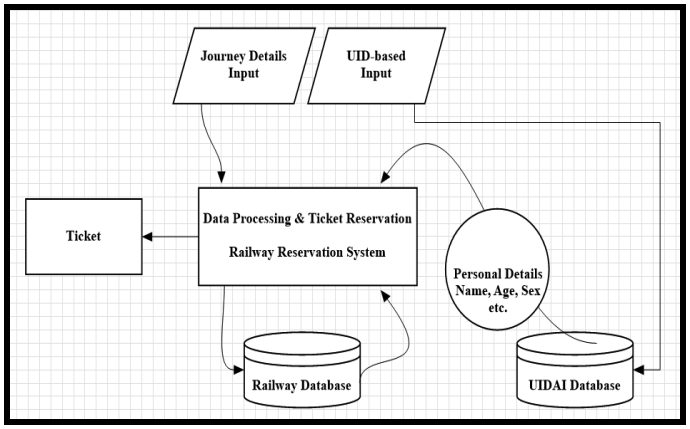


**Fig. 1.**Working of the UID-based Reservation System in Indian Railways

Hence the modification is to be implemented in a superficial layer, lying over the existing system of manually entering the personal details of the passenger. And for the time being, due to introduction of the new system, the two systems can run parallel.

Discussing with the advantages brings firstly the no breach in verification of the passengers travelling in the reserved coaches of the train. The new system involves comprehensive check of identity in case of every passengers travelling onboard. Also the huge overhead of typing the details of all the passengers is bypassed by a more intelligent and efficient method of data entry using UID. This identification is also comprehensively verified in a second phase at the running train, when the Travelling Ticket Examiner (TTE) verifies the passengers physically travelling. The passengers produce their Aadhaar cards to the TTE, who verifies the UID on his reservation chart with that of the card. Alternatively, the passengers can also show the auto-generated SMS from their mobile phone, bearing all journey details, as sent by the railway reservation portal. Also another point of checking can be the photograph of the passenger because this time new reservation charts can be prepared with photographs of the passengers. The corruption regarding impersonation of passengers can thus easily be avoided. Also the fraudulent booking of touts/travel agents can also be avoided. Presently these persons purchase bulk amount of tickets taking arbitrary names and ages. Later these tickets are sold to groups of persons matching the age groups and one person per ticket travels correctly, the other persons travel in false identity.

An example of such fraudulent booking will make this clear –

| **Reservation requisition form submitted at reservation counter** | | | |
|---|---|---|---|
| ***Serial No.*** | ***Name*** | ***Age*** | ***Sex*** |
| 1 | A. BANERJEE | 53 | Male |
| 2 | S. ROY | 41 | Female |
| 3 | T. MANDAL | 33 | Female |
| 4 | P. SINGH | 25 | Male |
| 5 | S. AGARWAL | 51 | Male |
| 6 | M. SAHA | 19 | Female |

The touts/fraudulent travel agents now sell the above ticket to a group of 5 persons bearing nearly the same ages and sex. At least one person per ticket is the same, as in this case A. Banerjee (Male, 53) is the actual passenger. The others are travelling with false identity. In practice, it is very rare that the Ticket Examiner asks for the ID card of all the passengers. Even if it is asked, the actual passenger shows his ID (which matches successfully with the reservation chart) and the other passengers remain undetected.

| **Actual passengers travelling in train** | | | |
|---|---|---|---|
| ***Serial No.*** | ***Name*** | ***Age*** | ***Sex*** |
| 1 | A. BANERJEE | 53 | Male |
| 2 | S. R**A**Y | **43** | Female |
| 3 | T. M**O**NDAL | **27** | Female |
| 4 | **R**. SINGH | **26** | Male |
| 5 | P. AGARWAL | **53** | Male |
| 6 | **D**. SAH | **20** | Female |

In this new model, this loophole can easily be fixed since here is a two-level check in identity. Firstly the identity of at least one passenger is verified at the reservation counter or in the online ticketing portal. Secondly the entry of UID would initiate the preparation of photo-reservation charts are prepared. During journey, the concerned Ticket Examiner verifies the UID number in the reservation chart with the Aadhaar card produced by the passenger. Also the photograph is verified with that of the passenger.

In case of E-tickets, the biometric verification at PRS counter could not be done. Instead the verification would be done using One-time Password (OTP) sent to the registered mobile number. During travel, the passenger shows the SMS (confirmation of reservation) or hard-copy of the reservation acknowledgement to the ticket examiner. Also he needs to show the Aadhaar card with which the ticket examiner verifies the Aadhaar number and the photograph. Thus from the verification point of view it can be confirmed that no passenger can travel in the train providing false identity or wrongly personifying a genuine passenger.

Indian Railways Vision 2020 addresses the catering of excellent and hassle-free services to all passengers. This model will leap a step ahead in this venture with the UID-based services.

## VII. SHORTFALLS OF THE PROPOSED MODEL

Basically, the smart model approach for passenger reservation system depends on some pre-requisites, without which the benefits would not be fully enjoyed. This includes the comprehensive UID registration of all passengers who needs to travel. Also it expects that every passenger (at least one for each ticket) possess a mobile phone. Though this is not compulsory for all the passengers booking through reservation counters. Also it is quite easier to implement a new system afresh, comparative to incorporating modifications to existing system. The huge domain of this reservation system, its zero-tolerance to break-of-service, and scarcity of properly handled huge data repository could have been threats in introducing and implementing this system to the existing one. Efficient searching and indexing operations are needed for fast query processing to actually offer the benefit of the smart model.

## VIII. EXTENDED SCOPE OF THE PROPOSED MODEL

Using the UID-based technology, it is possible to decentralize the task of reservation from booking clerks (in railway reservation counters) to automatic ticket vending machines (ATVM) also. Since the unreserved tickets are already getting issued through ATVMs, the reservation feature can also be implemented in the ATVMs. This could easily be done by linking the reserved accommodation of trains in the machines and by issuing biometrically verified/PIN protected Smart Travel Cards. Alternatively, the biometric information can be registered at Smart Card counters, while issuing the smart cards. This can easily remove some load from the existing reservation counters. Similar enhancements can be done in terms of ticketing outlets, like providing unreserved tickets based on mobile applications, interactive SMS and IVRS. The passenger verification during journey time could also be made against any authorized ID card (E.g. PAN card, Electoral Photo Identity Card etc.)

when Aadhaar card is not available for some reason. This would not be a problem since the reservation charts having photographs of the passengers (as extracted from UIDAI database) would serve as the most secured way of physically verifying the travelling passenger. Also passengers would be able to obtain reservation tickets from either of the railway counters, automatic ticket vending machines, or through online reservation.

Considering the refund policy, the refund money for any cancelled train or some other incident can be directly transferred to the Bank account linked to the Unique ID numbers (Aadhaar Number) of a passenger without any manual intervention.

According to Vision 2020 of Indian Railways, "It will be our endeavor to see that no train traveller has to wait for more than 5 minutes for getting a ticket even in the unreserved category." This would be a leap forward in promoting this fast environment of obtaining travel tickets besides supporting a robust and secured approach.

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