Object Oriented Design Approach for the Implementation of Secure Aircraft Management System Based on Machine Learning

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This paper presents the methodology for the development of a real-time application. In this paper, we've proposed a new methodology for aircraft management systems. It has been designed to solve the problem that has been arising in the existing models. The proposed technique will help to enhance security and shorten the processing time with the help of object-oriented techniques. The main objective of this paper is for the Simulation of the entire design process to be performed using object-oriented techniques and machine learning techniques which help to divide the components into small objects and to evaluate the system model to achieve the best accuracy.

Keywords: Machine learning; Object-oriented design approach; Aircraft management system.

1. Introduction

An aircraft management system (Online flight booking system) is an application used by the customer for easy and convenient booking of flight tickets considering various criteria. Such systems facilitate users with information such as Flight route, Price, Destination, Flight schedule, helping users to consider the best one.

After World War II, the necessity of air travel increased as a result the reservation of aircraft was also given more importance, due to which using a large display board for the passenger

used to reserve the flight and the confirmation used to come via telephone [1]. However, with growing advancement of technology a proper online reservation system was introduced by an American airline, in which the passengers were able to reserve the flight online and till now the same procedure has been applied where the reservation is done online [2]. Though many different reservation systems have been developed to make the reservation more convenient and user friendly, they might still lack in some of the aspects where people are unable to receive valid information.

Even though the online reservation came much early, it was not implemented as people used to rely on the traditional reservation method where they would go to the travel agency and book their tickets. However, with the advancement of technologies and with increasing benefits, people started prioritizing such online systems. Newer organizations providing innovative solutions to the problems started overtaking older systems. Online booking systems revolutionized the way people book flights forcing many traditional booking facilities to shut down [8]. Today we can see many such reservation systems, which has made the work of people easy. Even though there are many such systems, they only facilitate the ticket reservation and fail to provide precise information about the flight timing and the delays that might occur.

In this paper, we have developed an aircraft ticket reservation system conjointly with a machine-learning algorithm. The system will be able to provide precise possible delays of the flight, providing users the convenience to reserve the tickets based on the delay time. The major contributions of the paper are as follows:

- To design and develop an efficient and reliable system to search the route, find flights, and get tickets on the desired flight along with the possibility of viewing potential delays in a flight.
- Any airline can sell tickets using the Aircraft Management System, which includes passenger information, seat information, fares, flight schedules, and probable delay times, allowing them to deliver the greatest service to their passengers. The system allows users to book tickets online, has a simple return policy, is available 24 hours a day with constant support, and gives accurate flight information.
- The system was developed and designed using an object-oriented approach, along with a decision tree algorithm for delay time prediction and encryption/decryption for security features.

2. Literature Review:

Manju et. al. [6] focused on the analysis of different approaches which is useful to build the NLIDB system along with the advantages and disadvantages. Along with this a complete flight booking and enquiry system has been developed with the help of a natural language interface. It has concluded that modern approaches are more beneficial compared to the earlier ones.

In 2017, Norazah Mohd Suki, Norbayah Mohd Sukib [7] provided an analysis report on how an individual reacts to ticket booking apps through mobiles and what factors should be considered to attract more customers and make their work easy. Inclusive of these features the booking app must also have a variety of options for the user so that they can book the flight based on their necessity. It provides an overview of which means people considered

the mobile flight booking system convenient and has preferred the app at the time of booking or not. Although it has provided positive aspects, the means to remove some of the negative aspects are still not clear.

Tumennast Erdenebold et. al. [3] The major study and research of this paper revolved around the idea of avoidance of the amplified ticket pricing to the users upon viewing multiple times through the same device. The area of study to solve this issue was the implementation of block chain technology. The limitation of this paper was that the concepts to be researched and used in the actual system have not yet been validated through application and expertise. After that Many researchers have been focused on creating a robust backend system for ticketing systems in general to contribute to the shift of culture from the physical to the digital domain in various aspects of daily life. Ticketing is an important field to transform society into a digital format [17]. Therefore, the system with multiple features as well as two factor authentication techniques was developed along with the building of a prototype which could be scaled and used in the industry.

The limitation of this study was that the prototype created could not be tested in the environment as previously planned. Thus, it is prone to failure in an uncontrolled environment. Furthermore, advanced functionalities such as third-party API remain to be studied and implemented. In 2018, Thilina Jayasinghe, et. al. have worked on [5] web services are the zest of the service-oriented approach in the market; where the flight ticketing system falls. There are various unique approaches and data formats used to construct the system. Therefore, there is no uniformity in the various flight ticketing systems. This creates a problem for the users as well as the engineers and developers. There is no set standard for the construction of travel agent systems. Thus, creation of a standard system that can be utilized by all is the goal of this study. The internationally accepted standard is proposed by the paper. However, the shift in the market to adaptation of this standard is a big challenge in itself. Rajarajeswari et al have been focused on Machine learning approaches [8,9,16,17].

3. Proposed methodology:

The proposed methodology for this paper is based on the concept of object-oriented programming. In this method, the different aspects of the systems are divided into modules and objects. The aircraft management system can have various objects such as routes, tickets, planes, airlines, and customers. They are interlinked to each other accordingly. The objects comprise the modules; which together make the whole paper. The primary objective of this paper is to make it easy for customers to look into the system for routes, aircraft, and available tickets and book the tickets. 24% of the flights in Europe were delayed more than 5 minutes and 21% of the flights in the USA were delayed more than 15 minutes in 2018[11]. Furthermore, the concepts of machine learning are introduced to provide the users with the estimated delay time which would help users to compare the reliability of the airlines in terms of timing across various routes. The decision tree algorithm is forecasted to be efficient for such a task. Accordingly, in order to search the records in the database, the binary search algorithm shall be implemented. The data structures shall be used accordingly.

The searching and selection of the ticket in the database includes the following steps:

1. Signup/Login to the system
2. View the list of the routes or search routes to select one
3. View and select the tickets available in the route
4. Enter details for ticket/s
5. Payment
6. Download the confirmed ticket

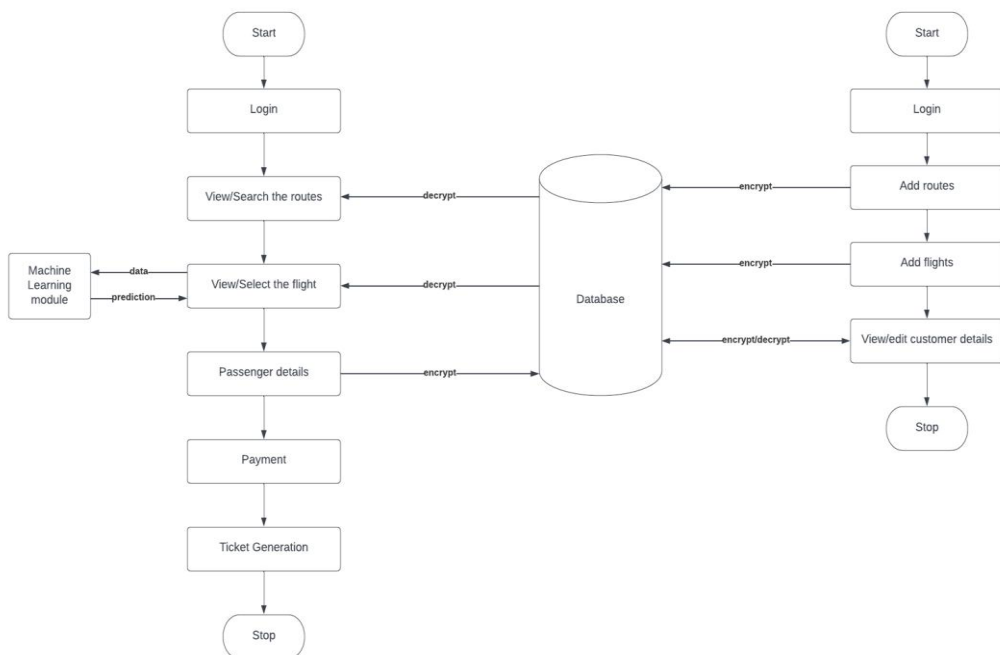The above step in the graphical format is shown below:

Fig. 1. Proposed methodology

3.1 The following object constraint language is used for aircraft management system:
- Accept login credentials
- if id in admin:
      receive route data
      initialize route
      receive airline detail
      initialize airline
      receive flight detail
      initialize flight
      store to database
- if id in user:
      receive route detail

      display flights in the route and projected delay

       receive airline/flight detail
       receive passenger information
       display price
       open payment portal
       accept payment
       print ticket

4. Design of aircraft Maintenance System

The design of aircraft maintenance system can be formed by using object-oriented design approaches. This design process can be performed by using a use case diagram, Sequence diagram, or Class diagram[17].
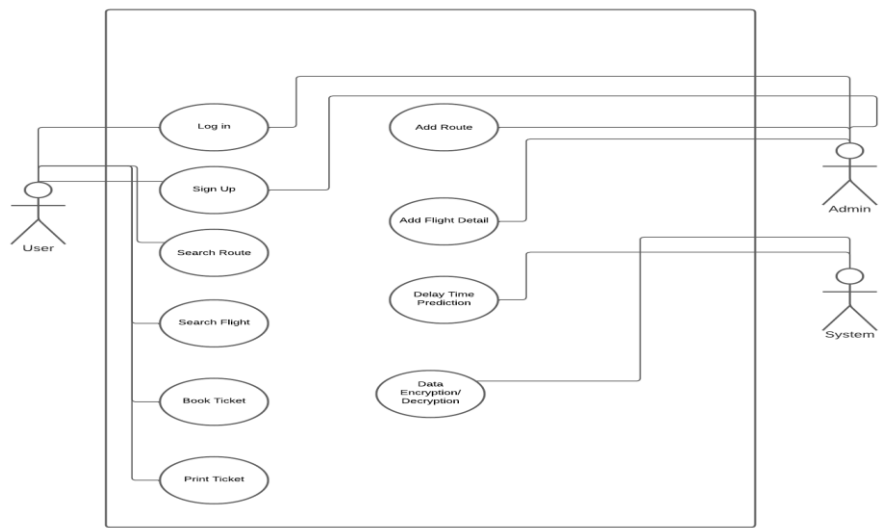

Fig. 2. Use Case Diagram

The above figure shows the Use cases and users and Admin. Here use cases are Login, signup, search route, search fight, book ticket, print ticket, add route, add fight detail, delay time prediction, data encryption and decryption.
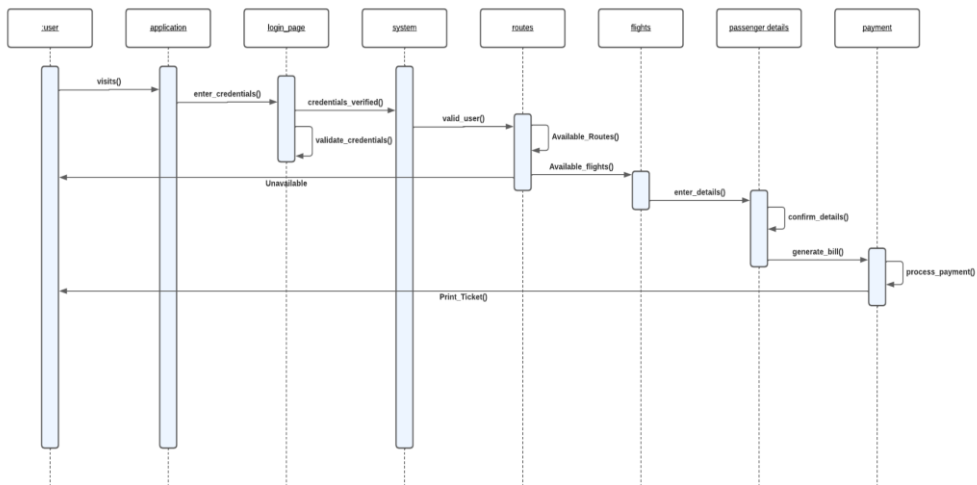
Fig. 3. Sequence Diagram

The above figure shows the sequences of event in an order. It shows the dynamic aspects of the system.
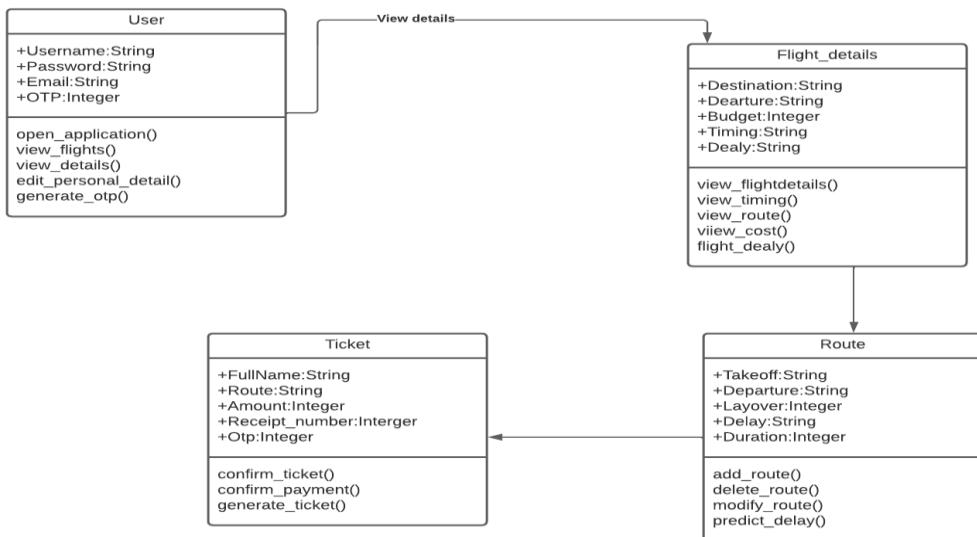

Fig. 4. Class Diagram

The above figure shows the class diagram. It shows the static nature of the system. Here classes are user, flight details, ticket and route.

4.1.   Aircraft management system based on Machine learning approaches:

The machine learning technique has been incorporated here in order to serve the users with a better experience alongside high amount and quality of information. If the passengers are

able to view the expected delay time beforehand, it is useful for them to assess the quality of service of the particular airlines in that route. As a good product should always remain customer oriented, this module plays a vital role in doing so.

Machine learning is a huge field in itself which incorporates various techniques and algorithms; the one that has been used here is the decision tree algorithm. The decision tree algorithm is a supervised learning technique used for classification. It is able to provide the optimized result by creating a tree structure based upon the attribute values. The accuracy of classification by the model is not significantly sensitive to the choice of feature selection for both balanced and imbalanced datasets [9].

The steps followed by the decision tree algorithm for complete functionality are:

Step 1: With the complete dataset, begin with a root node of the tree

Step 2: With the help of Attribute Selection Measure, find the best attribute in the dataset

Step 3: Divide the dataset into subsets containing the possible values for best attributes

Step 4: Generate decision tree node, with the best attribute

Step 5: Make new decision trees using the subset of datasets until no classification is possible

For the Attribute Selection measure, the gini index method is implemented. Gini index, also known as gini impurity, is the probability of a randomly selected feature to be classified incorrectly. The data is classified by splitting through a node. The best split creates the best nodes. The attributes of the nodes are chosen based on the gini index [12]. It is calculated by subtracting the sum of the squared probabilities of each class from 1. The value of gini index ranges from 0 to 1 where 0 represents the purity in classification and 1 represents the random classification.

Mathematically, gini index can be represented as:

$$G = \sum_{i=1}^{C} p(i) * (1 - p(i))$$

--Eq (1)

4.2. Encryption/Decryption

Security is always a major concern in the development of an application. Especially in the field of application of this paper, the security of the data is intricate. The physical capabilities of the devices need to be considered where RAM size and processing power of devices in use are integral parts [10]. Thereby, in order to secure the data efficiently, the encryption and decryption module is used in the system. The symmetric key encryption/decryption algorithm is simple to implement and also provides an additional layer of security to the data. Symmetric encryption can be done with both public and private keys [13].

There are two parts of a symmetric encryption module: data and encryption key. Encryption

key is a 128-bit binary value private key which should be kept secret as it is used to encrypt as well as decrypt the data. The data is a value that is to be encrypted. The encryption method returns a binary value as the result of the encryption of the content. Similarly, if the encryption key and the encrypted value is passed into the decryption function, the original content is returned.
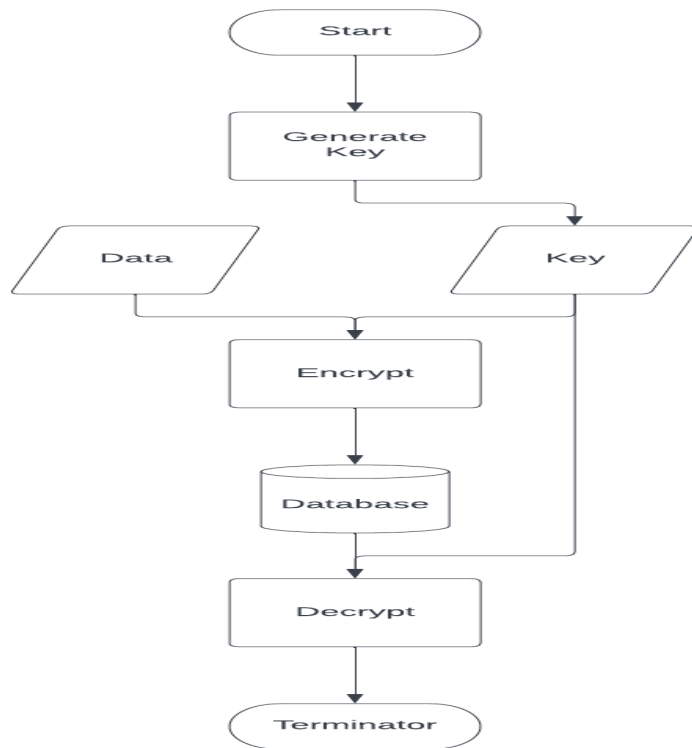

Fig. 5. symmetric encryption/decryption

This simple mechanism can be highly beneficial for safe storage of the data into the database.

5. Result and future work:

The proposed system was implemented following the object-oriented approach of development. The users are able to log into the system, search for routes and flights and then reserve and print the tickets into their system. Also, during the selection of flight, the estimated delay time is provided through the machine learning module which uses a decision tree for prediction. The machine learning provided the departure delay time of a flight with an accuracy of 0.99 in the dataset taken.

The dataset taken was the 2015 flight delays and cancellations dataset from Kaggle. The link to the dataset is here. The dataset was used to implement the decision tree algorithm as the data was read, preprocessed, dummy columns for categorical values created, scaled and

implemented into the decision tree algorithm with gini index for attribute selection. Thus, upon prediction of the delay time of the flight, an accuracy of 0.99 was achieved.

```
clf = DecisionTreeClassifier()
clf = clf.fit(X_train,y_train)

y_pred = clf.predict(X_test)
accuracy_score(y_pred, y_test)

✓  0.2s
```

```
0.9983347210657785
```

Furthermore, the user data in the system is encrypted and stored into the database.

A prototype of the system was constructed with all the features following the proposed methodology. The system was successfully tested on a small scale for accuracy, reliability and efficiency. As the system is based on object orientation, it is scalable. However, the web-based user interface could not be developed due to time constraints. Also, the data were stored in files locally in a database directory.

Upon storing the data, it was encrypted and was decrypted upon reading. This mechanism was implemented with a 128-bit symmetric encryption key. The example can be viewed below:

```
message = "Example data"

print(f"The key generated is: {init_key}")
print(f"The message is : {message}")
encrypted = encrypt(message,key=init_key)
print(f"The encrypted value is: {encrypted}")
decrypted = decrypt(encrypted,key=init_key)
print(f"The original value was: {decrypted}")
```

Output:

```
The key generated is: b'PKJxGWlV9LJ5ajiYHgJt_Vef_gfHZYazGvUsFfmF85U='
The message is : Example data
The encrypted value is: b'gAAAAABiuSTS-hWAkhBKZ5mHAjO7roZ7oHDqaODIw_LIipqfbpbZfFE2oRdurjImTjox-VkhK4NyKK
TrOWMswmzCmL4FSzPFVQ=='
The original value was: Example data
```

In the future, the system can be developed and implemented on a large scale as a web-based application. A proper UI can be constructed in order to make the service user-friendly. Furthermore, more advanced features such as the implementation of API can be added into the system to make it better and more efficient.

6. Conclusion:

The paper helps to design a system that is efficient, informative and user-friendly. The concepts of the object-oriented model of development can be extremely useful to implement in these types of scenarios. It is a platform where the various airlines and different routes can be listed which facilitates the ticketing experience of the passengers. Furthermore, the inclusion of the machine learning algorithm provides an extra dimension to the system, and an extra bit of useful information to the customer. Also, securing the data of the customers with proper security mechanisms is an important feature. There is a huge room for the development of this concept with improvements and innovations. There are still many aspects such as the user interface and interaction, which have not been included in the paper. This paper paves a path to the creation of a user-oriented system.

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