



Web Based Flight Journals, Billing and Forecasting Management System: The case of Ethiopia

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List of Acronyms

ADO.NET	: ActiveX Data Object NET work
ASP	: Active Server Page
ATC	: Air Traffic Controllers
C#	: C-Sharp
CLR	: Common Language Runtime
DB	: Database
DBMS	: Database Management System
EAE	: Ethiopian Airports Enterprises
EAL	: Ethiopian Air Lines
ECAA	: Ethiopian Civil Aviation Authority
FAA	: Federal Aviation Administration
FJ	: Flight Journal
FJBFMS	: Flight Journals, Billing, and Forecasting Managements System
FP	: Flight Plan
HTTP	: Hyper Text Transfer Protocol
HTTPS	: Secured Hyper Text Transfer Protocol
IATA	: International Air Transport Association
ICAO	: International Civil Aviation Organization
IIS	: Internet Information Service
SQL	: Structured Query Language
SSL	: Secure Socket Layer
URL	: Universal Resource Locator
UTC	: Coordinated Universal Time

Abstract

The availability of precise and exact flight data is crucial to effectively manage aircraft operator's billing, air transport business operations and also to ensure flight safety. This project work has aimed to design and implement systems that can efficiently manage flight journals, aircraft operators invoicing, and produce traffic Statistics and Forecasting for Ethiopian air transport industry.

System requirements have been rigorously collected from Ethiopian Civil Aviation and Ethiopian Airports Enterprises. Review of literatures and related works which are used in the transport industry are also conducted. The design and implementation of the system is done in accordance to the identified functional and non functional requirements. Object oriented software engineering and ASP.NET 2.0 platform is employed to develop the system. The system is designed in such a way to be accessible via the Internet. Users have access based on their privilege level. The system has different subsystems to meet its core functionalities. The Flight plan subsystem imports planned flights from Flight Plan database to the main database so as to enable Air Traffic controllers to produce actual flight journals. The Flight Journal Management subsystem manages registration and preparation of different flight journals. The Billing Management subsystem is in charge of processing different aircraft operator's charges. This subsystem also manages different invoice operations including sending the specified invoice to the customer via email. The System Utility Management subsystem manages user account management tasks and sets up different system parameters used by the system. The Statistics and Report subsystem generates different statistics and standard reports whereas the Forecasting subsystem enables users to generate aircraft movement traffic forecasting using the designed forecasting model.

The system has been tested with seven years actual data and it has been observed that the system successfully meets the entire requirement identified. In addition, we evaluated our system through a questionnaire which is prepared by considering the ISO 9241-11 usability test standard attributes. The results of the evaluation have shown that our system is easy to use, efficient, effective, accurate, and can save time of professionals.

Keywords: Flight Journal Management, Flight Journal and Billing Management System, Airport Revenue Management, Flight Journal Statistics and Forecasting System, Aircraft Operators Invoicing System, Aircraft Movement Statistics and Forecasting.

Chapter One

Introduction

1.1 Background

Civil Aviation is a category of flying that represents both private and commercial of all non-military aviation. Most of the countries in the world have their own civil aviation organization all of which are members of the International Civil Aviation Organization (ICAO), who establishes common standards and recommended practices by which the aviation industry is governed.

Air Traffic Control comprises the various aircraft navigation and communication systems that use computers, radar, radios, and other instruments and devices to provide guidance to flying aircraft. Trained personnel working as Air Traffic Controllers (ATC) constantly monitor these systems and track the locations and speeds of individual aircraft. They also coordinate the landings and takeoffs of all the aircraft within their Airport [3].

The goal of Air Traffic Control is to minimize the risk of aircraft collisions while maximizing the number of aircraft that can fly safely at the same time. Aircraft pilots and their onboard flight crews work closely with controllers to manage air traffic. Air traffic control systems also provide updated flight information to airports around the country, so aircraft can takeoff and land safely. This information is important not only to airline passengers but also to industries that rely on aviation for the timely transport of goods, materials, and personnel [2].

Aviation safety is the basis of expediting air traffic flow and improving the profitability of civil aviation transportation. Along with the rapid increase in air traffic flow in the world, air traffic controllers' workloads have been so greatly increased that can create an opportunity of man-made mistakes to frequently happen [1].

Along with the services given to aircraft pilots each individual aircraft movements, captured from the pilot's communication and/or flight plan, are registered by Assistant ATC on tower logbook called Flight Journal. Flight Journal is, therefore, the daily records of aircraft movements which might arrive to or department from one of the country's airport or over flight movements that crosses the country's boundary without landing. The registered flight journals are composed of useful information, that not only provide basic data for revenue generation but

also as a source of information for decision making and/or statistical analysis for other local and international aviation industry's organizations, including the data owner. Detail of what is recorded on logbook is given in section 2.1.1.

Most of the fields of the flight operations are important parameters of tariff calculations when invoicing both local and international customers, who got different services from ATC and/or airports, according to each service tariff set by the organizations. There are two classifications of aviation service charges or revenues: Aeronautical and Non-aeronautical. Aeronautical revenues include only revenues generated via service and facilities related to aircraft operations, passengers, and cargo. Non-aeronautical revenues are the ones produced by commercial services and facilities at the airports [4]. Landing charges, parking charges, En-route air navigation charges, terminal facility charges, lighting charges, over flight air navigation charges, security charges, passenger charges, and cargo and ground handling service charges are all types of Aeronautical revenue.

So, with the increasing demand for air transportation and highly competent industry, all parties involved in the air transportation system must have to manage hundreds of both commercial and non-commercial aircraft movement activities in modernized way to promote an efficient civil air transport service and ensure flight safety.

As described in [5,6], information integration, the driving force of this decade of IT (information technology) spending, is a technological approach that combines core elements from data management systems, content management systems, data warehouses, and other enterprise applications into a common platform. Based on the information integration technique and the thorough understanding of the problem, it is desirable to design an efficient web based system that enables the aviation organization to manage aircraft movement data integrated and fetched from flight plan and generate an invoice calculated from the records of flight journals, which should have to be mailed to both local and international customers automatically from the developed system interface.

1.2 Statement of the Problem

It is known that Ethiopia is one of the few African countries with competent air operator and safe air transport services [35]. As a result of this, relatively, there are a number of aircraft operators

from different angles of the world using the Ethiopian air space to perform their flight operations, which in turn creates workloads on traffic controllers and huge amount of flight data to be recorded.

Even though each flight is planned to operate in advance, the actual flight occurred in each day may not be always the same as the planned flight plan as some flights may be cancelled and/or changed, some may be planned as repetitive flight within a week, and also other non-scheduled flights may be permitted. In addition, some operators/states may not send complete flight plan data following international flight plan format which result in unable to invoice airport charges that depend on that missed fields. Moreover, the arrival and departure times in flight plan are estimate values and also some flights may change their planned entry and/or exit point when crossing the country's boundary. Therefore, relying completely on flight plan database will not provide the actual records of movements and hence generating billing information from that is not practical.

On the other hand, registering all the flight movements of an aircraft via radio communications, especially in busy flight hours, leads to production of huge amount of problems. Among them:

- The data can be registered error prone.
- Difficult to hear codes, time, call sign and other important parameters.
- The operators may not register the movements on the logbook, due to shortage of time or personnel or other reasons.
- The pilots themselves may not provide correct information of the flight to the controllers.

In Ethiopia many airport and civil aviation charges, including statistical analysis and forecasting operation, rely only on a single flight journal which is manually registered by ATC. So, missing or misleading the flight information and/or un-registering a given flight movements leads to loss of millions of foreign currency within a single month. To make the matters worse, a flight is ready for parking charge if it has two flight operations, arrival and departure. In another word, a given aircraft will not be invoiced for parking until its corresponding flight with the same flight number or consecutive flight number and registration with registered arrival and departure time is recorded as takeoff and vice versa.

The process of manually recording flight movements of all airports on daily flight journal logbook, collecting regional airport's journal logbook to head quarter office and entering the manual flight journals on the two organization's separate out dated Microsoft access billing database and spreadsheet system, and correcting wrong flight journals to produce actual flight journals so as to produce accurate invoice takes many days or a couple of months in the worst case to send the final invoice to the customer.

When the recorded flight journal copies are sent from regional airports to both civil aviation and airports head quarter, it may be lost or wrongly recorded by many reasons. Such acts not only reflect on the invoice produced but also on the preciseness of the analyzed statistical reports. Again, sending the processed invoice to hundreds of customers via postal office is not practical as the invoice may be lost or is unreachable.

Therefore, there should be an integrated automated system that handles the flight journal registration and validation process after importing information from the flight plan database, an archive of all outgoing and ingoing international flights, and generate an invoice for ready flights and send to the corresponding customers via mail from the system interface. The designed system can replaces the two organizations out dated Microsoft access billing system, avoids manual processing of some billings, and also other data entry problems by making analysis of planned and actual flights in addition to making the working environment paperless.

1.3 Objectives of the Study

1.3.1 General Objective

The general objective of this project is to develop a Web based Flight Journal and Invoicing Management System for the Ethiopian Aviation Industry.

1.3.2 Specific Objectives

The specific objectives of the project are:

- ✓ To conduct literature review and study related systems which were already implemented.
- ✓ To identify requirement of the system.
- ✓ To design and develop the prototype of the system
- ✓ To evaluate the system

1.4 Methodology

To develop the system, object oriented software engineering, which consists of requirement elicitation and analysis, system and object design, implementation and testing activities are used.

- **Requirement Elicitation and Analysis**

To identify the functional and non functional requirements of the system, requirement elicitation and analysis has been done. As a starting point, we conducted extensive literature review to understand the domain knowledge and characteristics of related systems. To come up with the specific requirements, we have employed data collection by conducting informal interview, reviewing documents and on site observation. The collected data has been analyzed to produce a model of the anticipated system that is complete.

- **System and Object Design**

Following the completion of requirements analysis, the system is modeled using UML tools. The system then is developed using object oriented concepts in a tiered architecture. During system design, the design goal of the project has been defined and the system has been decomposed into smaller subsystems that can be realized thoroughly. We also used strategies for building the system, such as the hardware/software mapping, and persistent data management strategy.

- **Tools**

The designed functionalities and services are implemented on the .NET Framework platform using C# programming language. Different web pages were developed using ASP.NET and Microsoft SQL server 2005 for developing the backend of the database. We used crystal report to design our reports.

- **Testing**

The system was tested for all functionalities including, statistics and forecasting, by importing 7 years flight data and all records of the flight plan to the database.

- **Usability Testing**

We evaluated the prototype of our system for usability by conducting user acceptance testing which was performed based on the ISO 9241-11 usability testing attributes using five levels Likert scale after collecting data from the participants.

1.5 Significance of the Study

The project's result could be applicable in different areas benefiting different target groups.

The main beneficiaries could be the following:

- Ethiopian Airport Enterprises (EAE),
- Ethiopian Civil Aviation Authority (ECAA), and other state's civil aviation organizations,
- Different Airlines currently operating and will want to operate in Ethiopia,
- Immigration and National Security Agencies,
- Custom and Revenue organization,
- ICAO,
- International Air Transport Association (IATA),
- Federal Aviation Administration (FAA),
- Planning and Statistics Agencies,
- Researchers,
- Insurance companies,
- Pilots,
- Tour and Travel organizations,
- Hotel owners,
- Airline Ticket Agencies,
- State's Defense Organization,
- Aviation Training Institutes, and
- Passengers

1.6 Scope and Limitations

Scope

This project is limited to providing the following features

- Import flight plan records,
- Produce and managing En-route navigation, over flight, and terminal facility usage journals via the Internet,

- Produce different invoices for EAE and ECAA charges,
- Send invoices to customer via email from the system interface,
- Access to forms based on privilege level of users,
- Generate statistical and standard report based on users query, and
- Generate traffic forecasts

Limitation

The project has the following limitations

- Doesn't register passenger manifest of the flight such as their names, passport number, and the like,
- Does not incorporate security, surcharge, noise, and cargo handling charges,
- Does not also include billing for non-aeronautical revenues, and
- Does not support local languages and languages other than English.

1.7 Organization of the Document

This project is organized into seven chapters including the current one. The Second Chapter presents the literature review conducted to understand the domain knowledge. The Third Chapter discusses about related work. The Fourth Chapter presents about the proposed system including functional, nonfunctional, and system models. The Fifth Chapter presents the general system architecture of the proposed system, the qualities that need attention of the developer, decomposition of the system into subsystems, and the relational model defined for the system. The Sixth Chapter presents the prototype and usability test. Finally, Chapter Seven presents conclusion and future works.

Chapter Two

Literature Review

2.1 Aircraft Movement Data

In order for aviation organizations to be fully aware of the level of flight safety and even suggest better decision on future planning, it is necessary to collect information on aircraft movements and to keep data in a form that allows analysis to be undertaken and in order to make sure the operators are paid properly for the supply of all services given to them [9].

The availability of flight data is a prerequisite for efficient aviation revenue management and statistics system. Comprehensive, validated, and actual flight data is needed to present the scope of air traffic congestion problems within the air space region and provide relevant information regarding schedule changes, capacity utilization, and performance evaluation and also offers the best way to visualize delay statistics, financial activities, and operational efficiency [10, 11, 12].

Each event of landing, takeoff, and over flight movement of an aircraft is associated with the generation of information. This set of information, called flight journal, is identical for every movement at any airport and is used all over the world to assess flight safety and traffic movements. According to [10, 11, 12, 19, 20, 22], the flight information captured by air traffic controllers from different sources at the airport are not only used as input data for billing system for the generation of invoice but also for interpretation and analysis of:

- Busy and quiet periods,
- Amount of local and visitor aircrafts,
- Percentage of use by different types of aircrafts,
- Traffic flow of particular taxiways and/or routes,
- The number and nature of passengers,
- The types and purpose of flights,
- Excess or shortage of resource utilization, and
- Future capacity planning.

Potential source of these flight data include [7, 1]:

- Flight plan,
- Radar view,
- Pilot's radio communication, and
- The weather bureau.

2.1.1 Capturing and Recording Aircraft Movement Data

Data about any flight is captured and recorded by ATC, who direct the safe and orderly movements of aircraft while they are flying, landing, taking off, and taxing. ATC receive information from flight plans, pilot reports, radar and observations, and have the ability to update it, with correct times, route, level and other data, during the progress of flights through air space [9, 28].

In addition, ATC have many responsibilities among others [9, 28]:

- direct aircraft to manage aircraft traffic flows so that accidents are avoided;
- advise pilots on weather conditions, the status of facilities, airports and other services;
- give pilots permission to takeoff, land and change altitude and direction;
- give airport workers permission to move around on the terminal and runway;
- monitor aircraft in the air on a radar and look for possible conflicts;
- check equipment used for navigation;
- communicate by telephone, radio and satellite communication systems with pilots, air traffic controllers and other airport professionals;
- alert airport fire crew and rescue services in cases of emergency; and
- Write reports on incidents.

Information captured and updated by ATC on tower logbook daily should have to be in ICAO format, and consists of [9, 26, 27]:

- Date of flight: is the date at which the flight is operated and it should be in Coordinated Universal Time (UTC) format.

- Flight number: A flight number, when combined with the name of the airline (operator) and the number, identifies a particular flight. A particular aircraft may fly several different flights in one day, and different aircrafts may use the same flight number on successive days. It is just the airlines designation for the flight.
- Registration no: Aircraft registration numbers internationally follow the pattern of a country prefix, followed by a unique identifier made up of letters and numbers. It is a unique alphanumeric string that identifies a civil aircraft, in similar fashion to a license plate on an automobile. In accordance with the Convention of ICAO, all aircraft must be registered with a national aviation authority and they must carry proof of this registration in the form of a legal document called Certificate of Registration at all times when in operation. So, all aircrafts on the world have unique registration number.
- Aircraft type: Aircraft type will be entered in a universal aircraft format as the same as ICAO format (example, C172, PA44, B733). A Cessna 172 is C172, a Boeing 747-400 is B744, a Piper Seminole is PA44, etc. This identification code is well known by all aviation operators and stake holders worldwide and each aircraft type has its own weight, length, engine type and wing span (width), which are very important parameters for different charges such as landing, over flight navigation, parking and others. The same aircraft, for instance B733, can be sold to different aviation operators (who are considered as owners) in different countries but each of them has different Registration no.
- Operator/owner: The owner is who owned Certificate of Authority of the aircraft. But sometimes the current operator of the aircraft may be different from the owner, in case the aircraft is rented to another customer. In any case, it is the current operator who is invoiced for the services used.
- Starting and Destination airport: Each airport in the world has a unique 4 digit code known by aviation industry stakeholders. Any flight whether it is international or domestic has the origin and destination airports. A flight that crosses the country air region without landing, called over flight, has also the origin and destination airports.
- Entry and exit point: The point at which the aircraft enters or exits the country's boundary. This is very important to extract the route used and also the total distance the

aircraft traveled within the country's air space. In case of over-flight movements, both the entry point and exit points are recorded. All points have unique identification of x and y geometric coordinates known all over the world. The distance between the two points is obtained by calculating the geometric difference between the two point's coordinates. In case of landing or departing flight either one of the two points is recorded. If the aircraft is arriving, the entry point is recorded, but if it is a departing flight the exit point is registered.

- Entry and exit time: the time at which the aircraft enters and exits the country's boundary should be registered so as to know whether the service is rendered at night or day time which affects the tariff rate of the given services. The time format should be in Zulu 24 hour format which uses four digit numbers, i.e., HHMM format.
- Arrival or departure time: These are recorded for landing or takeoff flights respectively in which case either of the two is recorded in order to know the total parking hours and the period at which the service was rendered for customers.
- Number of passengers and crew: Recording number and nature of passengers for landing aircraft is important for calculating passenger and security fees. Also some statistical and forecasting reports are based on the movements of passengers.
- Flight purpose: All flights operated over the world are not purely commercial flights. Some of them are general aviation (any flight that is flying recreationally or training), others are military flight, and others may be for experimental, or state/government flights. Since each of them has its own rule and regulation regarding service rendering and invoicing, traffic controllers record the flight by classifying them as scheduled, non-scheduled, training, military, UN-mission, and others.
- Type of facility used: Different facilities are provided for the operator for a given flight at the airport. Among them are the runway and taxi lights, airport radar, instrument landing system, and terminal and traffic control services. To calculate the appropriate charges for each facility and to assess at which periods resources are utilized more or less, the starting and ending time the facility is used should be registered.

- Flight Level: is described by a number, which is the nominal altitude in feet, divided by 100. Therefore an apparent altitude of, for example, 32,000 feet is referred to as "flight level 320". Flight levels are usually designated in writing as *FLxxx*, where *xxx* is a one- to three-digit number indicating the pressure altitude in units of 100 feet.

2.1.2 Potential Users of Aircraft Movement Data

In order to help in invoicing airline operators accurately for the services they get and analyzing the past, present, and future trends of aviation industry's operations, the availability of reliable and comprehensive flight movement data is critical. These data must be made accessible to all those concerned bodies especially for those involved in the aviation industry. Indeed, it is likely that wrongly recorded or inaccessible flight database will only lead to inefficient management of flight safety and loss of millions of income.

Flight movement data can be utilized by different organizations and/or government agencies as indicated in section 1.5. They all tend to have slightly different needs and reasons for wanting the data. These include [7, 10, 11, 12, 15, 19, 20, 22, 24, 26]:

- Billing of the services the aircraft operators consumed,
- Identifying traffic overloaded and/or under loaded for routes and/or periods,
- Recovering uncaptured billable fees,
- Identifying high risk safety problems,
- Optimization of future investments in infrastructure through better planning and timing,
- More efficient use of existing airport resources,
- Evaluating the effectiveness of the business,
- Monitoring achievements of targets,
- Designing security schemes and devices,
- Designing and preparing future flight plans, and
- Better understanding the flight movement activities worldwide and decide for state bilateral agreements.

It is necessary, therefore, for all concerned to have access to a relevant sub-set of the flight movement data, or for them to maintain their own independent database consisting of a subset of the original data with a common link for interconnectivity. It should, therefore, be a requirement

of a successful system that it meets the needs and aspiration of all these and other stakeholders [7, 17, 24].

2.2 Airport and Civil Aviation Revenue

The aviation industry traditionally grew due to the increase in demand of business travelers as the companies started expanding their operations in different places all over the world. Moreover, rise of income of people had a positive effect on the tourism industry and thus leading to the growth of the aviation industry. Deregulation and privatization of the aviation industry provided further drive to its growth. In the last decade, the growth rate in the aviation industry has been about 7% per year. Thus the aviation industry remains a large and growing industry. It facilitates world trade, tourism, economic trade and thus leading to globalization [18, 23].

Airport is a complex unit of runways and buildings that supplies aviation services to airlines and passengers. These services include runway facilities for aircraft landing and takeoff, air traffic navigational services, technical services such as fueling and maintenance, and passenger related services [8].

As it is used by passengers, airlines, and cargo and ground handling agent companies, airport is the central point of the aviation industry's operations and services. Being such a key infrastructure for the aviation industry, airports help to achieve economic growth for every country by serving other industries such as tourism, shipping, and postage by increasing the accessibility for passengers and global connectivity [14].

Like other services in many industries, the service supplied by airport and civil aviation has a cost and hence requires a fee to be paid by the user of the services. Even though airlines are the main users of the airports, their passengers are also considered as customers of airports. This reality has also made possible the appearance of other businesses such as parking, shops, hotels, conference centers, and tourism. These parallel businesses have grown to be an integral part of aviation revenue [8].

The charges levied by an airport and civil aviation on the airline are generally broken down into smaller fees. Some of these fees are paid to the airport organization whereas air traffic and navigation service fees are paid to the civil aviation authority [17].

Aviation charges are established according to sets of guidelines and principles. In this process, the government plays an important role, since it is the national government who sets procedures which have to be followed by airports and ultimately determine the amount of airport charges [17].

2.2.1 Types of Revenues

Aviation charge is made up of several smaller parts, which together form the total charge paid by airlines. Some of these smaller charges can be applied to each landing and/or takeoff, while others can be applied for the total aircraft movement.

In general, aviation revenues are classified as aeronautical and non-aeronautical [13, 14]. Aeronautical revenues include those generated via services and facilities related to aircraft operations, passengers, and cargo. Non-aeronautical revenues are the ones produced by commercial services and facilities at the airport such as aviation fuel suppliers, food and beverage concessions (restaurants, bars, cafeterias, vending machines, etc.), various shops including duty free, banks/foreign exchange, airline catering services, taxi services, car rentals, car parking, airport advertising, airport/city transport services, petrol/automobile service stations, hotels/motels, freight consolidators/forwarders or agents, and souvenir shops [7, 8].

While each airport differs somewhat, most of aeronautical revenues will assess the following fees and charges [16, 17, 24] and this project will focus only on aeronautical revenues.

a. Landing fees

It is the fee that is paid for the use of runways, taxiways, and apron areas, which is calculated based on maximum takeoff weight of the aircraft indicated on the aircraft's airworthiness certificate and may vary depending on the engine type, the noise level of the aircraft, and the airports runway type. Landing fees are paid by passenger airlines, cargo airlines and also non-commercial aircraft.

b. Passenger fees

It is a fee paid for the use of the common areas of airport terminal, such as boarding gates and queuing space in ticketing areas and other passenger-processing facilities (e.g., for passengers embarking or disembarking). Its scale is based on the number of passengers in the considered aircraft movement. A fixed fee is paid for each departing passenger on an airport and it can vary

by the type of passenger (direct/originating, or transit) since the amount of terminal facilities used vary. Only passenger carriers pay passenger fees; cargo carriers and non-commercial customers do not pay.

c. Security fees

This charge is to cover the costs of airport security such as luggage controls, security staff and equipment. This charge also scales directly with the number of departing passengers, and may also be different based on the type of passenger (e.g., transit passengers may not be required to go through luggage controls so they may not pay). Especially since 9/11 this charge has become one of the most expensive charges at most airports.

d. Parking fees

Parking charges are assessed on the basis of space occupied by the aircraft and is calculated by multiplying wingspan with length and total parking hours. Some airports do not charge for the first two or three hours and there after the fees for parking shall be payable in respect of each aircraft for each period of 24 hours or part thereof. Some airports have a fee that scales based on maximum takeoff weight, not by dimension of aircraft, while others only factor the time spent parked, not maximum takeoff weight. The time of day and place of parking can also have an impact on the amount of charge. Those airports who owned hangars (aircraft housing) also include hanger fee and towing fee under parking charge.

e. Light facility fees

The lighting facility charges at aerodromes are based on the maximum all-up weight of the aircraft specified in the certificate of airworthiness and number of flights per week. The lighting facility charges at aerodromes will be assessed for each landing or takeoff made at night or in conditions of poor visibility when lighting may be used except where the takeoff is within one hour of landing.

f. En route air navigation fees

This is the navigation facility (use of air space) charge for both domestic and international flights which might be depart from or arrive at one of the country's airport and is calculated based on

aircraft weight and route distances of flight movements. Since each airport (for arrival or departing) has geometric coordinates, route distance for landing or departing flights are calculated by taking the difference of exit or entry point and the airport's coordinate point. In most states this fee belongs to the local civil aviation authority.

g. Over flight air navigation fees

This is a fee that is collected from operators crossing the country, without landing or departing. Like En route air navigation fee, the tariff is calculated based on aircraft weight and route distances. The route distances for over-flight are calculated from the geometric coordinates of entry and exit points. Operators engaged in over flight operations do not pay other airport fees even passenger fees as they never touch any of the country's airport facility. Like en route navigation fee, this fee also belongs to the local civil aviation authority.

h. Terminal Facility fee

This fee is also called aerobridge service fee. It is the cost attributable to the provision and operation of aerobridges.

i. Ground handling fees

This refers to fees collected from aircraft operators for the use of facilities and services provided by the airport for the handling of aircraft. Some airports separate the ground handling from the passenger charge, and on those that do this charge it is calculated based on the number of passengers. This fee includes ramp services, cleaning of the aircraft, removal of snow and ice and de-icing service, catering service assistance, etc.

It should be noted that at the majority of airports, ground handling is largely carried out by one or more airlines or special ground-handling enterprises. In the latter case, the airport will impose concession and/or rental fees which should be recorded as revenue from non-aeronautical activities.

j. Airport noise fee

These are charges related to noise alleviation and prevention measures. These fees are directly dependent on the time of the day, which may be higher at night time. Engine type is usually the

main factor determining the level of the charge. Newer airplanes tend to have less polluting engines, and hence such an aircraft will pay less at airports.

k. Cargo service fee

This fee covers the cost of cargo processing facilities and it is calculated as a fee per ton of freight. The cargo operators are charged for the use of airport infrastructure during loading and unloading operations of goods. For goods in transit, the cost will be reduced by 50%.

l. Surcharge fee

Surcharge is an additional terminal facility service charge levied for the use of airport outside the published operational hours. It is a charge that is added on in addition to the regular charge.

2.2.2 Airport and Air Navigation Services Tariff Rate

Each state in the world has its own airport and air navigation service tariff rate set by its government [25]. Some states may categorize the rate into international flight and domestic flight. However, the tariff rate set by each state should be grounded on the rules and regulation set in [24] and must be known and accessible online or via documents [17, 25]. The public tariff defined by each state not only considers these standard fees and charges, but also price influencing factors like, for example, time of operation (e.g., surcharges for night operations or bank holidays), aircraft weight or type, exemptions, and many more. Also sometimes special contracts with airlines may have to be signed [17, 25].

2.3 Aeronautical Billing Management

The accurate recording and billing of aeronautical fee is a complex task for airports and civil aviation authorities since the operation undergoes multiple steps which all have to be executed with at most precision in order to make sure that the airport is paid properly for the supply of all services and infrastructure to customers.

Due to multiple data sources and many different file formats which are hard to merge, the collection of data is often very complicated. In addition to this, the preparation, editing and presentation of meaningful results is also a laborious and time consuming task [7, 15].

The traditional billing process for handling operations involved the manual processing of large amounts of paperwork and service dockets. Members of the billing team would scan operational details, look up the required rates in the contracts and make manual entries into the accounts package – a process that was manually intensive, time consuming and error prone [7, 15].

Many airports in the world have removed this burden by receiving operational details electronically and automatically generating invoice required after clearing errors from the flight data. It is such automation that leads to staff productivity and efficiency, accurate invoicing and a significant reduction in the billing cycle and the flexible and comprehensive features ensure users have a complete control over the billing and flight analysis process, enabling them to deliver a more cost effective and comprehensive service to their customers and partners alike [7, 15, 18].

The billing management process should have the capability to export consolidated financial details into an account and spreadsheet package so as to fit perfectly between aviation operation and organization accounts.

2.3.1 Flight Plan, Flight Planning, and Flight Plan Database

Flight plans are documents filed by pilots or a Flight Dispatcher with the local Civil Aviation Authority prior to departure. Flight plan format specified in [27] generally includes basic information, as shown in Figure 2.1, such as departure and arrival points, estimated time en route, alternate airports in case of bad weather, type of flight (whether instrument flight rules or visual flight rules), pilot's information, number of people on board and information about the aircraft itself [26, 27].

Whether a flight is private or commercial, there is one very important detail to be considered before the aircraft leaves the ground. Flight planning is a vitally important part of any journey and prior to takeoff there are many details to be arranged. Some of the major points to be considered in a plan are fuel, weather and route; these details must be worked out to the best advantage in order to conserve fuel and to enable the aircraft to take the safest and fastest route available. Flight planning requires accurate weather forecasts so that fuel consumption calculations can account for the fuel consumption effects of head or tail winds and air temperature. Safety regulations require aircraft to carry fuel beyond the minimum needed to fly

from origin to destination, allowing for unforeseen circumstances or for diversion to another airport if the planned destination becomes unavailable. Furthermore, under the supervision of air traffic control, aircraft flying in controlled airspace must follow predetermined routes known as airways, even if such routes are not as economical as a more direct flight [21, 26, 27].

The screenshot shows a software interface for creating an ICAO flight plan. The window is titled 'ACARS - ICAO International Flight Plan'. The main heading is 'International Flight Plan'. In the top right corner, there is the ICAO logo. The form is organized into several sections, each with a label and a set of input fields:

- 7 aircraft ident.:** A text field containing '(FPL' followed by a dropdown menu.
- 8 flight rules:** A dropdown menu.
- type of flight:** A dropdown menu.
- 9 number:** A dropdown menu.
- type of aircraft:** A dropdown menu.
- wake turbulence cat.:** A dropdown menu.
- 10 equipment:** A dropdown menu.
- 13 departure aerodrome:** A text field.
- departure time:** A text field.
- 15 cruising speed:** A dropdown menu.
- level:** A dropdown menu.
- route:** A large text area.
- 16 destination aerodrome:** A text field.
- total EET:** A text field.
- altn aerodrome:** A text field.
- other information:** A text area.
- supplementary information:** A section containing:
 - 19 endurance:** A text field.
 - persons on board:** A text field.
 - pilot in command:** A text field.
 - aircraft color and markings (MTL):** A dropdown menu.

At the bottom of the window, there are five buttons: 'Load...', 'Save...', 'Reset', 'Send FPL', and 'Cancel'.

Figure 2.1: ICAO flight plan

This planned flight data, shown in Figure 2.1, which is prepared in ICAO format must be sent to, via flight plan system and flight plan network, each concerned state's local civil aviation authority at the minimum 24 hours prior to leaving the ground. It is this data, stored in state's flight plan database, which is used as a source of information for radar system, air traffic controller navigation service preparation, and also for billing system for some airports and aviation authorities [26, 27].

According to [21], flight planning involves two safety-critical aspects: fuel calculation, to ensure that the aircraft can safely reach the destination, and compliance with air traffic control requirements, to minimize the risk of mid-air collision. In addition, flight planners normally wish to minimize flight cost by appropriate choice of route, height, and speed, and by loading the minimum necessary fuel on board. This implies that the flight plan prepared by planners of the airlines operator will not aim their data to be used as input for the invoicing system of the service provider organization and statistical consumption. It is therefore the requirement of flight journal management system to replace the planned data with accurate information so as to produce valid input data for Billing and Statistics system.

2.3.4 Statistics and Analysis

Flight data collection and due analysis have a significant impact on improving efficiency of the concerned stakeholders, notably, airlines, airports and aviation service providers. In addition statistical analyses have a great role in interpreting accident rates and in the conduct of safety analysis using statistical data [7, 22].

Many countries have developed their own in house system to manage the Air Traffic flows having the capability to capture aircraft movement data across their flight regions and generate valuable reports which will help in identifying choke points on the traffic route system thus improving efficiency and safety of operations [19].

It is very important for airport planners and investors to know whether there is a sustainable positive trend in passenger and aircraft movements that will continue into the future. It is the statistical method and interpretation that facilitates such decision making process [20].

In general, statistics are important to [10, 11, 12]:

- Monitor the environmental impact on air transport and the sustainable air transport development,
- Analyze the air transport market,
- Assess needs for future runway and terminal infrastructure,
- Forecast aircraft movements,

- Measure the workload of air traffic controllers, aircraft activity on air routes and runway utilization,
- Plan the development of airport and aviation facilities,
- Negotiate bilateral agreements,
- Calculate the individual financial contribution of states,
- Provide an audit mechanism for the collection of different fees, and
- Implement future training strategies.

The planning of airport facilities requires information on both the future levels of aircraft movements and the variation in those movements by time of day [10].

2.4 Summary

This chapter reviewed the benefits of organizing aircraft movement data in a way that helps analysis to be undertaken and accurately invoice air operators for the services rendered to them. Also the major classification of airport revenue has been addressed briefly because of its relevance to our research.

Literature shows that each event of landing, takeoff, and over flight movements of an aircraft, when managed in a comprehensive and validated way, is not only used as source of efficient billing management system but also for interpretation and analysis of many statistical and forecasting management information systems which are badly needed by many aviation stakeholders, organizations, researchers, and even passengers for better decision making process. So, all the points reviewed regarding aircraft data recording, statistics and analysis, flight plan, billing management, and revenue types are vital for better design consideration of our research work.

Chapter Three

Related Work

3.1 AIRevenue- Airport Revenue Management System

The Airport Parking and Billing Management is an automated airport parking and billing management system designed by Techno Brain Company for airports of all size to invoice customers, examine airport traffic, and manage lease and concession revenues. The system manages data by eliminating errors so as to deliver accurate and error free information for accurate billing on time. It covers all sources of revenue including landing, parking and hangar age, air navigation, over flight, passenger service and non-aeronautical charges [29].

The system uses separate databases for data and processing for airports and enables the user to perform monthly billing after specifying the period (month) in which the billing is being done. It has three modules: Admin, Billing, and Statistics. The admin module helps to setup security, rates, air operators, aircrafts, and various parameters. The billing module performs different billing components according to their principles and tariff rate and the statistics module produces different reports [29].

Its benefits and features include [29]:

- User driven and flexible for future change,
- Can be installed at Head office with multiple airport data,
- Stores information for billing and statistics purposes,
- Interface with accounting system on the market,
- Reduces the level of effort required to generate billing,
- Eliminates data entry errors and delays in the billing process,
- Unlimited setting and automations,
- Exports data easily, handles multi currency and guarantees security of data in the database, and
- Improves revenue collection and ensures maximization of revenues with minimal administrative cost and effort.

3.2 ALFA- Airport Landing Fee and Revenue Management Software

This system is a powerful airport billing software solution designed to manage aircraft movements and services, passenger movements and others through a high degree of automation, customizable functionality, and ease of use. It is developed on client-server model and also connected to the Internet to access updated aircraft registries, ICAO air carrier designators, international airport codes, and ICAO aircraft type codes [30].

The system has scalability features by its four modules which are designed to work in cooperation as a comprehensive solution to complex airport tasks. The aviation charge module is a utility used to process aircraft movement's data with supplement fees and/or exemption. The fee structure is based on weight, seat, time of day, engine type, sector, operation and wing type for automatic charge calculation. In addition to importing automated digital aircraft movements from 3rd party vendors such as NavCanada, the modules also allow users to manage multiple discounts/exemptions by customer and/or aircraft and prepare detailed movement statistics.

The recurring charge module is designed to assist airports to manage the multitude of recurring fees and charges associated with airport operation such as leases, concessions, licenses, utilities, employee parking, hangar rentals, aircraft parking, etc. The miscellaneous charge module allows airports to capture and invoice basic, single event charges whereas the statistical module targets passenger volume and local traffic movements to produce statistical reports which may be tracked by customer, flight no, origin/destination, and aircraft type [30].

3.3 ATOM Flight Revenue and Billing

This product categorizes the billing management into Over-flight revenue and Airport Billing, to be used by Civil Aviation Authority and Airport Authority respectively, each having advanced functions that manage invoice on periodic (monthly) and real time basis [31].

The Over-flight Billing uses the flight plan information to automatically determine information including the airline, operator, registration mark, aircraft type, weight, and the distance flown through the airspace. However, there are some flights, for instance general aviation, which cannot be billed directly by Civil Aviation Authority. Such flights are handled by Over-flight real time billing by collaborating with airport to collect the fee in cash just before departing, unless the operator has an account with the airport. According to [31], this capability works best when both the Civil Aviation and the cooperating Airport use ATOM system, but it can also

work for both if either one has ATOM's system because the system automatically sends a text message to the cooperating airport in case of general aviation so that en route over flight fee due to the Civil Aviation can be added to the airport's landing and parking fees to be refunded later.

The Airport Revenue function of this system, on the other hand, manages airport operation fee after matching flight plan data with updated tower information such as actual arrival and departure times and registration information. The system also tracks the airlines and individual aircraft that have account with the airport so that there is no need to send invoice to their address [31].

The Airport real-time billing manages the aircraft that should pay before departing, not on a monthly billing agreement. The system produces on-demand immediate bills for those flights that must pay before departure [31].

3.4 ATRAK- BS Flight Billing and Statistics System

The ATRAK-BS Billing and Statistics system developed by LIAC Company provides a powerful billing management, billing reporting, and statistical analysis solution, in one comprehensive package. The system automatically collates base flight data from the relevant flight data processing system, while allowing members of the charge office to clear data from errors, insert, and delete flights and supplement data with additional information. This automation leads to improved staff productivity and efficiency, accurate invoicing, and a significant reduction in the billing cycle and ensures users have complete control over the billing and flight analysis process [30].

The system generates comprehensive statistics that can be represented in multidimensional way such as a table, simple bar chart, pie chart, clustered bar, stacked bar, multi line and 3D bar chart. Its reports can be exported to pdf, XLS, or CSV format or saved as a URL [30].

3.5 SMART- Airport Information Management System

The objective of this product is to provide airport management and other users with real-time information originating from integrated systems at the airport using a shared secure data warehouse as the single source of data.

The system is made up of 5 integrated systems [33]:

1. SMART Semantic Message Processor (SMART/SMP),
2. SMART Operational Database System (SMART/AODB),
3. SMART Airport Statistical Data Management System (SMART/STAT),
4. SMART Airport Billing System (SMART/BILL), and

5. SMART Airport Connectivity (SMART/CONNECT).

The SMART/SMP processes a series of standard messages commonly used at airports such as movement messages, load messages, statistical load summary messages, passenger transfer messages, passenger information messages, baggage processing messages, and flight schedule messages. It is deployed in order to integrate all distributed airport applications and interfaces with many standard message gateways such as POP3, IMAP [5].

The SMART Operative Database is a centralized and shared data warehousing system that consolidates all airport flight schedules and airport operational data in a single database. Its key role is to automatically capture and update information from different sources that are decoded and received from the SMART/SMP system [33].

The database handles and stores all flight schedules, passenger and load information, and all physical airport resources such as terminals, check-in desks, boarding gates, aprons/stands, conveyor belts, carousels, etc.

The Statistical Data Management System (SMART/STAT) performs statistical analysis on flight and airport operational data in AODatabase so as to make the airport management to [33]:

- evaluate the current status of ground handling operations,
- optimize the deployment of existing airport resources,
- determine future need for additional airport resources,
- consolidate data for billing, and
- make informed decisions on current and future operations and resource requirements.

On the other hand the SMART Airport Billing System allows airport management to accurately produce different invoices according to a set of billing rules and formulae per airline/client which cumulatively lead to increased revenue due to accurate invoices, improved cash-flow, and automated gathering of billing data without any additional data entry requirement. The Invoices are distributed by email to speed up the billing process and all the invoices are stored in a database by SMART/Bill system which makes invoice retrieval and management easier [33].

The SMART/CONNECT provides international airports with a comprehensive dedicated connectivity network/solution that enables airports to integrate their applications with a standard messaging service. The Airport Connector System encrypts the data to ensure complete privacy.

3.6 TOaL -Airport Management and Surveillance system

The system is an integration of effective billing aircraft and surveillance into one state of the art system. A customized surveillance camera takes a sequence of photographs of the aircraft stamped with time, date, and camera number which are then wirelessly transmitted to TOaL's server. The images and videos are processed to identify the time, day, aircraft identification, location and direction of travel of each movement. The surveillance system uses movement sensor to record the movements 24 hours a day and 7 days a week so as to facilitate visual inspections of airport grounds without having to leave the office [34].

The advantages of this system include stable accurate system, efficient and quick billing process, minimizing human error, photographic proof of movements, avoidance of registration mark mischief, increased billing opportunity, and monitoring. Its statistics report facilitates interpretation and analysis of total number of movements, historical movement of individual aircraft, and periodic reports [34].

3.7 Summary

The above related works are purely commercial systems which are focusing on invoicing operators from flight plan whereas some of them invoice operators after registering aircraft movements on the corresponding flight journals on a daily basis. Moreover, they have no feature that enables regional airport's aircraft movements to be recorded and billed centrally under head office administration. However, we will propose a new system that has the following features, not provided by the reviewed works and existing Microsoft access system:

- import data from flight paln to produce actual flight journals;
- enable all airports in the country to manage their flight movements centerally by single web based system;
- enable both civil aviation authority and airport enterprise bill their customers from the same journals;
- enable single flights to be invoiced by their exact flight periods and reports them as 'Single' for further analysis whether they are actual flights or wrongly entered;
- mail invoices to customers directly from the screen;
- analyse flight journal against flight plan to show unregistered flights, unplanned flights, and/or repeated flights; and
- have forecasting algorithms for flight movement prediction.

Chapter Four

The Proposed System

4.1 Existing Aircraft Data Management and Invoicing System in Ethiopia

The Ethiopian air space is managed by ECAA according to rules and standards set by ICAO. In addition to regulating the corresponding air operators and airports, the authority also provides air traffic services, aeronautical information services, including flight plan management, communication, navigation and surveillance equipment services to the aviation society in all international and domestic airports of the country.

The activities of all aircraft movements in all airports of the country are recorded by the authority's traffic controllers on flight journal manually at the tower. Excluding aircraft terminal facility (such as boarding bridge) usage journal, there are two types of flight journals: over flight journal and en-route navigation flight journal. The former is used to register flights that cross the Ethiopian air space without landing and departing whereas the later is a type of journal that registers all flights that depart from or arrive at one of the Ethiopian airports. All over flight journals are registered at Bole International Airport ATC tower; and the en-route navigation flights are registered at the landing or takeoff airports which must be sent to the head office on a monthly basis for the purpose of billing and preparation of statistical reports. Both the civil aviation and airport revenue systems use these flight journals collected from different airports to invoice their customers for over flight navigation, en-route navigation, landing fee, parking fee, passenger fee, and light facility fee. The first two fees belong to ECAA whereas the rest belong to EAE. The airport enterprise uses separate journals for boarding bridge terminal facility registered by marshaler office which should be collected monthly from all airports to the head office.

The two organizations' finance offices currently register the manual flight journal on their corresponding standalone access system for billing purpose even though the passenger and terminal facility fees are manually managed by spreadsheet software. Again, the two organization's planning and statistics departments on the other hand receive the copy of registered flight journal in order to prepare the necessary statistics and forecasting report using

spreadsheet and/or statistical tools. However, both organizations receive a hard copy of passenger, cargo, and mail information from each airlines and then process them manually.

There is no security, noise and surcharge fee in any of the airports of Ethiopia. The cargo and ground handling fee is managed by EAL (Ethiopian Air Lines) and other private companies on contractual basis where each of them pays 1% of total revenue to EAE annually.

Due to the difference in infrastructure deployed and type of runway, each airport has its own rank set by the aerodrome section of the civil aviation authority. Based on their rank, the tariff rate may vary from airport to airport. The tariff rate is also different for international flight and domestic flight for passenger fees and en-route navigation services. International flight is the one that originates from one of the local airports and exits (crosses) the country's boundary or enters the country's boundary and arrives at one of the local airports. On the other hand, domestic flight is any flight that navigates from local airport to another local airport without crossing the country. There is also an opportunity that a single flight with a single flight number can be both domestic and international when the aircraft operates on more than one local airport and crosses the country's boundary; in that case the navigation between the exit point and the last local airport or the entry point and the first local airport is taken as international.

The two organizations work in cooperation to bill non-schedule flights that are operated by customers who do not have permanent address or that may operate the flight once in a blue. Such kind of customers may be VIP, tourist, researchers, or others. In that case, the operators are charged by airports cash collector automatically by cash before the flight departs. The cash collected for en-route navigation services are then sent (transferred) to ECAA.

As indicated in problem statement section, the organization's poorly manages invoice production and also there is no mechanism to track the status of a given invoice. Moreover, the current billing system will not invoice single flights, which is reported by the system as orphan flights, meaning flight having landing data without departing information or vice versa. Such kind of situation occurs due to several reasons:

- the two operations (landing and departing) might occur in different billing periods;
- one of the operation's data might be recorded on journals wrongly or totally missed;

- the aircraft itself might not perform one of the operations because of accident or other reasons; and
- others

The finance officers analyze and solve orphan flight problems by adjusting (i.e., falsifying) flight periods, correcting the wrongly recorded flight information, communicating with ATC supervisors to know the status of aircraft or flight, and others.

In addition to the time and labor wasted by the above process, the organizations may lose millions of foreign currency due to the absence of cross checking the recorded flights against flight plan for actual flight.

In general, due to lack of centralization and integration, both organizations poorly manage the billing management and redundantly produce statistical analysis and forecasting tasks manually.

Other stakeholders such as airlines and investors also regularly request one of the organizations about aircraft movement traffic and cargo operations performance for their decision making and organizational planning.

Another constraint is security of the flight journal logbook. When the recorded flight journal copies are sent from regional airports to both civil aviation and airports head quarter, it may be lost or wrongly recorded by many reasons. Such acts not only reflect on the invoice produced but also on the precision of the analyzed statistical reports.

4.2 Overview of the Proposed System

From the fact that the current system is not suitable to serve the aviation society centrally and also it is resource consuming, labor intensive, and disorganized, we have proposed an integrated web based system that enables the air traffic controllers from any tower central positions to prepare centralized actual flight journals from the distributed international flight plan. The centralized flight journals can serve the two organizations in generating invoice and analysis of both actual and forecasted statistical reports without re-keying or re-entering the data into the system. Hence, the system is web based and any traffic controller from regional airports having access to the Internet can adjust the flight journals without recording and sending the logbook to the head office.

The system enables the two organizations' finance departments to invoice their customers using a flight journal designed by air traffic controllers according to the corresponding setup parameters. There is no need to re-type any data, including passenger and freight information, hence much of the data is corrected and adjusted at the corresponding tower during flight.

Moreover, the proposed system is designed in such a way that any stakeholders including the two organizations statisticians and planners can get the actual and forecasted statistical information and even can get the flight data and/or their summarized statistics for various activities and researches without requesting the organizations for access. Thus, the system totally avoids the burdens and loss of precious time of the professionals (such as air traffic controllers, finance officers, and statisticians) of all Ethiopian aviation organizations by:

- avoiding recording and exchanging manual flight journals;
- providing centrally accessible flight journals;
- enabling the finance officers of the two organizations to process billing without recording flight journals;
- sending invoice to the customer from the system screen;
- analyzing flight journals for correctness;
- providing statistical reports of all airports for monitoring operations; and
- forecasting aircraft and passenger movements of the future.

The system is also capable of keeping each invoice in a database by categorizing according to their type so that any finance officer can monitor the status of each invoice whether it is sent, paid, and/or cancelled.

The proposed system has the ability to increase management satisfaction not only because of its easy access and avoiding redundancy but also providing information to support in the decision making process and future capacity planning. It presents the opportunity for aviation organizations to retain revenue good performances, technology know-how by offering value added, innovative services and motivate employees in their corresponding organizations.

It is obvious that we need to know what the system is supposed to do before we build it. Thus, we identified the functional and non functional requirements and then modeled the requirements in an understandable language, which is UML.

4.3 Functional Requirements

A functional requirement defines a function of a software system or its components. A function is described as a set of inputs, the behavior, and outputs. Functional requirements may be calculations, technical details, data manipulation processing, and other specific functionality that show how a use case is to be fulfilled.

They are supported by non-functional requirements, which impose constraints on the design or implementation. The functional requirements of the proposed system are the following:

System utility management

The proposed system should enable system administrators to create system users, group users by category, set their privileges, activate or deny users, and update their profile. The users should be able to login and logout and change their password. The administrators must be able to maintain operators (customers), local airports, entry and exit points, aircraft registration number and their types, geometric coordinates of locations, flight types, flight purposes, routes, terminal facility types, origin and destination aerodromes, tariff rates, invoice email accounts, and finance account codes.

Capturing flight data

The proposed system should import flight plan data from existing Ethiopian flight plan database for the preparation of actual flight journal.

Flight Journal Preparation

The system must allow traffic controllers to modify the imported flight journal corresponding to flight number and/or insert new flights which does not exist in the flight plan so as to produce actual validated flight journal.

Process Billing

The proposed system should have to calculate all airports and civil aviation charges based on their tariff rate for ready flights.

Generate Invoices

The system should have to generate invoice for each customer and store the invoices in a database to monitor the status of each invoice. In addition, it should allow finance officers to generate real-time invoices for temporary customers that must pay before departing.

Register Airport terminal facility usage

The proposed system should allow the marshaler officer to register aircrafts (flights) that use boarding bridge and that do not.

View Reports

The proposed system should allow the privileged users to generate different reports including unbilled and wrongly billed flights analysis.

Send invoices to customer

The system must allow the finance officers to mail each invoice to the corresponding customers.

View/update invoice status

The system should allow the users to view generated invoices and track paid or unpaid invoices.

Aircraft Movements Statistical and forecasting analysis

The proposed system should have a feature that analyzes traffic movements by year, operation type (domestic/international), passenger type, freight type, mail type (loaded/unloaded), business type (scheduled/nonscheduled, commercial/non-commercial), airports type, aircraft type, operators, increase/decrease in percentage movements, revenue analysis, and traffic and revenue forecast for different management and planning decisions.

4.4 Non-Functional Requirements

Non-functional requirements describe user visible aspects of the system that are not directly related with the functional behavior of the system. In other words, they are beyond the functionality of the system. These include quantitative constraints such as performance, security, modifiability, error handling, hardware, platform, and physical environment and user interface.

The non-functional requirements of the system are stated as follows:

Security

The new system will have reliable and dependable security features that have the advantage of preventing unauthorized access to the system and creating strong access control for the users to restrict them to some specific authorized operations. We designed cryptography algorithm to secure user accounts and email accounts, and also design SSL protocol between transport layer and application layer to secure transmission and protect essential data from eavesdroppers during

communication and when stored. In addition, the system should be hosted in secured web environment.

User Interface

It is clear that good systems are user friendly, easy to learn and highly interactive. Thus, the new system shall comply with these facts. The interface is designed in a simple and descriptive way considering the skill level of the majority of the aviation society. The designed system is web based having simple and easy interface that will be accessed through any web browser. Any user having an account and Internet connected computer can interact with the system. All functionality allowed for a logged user will have to be reachable through menus and names that will be as expressive as possible based on the currently used terms.

Performance requirement

Since the system is web based, the performance can be directly affected by the quality of hardware, robustness of the software and network traffic. So, the response time should be reasonable. Reasonable number of concurrent accesses should be enabled. The system should be capable of handling multiple users at a time with reasonable processing time. It should have to be available all the time. The hardware of the system should have to be good enough to support the performance of the system as it is the great factor in the systems performance.

System Modification

This is a system whose design principle takes into consideration future growth. It is a systematic measure of the ability to extend a system and the level of effort required to implement the extension. Because we are using object-oriented approach, which uses classes that have data and functionality, adding or modifying will not affect the system as a whole. Thus new modules can be added to the system without affecting it at any time when the need arises.

Hardware and software consideration

The server side of the system should be accessible using the well known web browsers like Internet Explorer, Firefox, Google chrome, and Opera. This implies that the system is platform independent and supports every user. Since the system supports many organizations and more than 14 airports in the country, the web server has to be equipped with devices of super

capability. As a web application the concurrent number of users varies, so to enable handling the worst case the server has to have multiple modems, super processing capability, large storage capacity, and redundant storage devices.

Documentation

System users and system administrators will be provided with a short and brief documentation on how to use the systems. The documentation prepared has detailed information on how to make use of the system and covers all use cases of the application including the user interface.

Error Handling

Error could rise from the user of the system or from the system itself. The system should have to handle both errors when they appear. The run time error should be reported by the system and errors occurred due to wrong doing of users will be handled by appropriate exception handling mechanisms. To reduce the occurrence of error from user input the system is designed in a way that users only select from available lists to avoid spelling error and input error. On the occurrence of error the system will identify the where about of the error and informs or notifies the user to take the appropriate action, but not all errors will be handled with notifications on how to fix it.

- The system must be able to validate all input to their assigned value and display informative message to the user.
- Well structured client side validation should be implemented for ease of functionality

4.5 Use Case System Models

4.5.1 Introduction

Use case modeling is composed of a use case diagram and the accompanying documentation describing the use cases, actors and their associations.

A use case defines a goal-oriented set of interactions between external actors and the system under consideration. Actors are parties outside the system that interact with the system. An actor may be a class of users, roles users can play, or other systems. A use case is initiated by a user with a particular goal in mind, and completes successfully when that goal is satisfied. It describes the sequence of interactions between actors and the system necessary to deliver the service that

satisfies the goal. It also includes possible variants of this sequence, i.e., alternative sequences that may also satisfy the goal, as well as sequences that may lead to failure to complete the service because of exceptional behavior, error handling, etc.

4.5.2 Actor Description

The lists of actors identified in the proposed system are:

Name: System Administrator

Description: System administrator is a person who is responsible for managing users and their permission. He also setup look up parameters necessary for flight journals.

Name: ECAA and EAE finance officers

Description: Finance officers are users selected from the two organizations' finance department and assigned to manage billing and invoices. They also setup finance related set up parameters System administrator such as tariff rate and accounts.

Name: Air traffic controllers

Description: Air traffic controllers are users who are responsible to import flight plan records and prepare over flight and navigation flight journals. They also assigned to setup journal lookups parameters.

Name: Marshaler officers

Description: Marshaler officers are responsible to register and modify terminal usage journals.

Name: Planning and statistics officers

Description: Planning and statistics officers are users in charge of managing statistics and forecasting.

Name: Stakeholders

Description: Stakeholders are users outside the two organizations' who seek statistical data. They are assigned to view specific statistical information including flight journal report.

Name: Managers and supervisors

Description: Managers and supervisors are ECAA and EAE department and section heads that are assigned to view different statistical and forecasted information and flight analysis report.

4.5.3 Use Cases

The lists of use cases identified in the proposed system are:

- Manage users
- Assign Operations
- Deny Operations
- Login
- Change password
- Setup aircraft types
- Register aircraft identification
- Setup operators/customers
- Setup local airports
- Setup routes
- Setup entry/exit points
- Setup flight types
- Setup Facility types
- Setup flight purpose
- Setup origin and destination
- Setup tariff rates
- Setup Invoice emails
- Setup Finance account codes
- Import flight plan
- Produce flight journals
- Edit flight journal
- Register terminal facility usage
- Process over flight fee
- Process en-route navigation fee
- Process Landing fee
- Process Parking fee
- Process Light facility fee
- Process Terminal facility fee
- Process Passenger fee
- Email invoice
- View/Update invoice status
- Export finance journal entry
- Generate flight statistics
- View reports
- Generate traffic forecasting

4.5.4 Use Case Diagram

The use case diagram of the proposed system is presented in Figure 4.1 as shown below.

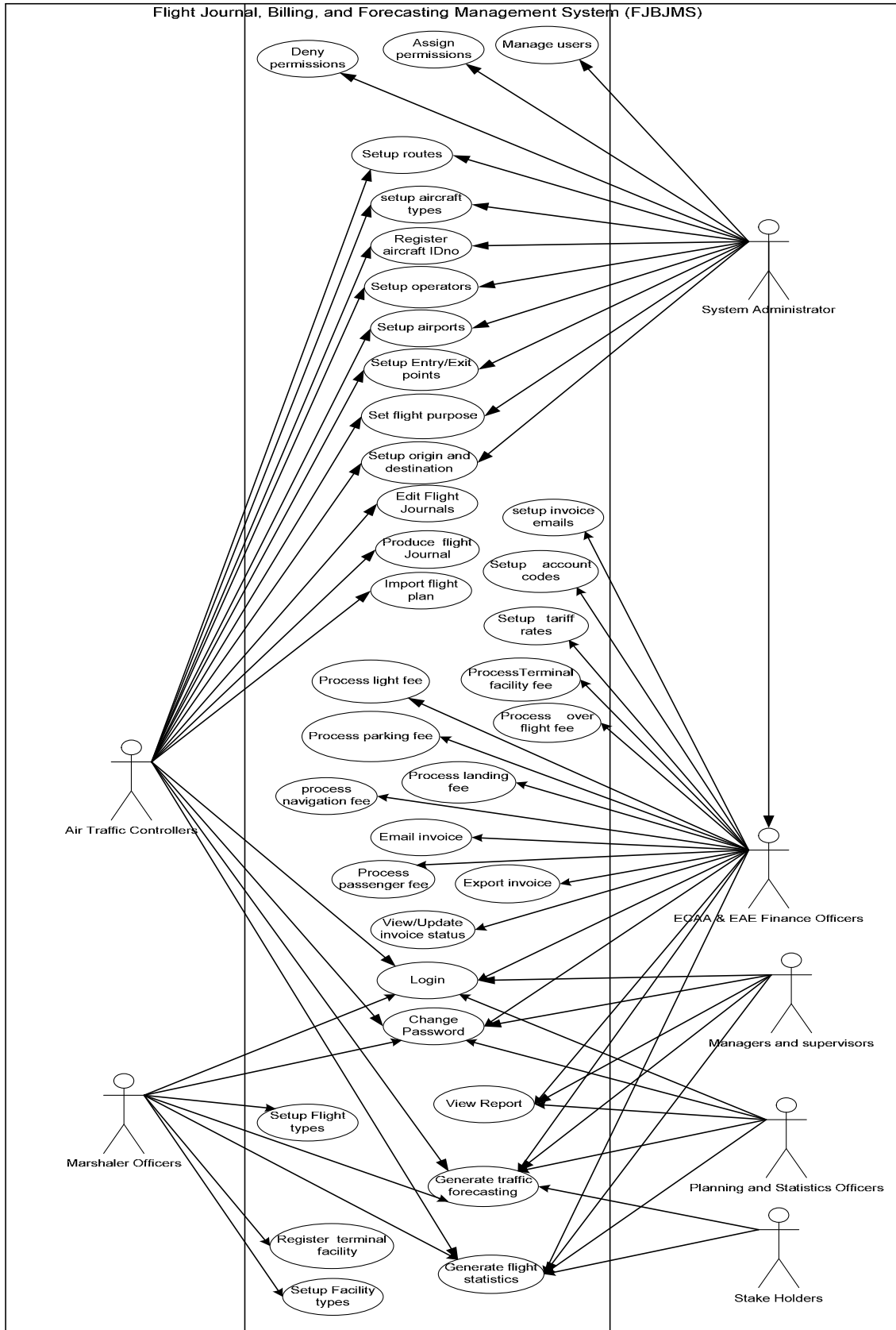


Figure 4.1: Use case diagram

4.5.5 Use Case Description

Name: Mange users

Actor: System administrator

Purpose: create new user account, set its group and organization, and set their status

Precondition: the administrator, should have successfully logged into the system, and user group data should exist

Flow of events

1. The administrator wants to create user account, change user group or edit user or search user or deny user access or enable user access
2. The administrator presses “Manage users” link under Setup-Account submenu
3. The system displays the Manage users form [C.3]
4. The administrator input user account information’s such as username, password, and also specify the user group
5. The administrator presses “create” button
6. The system checks that all the required information are entered [A.6]
7. The system checks that other user account with similar account was not registered [B.7]
8. The system stores user account information
9. The system displays a success message to the administrator
10. The use case ends

Alternate Course A: the system determines one or more of the required information is missing

A.6.1. The system informs the missing information

A.6.2. The use case resumes at step 4 of the basic flow of events

Alternate Course B: the system determines that the username is already registered

B.7.1. The system informs that the user is registered

B.7.2 The system informs the administrator to enter other username

B.7.3 The use case resumes at step 4 of the basic flow of events

Alternate Course C: The administrator wants to change user group or edit user or search user or deny user access or enable user access

C.3.1 The administrator selects one of the user from the grid view list

C.3.2 The system displays the user information’s in the form’s control

C.3.3 The administrator select one of the managing button

C.3.4 The system performs the selected command operation

C.3.5 The system displays a success message to the administrator

C.3.6 The use case ends

Post condition: User information was managed successfully

Name: Change Password

Actors: All

Purpose: Enable the users to change their password

Precondition: The Actors should have logged into the system.

Flow of events

1. The users wants to change their password
2. The users press on “Change password” menu
3. The users fill old password and new passwords in the corresponding text boxes and click on change
4. The system checks the correctness and changes the password[A.6]
5. The system displays a success message to the users

6. Use case ends

Alternate Course A: the system determines passwords do not match or incorrect old password

A.6.1 The system informs either new passwords do not match or the old password is not correct

A.6.2 The use case resumes at step 3 of the basic flow of events

Post condition: A password for a given user was changed

Name: Assign Operations

Actors: System administrator

Purpose: helps to grant groups which operations to access/use

Precondition: user group, and user account must have to be created, the administrator has successfully logged into the system.

Flow of events

1. The administrator wants to assign operations to groups
2. The administrator presses “Manage Permission” link under Setup-account submenu
3. The system displays the Manage Permission form and populate available groups and list of operations provided by the system from the Database
4. The administrator selects the group name from the available groups displayed in the combo box and also selects the operation name from the list
5. The administrator presses the assign button[A.6]
6. The system accomplishes the selected operation
7. The system updates the access control list status
8. The system displays a success message to the administrator
9. The use case ends

Alternate Course A: The system determines the group and/or operation name is not selected

A.6.1 The system informs the group name and/or operation name is not selected

A.6.2 The use case resumes at step 4 of the basic flow of events

Post condition: the group has granted access to the operations

Name: Deny Operations

Actors: System administrator

Purpose: helps to deny groups not to access the selected operations

Precondition: User group, and user account must have to be created, the administrator has successfully logged into the system.

Flow of events

1. The administrator wants to deny from using the operations
2. The administrator presses “Manage Permission” link under Setup-account
3. The system displays the Manage Permission form and populate list of operations provided by the system from the Database
4. The administrator selects the group name from the available groups displayed in the combo box and also selects the operation name from the list
5. The administrator presses the deny button[A.6]
6. The system accomplishes the selected operation
7. The system updates the access control list status
8. The system displays a success message to the administrator
9. The use case ends

Alternate Course A: The system determines the group and/or operation name is not selected

A.6.1 The system informs the group name and/or operation name is not selected

A.6.2 The use case resumes at step 4 of the basic flow of events

Post condition: the group has denied access to the operations

Name: Setup Aircraft types

Actors: System Administrator or air traffic controllers

Purpose: Enables the actors to setup Aircraft types and their weight, dimensions, and engine type etc

Precondition: The Actors should have logged into the system, and have assigned to do this operation

Flow of events

1. The Actors want to setup Aircraft information
2. The Actors press “Aircraft types” Link under Setup-Journals lookup submenu
3. The system displays the Aircraft information form
4. The Actors fills the data
5. The Actors presses “Save/update” button
6. The system checks that all the required information are entered [A.6]
7. The system checks weather the aircraft information has already registered or not [B.7]
8. The system displays a success message to the Actors
9. The use case ends

Alternate Course A: The system determines data for some field is not selected

A.6.1 The system informs the actor about the missing ones

A.6.2 The use case resumes at step 3 of the basic flow of events

Alternate Course B: the system determines that the aircraft information is already registered

B.7.1. The system informs that the aircraft was registered

B.7.2 The system informs the administrator to enter/edit other aircraft information

B.7.3 The use case resumes at step 4 of the basic flow of events

Post condition: the Aircraft information details is recorded in the Data Base

Name: Setup Operators/Customers

Actors: System Administrator or air traffic controllers

Purpose: Enables the actors to setup operators(customers)

Precondition: The Actors should have logged into the system, and have assigned to do this operation

Flow of events

1. The Actors want to setup aircraft operators
2. The Actors press “Operators” Link under Setup-Journals lookup submenu
3. The system displays the customer setup information form
4. The Actors fills the data
5. The Actors presses “Save/update” button
6. The system checks that all the required information are entered [A.6]
7. The system checks weather the customer information has already registered or not [B.7]
8. The system displays a success message to the Actors
9. The use case ends

Alternate Course A: The system determines data for some field is not selected

A.6.1 The system informs the actors about the missing ones

A.6.2 The use case resumes at step 3 of the basic flow of events

Alternate Course B: the system determines that the customer information is already registered

B.7.1. The system informs that the customer is registered

B.7.2 The system informs the actors to enter/edit other customer information

B.7.3 The use case resumes at step 4 of the basic flow of events

Post condition: the customer detail information is recorded in the Data Base

Name: Register aircraft identification**Actors:** System Administrator or air traffic controllers**Purpose:** Enables the actors to register aircraft registration no, type, its owner (operator), and current operator**Precondition:** The Actors should have logged into the system, permission to do this operation, and aircraft information and operators must have to be setup**Flow of events**

1. The Actors want to setup register the aircrafts
2. The Actors press “Register Aircraft” Link under Setup-Journals lookup submenu
3. The system displays the Register aircraft form
4. The Actors fills the data
5. The Actors presses “Save/update” button
6. The system checks that all the required information are entered [A.6]
7. The system checks weather the aircraft call sign has already registered or not[B.7]
8. The system displays a success message to the Actors
9. The use case ends

Alternate Course A: The system determines data for some field is not selected

A.6.1 The system informs the actors about the missing ones

A.6.2 The use case resumes at step 3 of the basic flow of events

Alternate Course B: the system determines that the customer information is already registered

B.7.1. The system informs that the call sign is registered

B.7.2 The system informs the actors to enter/edit other call sign information

B.7.3 The use case resumes at step 4 of the basic flow of events

Post condition: the Aircraft call sign with detail information is recorded in the Data Base**Name: Setup local airports****Actors:** System Administrator or air traffic controllers**Purpose:** Enables the actors to setup airports**Precondition:** The Actors should have logged into the system, and have assigned to do this operation**Flow of events**

1. The Actors want to setup local airports including their rank, and geometric coordinates
2. The Actors press “Local Airports” Link under Setup-Journals lookup submenu
3. The system displays the setup airport form
4. The Actors fills the data
5. The Actors presses “Save/update” button
6. The system checks that all the required information are entered [A.6]
7. The system checks weather the airports has already registered or not [B.7]
8. The system displays a success message to the Actors
9. The use case ends

Alternate Course A: The system determines data for some field is not selected

A.6.1 The system informs the actors about the missing ones

A.6.2 The use case resumes at step 3 of the basic flow of events

Alternate Course B: the system determines that the airport is already registered

B.7.1. The system informs that the airport is registered

B.7.2 The system informs the actors to enter/edit other airport information

B.7.3 The use case resumes at step 4 of the basic flow of events

Post condition: the airport's detail information is recorded in the Data Base

Name: Setup entry/exit points

Actors: System Administrator or air traffic controllers

Purpose: Enables the actors to setup the country's exit/entry point

Precondition: The Actors should have logged into the system, and have assigned to do this operation

Flow of events

1. The Actors want to setup entry/exit points including their geometric coordinates
2. The Actors press "Entry or Exit points" Link under Setup-Journals lookup submenu
3. The system displays the setup entry/exit points form
4. The Actors fills the data
5. The Actors presses "Save/update" button
6. The system checks that all the required information are entered [A.6]
7. The system checks weather the entry/exit points has already registered or not [B.7]
8. The system displays a success message to the Actors
9. The use case ends

Alternate Course A: The system determines data for some field is not selected

A.6.1 The system informs the actors about the missing ones

A.6.2 The use case resumes at step 3 of the basic flow of events

Alternate Course B: the system determines that the entry/exit point is already registered

B.7.1. The system informs that the entry/exit point is registered

B.7.2 The system informs the actors to enter/edit other entry/exit information

B.7.3 The use case resumes at step 4 of the basic flow of events

Post condition: the entry/exit points detail information is recorded in the Data Base

Name: Setup routes

Actors: System Administrator or air traffic controllers

Purpose: Enables the actors to setup the country's navigation routes

Precondition: The Actors should have logged into the system, and have assigned to do this operation

Flow of events

1. The Actors want to setup navigation routes
2. The Actors press "Routes" Link under Setup-Journals lookup submenu
3. The system displays the setup routes form
4. The Actors fills the data
5. The Actors presses "Save/update" button
6. The system checks that all the required information are entered [A.6]
7. The system checks weather the entry/exit points has already registered or not [B.7]
8. The system displays a success message to the Actors
9. The use case ends

Alternate Course A: The system determines data for some field is not selected

A.6.1 The system informs the actors about the missing ones

A.6.2 The use case resumes at step 3 of the basic flow of events

Alternate Course B: the system determines that the entry/exit point is already registered

B.7.1. The system informs that the entry/exit point is registered

B.7.2 The system informs the actors to enter/edit other entry/exit information

B.7.3 The use case resumes at step 4 of the basic flow of events

Post condition: the entry/exit points detail information is recorded in the Data Base

Name: Setup flight types**Actors:** Marshaler officers**Purpose:** Enables the actors to setup flight types**Precondition:** The actors should have logged into the system, and have assigned to do this operation**Flow of events**

1. The Actors want to setup flight types
2. The Actors press “Flight types” Link under System setup section
3. The system displays the setup flight types form
4. The Actors fills the data
5. The Actors presses “Save/update” button
6. The system checks that all the required information are entered [A.6]
7. The system checks weather the flight type has already registered or not [B.7]
8. The system displays a success message to the Actors
9. The use case ends

Alternate Course A: The system determines data for some field is not selected

A.6.1 The system informs the actors about the missing ones

A.6.2 The use case resumes at step 3 of the basic flow of events

Alternate Course B: the system determines that the flight type is already registered

B.7.1. The system informs that the flight type is registered

B.7.2 The system informs the actors to enter/edit other flight type information

B.7.3 The use case resumes at step 4 of the basic flow of events

Post condition: the flight type detail information is recorded in the Data Base**Name: Setup flight purpose****Actors:** System Administrator or air traffic controllers**Purpose:** Enables the actors to setup flight purpose**Precondition:** The Actors should have logged into the system, and have assigned to do this operation**Flow of events**

1. The Actors want to setup flight purposes
2. The Actors press “Flight purpose” Link under Setup-Journals lookup submenu
3. The system displays the setup flight purpose form
4. The Actors fills the data
5. The Actors presses “Save/update” button
6. The system checks that all the required information are entered [A.6]
7. The system checks weather the flight purpose has already registered or not [B.7]
8. The system displays a success message to the Actors
9. The use case ends

Alternate Course A: The system determines data for some field is not selected

A.6.1 The system informs the actors about the missing ones

A.6.2 The use case resumes at step 3 of the basic flow of events

Alternate Course B: the system determines that the flight purpose is already registered

B.7.1. The system informs that the flight purpose is registered

B.7.2 The system informs the actors to enter/edit other flight purpose information

B.7.3 The use case resumes at step 4 of the basic flow of events

Post condition: the flight purpose detail information is recorded in the Data Base

Name: Setup origin and destination**Actors:** System Administrator or air traffic controllers**Purpose:** Enables the actors to setup origin and destination**Precondition:** The Actors should have logged into the system, and have assigned to do this operation**Flow of events**

1. The Actors want to setup international aerodrome origin and destinations
2. The Actors press “Origin and Destination” Link under Setup-Journals lookup submenu
3. The system displays the setup origin and destination form
4. The Actors fills the data
5. The Actors presses “Save/update” button
6. The system checks that all the required information are entered [A.6]
7. The system checks weather the origin/destination has already registered or not [B.7]
8. The system displays a success message to the Actors
9. The use case ends

Alternate Course A: The system determines data for some field is not selected

A.6.1 The system informs the actors about the missing ones

A.6.2 The use case resumes at step 3 of the basic flow of events

Alternate Course B: the system determines that the origin and destination is already registered

B.7.1. The system informs that the origin and destination is registered

B.7.2 The system informs the actors to enter/edit other origin/destination information

B.7.3 The use case resumes at step 4 of the basic flow of events

Post condition: the origin and destination detail information is recorded in the Data Base**Name: Setup facility types****Actors:** Marshalar officers**Purpose:** Enables the actors to setup terminal facility types**Precondition:** The Actors should have logged into the system, and have assigned to do this operation**Flow of events**

1. The Actors want to setup terminal facility types
2. The Actors press “Terminal facility types” Link under Setup-Journals lookup submenu
3. The system displays the setup terminal facility types form
4. The Actors fills the data
5. The Actors presses “Save/update” button
6. The system checks that all the required information are entered [A.6]
7. The system checks weather the hours has already registered or not [B.7]
8. The system displays a success message to the Actors
9. The use case ends

Alternate Course A: The system determines data for some field is not selected

A.6.1 The system informs the actors about the missing ones

A.6.2 The use case resumes at step 3 of the basic flow of events

Alternate Course B: the system determines that the terminal facility types is already registered

B.7.1. The system informs that the terminal facility types is registered

B.7.2 The system informs the actors to enter/edit other facility information

B.7.3 The use case resumes at step 4 of the basic flow of events

Post condition: the terminal facility types is recorded in the Data Base

Name: Setup tariff rates

Actors: ECAA and EAE finance officers

Purpose: Enables the actors to setup different tariff rates

Precondition: The Actors should have logged into the system, have assigned to do this operation, and setup all information's.

Flow of events

1. The Actors want to setup tariff rates
2. The Actors press one of tariff rates radio button Link under Setup-Finance submenu
3. The system displays the corresponding setup tariff rates form
4. The Actors fills the data for the selected tariff rate
5. The Actors presses "Save/update" button
6. The system checks that all the required information are entered [A.6]
7. The system checks weather the tariff rate has already registered or not [B.7]
8. The system displays a success message to the Actors
9. The use case ends

Alternate Course A: The system determines data for some field is not selected

A.6.1 The system informs the actors about the missing ones

A.6.2 The use case resumes at step 3 of the basic flow of events

Alternate Course B: the system determines that the tariff rate is already registered

B.7.1. The system informs that the tariff rate is registered

B.7.2 The system informs the actors to enter/edit other tariff rate information

B.7.3 The use case resumes at step 4 of the basic flow of events

Post condition: the selected tariff rate is recorded in the Data Base

Name: Setup finance account codes

Actors: ECAA or EAE finance officers

Purpose: Enables the actors to setup finance account codes

Precondition: The Actors should have logged into the system, and have assigned to do this operation

Flow of events

1. The Actors want to setup finance account codes
2. The Actors press "Account codes" Link under Setup-Finance submenu
3. The system displays the setup finance account codes form
4. The Actors fills the data
5. The Actors presses "Save/update" button
6. The system checks that all the required information are entered [A.6]
7. The system checks weather the Account code has already registered or not [B.7]
8. The system displays a success message to the Actors
9. The use case ends

Alternate Course A: The system determines data for some field is not selected

A.6.1 The system informs the actors about the missing ones

A.6.2 The use case resumes at step 3 of the basic flow of events

Alternate Course B: the system determines that the Account code is already registered

B.7.1. The system informs that the Account code is registered

B.7.2 The system informs the actors to enter/edit other Account code information

B.7.3 The use case resumes at step 4 of the basic flow of events

Post condition: the Account code detail information is recorded in the Data Base

Name: Setup invoice email**Actors:** ECAA or EAE finance officers**Purpose:** Enables the actors to setup email account for invoice senders**Precondition:** The Actors should have logged into the system, and have assigned to do this operation**Flow of events**

1. The Actors want to setup email accounts
2. The Actors press “Invoice email” Link under Setup-Finance submenu
3. The system displays the setup email account form
4. The Actors fills the data
5. The Actors presses “Save/update” button
6. The system checks that all the required information are entered [A.6]
7. The system checks weather the Account code has already registered or not [B.7]
8. The system displays a success message to the Actors
9. The use case ends

Alternate Course A: The system determines data for some field is not selected

A.6.1 The system informs the actors about the missing ones

A.6.2 The use case resumes at step 3 of the basic flow of events

Alternate Course B: the system determines that the email account is already registered

B.7.1. The system informs that the email account is registered

B.7.2 The system informs the actors to enter/edit other email account information

B.7.3 The use case resumes at step 4 of the basic flow of events

Post condition: the email account detail information is recorded in the Data Base**Name: Import flight plan****Actors:** Air traffic controllers**Purpose:** Enables the actors to import flight plan from AMHS flight plan Database**Precondition:** The actor should have logged into the system, and have assigned to do this operation**Flow of events**

1. The actor want to import daily flight plan to temporary table
2. The actor press “Import flight plan” Link under Flight Journal-Import FP submenu
3. The system displays the import flight plan form
4. The actor disconnects the dedicated workstation from the normal network and connect (plug) to Flight Plan network
5. The actor presses “Import” button
6. The system automatically adjusts the network configuration and imports all flight plan records from Fox Pro Database and store in a local Sqlserver Database
7. The system resets the network configuration back to the previous state when finished
8. The actor then reconnect the workstation back to normal network and presses “Export” button
9. The system exports the imported flight plan records from the local database to FJBS server database
10. The system displays a success message to the actor
11. The use case ends

Post condition: All flight plan records are imported

Name: Produce Flight Journals**Actors:** Air traffic controllers**Purpose:** Enables the actor to edit the imported flights or enter new entry so as to make valid flight journal**Precondition:** The actor should have logged into the system, have assigned to do this operation, aircraft information, Call sign, airport, operators, entry/exit points, flight type & purposes, origin & destination, and passenger types should be setup**Flow of events**

1. The actor wants to enter new flights or modify the imported flight plan to produce exact flight journal
2. The actor press “Navigation or Over flight” Link under Flight Journal-Navigation or Over Flight submenu
3. The system displays the flight journal form for the selected Flight journal [A.3]
4. The actor retrieves imported flight plan by searching with flight date/flight number/registration no after selecting the searching criteria and typing searching text in the text box (flight date should be in yy/mm/dd format)
5. The system generates the flight plan fulfills the searching criteria in the grid view
6. The actor selects the row containing the flight he/she wants to edit
7. The system displays the selected row in their corresponding controls
8. The actor adjust/edit the flight data accordingly
9. The actor press on "Save" button
10. The system store the flight data in the corresponding journal type table
11. The system displays a success message to the actor
12. The use case ends

Alternate Course A: The actor wants to enter new flight data

A.3.1 The actor press in Edit flight journal button

A.3.2 The system displays the edit form and actor fills the flight information in the controls

A.3.3 The use case resumes at step 9 of the basic flow of events

Post condition: The selected flight journal data is successfully saved to database**Name: Edit flight journal****Actors:** Air traffic controllers**Purpose:** Enables the actor to edit flight journal**Precondition:** The actor should have logged into the system, have assigned to do this operation, aircraft information, Call sign, airport, operators, entry/exit points, flight type & purposes, origin & destination, and passenger types should be setup**Flow of events**

1. The actor wants to edit flight journal
2. The actor press “Navigation or Over flight” Link under Flight Journal-Navigation or Over Flight submenu
3. The system displays the flight journal form for the selected Flight journal
4. The actor press on Edit Journal link button
5. The system displays Edit flight journal form
6. The actor search for the journal record by searching with flight date/flight number/registration no/operator/Aircraft type/airport after selecting the searching criteria and typing searching text in the text box
7. The system generates the flight journal records fulfills the searching criteria in the

grid view

8. The actor selects the row containing the flight he/she wants to edit
9. The system displays the selected row in their corresponding controls
10. The actor adjust/edit the flight data accordingly
11. The actor press on "update/delete" button
12. The system updates the database table for the selected journal
13. The system displays a success message to the actor
14. The use case ends

Post condition: The flight journal data is registered to the database

Name: Register Terminal Facility Usage

Actors: Marshaler officers

Purpose: Enables the actor to register/Edit terminal facility usage

Precondition: The actor should have logged into the system, have assigned to do this operation, aircraft information, Call sign, airport, and operators should be setup

Flow of events

1. The actor want to register/Edit flights that use boarding bridge or do not
2. The actor press "Register Terminal facility" Link under Flight Journal-Terminal Usage submenu
3. The system displays the Terminal facility form
4. The actor fills all the necessary data or searches for the records and edit
5. The actor press on "Save/update" button
6. The system checks that some of the fields are wrongly registered [A.6]
7. The system displays a success message to the actor
8. The use case ends

Alternate Course A: The system determines data for some field is not selected

A.6.1 The system informs the actors about the missing ones

A.6.2 The use case resumes at step 3 of the basic flow of events

Post condition: The Terminal facility usage data is saved/updated to the database

Name: Process Landing fee

Actors: EAE finance officers

Purpose: Enables the actor to process the landing fee for operators

Precondition: The actor should have logged into the system, have assigned to do this operation, flight journal should have been prepared/adjusted, and also aircraft information, Call sign, airport, tariff rates and operators should be setup

Flow of events

1. The actor want to process landing fee
2. The actor press "Landing" submenu under Billing and Invoice menu
3. The system displays the Process landing fee form
4. The actor enters the invoice period, invoice date, and the USD rate
5. The actor press on "Generate" button
6. The system checks that the required fields are not selected [A.6]
7. The system checks that the landing fee for the selected period is already processed [B.7]
8. The system retrieves landing tariff rate and process landing billing for the selected period
9. The system assign unique sequential invoice no for each operator and store invoice

- information in the database table
- 10. The system displays a success message to the actor
- 11. The use case ends

Alternate Course A: The system determines data for some field is not selected

- A.6.1 The system informs the actors about the missing ones
- A.6.2 The use case resumes at step 3 of the basic flow of events

Alternate Course B: The system determines that the landing fee is already processed

- B.7.1. The system informs the actors as the landing fee is already processed
- B.7.2 The system requests the actor whether to reprocess the fee or not
- B.7.3 The use case resumes at step 5 of the basic flow of events if 'yes' is selected
- B.7.4 The use case ends if 'no' is selected

Post condition: The system produces invoice for each operator and store the fee in DB

Name: Process over flight fee

Actors: ECAA finance officers

Purpose: Enables the actor to process the over flight fee for operators

Precondition: The actor should have logged into the system, have assigned to do this operation, flight journal should have been prepared/adjusted, and also aircraft information, Call sign, entry/exit points, flight purpose, airport, tariff rates and operators should be setup

Flow of events

1. The actor want to process over flight fee
2. The actor press “over flight” submenu under Billing and Invoice menu
3. The system displays the Process over flight fee form
4. The actor enters the invoice period, invoice date, and the USD rate
5. The actor press on "Generate" button
6. The system checks that the required fields are not selected [A.6]
7. The system checks that the over flight fee for the selected period is already processed [B.7]
8. The system calculates flight distance, retrieves over flight tariff rate and process over flight billing for the selected period
9. The system assign unique sequential invoice no for each operator and store invoice information in the database table
10. The system displays a success message to the actor
11. The use case ends

Alternate Course A: The system determines data for some field is not selected

- A.6.1 The system informs the actors about the missing ones
- A.6.2 The use case resumes at step 3 of the basic flow of events

Alternate Course B: The system determines that the over flight fee is already processed

- B.7.1. The system informs that the over flight fee is already processed
- B.7.2 The system requests the actor whether to reprocess the fee or not
- B.7.3 The use case resumes at step 5 of the basic flow of events if 'yes' is selected
- B.7.4 The use case ends if 'no' is selected

Post condition: The system produces invoice for each operator and store the fee in DB

Name: Process Parking fee

Actors: EAE finance officers

Purpose: Enables the actor to process parking fee for operators

Precondition: The actor should have logged into the system, have assigned to do this operation, flight journal should have been prepared/adjusted, and also aircraft information, Call sign,

airport, tariff rates and operators should be setup

Flow of events

1. The actor want to process parking fee
2. The actor press “parking” submenu under Billing and Invoice menu
3. The system displays the Process parking fee form
4. The actor enters the invoice period, invoice date, and the USD rate
5. The actor press on "Generate" button
6. The system checks that the required fields are not selected [A.6]
7. The system checks that the parking fee for the selected period is already processed [B.7]
8. The system calculates paired flights and parking hrs and store in tempNav table, retrieves parking tariff rate and process parking billing for the selected period
9. The system assign unique sequential invoice no for each operator and store invoice information in the database table
10. The system displays a success message to the actor
11. The use case ends

Alternate Course A: The system determines data for some field is not selected

A.6.1 The system informs the actors about the missing ones

A.6.2 The use case resumes at step 3 of the basic flow of events

Alternate Course B: The system determines that the parking fee is already processed

B.7.1. The system informs that the parking fee is already processed

B.7.2 The system requests the actor whether to reprocess the fee or not

B.7.3 The use case resumes at step 5 of the basic flow of events if 'yes' is selected

B.7.4 The use case ends if 'no' is selected

Post condition: The system produces invoice for each operator and store the fee in DB

Name: Process Light facility fee

Actors: EAE finance officers

Purpose: Enables the actor to process the light facility fee for operators

Precondition: The actor should have logged into the system, have assigned to do this operation, flight journal should have been prepared/adjusted, and also flight purpose, airport, tariff rates and operators should be setup

Flow of events

1. The actor want to process light facility fee
2. The actor press “lighting” submenu under Billing and Invoice menu
3. The system displays the Process lighting fee form
4. The actor enters the invoice period, invoice date, and the USD rate
5. The actor press on "Generate" button
6. The system checks that the required fields are not selected [A.6]
7. The system checks that the lighting fee for the selected period is already processed [B.7]
8. The system retrieves lighting tariff rate and process lighting billing for the selected period
9. The system assign unique sequential invoice no for each operator and store invoice information in the database table
10. The system displays a success message to the actor
11. The use case ends

Alternate Course A: The system determines data for some field is not selected

A.6.1 The system informs the actors about the missing ones

A.6.2 The use case resumes at step 4 of the basic flow of events

Alternate Course B: The system determines that the light facility fee is already processed

B.7.1. The system informs that the light facility fee is already processed

B.7.2 The system requests the actor whether to reprocess the fee or not

B.7.3 The use case resumes at step 5 of the basic flow of events if 'yes' is selected

B.7.4 The use case ends if 'no' is selected

Post condition: The system produces invoice for each operator and store the fee in DB

Name: Process Terminal facility fee

Actors: EAE finance officers

Purpose: Enables the actor to process the terminal facility fee for operators

Precondition: The actor should have logged into the system, have assigned to do this operation, terminal usage journal should have been prepared/adjusted, and also aircraft information, Call sign, airport, tariff rates and operators should be setup

Flow of events

1. The actor want to process terminal facility fee
2. The actor press “terminal facility” submenu under Billing and Invoice menu
3. The system displays the Process terminal facility fee form
4. The actor enters the invoice period, invoice date, and the USD rate
5. The actor press on "Generate" button
6. The system checks that the required fields are not selected [A.6]
7. The system checks that the terminal facility fee for the selected period is already processed [B.7]
8. The system retrieves terminal facility tariff rate and process terminal facility billing for the selected period
9. The system assign unique sequential invoice no for each operator and store invoice information in the database table
10. The system displays a success message to the actor
11. The use case ends

Alternate Course A:

A.6.1 Some fields are not selected

A.6.2 The use case resumes at step 4 of the basic flow of events

Alternate Course B:

B.7.1. The system informs that the terminal facility fee is already processed

B.7.2 The system requests the actor whether to reprocess the fee or not

B.7.3 The use case resumes at step 5 of the basic flow of events if 'yes' is selected

B.7.4 The use case ends if 'no' is selected

Post condition: The system produces invoice for each operator and store the fee in DB

Name: Process en-route navigation fee

Actors: ECAA finance officers

Purpose: Enables the actor to process the navigation fee for operators

Precondition: The actor should have logged into the system, have assigned to do this operation, flight journal should have been prepared/adjusted, and also aircraft information, Call sign, flight type, flight purpose, airport, tariff rates and operators should be setup

Flow of events

1. The actor want to process navigation fee
2. The actor press “navigation” submenu under Billing and Invoice menu

3. The system displays the Process navigation fee form
4. The actor enters the invoice period, invoice date, and the USD rate
5. The actor press on "Generate" button
6. The system checks that the required fields are not selected [A.6]
7. The system checks that the navigation fee for the selected period is already processed [B.7]
8. The system calculates flight type and distance, retrieves navigation tariff rate and process navigation billing for the selected period
9. The system assign unique sequential invoice no for each operator and store invoice information in the database table
10. The system displays a success message to the actor
11. The use case ends

Alternate Course A: The system determines data for some field is not selected

A.6.1 The system informs the actors about the missing ones

A.6.2 The use case resumes at step 3 of the basic flow of events

Alternate Course B: The system determines that the navigation fee is already processed

B.7.1. The system informs that the navigation fee is already processed

B.7.2 The system requests the actor whether to reprocess the fee or not

B.7.3 The use case resumes at step 5 of the basic flow of events if 'yes' is selected

B.7.4 The use case ends if 'no' is selected

Post condition: The system produces invoice for each operator and store the fee in DB

Name: Process Passenger fee

Actors: EAE finance officers

Purpose: Enables the actor to process the passenger fee for operators

Precondition: The actor should have logged into the system, have assigned to do this operation, flight journal should have been prepared/adjusted, and passenger types, airport, tariff rates and operators should be setup

Flow of events

1. The actor want to process passenger fee
2. The actor press "passenger" submenu under Billing and Invoice menu
3. The system displays the Process passenger fee form
4. The actor enters the invoice period, invoice date, and the USD rate
5. The actor press on "Generate" button
6. The system checks that the required fields are not selected [A.6]
7. The system checks that the passenger fee for the selected period is already processed [B.7]
8. The system retrieves passenger tariff rate and process passenger billing for the selected period
9. The system assign unique sequential invoice no for each operator and store invoice information in the database table
10. The system displays a success message to the actor
11. The use case ends

Alternate Course A: The system determines data for some field is not selected

A.6.1 The system informs the actors about the missing ones

A.6.2 The use case resumes at step 3 of the basic flow of events

Alternate Course B: The system determines that the passenger fee is already processed

B.7.1. The system informs that the passenger fee is already processed

- B.7.2 The system requests the actor whether to reprocess the fee or not
- B.7.3 The use case resumes at step 5 of the basic flow of events if 'yes' is selected
- B.7.4 The use case ends if 'no' is selected

Post condition: The system produces invoice for each operator and store the fee in DB

Name: Email invoice

Actors: ECAA and EAE finance officers

Purpose: Enables the actors to send the invoice via e-mail

Precondition: The actor should have logged into the system, revenue fees are processed, email account have to be setup, have assigned to do this operation, and also operators should be setup

Flow of events

1. The actors want to mail invoice to customer
2. The actors press on the type of invoice he wants to send under Bill and Invoice submenu
3. The system displays the Billing page for the selected invoice category
4. The actors searches the invoice by invoice number under view invoice by section
5. The system checks that the invoices to be sent is not selected[A.4]
6. The system generates/displays the detail of invoice in the crystal reports
7. The actor enters the receiver email in the text box and then press on Send button
8. The system retrieves the sender email account from tables, export invoice to pdf file, and finally send the pdf file to the receiver as attachment
9. The system displays a sent message to the actor and use case ends

Alternate Course A: The system determines data for some field is not selected

A.5.1 The system informs the actors about the missing ones

A.5.2 The use case resumes at step 4 of the basic flow of events

Post condition: The invoice is sent to the customer

Name: View/Update invoice status

Actors: ECAA and EAE finance officers

Purpose: Enables the actors to view or update invoice status

Precondition: The actor should have logged into the system, revenue fees are processed, have assigned to do this operation, and also operators should be setup

Flow of events

1. The actor want to view or update invoice status
2. The actors press on the type of invoice he wants to send under Bill and Invoice submenu
3. The system displays the Billing page for the selected invoice category
4. The actors searches the invoice by invoice number/period/Flight date to view
5. The system displays the detail of invoices in the crystal report including invoice status information
6. The actors selects the invoice status from the invoice status combo boxes
7. The actor press on "Update" button to update its status
8. The system checks that the required fields are not selected [A.6]
9. The system displays a success message to the actor
10. The use case ends

Alternate Course A: The system determines data for some field is not selected

A.6.1 The system informs the actors about the missing ones

A.6.2 The use case resumes at step 4 of the basic flow of events

Post condition: The invoice status is updated or viewed

Name: Export Finance Journal Entry**Actors:** ECAA or EAE finance officers**Purpose:** Enables the actors to export finance journal entry**Precondition:** The actor should have logged into the system, revenue fees are processed, have assigned to do this operation, and also account number should be setup**Flow of events**

1. The actor want to export finance journal entry
2. The actor press “Export to finance” Link under Billing section
3. The system displays the export to finance form
4. The actor enters the period and select the revenue type from combo box
5. The actor press on "Display" button
6. The system checks that the required fields are not selected [A.6]
7. The system generates the journal entry to be exported in crystal report
8. The actor presses on "Export" button
9. The system retrieves the finance account no from tables, export invoice to .csv file
10. The system displays a success message to the actor
11. The use case ends

Alternate Course A:

A.6.1 Some fields are not selected

A.6.2 The use case resumes at step 4 of the basic flow of events

Post condition: The system exports the revenue data for the period into .csv file**Name: Generate flight statistics****Actors:** All**Purpose:** Enables the actors to generate movement statistics**Precondition:** The actor should have logged into the system**Flow of events**

1. The actors want to view aircrafts movement statistics
2. The actors press on “Statistics” menu
3. The system displays the movement statistics form
4. The actors selects the category of statistics from combo box
5. The actors press on "Display" button
6. The system checks that the category is not selected [A.5]
7. The system displays the statistics for the selected category
8. The use case ends

Alternate Course A: The system determines data for some field is not selected

A.5.1 The system informs the actors about the missing ones

A.5.2 The use case resumes at step 4 of the basic flow of events

Post condition: The aircraft movement statistics is generated**Name: Generate traffic forecasting****Actors:** All**Purpose:** Enables the actors to perform aircraft movement forecasting**Precondition:** The actor should have logged into the system**Flow of events**

1. The actors want to perform Aircraft movement forecasting
2. The actors press on “Forecasting” menu
3. The system displays the Aircraft movement forecasting form
4. The actors selects the traffic category to forecast and enters the forecasting year

5. The actors press on "Generate" button
6. The system checks that the parameters are not selected/entered [A.5]
7. The system generates Aircraft movement forecasting by using designed forecasting model, and also displays the "Show graph" button
8. The use case ends

Alternate Course A: The system determines data for some field is not selected

A.5.1 The system informs the actors about the missing ones

A.5.2 The use case resumes at step 3 of the basic flow of events

Post condition: The Aircraft movement forecasting is generated

Name: View reports

Actors: Finance officers/Managers/supervisors/Planners/ATC

Purpose: Enables the actors to view reports

Precondition: The actor should have logged into the system, have assigned to do this operation

Flow of events

1. The actors want to view report
2. The actors press on one of the reports categories under "Reports" menu
3. The system displays the view report form
4. The actors selects the report type from the combo box, and other necessary parameters
5. The actors press on "Display" button
6. The system checks that the report type and/or parameters is not selected[A.5]
7. The system displays the selected report
8. The use case ends

Alternate Course A: The system determines data for some field is not selected

A.6.1 The system informs the actors about the missing ones

A.5.2 The use case resumes at step 3 of the basic flow of events

Post condition: The selected report is generated

Name: Login

Actors: All

Purpose: Enables the actors to log into the system

Precondition: None

Flow of events

1. The actors want to log into the system
2. The actors enters the system URL in a web browser
3. The system displays the Login form window
4. The actors enters his username and password
5. The actors press on "Login" button
6. The system checks that the username and/or password is not entered[A.5]
7. The system checks that the entered account information does not exist in the database[B.5]
8. The system displays the home page
9. The use case ends

Alternate Course A:

A.5.1 Either username or password or both are not provided

A.5.2 The use case resumes at step 4 of the basic flow of events

Alternate Course A: The system determines that user name or password or both are wrong

B.5.1 Either the username or password or both are wrong or not registered/enabled

B.5.2 The use case resumes at step 4 of the basic flow of events

Post condition: The user successfully log and the system home page is displayed

4.6 Object Modelling

Class Diagram

We used class diagram to describe the structure of the proposed system in terms of objects, classes, attributes, operations, and their associations. Classes are abstractions that specify the common structure and behavior of a set of objects in Use Cases. Objects are instances of classes that are created, modified, and destroyed during the execution of the system. The class diagram of our proposed system is shown in Figure 4.2.

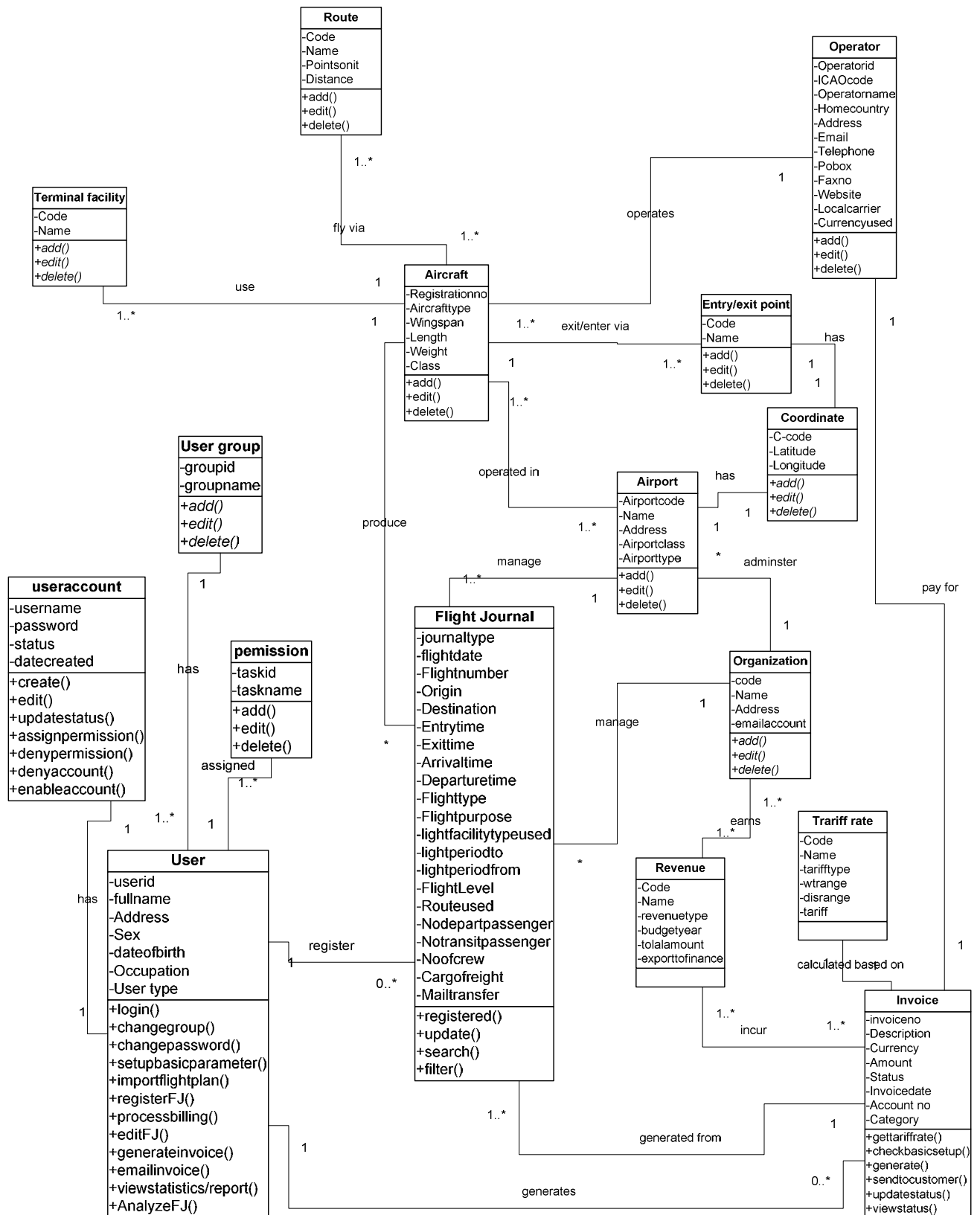


Figure 4.2: Class diagram

4.7 Dynamic Modeling

Sequence Diagram

Sequence diagrams are used to model the logic of the usage scenarios. A usage scenario is the description of the potential way the system is used. The logic of a usage scenario may be part of a use case: perhaps an alternative course. It may also be an entire pass through a use case, such as the logic of the basic flow of events plus one or more alternates.

The sequence diagram for some of the use cases for the proposed system is shown in Figures 4.3-4.7. The other sequence diagrams are annexed (see Annex A).

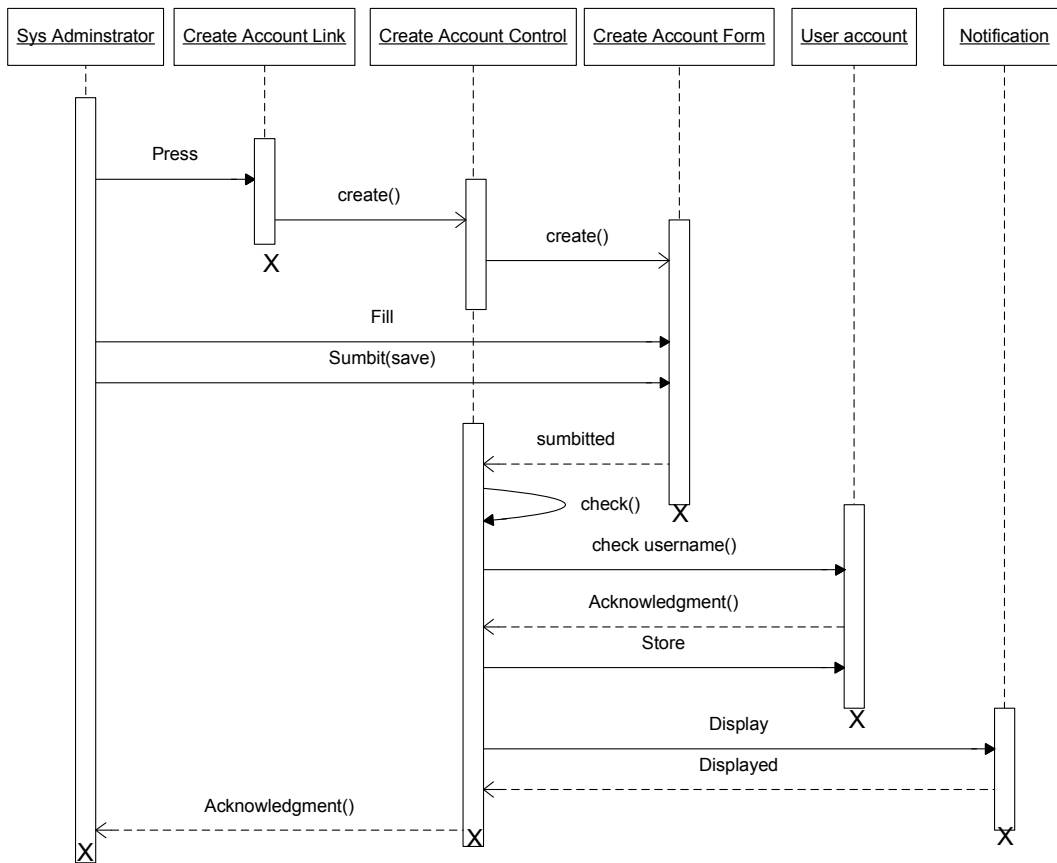


Figure 4.3: Create user account sequence diagram

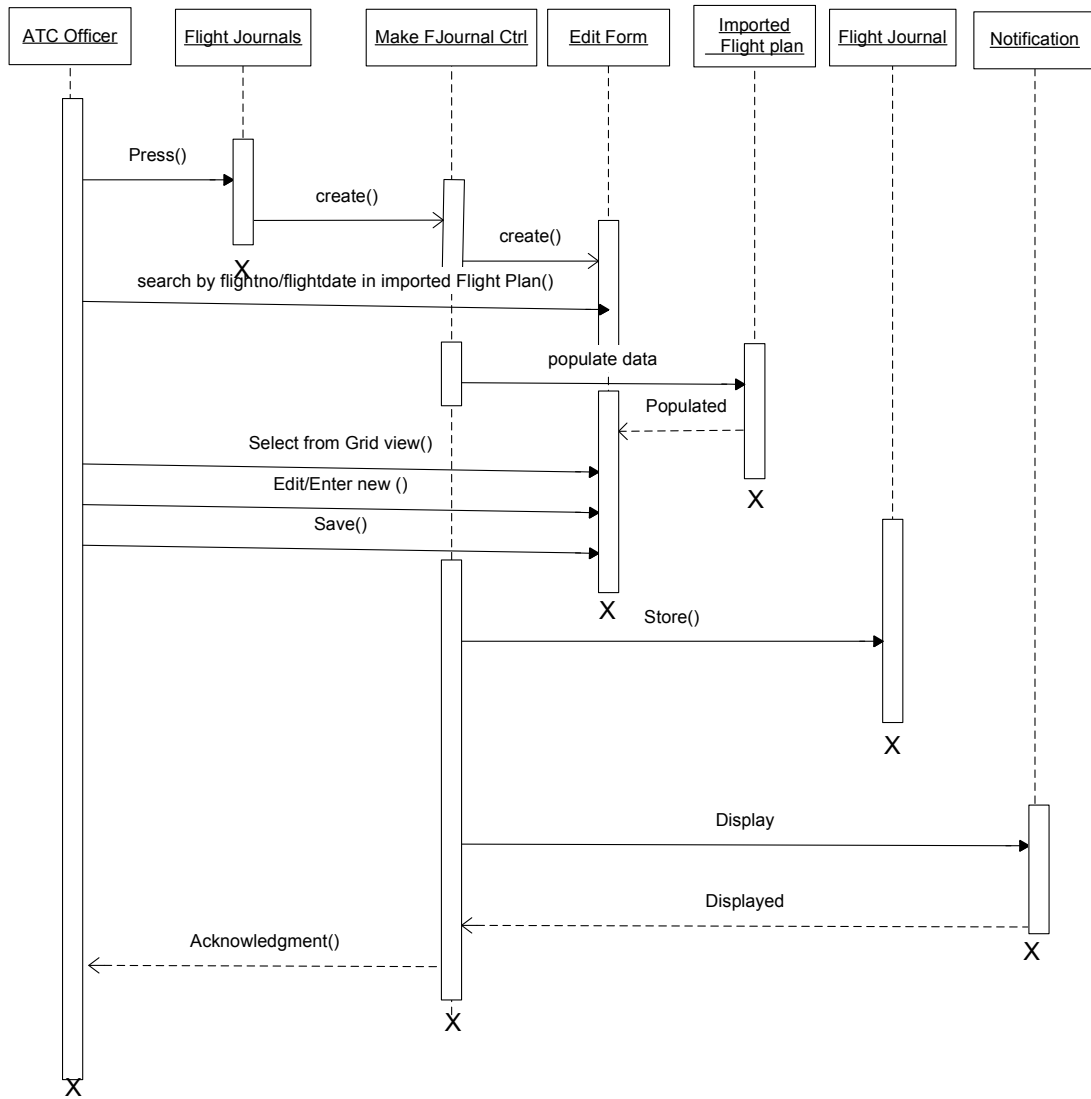


Figure 4.4: Prepare flight journal sequence diagram

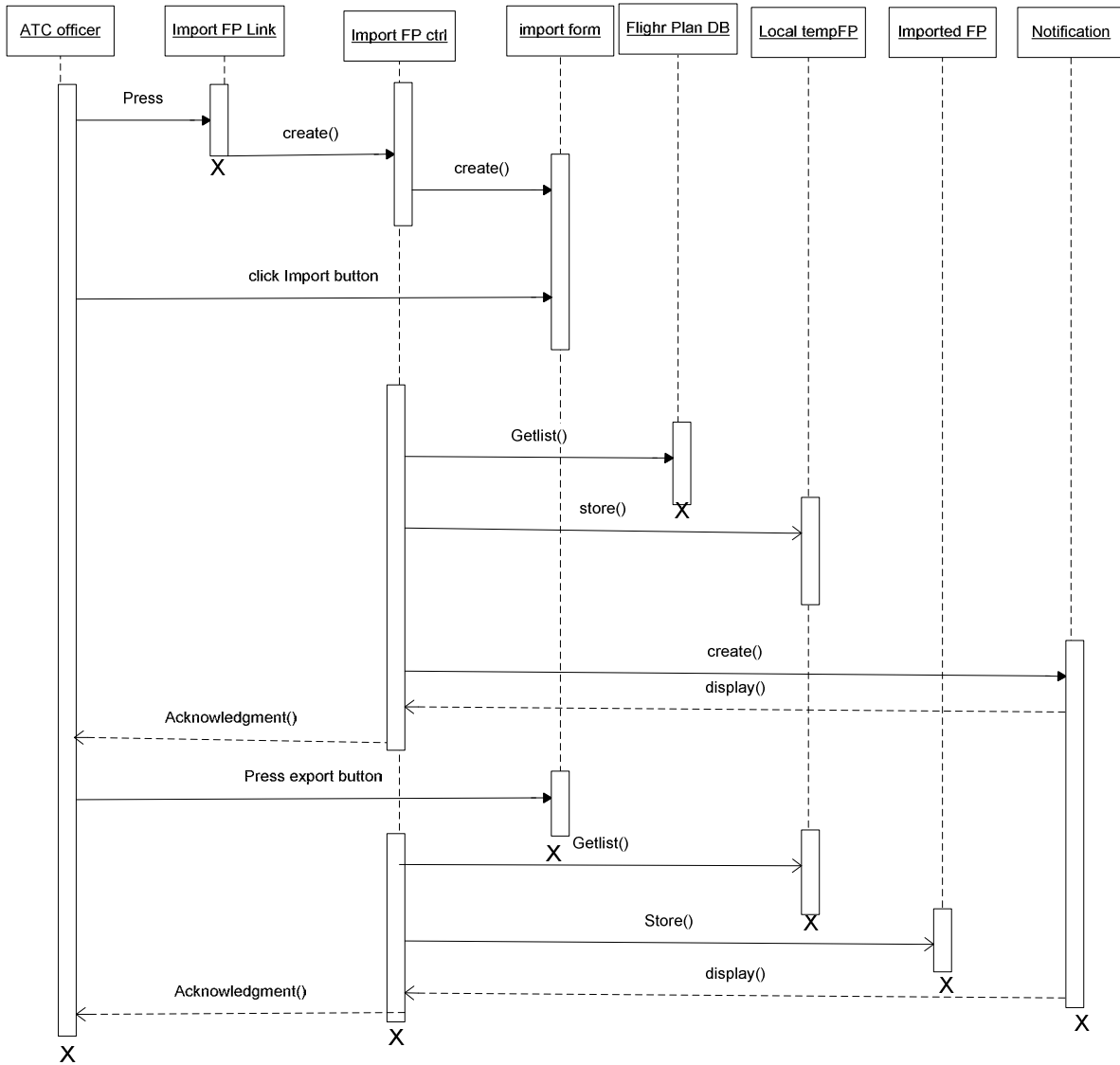


Figure 4.5: Import flight plan sequence diagram

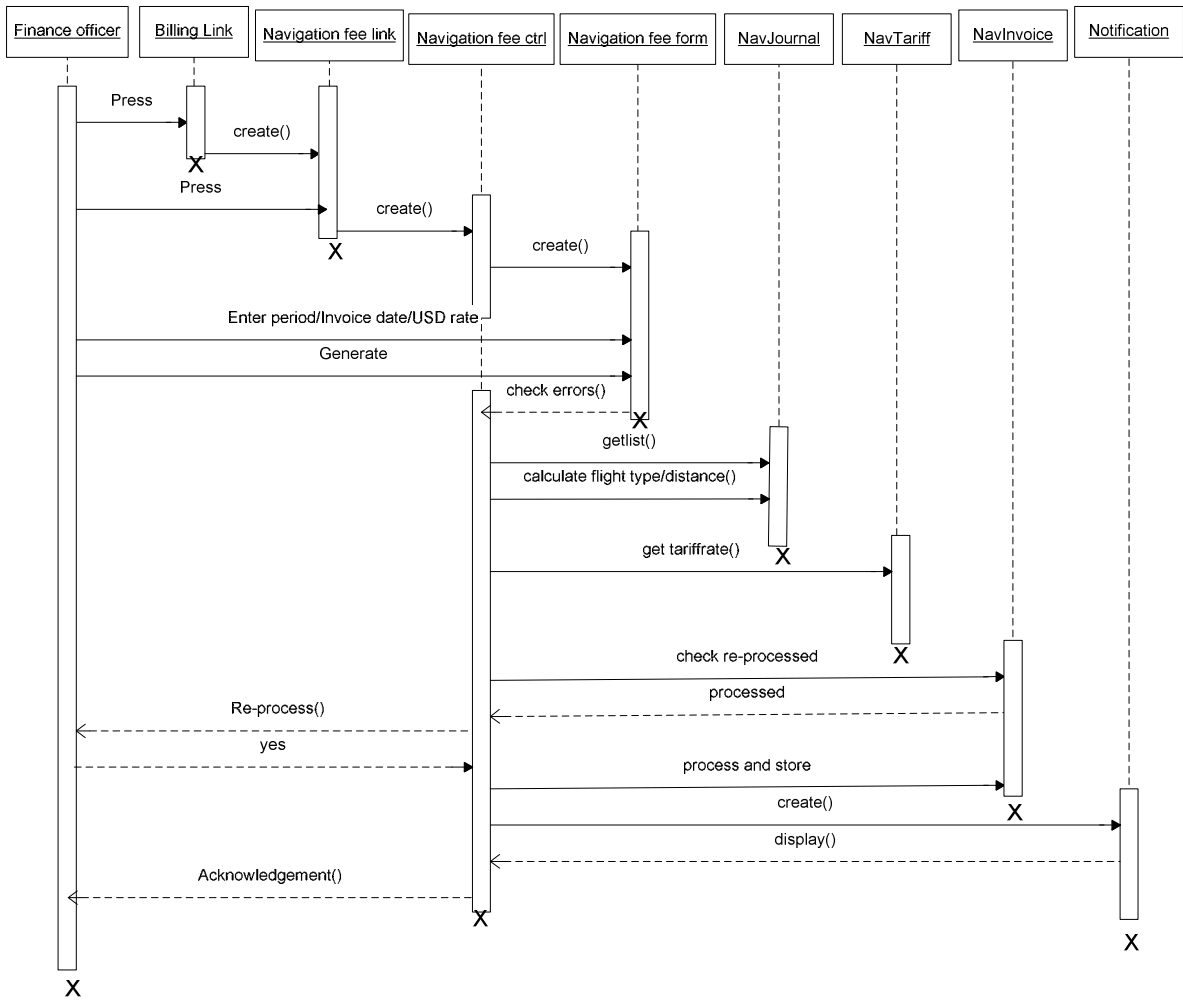


Figure 4.6: Process en-route navigation fees sequence diagram

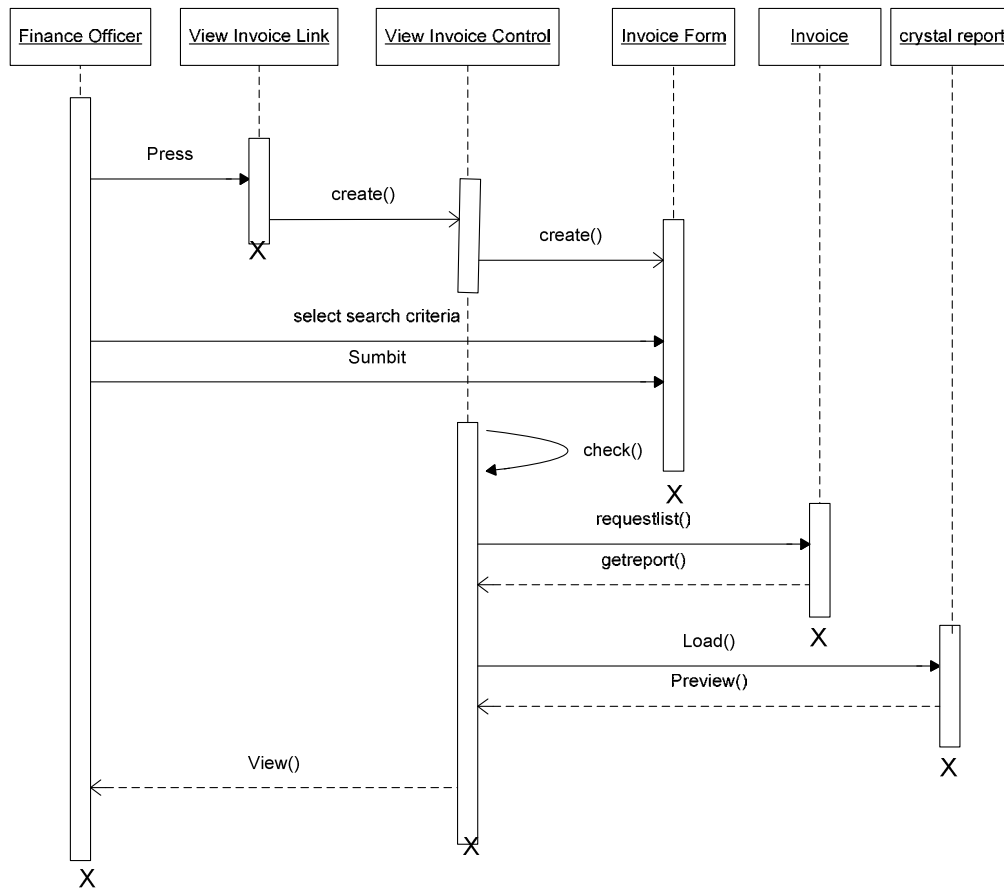


Figure 4.7: View invoice sequence diagram

4.8 Summary

In this section, we started by discussing the current system flight data management and their billing and then we proposed our new solution after identifying both functional and non-functional requirements. We used use case modelling to describe the interactions between actors and the system services both in descriptive and graphical format. We also designed class diagram of the proposed solution to describe the structure of the proposed system in terms of objects, classes, attributes, operations, and their associations. We also discussed the dynamic nature of our proposed solution to elaborate the logic of the usage scenarios.

Chapter Five

System Design

The system design is used to fill the gap between the system specification produced during requirements analysis and the system that is to be delivered to the user.

5.1 Design Goals

Design Goals describe the qualities of the system that developers should optimize. Such goals are normally derived from the non-functional requirements of the system that are laid in the analysis document. One can generally group design goals into four criteria: performance, dependability, maintenance, and end user.

Performance Criteria

- **Response time:** the system should provide as fast response as possible, at least before the session expires in processing fees, recording journals, forecasting, and displaying statistical reports. In order to minimize the time it takes to provide response, interface design has not included any large graphic files and middle-tier processing code is made as efficient as possible.
- **Throughput:** The system should be able to support a number of users at a time using the available bandwidth of the system. Since the system is web based, it has to demand minimal memory and reasonable processing power so that any user can access it simultaneously with available resources unless there are hardware and Internet connection constraints. In addition, we will use a DBMS that supports concurrent access to a number of users at a time.

Maintenance criteria

- **Modifiability:** the system should be easily extensible when any need arises by flight journals formats and/or billing system business rule. The setup utility allows the users to easily add and modify many of the system parameters including tariff rate. The system is designed and implemented in Object Oriented approach that helps developers to build the system from several more or less independent classes which can be used as a standalone application or replaced by other classes. This makes the system easy to change the existing functionality or add new ones when the need arises without affecting the whole.

Also the code should be written using readable and understandable format to be easily later modified by any programmer.

- **Portability:** The system should be platform independent. The system is implemented by ASP.NET languages that achieved platform independence through the Common Language Runtime (CLR) where the end user can use the system using any browser such as Firefox and Internet Explorer.

Dependability criteria

- **Robustness:** The system should be designed to be able to validate user input during flight journal preparation, billing processing, and other related activities and must handle error using errors handling mechanisms so that the user gets informed about the errors and fix them. Then after the system should reset itself to the previous safe state.
- **Security:** The system should also be able to prompt the users for supplying user name and password before appropriate access is granted. It should also secure some sensitive services such as set up information, editing flight journal, processing billing as these services are only performed by some authorized users. Cryptography and Secure Socket Layer security should be employed to protect from eavesdroppers during storage and communication on the Internet.

End User Criteria

- **Utility:** The system must address the possible functional requirements of the system users. Consequently, all the functional requirements identified in the preceding Chapter have been implemented in the system.
- **Documentation:** System administrator and users of the system should be provided with proper documentation on how to use the system.
- **User Interface:** In order to make the system user friendly and easy to use, easily navigate-able visual interface and interactive features should be implemented. So, the system should provide user friendly and self-explanatory graphical user interface that eases the interaction of the user with the system. In addition, the system should support and facilitate work like automatic generation of statistical data and forecasting of aircraft and also enabling customers to generate information based on demand.

- **Availability:** Since the aviation industry operates 24 hours a day, the system should be available at any time to provide the services unless otherwise, power, Internet connection and other constraints interfere.

5.2 System Architecture

At a high level, the architecture of an application defines how different parts of the system are organized and logically connected ensuring that they work together. The architecture of the system is designed to be three tiers client-server architecture: client tier, middle/web tier and the data tier as shown in Figure 5.1. Three-tier client-server architecture provides greater application scalability, high flexibility, high efficiency, lower maintenance, and better reusability of components.

The Client Tier

The client tier is the application's user interface containing setup and flight journals management forms, import flight plan and reports access links, view graphs of statistical and forecasting information, and client side applications that are running on the web browser of the user machine. All users, including the one who is assigned to import flight plan to the main database using dual network system, directly interact with the system through this tier. It interacts with the web server to make requests and to retrieve data from the database. The user who might be administrator or traffic controller interacts directly with Import server (of the middle tier) to import flight plan to the main database.

The Middle/Web Tier

The middle tier contains web server, Import server and the business logic. The web server (IIS) handles all the HTTP and HTTPS requests coming from the client machines. It also manages the responses that are forwarded to the client machines. The Import is a set of server-side controls and components that allow a dedicated workstation to import flight plan from flight plan database to the main database. The business logic is responsible for handling the main activities such as input validation, report generation, performing calculations, and access and retrieval of data required by the client. It also interacts with an external system such as Flight plan database to import flight plan data and store it in temporary flight plan table.

The Data Tier

The data tier is responsible to store the actual data in the database. It is implemented using Microsoft SQL server 2005 database. The database should be stored on a separate machine to facilitate the interaction with both the web server and the Import server.

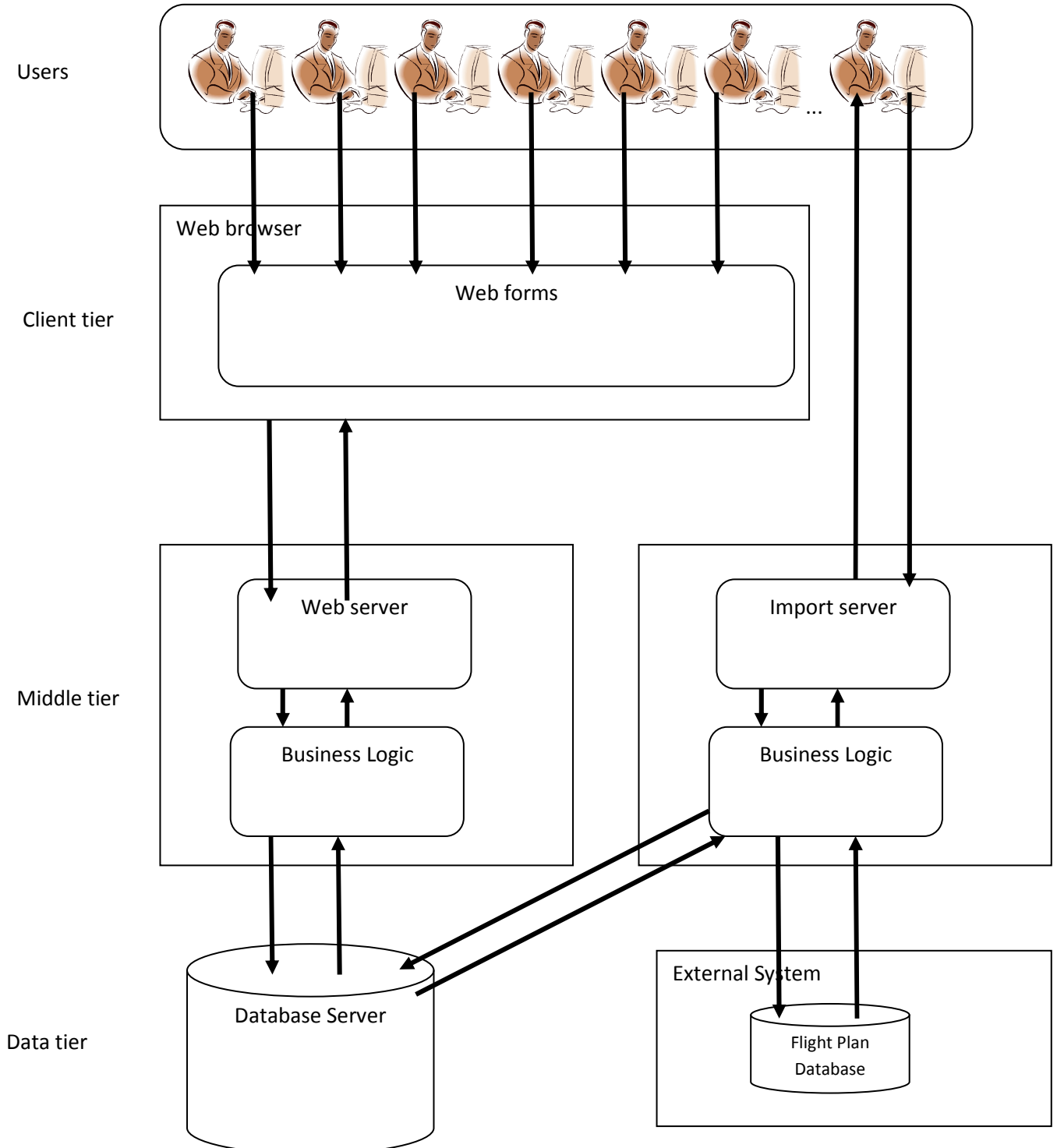


Figure 5.1: Architecture of the proposed system

5.3 System Decomposition

Recall that we have identified smaller parts called classes in Chapter four in order to reduce the complexity of the system analysis (application domain) tasks of the system. Similarly, we decompose the system into simpler parts called subsystems, to reduce the complexity of the system design (solution domain). The system is decomposed into six subsystems to reduce the complexity of the system. While performing system decomposition, we considered the two basic concepts namely coupling (the dependencies between two subsystems) and coherence (the dependencies among classes within a subsystem). Figure 5.2 shows the subsystem decomposition of the system.

The Flight Journal Management subsystem is responsible for registering and preparing over flight movements, aircraft landing and takeoff activities, and airport facility usage information.

The Flight Plan Importing subsystem enables a dedicated user to import monthly flight plan data to the temporary table in the flight journal database, which then should be converted to actual flight journals data by flight journal management subsystem.

The Billing Management subsystem is in charge of processing over flight fee, en-route navigation fee, parking fee, passenger fee, light and terminal facility fee, and landing fee. This subsystem also manages different invoice operations including sending the specified invoice to the customer via email.

The System Utility Management subsystem enables the system administrator and traffic controllers to manage user accounts including their permission, setup parameters that are used by different sub systems such as aircraft information, local and international airports, tariff rates, routes, and entry/exit points with their geometric coordinates.

The Statistics and Report subsystem generates different statistics and reports based on the requirements like total number of flight movements or passenger or cargo (freight) or mail by year/month/airport/operation type/peak hour/flight type/business type/aircraft type/airline operators and so on. Moreover, it helps users to easily view different statistical graphs on the screen.

The Forecasting subsystem enables users to generate aircraft movement traffic forecasting using the designed forecasting model.

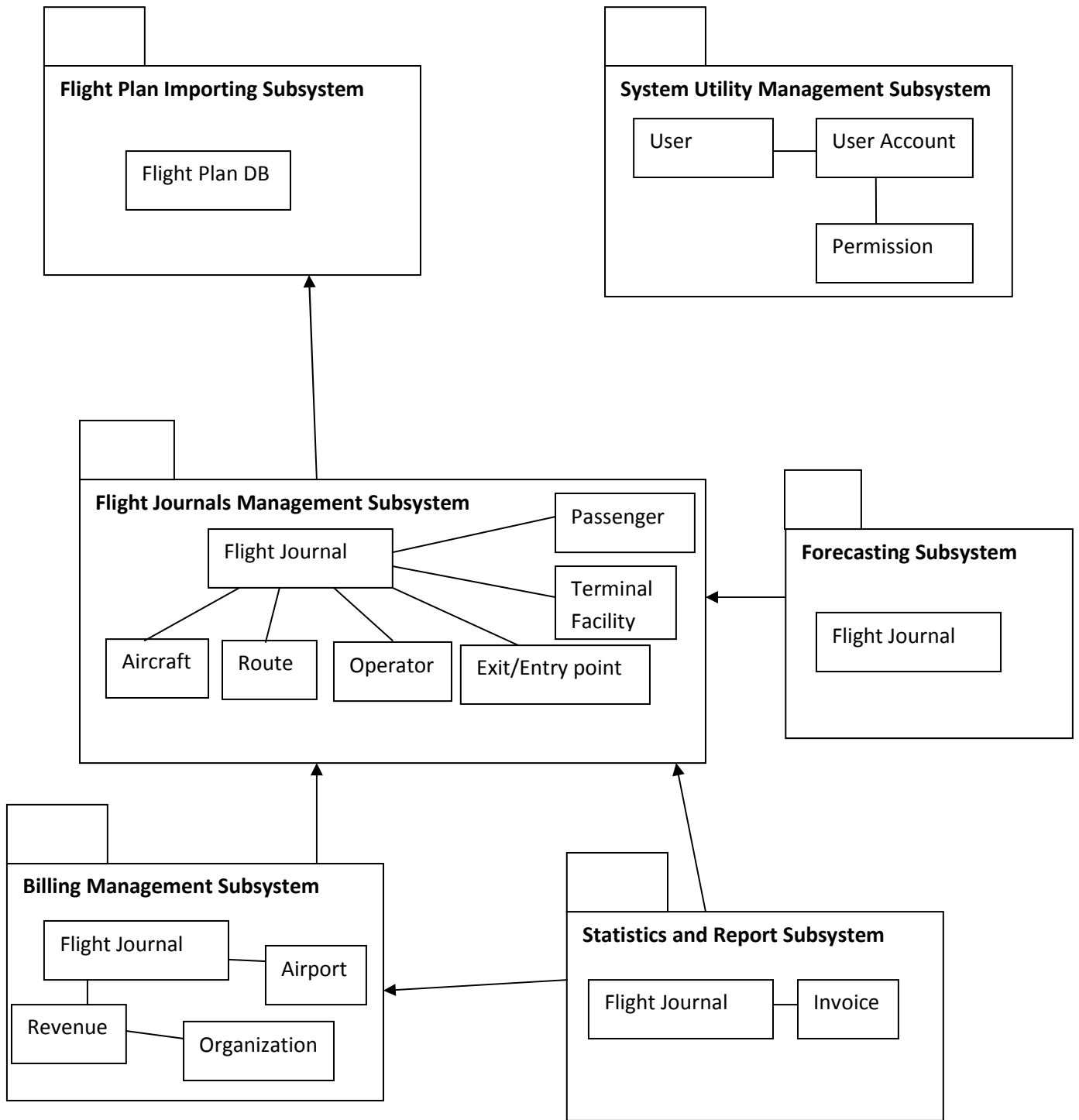


Figure 5.2: Subsystem Decomposition

5.4 Hardware/Software Mapping

The hardware/software mapping describes which components would be mapped in which hardware node and is described by deployment diagram. The subsystems identified in the preceding section are mapped onto the client and server nodes as shown in Figure 5.3 deployment diagram. The client node uses the web browser or a dedicated machine to communicate with those ASP.NET applications (subsystems) residing on the web-server through an HTTP/HTTPS connection. Those subsystem components on the web server communicate with the database subsystem through an ADO.NET connection.

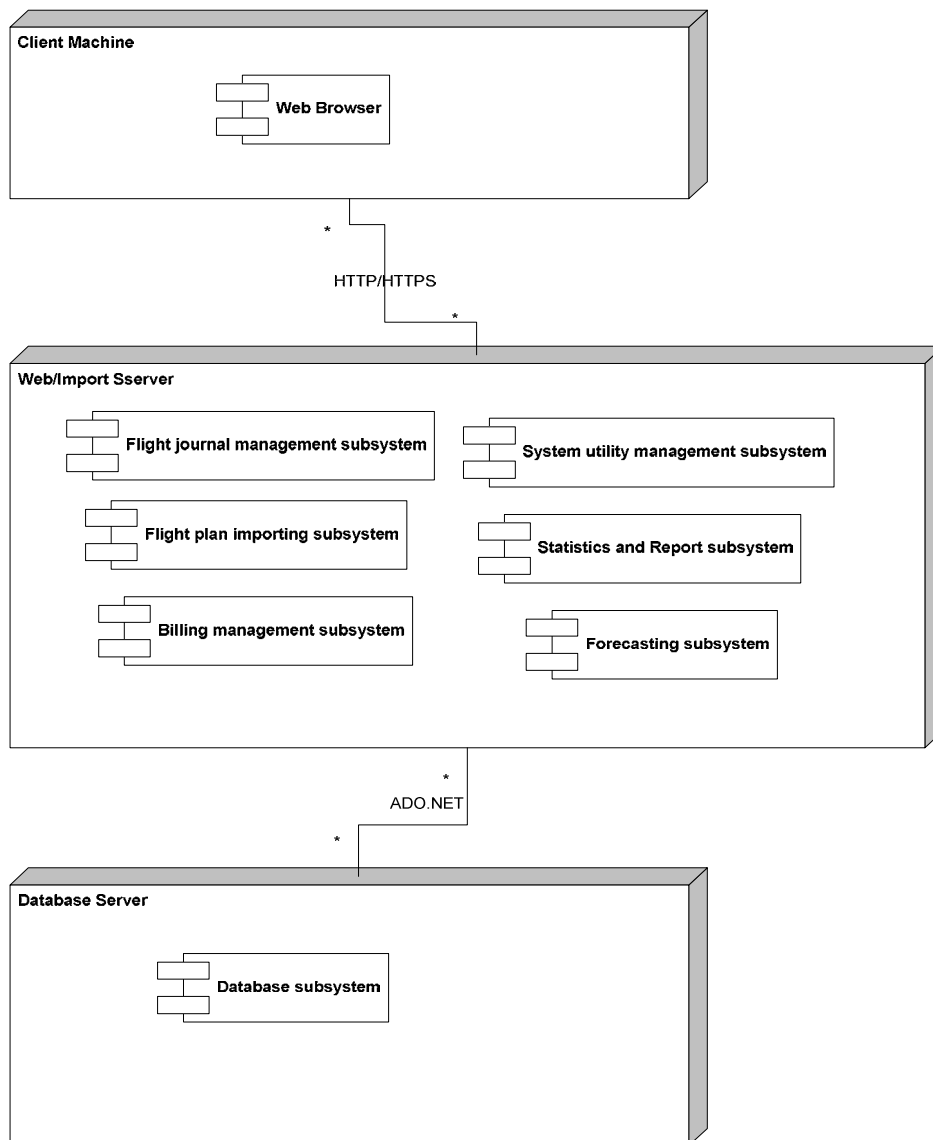


Figure 5.3: Deployment Diagram

5.5 Persistent Data Management

Persistent data management deals with how the persistent data are stored and managed. Information related to flight journals, flight plan, invoices (billing), and other related information are persistent data and stored in a database management system. In order to store data persistently in a database, those entity classes illustrated in class diagram in the analysis model should have to be mapped into tables and the attributes into fields to the respective tables as shown in Figure 5.4.

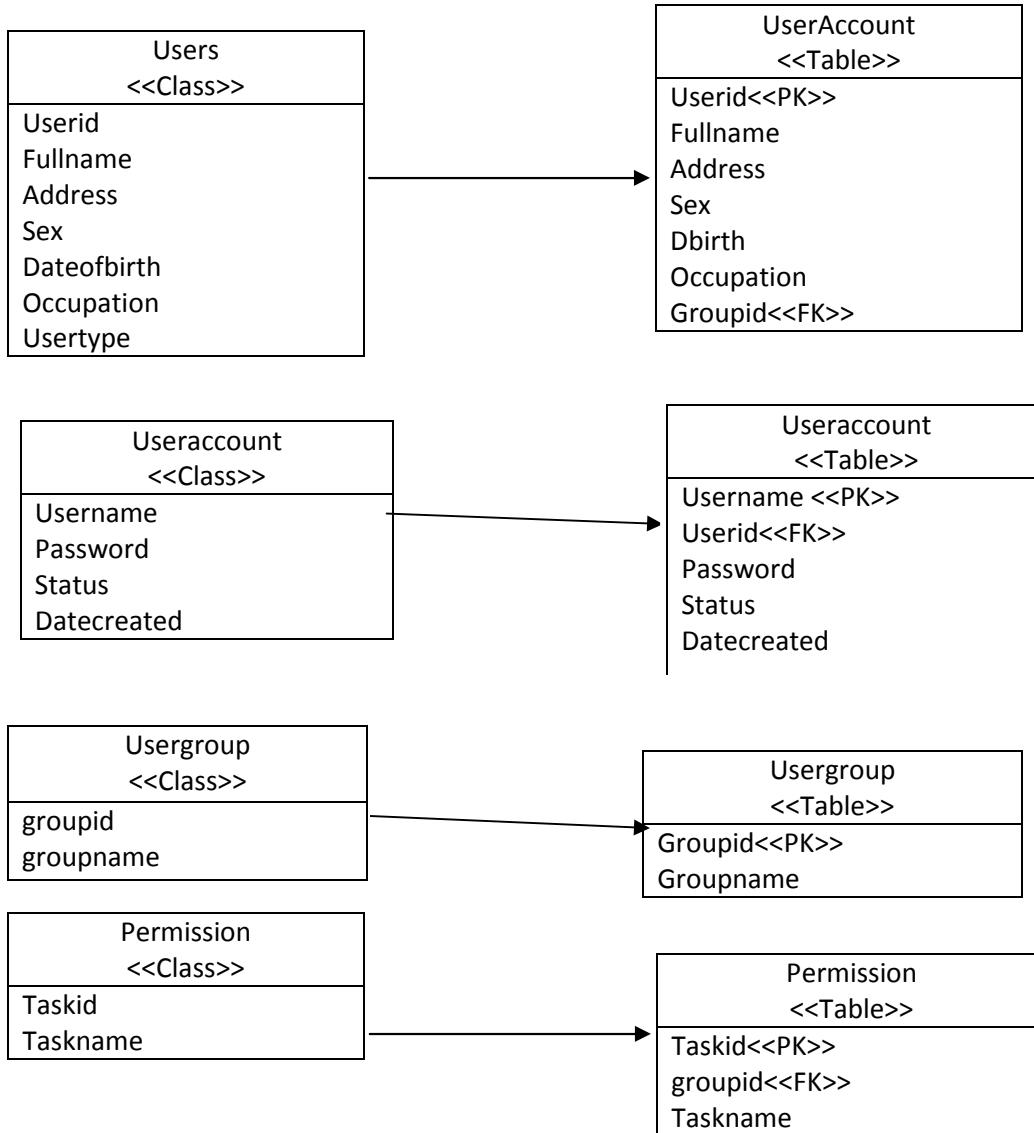


Figure 5.4: Mapping objects into tables

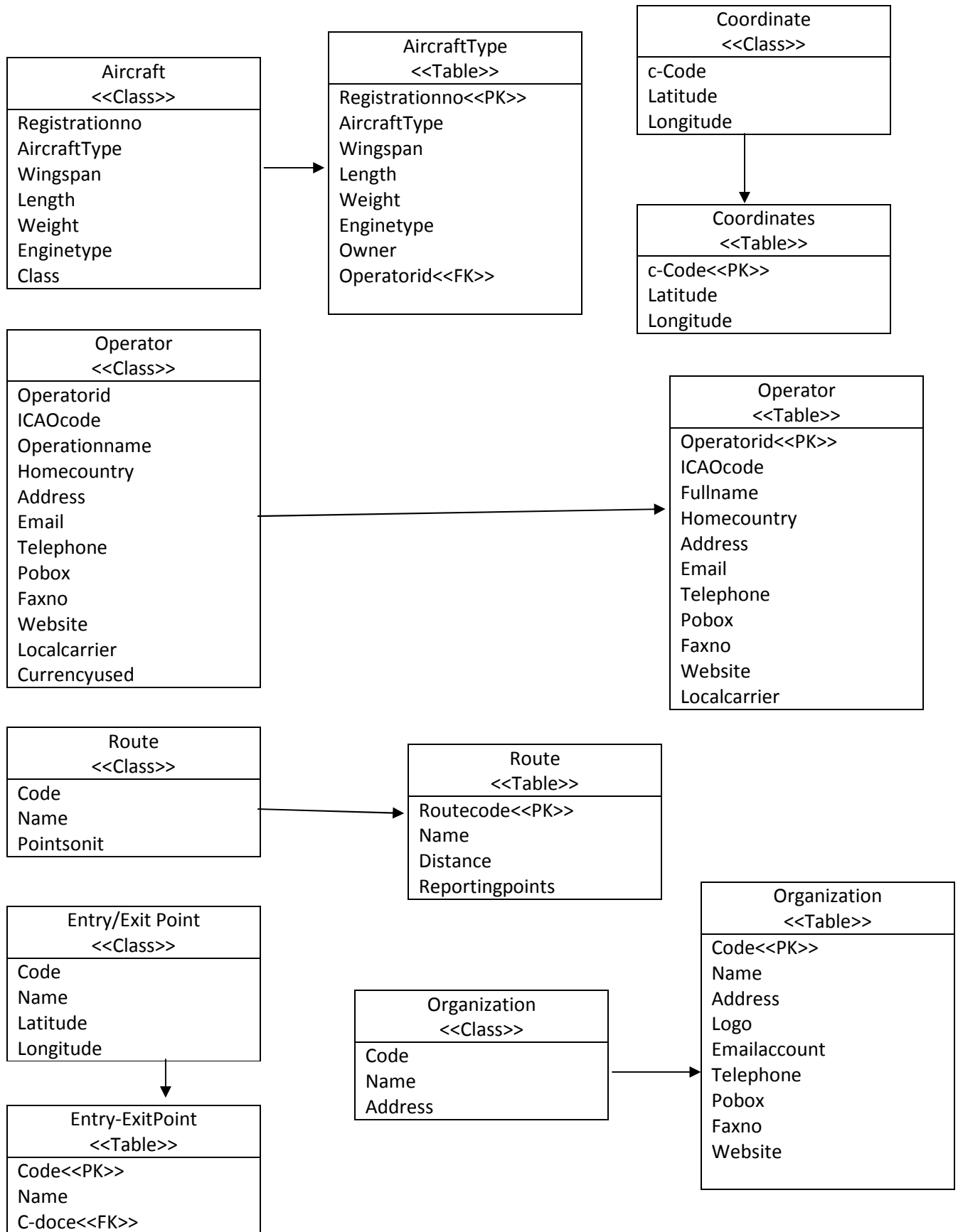


Figure 5.4 (Continued)

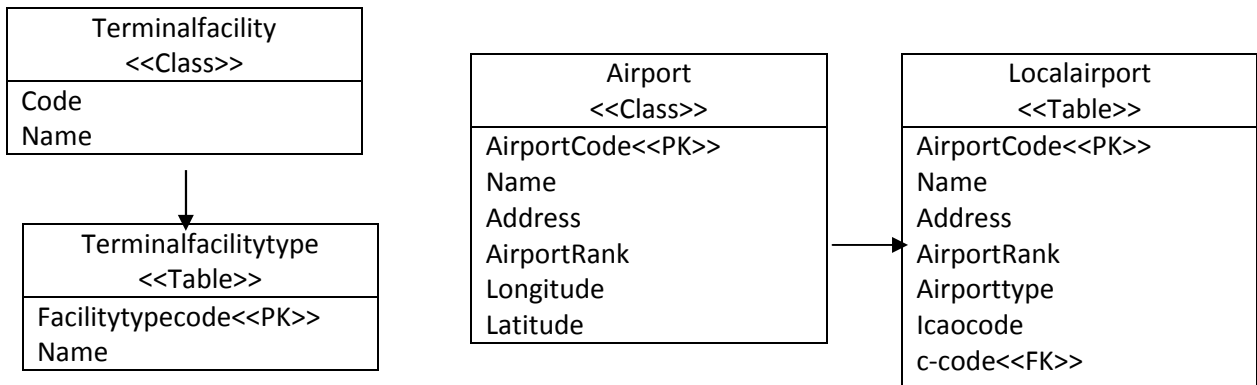
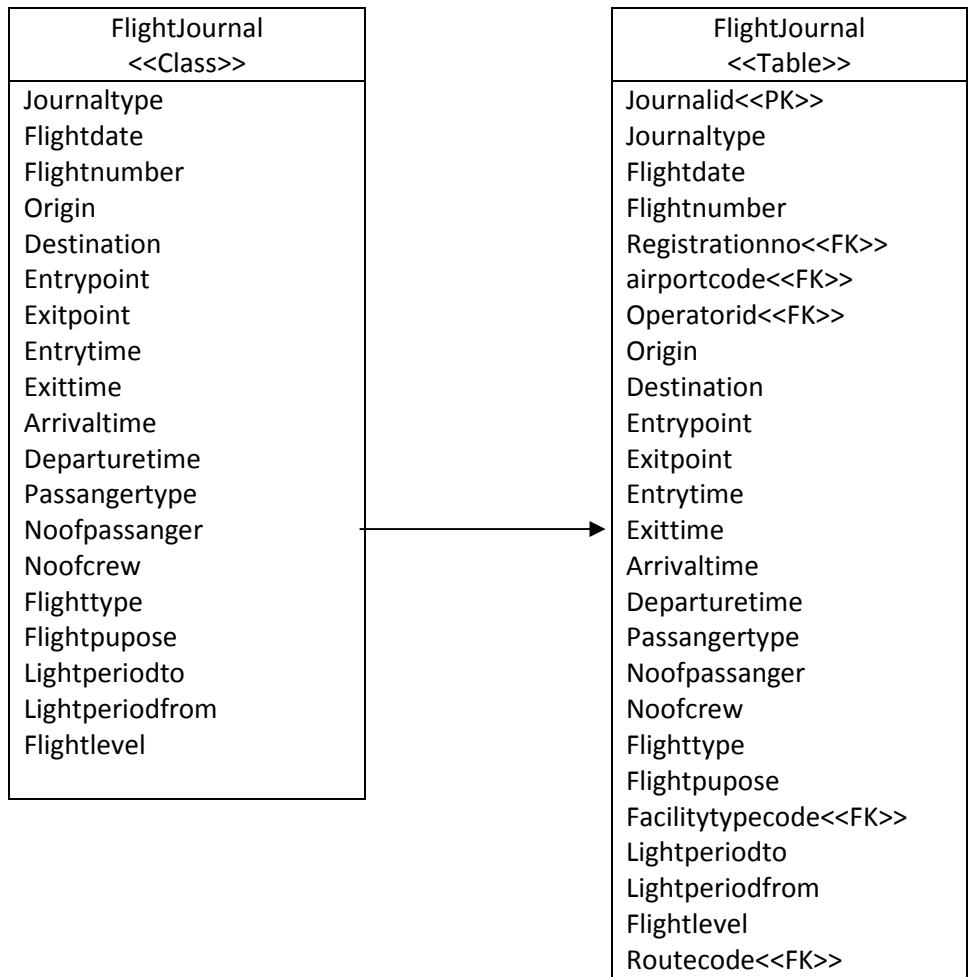


Figure 5.4 (Continued)

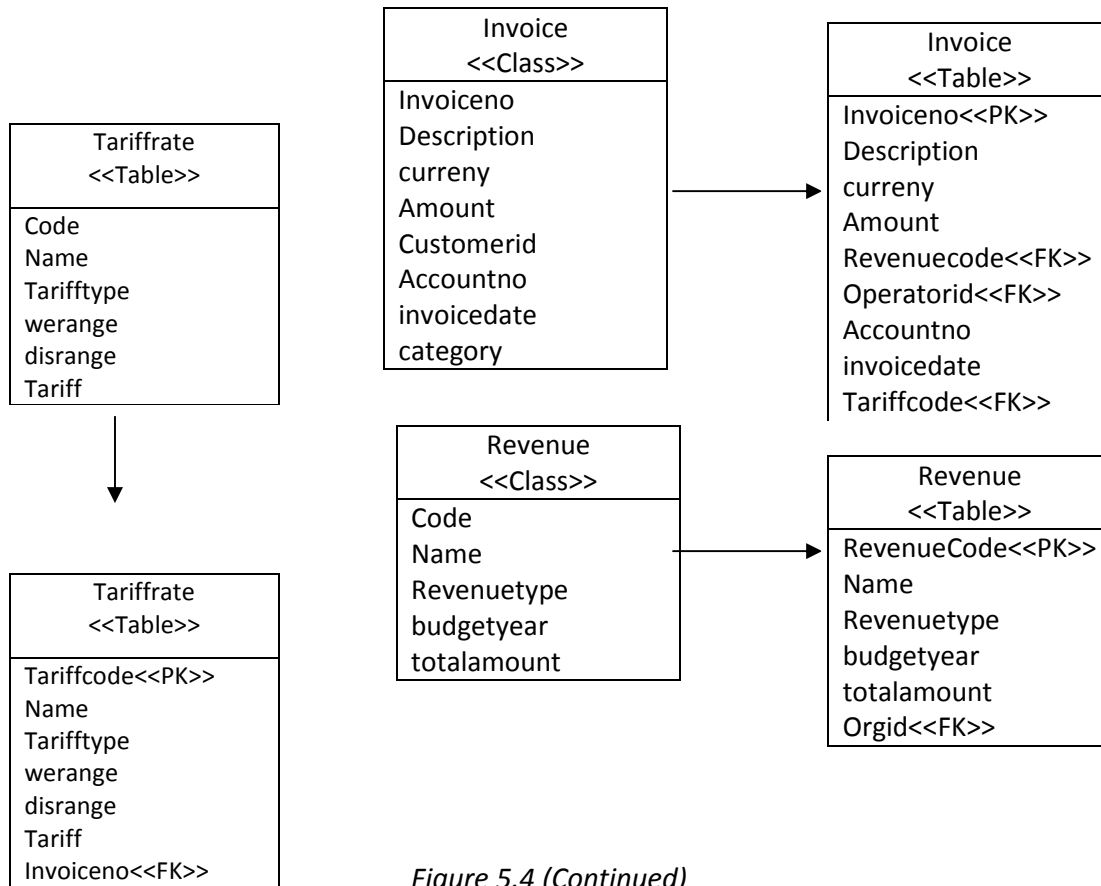


Figure 5.4 (Continued)

5.6 Summary

This section clearly describes about the qualities of our system and its architecture. System decomposition and hardware mapping are also presented under this section. We clearly showed how the persistent data are stored and managed and how classes are mapped to tables and class attributes to fields.

Chapter Six

Implementation

6.1 Tools Used

To develop a prototype which can meet the design goals of the system, various tools have been used. Since our system is web based, we used ASP.NET platform with .NET Framework 2.0. The business logic and code behind pages are defined using C# programming language in the Visual Studio 2005 environment.

In addition,

- Microsoft SQL Server 2005 is used for data storage and management
- We used IIS to make a computer a web server. And we configured IIS together with designed special class to enable secure socket layer security service for some of the system pages
- Cascading Style Sheet is used to manage the site presentations (styles)
- Crystal report is used to design reports
- Microsoft Office Visio 2003 and Microsoft Office Word 2007 are used for documentation.

6.2 The Prototype

As per the design specification of the system, a web application is developed. A screenshot of the major system functionalities along with their description is provided in this section.

User accounts for users of the system should have to be first created by a system administrator and privileged for which component of the system to use. Even though the system provides the same interface for all users, each user is privileged to only access the components assigned by the administrator. So, immediately after each user is authenticated, the system enables or disables menu items of each page by reading tasks assigned to each user group from an access control list. The login page, shown in Figure 6.1, is designed for authentication and opens the home page of the system as shown in Figure 6.2. Any user gets access to the home page and other privileged pages only after successful authentication.

A login form with a pink background. It contains two input fields: "User Name:" and "Password:". Below the fields is a "Login" button.

Figure 6.1: Login form



Figure 6.2: Home page

The home page consists of menus containing links to open different pages. The Home, Change Password, Help and Logoff links are enabled for every user. Other links are only enabled for

authenticated users depending on the privilege set for them by the administrator as we discussed above, otherwise disabled.

As we have proposed in Chapter 4, the system is composed of six major functional components namely System Utility Management, Import Flight Plan, Flight Journal Management, Billing Management, Statistics and Report, and Forecasting. Each component is responsible for assigned tasks and it has its own blocks of codes.

6.2.1 System Utility

This component comprises of account management operations and setup parameters for the system. They are organized under Setup menu as submenu as shown in Figure 6.3, which might be accessible by different privilege level.



Figure 6.3: Menu and sub menu

The accounts sub link opens the manage account form, shown in Figure 6.4, which is in charge of creating user group and accounts, and also enables the administrator to assign permission to user groups.



Figure 6.4: Create user page

This page, including login and change password pages, contains user’s credentials we manage to enable HTTPS protocols so as to secure them over the web. When the user tries to access these pages over unsecured protocol (HTTP channel), the system automatically switches (redirects) to secured HTTPS channel and displays the pages. The system encrypts user password when stored in the database and decrypts when used/accessed.

The setup submenu opens Setup parameters pages, shown in Figure 6.5, which enables a privileged user to setup different parameters of flight journals, all in a single panel as shown in Figure 6.6. The setup menu also contains another submenu that enables the user to set finance related setup parameters such as tariff rates and account codes.

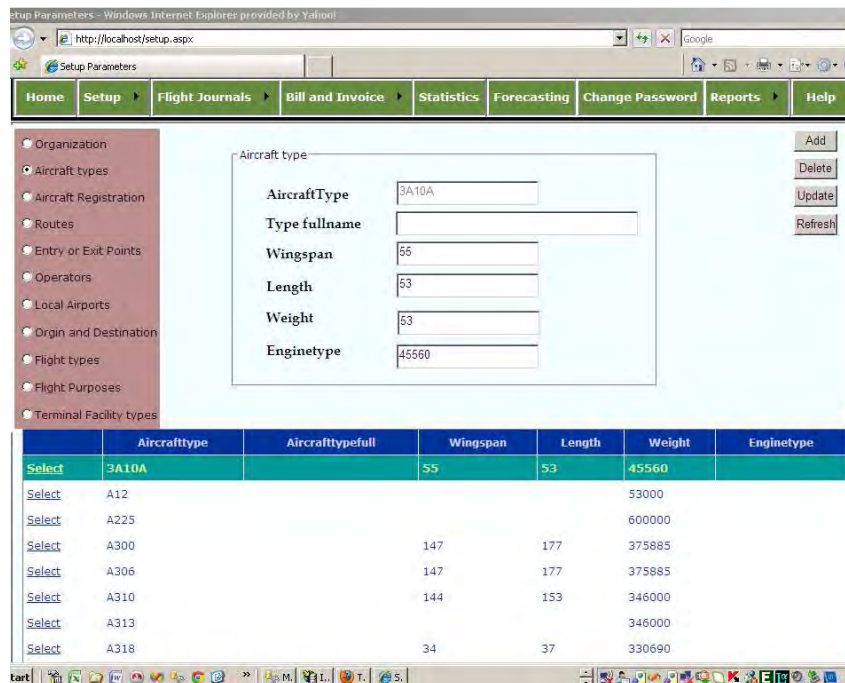


Figure 6.5: Setup lookup parameters page

6.2.2 Import Flight Plan

This component is responsible to import flight plan from Fox Pro flight plan database stored on a separate Ethiopian flight messaging network system. So, this module is managed by a dedicated workstation, which should be plugged to flight messaging network to import flight plan records to a local computer by clicking on “**Import from FP**” button (see Figure 6.6). Again the user should plug the workstation back to the normal network to export the imported records from local database to the FJBS server database by simply clicking on “**Export to FJ**” button. The network configurations for both operations are managed by designed code which sets the

corresponding network IP address and Gateway back and forth automatically. The import flight plan form is shown in Figure 6.6.

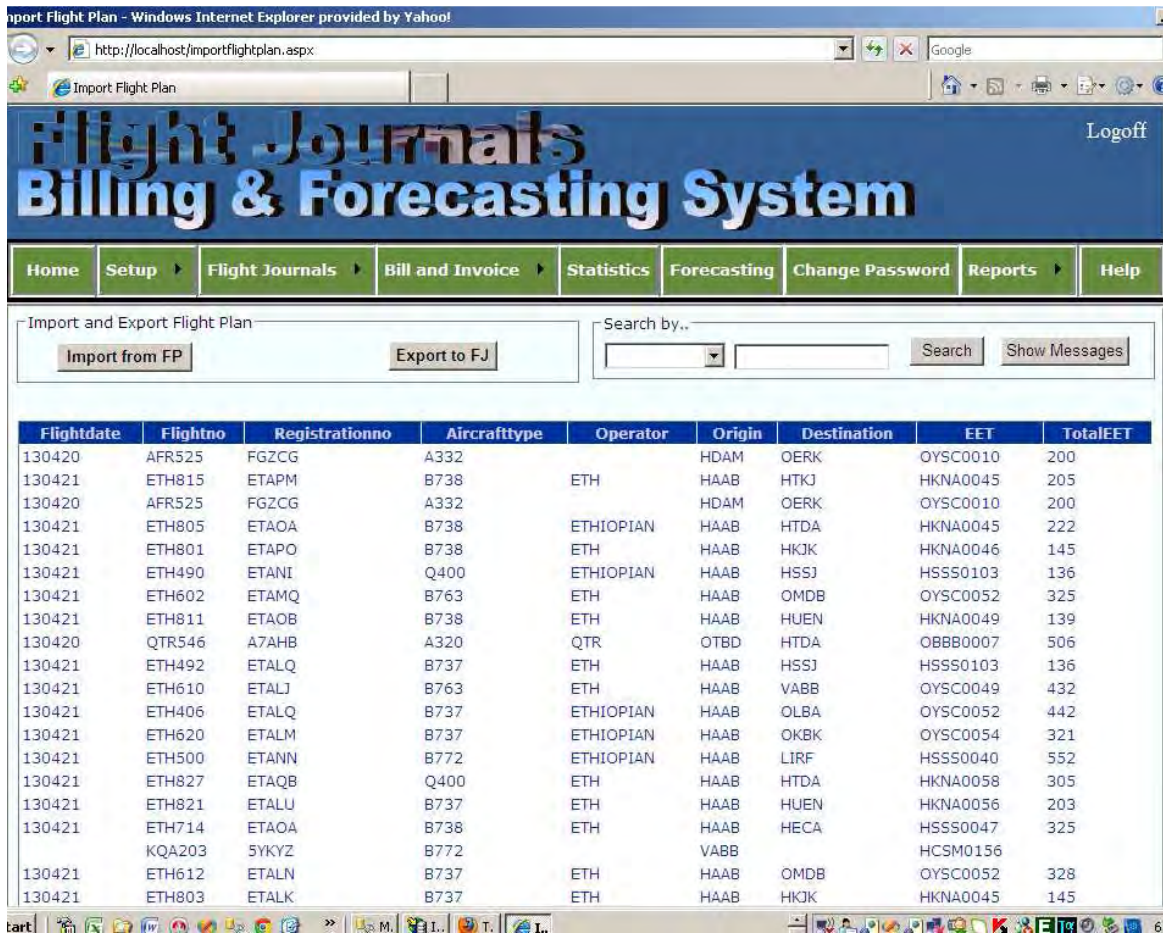


Figure 6.6 Import Flight Plan Form

6.2.3 Flight Journals Management

This module is designed to manage the flight journals used by the system which enables the user either to edit the imported flight plan records or insert new records from scratch. The user should search for flight plan records at the flight date using one of the available search options, and then click on the corresponding flight from the grid to modify/edit and save to the flight journals (as shown in Figure 6.7). If the flight is not available in the imported flight plan records, the user can insert new flight plan entry and click on the Save button. The flight journals data can be edited by clicking on the Edit Journal link, which displays a separate page for journal editing. However, the terminal usage journal has no flight plan associated with it, and hence it is managed by

entering new records from scratch as shown in Figure 6.8. The links to the three flight journals, including Import flight plan, are accessed from Flight journals submenu.

Navigation Journal Entry - Windows Internet Explorer provided by Yahoo!

http://localhost/Navigationjournals.aspx

Navigation Journal Entry

Home Setup Flight Journals Bill and Invoice Statistics Forecasting Change Password Reports Help

Import from flight plan By

Flight Date: 130617 Search Save Edit Journal Refresh

Enter flight date as YYMMDD

Period: Route:

Flight date: NoTG:

Flight no: Entry/Exit point:

Local airport: Arrival time:

Registration no.: Departure time:

Aircraft type: Flight purpose:

Operator: Light from:

Origin: Light to:

Destination: Flight level:

No of Arr/Originating passenger:

No of Transit Passenger: / /

No of Infant Passenger:

No of other Passenger:

Total No Crew:

Total Cargo Freight:

Total Mail Transferred:

	Flightdate	Flightno	Registrationno	Aircrafttype	Operator	Origin	Destination	Froute	Flightlevel	EET	totalEET
Select	130617	KQA321	5YKQB	B733		HSSS				HAAA0056	
Select	130617	ETH921	ETAMF	B763	ETH	HAAB	DGAA			HSSS0046	532
Select	130617	ETH809	ETANP	B772	ETH	HAAB	FAOR			HKNA0042	438
Select	130617	ETH819	ETALM	B737	ETH	HAAB	FQMA			HKNA0044	515
Select	130617	ETH915	ETAPL	B738	ETH	HAAB	FGSL			HSSS0051	410

Figure 6.7: Navigation Journal Page

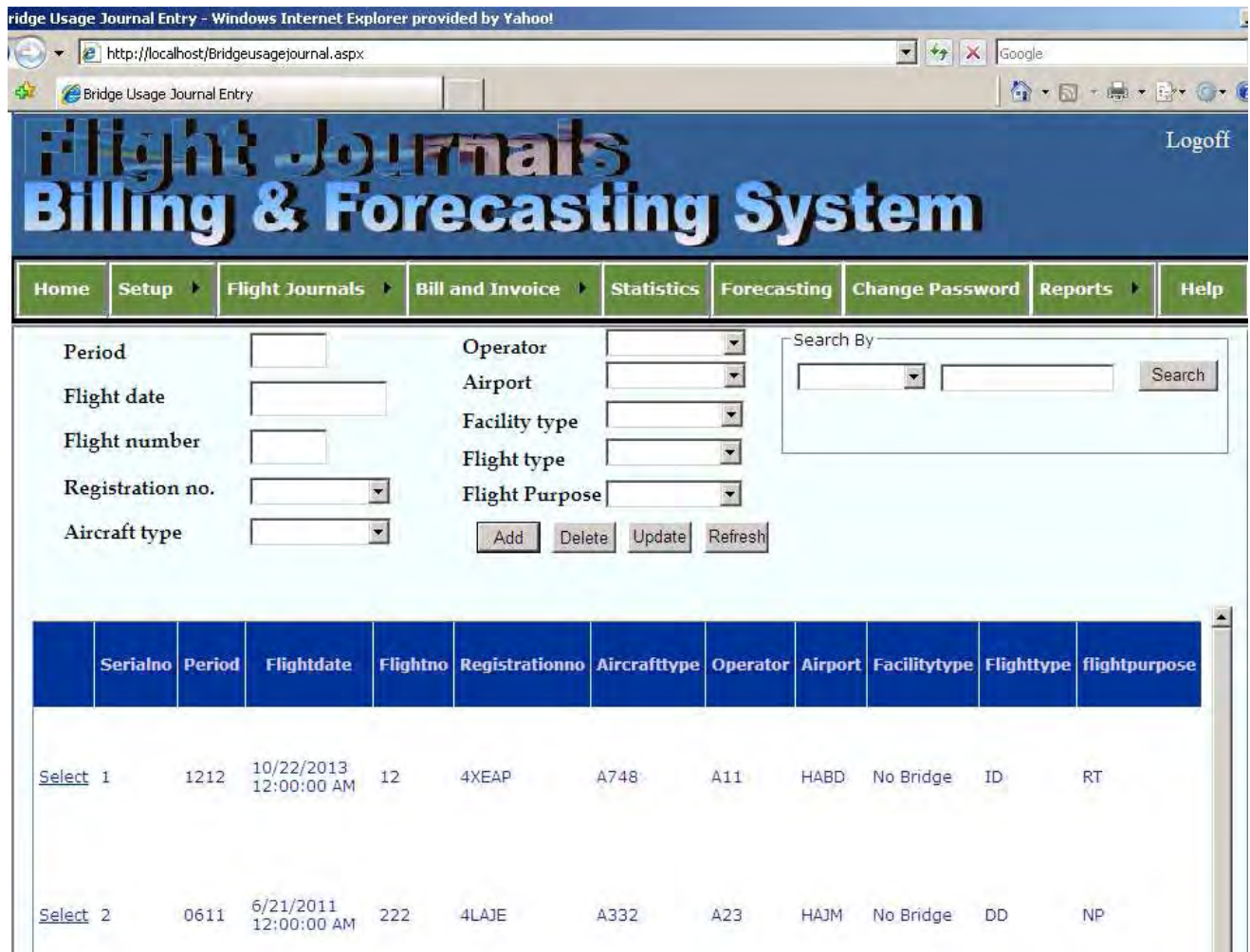


Figure 6.8: Terminal Usage Journal Page

6.2.4 Billing and Invoice Management

This component is designed to generate different billing by flight periods and manage the corresponding invoices by providing features to view, email to customer, print, export to finance, and update status of invoices. The system has the capability to assign consecutive unique invoice numbers for each billing and store the invoice in a database table. Figure 6.9 shows the Navigation Billing page showing invoice with invoice no NC00000874. The other billing pages have similar interface as of the Navigation page except that all have their own business rules. All the billing links are accessed from Bill and Invoice submenu depending on the user privileges. The system can send the invoice to a customer by designed email class as attachment after exporting invoice automatically to a pdf file, while securing (encrypt and decrypt) sender credentials.


Flight Journals Billing & Forecasting System

Logoff

Home Setup Flight Journals Bill and Invoice Statistics Forecasting Change Password Reports Help

Invoice Period <input type="text"/>	Invoice Date <input type="text"/>	Tarrif Rate <input type="text"/>	View invoice by Invoice no <input type="text" value="NC00000874"/>	Reciever Email <input type="text"/>	Invoice status <input type="text"/>	Journal period <input type="text"/>
<input type="button" value="Generate"/>			<input type="button" value="View"/>	<input type="button" value="Send"/>	<input type="button" value="Update"/>	<input type="button" value="Export"/>

Main Report | 100% | BusinessObjects




Ethiopian Civil Aviation Authority
Navigation Charge Invoice

Ethiopian Civil Aviation Authority
P.O.Box 978
Addis Ababa, Ethiopia
Tel. (251) 116650282
Tel. (251) 116650200 ext 237
Fax (251) 116650281
email- caa.revenue@ethionet.et
caa.airnav.@ethionet.et


Customer: A48 Email: Flight Period: June 2011 Invoice No: NC00000874
SUDAN GOVERNMENT Invoice Date: 1/8/2014 Invoice Status: Not paid

S No	Registration No	Aircraft Type	Flight Date	Flight No	Airport	ChargeinUSD	Charge ETB Birr
1	STFSA	L298	06/14/2011	STSFSA	HAAB	32.48	649.60
2	STPRK	AN72	06/22/2011	STPRK	HAAB	81.20	1,624.00
3	STFSA	L298	06/14/2011	STFSA	HAAB	32.48	649.60
4	STPSR	DA50	06/07/2011	STPSR	HAAB	32.48	649.60
5	STPRK	AN72	06/23/2011	STPRK	HAAB	81.20	1,624.00
6	STPSR	DA50	06/08/2011	STPSR	HAAB	32.48	649.60
Grand Total:						292.32	5,846.40

N.B
Please settle this Invoice only by telegraphic transfer to our Bank Account No. 0172094005100 Commercial Bank of Ethiopia, Airport Branch, Addis Ababa within 15 days upon receipt of this invoice and also indicate our specific Invoice ref. No. The total amount does not include the bank service charge which shall be covered by the client.



Prepared By



Authorized By

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Ready




Figure 6.9: Navigation Billing Page

6.2.5 Statistics and Report

This is a component designed to generate different statistical data and reports both in tabular format and/or graphical representation. Screenshots for some of them are shown in Figures 6.10-6.12.

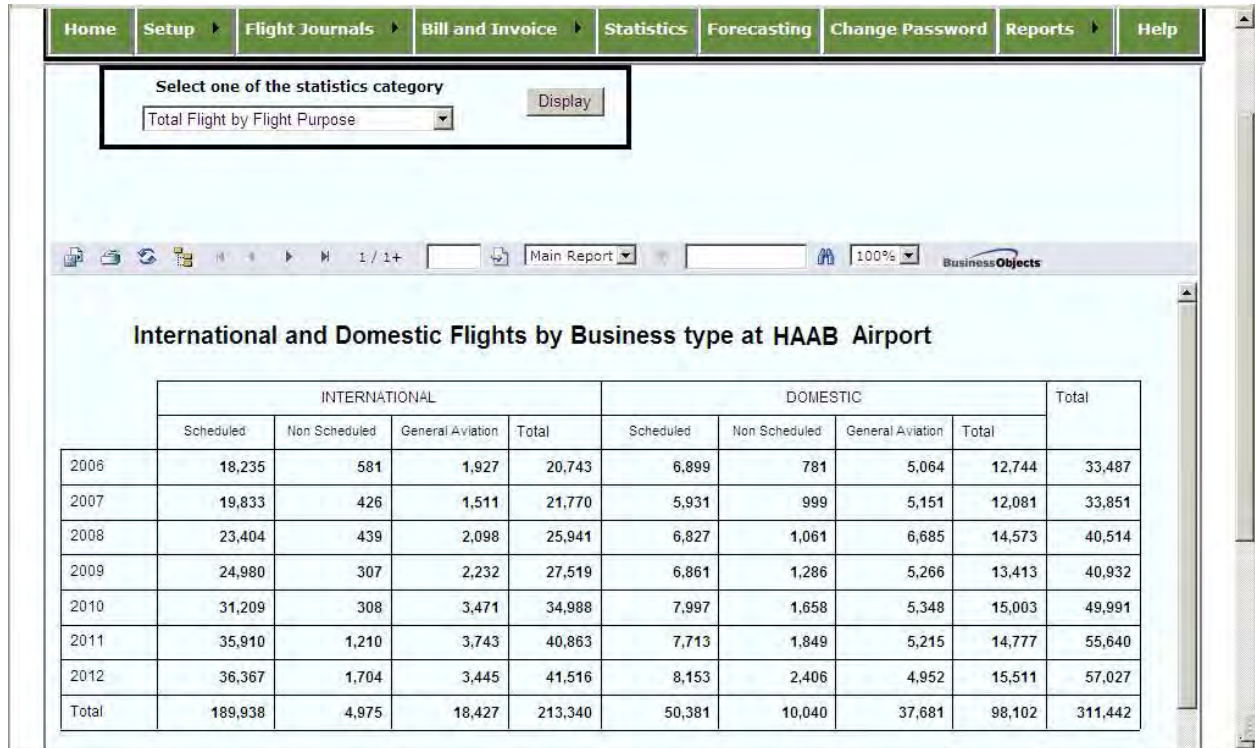


Figure 6.10: Flight Statistics by Business type

International Airports Aircraft Movement Statistics by hours of operation in 2012

	HAAB		HABD		HADR		HAMK	
	Arrival	Departure	Arrival	Departure	Arrival	Departure	Arrival	Departure
2301-2400	26,263	26,601	808	810	2,040	2,025	1,527	1,522
2201-2300	223	1,190	3	1	0	3	0	1
2101-2200	595	2,349	2	2	0	0	0	1
2001-2100	293	2,348	1	5	0	3	0	0
1901-2000	515	1,854	6	40	1	2	0	0
1801-1900	1,456	613	80	77	4	3	0	0
1701-1800	3,568	302	41	82	3	8	0	0
1601-1700	2,141	275	77	5	22	26	0	3
1501-1600	1,112	177	5	5	44	64	11	24
1401-1500	1,060	154	11	55	174	283	24	67
1301-1400	1,104	898	36	86	701	187	246	274
1201-1300	1,278	1,204	97	7	503	455	146	83
1101-1200	1,215	1,369	4	9	480	526	48	50
0901-1000	1,323	1,148	14	22	768	678	120	46
0801-0900	1,031	2,181	21	21	924	400	102	149
0701-0800	1,116	3,658	20	19	610	662	218	63
0601-0700	1,614	3,455	28	183	728	851	56	344

Figure 6.11: Flight Statistics by Hours of Operation at each Year

Home Setup Flight Journals Bill and Invoice Statistics Forecasting Change Password Reports Help

Select one of the statistics category
 Total Flight by Business type [Display]

International Airports Flight Statistics by Business type

	HAAB						HABD						HADR			
	Government	Military	Others	Training	Non-Schedule	Scheduled	Government	Military	Others	Training	Non-Schedule	Scheduled	Government	Military	Others	Training
2012	3,435	18	5	4,939	4,110	44,520	0	2	0	0	74	1,543	667	7	0	5,074
2011	3,738	10	8	5,202	3,059	43,623	0	348	0	3	81	1,783	690	41	0	4,041
2010	3,497	0	42	5,280	1,966	39,206	0	5	1	4	52	2,100	801	21	2	2,017
2009	2,219	0	41	5,238	1,593	31,841	0	3	0	1	22	2,240	931	15	4	885
2008	2,087	0	21	6,675	1,500	30,231	1	12	5	0	50	3,143	880	9	3	1,531
2007	1,518	1	22	5,121	1,425	25,784	1	0	1	50	174	2,861	1,119	1	1	1,321
2006	1,979	9	38	4,965	1,362	25,134	1	65	4	6	56	3,014	1,018	76	0	817

Figure 6.12: Flight Statistics by Year, Airport and Business type

6.2.6 Forecasting

This is another component of the system that enables planners and statisticians to generate forecasted values for the specified year via designed forecasting model. We designed a forecasting model by combining moving average and simple exponential smoothing concepts and call it Hybrid moving average, as shown below.

$$F_t = \frac{Y_{t-1} + \alpha_1(Y_{t-1}) + Y_{t-2} + \alpha_2(Y_{t-2}) + Y_{t-3} + \alpha_3(Y_{t-3}) + Y_{t-4} + \alpha_4(Y_{t-4}) + \dots + Y_{t-n} + \alpha_n(Y_{t-n})}{n}$$

Where

F_t is forecasted value for period t , Y_{t-1} is Last period actual value,

$\alpha_t = \sqrt{(No_of_data + (rowno)^2)/100}$, where No_of_data is the number (length) of available actual data and rowno is the serial no (sequence no) of the actual/forecast value at period t .

We generate 10 years forecast for International Scheduled flights and also evaluated the fitness of our model by calculating R-square as shown in Figures 6.13. And also design and present a line graph showing both the actual and forecast values for the indicated traffic type to elaborate the fitness of our model as shown in Figures 6.14.

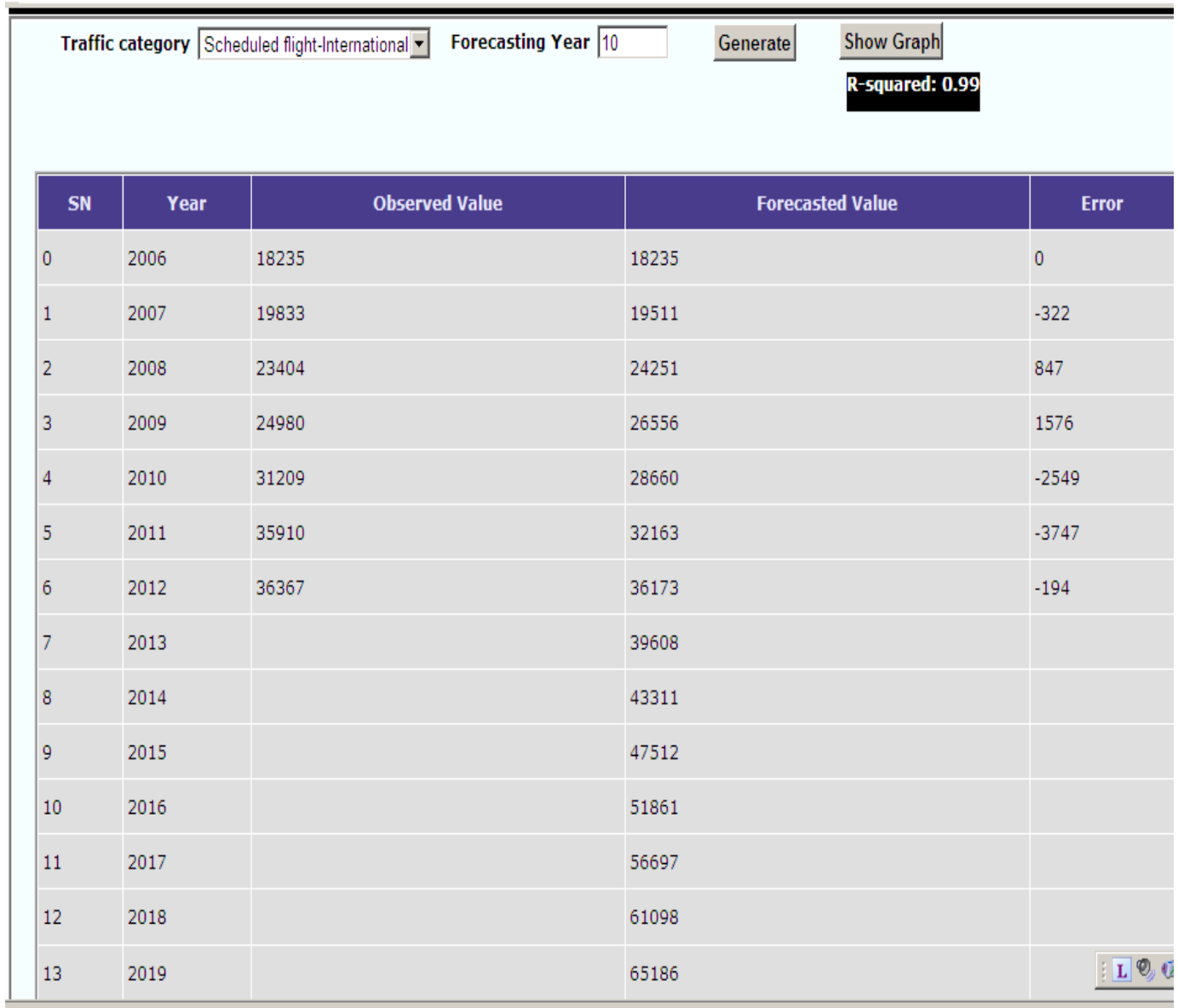


Figure 6.13: 10 Years Forecasted values for International Scheduled flights using 7 years actual data

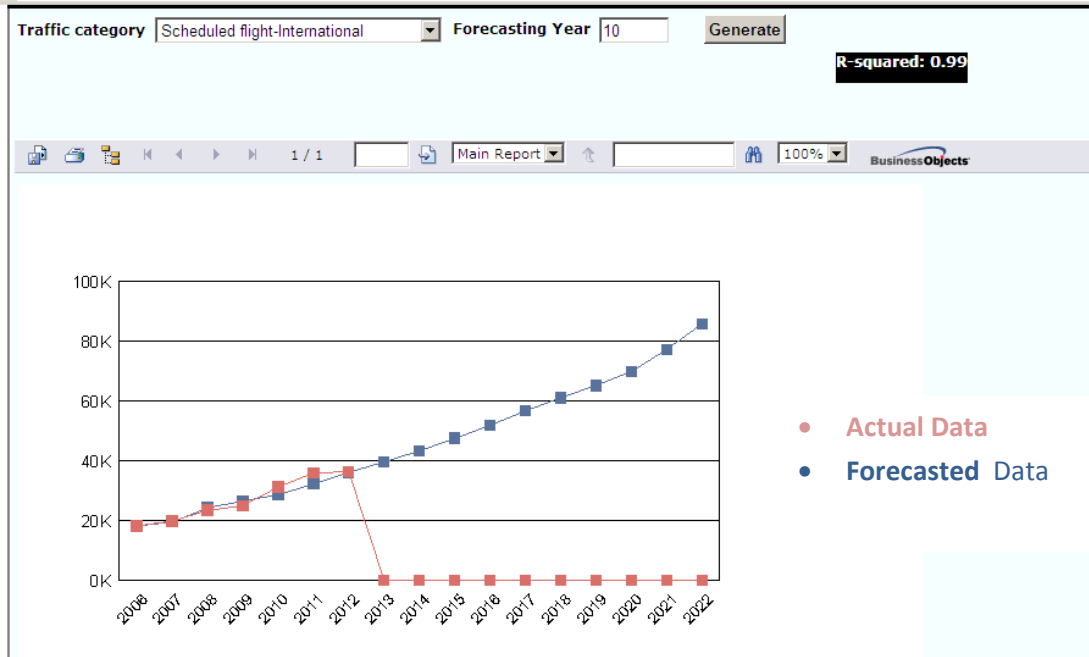


Figure 6.14: Line Graph showing Actual and Forecasted Value for data generated in Figure 6.13

6.3 Usability Testing

We evaluated the developed Web based Flight Journals, Billing, and Forecasting Management System by conducting user acceptance testing which was performed based on the ISO 9241-11 usability testing attributes, such as efficiency (refers to how fast users can accomplish a task while using the system), effectiveness (refers to completeness and accuracy with which users achieve certain goals) and user satisfaction.

In the system evaluation, 3 different types of user's categories are involved. 5 users from finance departments, 4 from Air Traffic controllers, and 3 from statistics and planning department were participated in the testing. Before conducting the testing process, the published system was hosted on ECAA local intranet to enable the users to test the system with actual data. In addition, user manual and system demonstration has been given to each user. Three different questionnaires have been prepared (see Annex B, C, and D) and provided to each respective category of users. A five level Likert scale (strongly agree (5), agree (4), neutral (3), disagree (2) and strictly disagree (1)) is used for the responses of the questions. The summary of each user's category response is given below in Tables 6.1 – 6.3.

Table 6.1 Detailed summary of questionnaire result (Finance group)

Qn no	Strongly agree	Agree	Neutral	Disagree	Strongly disagree	Mean
1	3	2	0	0	0	4.6
2	2	2	0	1	0	4
3	1	2	1	1	0	3.6
4	4	1	0	0	0	4.8
5	3	1	1	0	0	4.4
6	1	2	1	1	0	3.6
7	4	0	1	0	0	4.6
8	5	0	0	0	0	5
9	4	1	0	0	0	4.8
10	5	0	0	0	0	5
11	3	2	0	0	0	4.6
Overall usability (%) : 89.1%						

Table 6.2 Detailed summary of questionnaire result (ATC group)

Qn no	Strongly agree	Agree	Neutral	Disagree	Strongly disagree	Mean
1	4		0	0	0	4
2	4	0	0	0	0	4
3	3	1	0	0	0	3.8
4	3	0	1	0	0	3.6
5	4	0	0	0	0	4
6	4	0	0	0	0	4
7	2	2	0	0	0	3.6
8	1	3	0	0	0	3.4
9	3	1	0	0	0	3.8
10	4	0	0	0	0	4
Overall usability (%) : 95.5%						

Table 6.3 Detailed summary of questionnaire result (Statistician and planner group)

Qn no	Strongly agree	Agree	Neutral	Disagree	Strongly disagree	Mean
1	2	1	0	0	0	2.8
2	2	1	0	0	0	2.8
3	1	2	0	0	0	2.6
4	2	1	0	0	0	2.8
5	1	2	0	0	0	2.6
6	1	2	0	0	0	2.6
7	3	0	0	0	0	3
8	2	1	0	0	0	2.8
9	3	0	0	0	0	3
10	3	0	0	0	0	3
Overall usability (%) : 93.3%						

The result of the evaluation has shown that the FJBFMS is easy to use, efficient, effective, accurate, and can save time of professionals.

6.4 Summary

As we have stated above, all proposed functionalities are designed and implemented. We used seven years navigation and over flight actual data for testing of billing, statistics, and forecasting modules. Again, the security is implemented with Secure Socket Layer (SSL) protocol by testing with self generated certificate authority. Moreover, we encrypt connection string in web.config file, user passwords stored in a table, and email passwords to protect both from insider and outsider hackers. We also implemented security at low level by defining access control matrix for each actor and the corresponding class access right. In addition to advanced statistical analysis that might be accessible by different stake holders via web, we have also implemented advanced reports that undergo deep analyses on the flight journals for:

- billable but not invoiced flights;
- planned but unregistered flights;
- flied but unplanned flights;
- invoiced but not paid flights;
- duplicate flights;
- single trip (orphan) flights; and
- unusual paired flight plan (arrive-depart) flights so as to enable the concerned officers to take appropriate actions.

Most of the businesses rules such as billing calculations, identifying paired flights, flight type identification, calculating flight distance from geometric coordinates, generating consecutive invoice number, and others are implemented on the database's stored procedure and/or scalar value functions so as to tune up system performance and also to prevent SQL injection attack.

Chapter Seven

Conclusion and Future Works

7.1 Conclusion

In this project, we developed a web based Flight journal management and Airport Billing system for Ethiopia which also has features for producing different statistical and flight analyses and able to forecast flight traffic in the future using past data in the database. In our system, we implemented the flight information, passenger information, cargo freight, and mail transfer data of all flights of all airports to be managed and billed by a single central journal so as to totally eliminate the time wasted by the Ethiopian civil aviation and Ethiopian airport organizations different departments. Even the Air Traffic Controllers, who manage flight journals, also save their times as our system is designed to import flight plan data to their screen for minor modification and update; a feature which was not so far designed and implemented by any billing system of flight journals in any of the literature review we have reviewed.

To realize the feasibility and validity of the proposal, object oriented software engineering is used to develop the prototype. Accordingly, the requirements identified are analyzed and structured using application domain modeling. Then to achieve the requirements, centralized client/server architecture is selected. Then design goals are inferred from the non functional requirements set during the requirement analysis. Then the solution domain is modeled to achieve what the clients anticipate. Finally, the solution domain model is mapped to a source code to provide a web application which can be accessed via the Internet, using Visual Studio 2005, ASP.NET, C#, and SQL Server 2005 Database. The system in general contains six major components namely: Flight plan importing, Flight Journal Preparation, Billing and Invoice management, Statistics and Report, Forecasting, and Utility management. We evaluated our system through a questionnaire which is prepared by considering the ISO 9241-11 usability test standard attributes. The results of the evaluation have shown that our system is easy to use, efficient, effective, accurate, and can save time of professionals.

In General, in addition to the unique features stated under Related Work (Chapter three) we proposed to implement, we have designed and implemented high security scheme, SSL and cryptography, to prevent user credentials information from eavesdroppers.

7.2 Future Works

We have implemented all of the functional requirements required and defined for the system. However we identified, as future work, Flight Monitoring System that integrates radar information and flight plan information so as to monitor actual flight operation and precise flight journal production and hence provide Air Traffic Controllers good decision-making information.

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ANNEX A

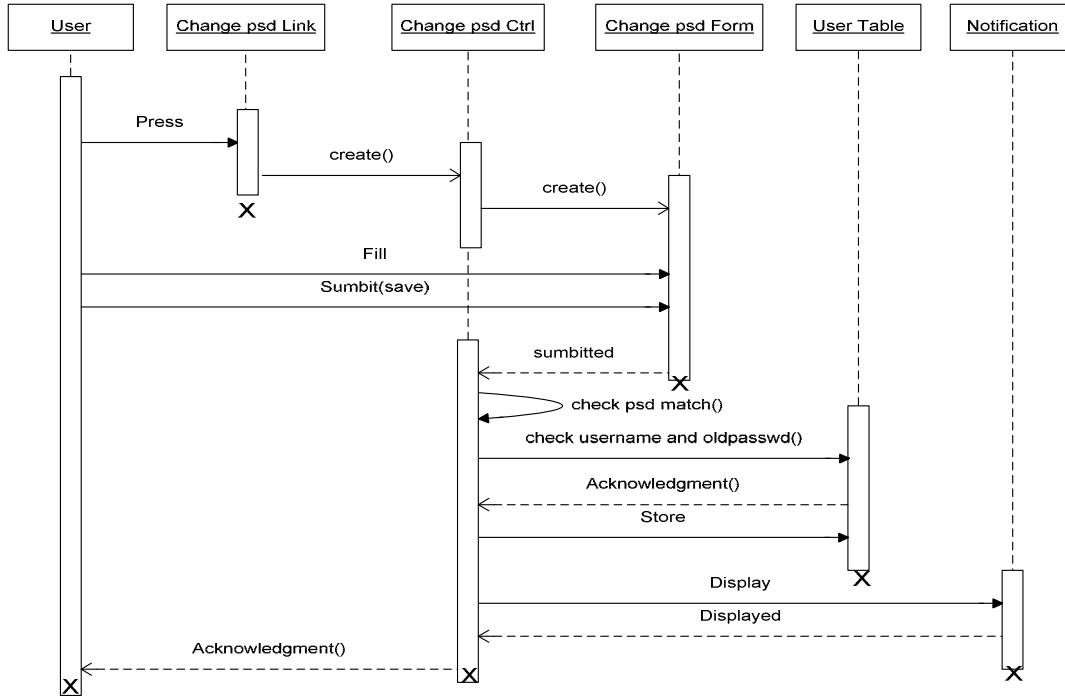


Figure A.1: Change password sequence diagram

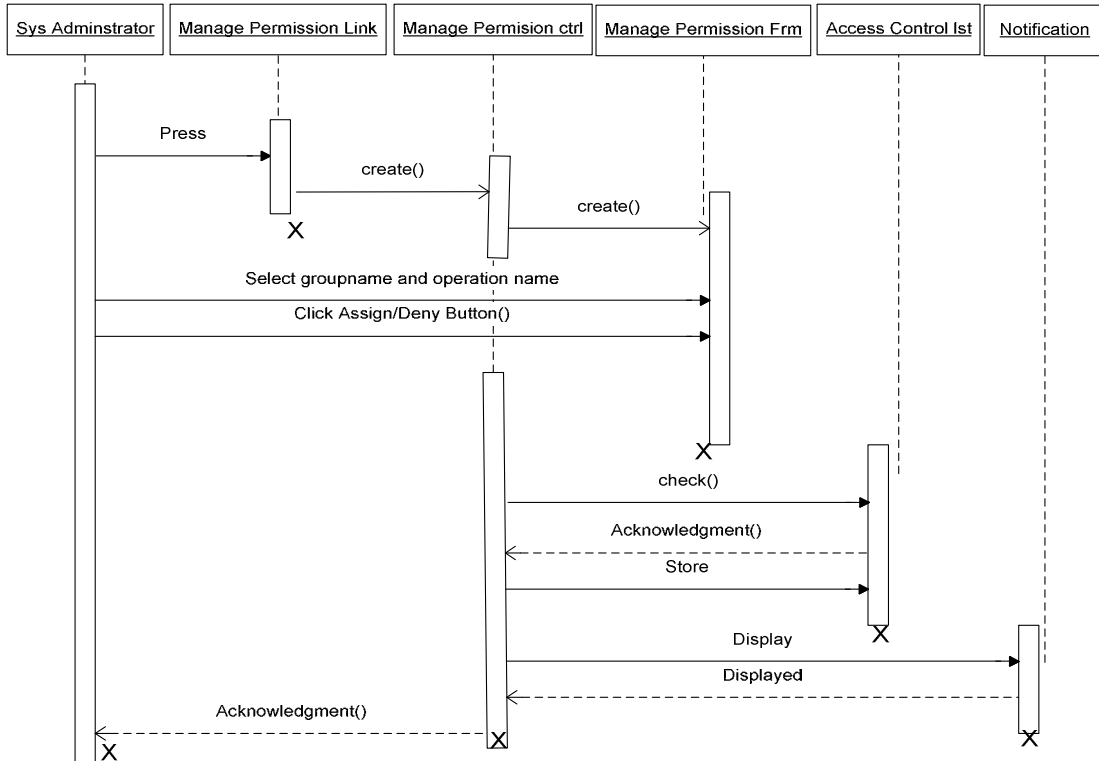


Figure A.2: Assign/Deny operations sequence diagram

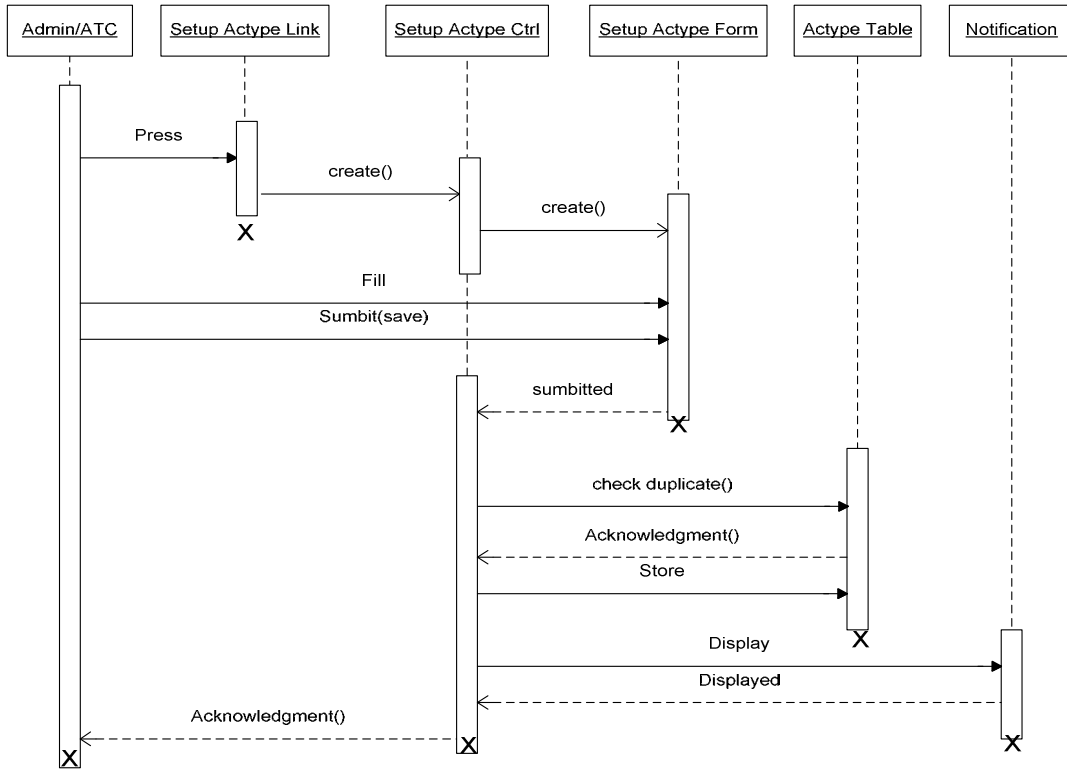


Figure A.3: Setup Aircraft types sequence diagram

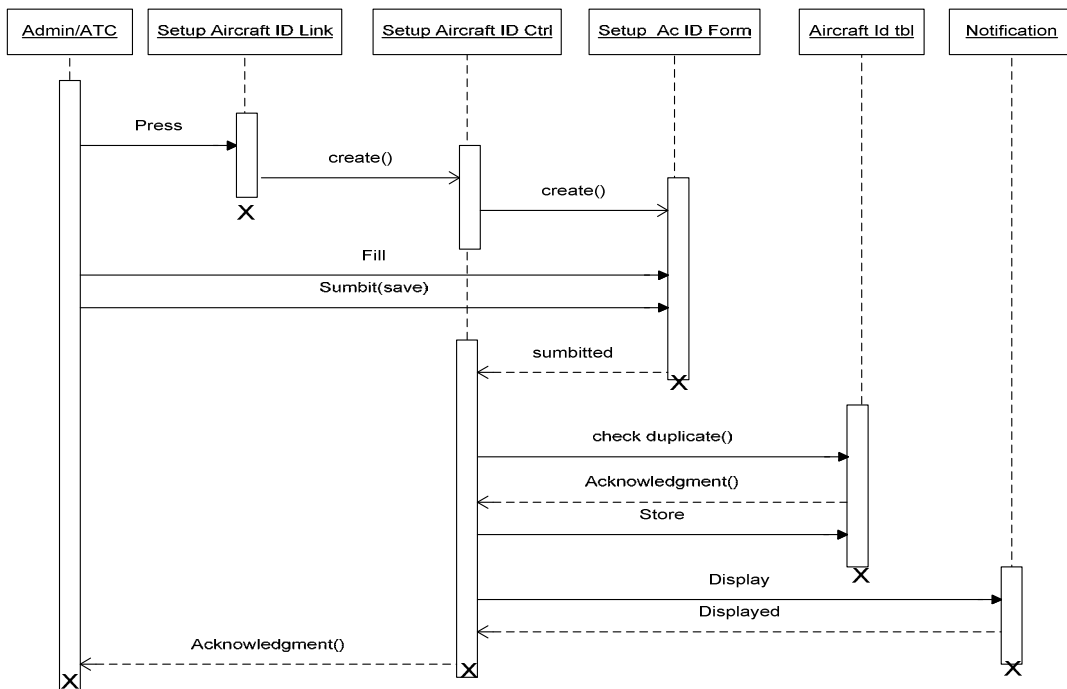


Figure A.4: Setup Aircraft ID sequence diagram

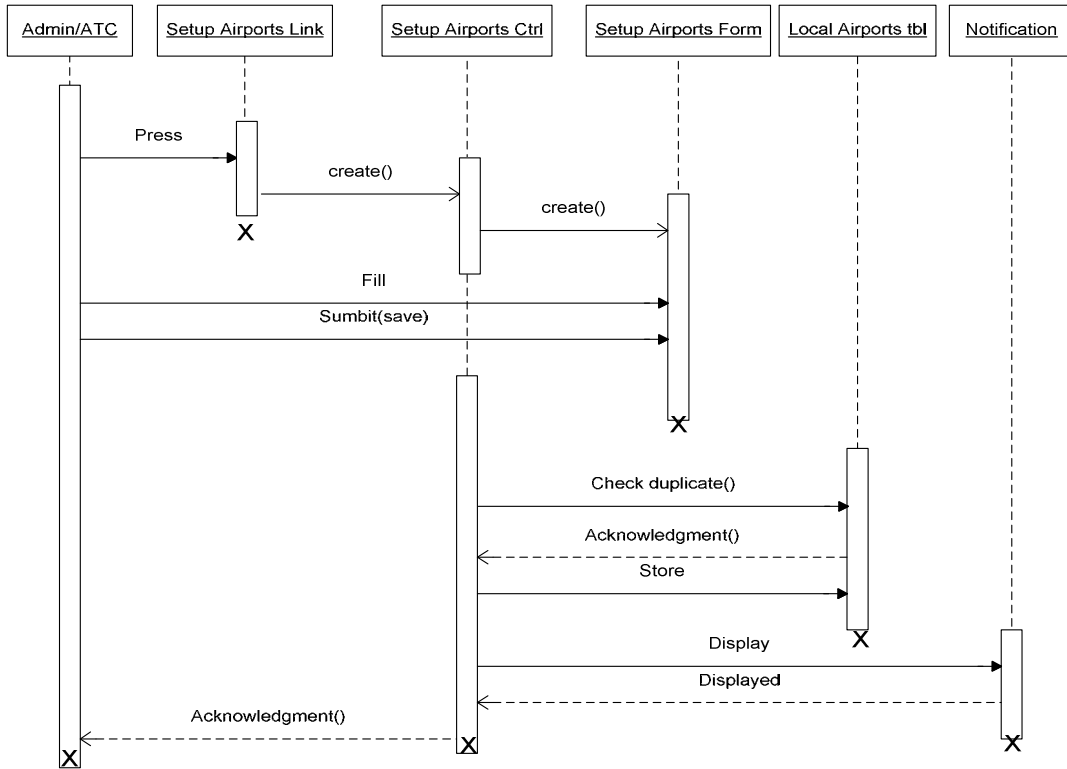


Figure A.5: Setup Local Airports sequence diagram

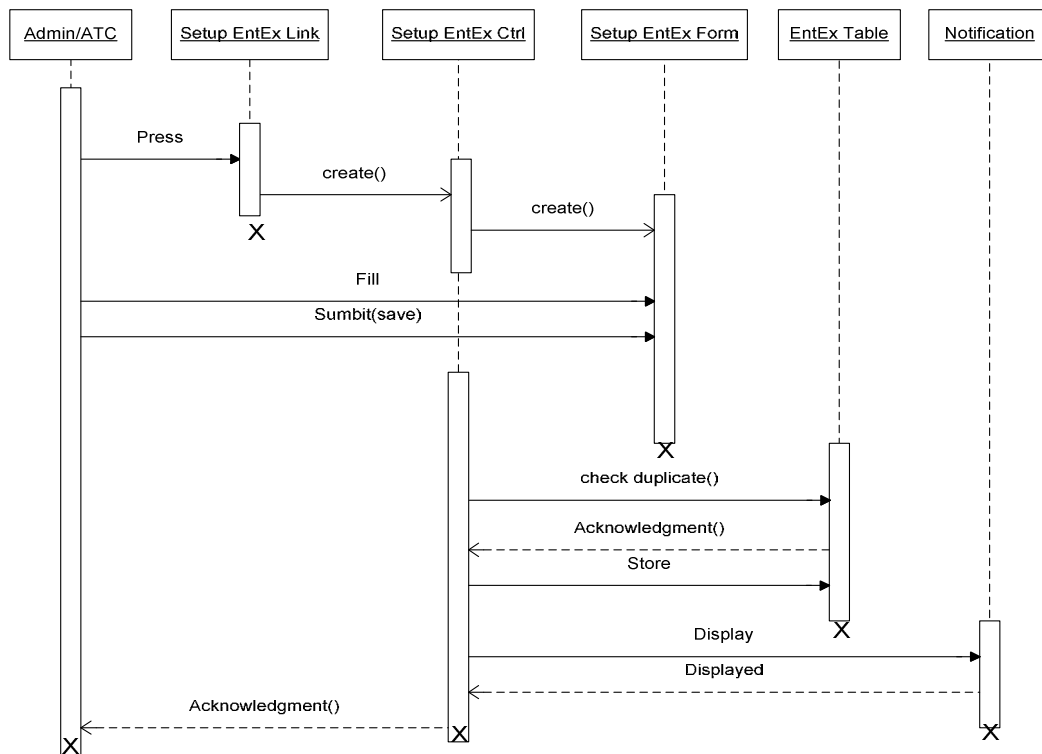


Figure A.6: Setup Entry/Exit points sequence diagram

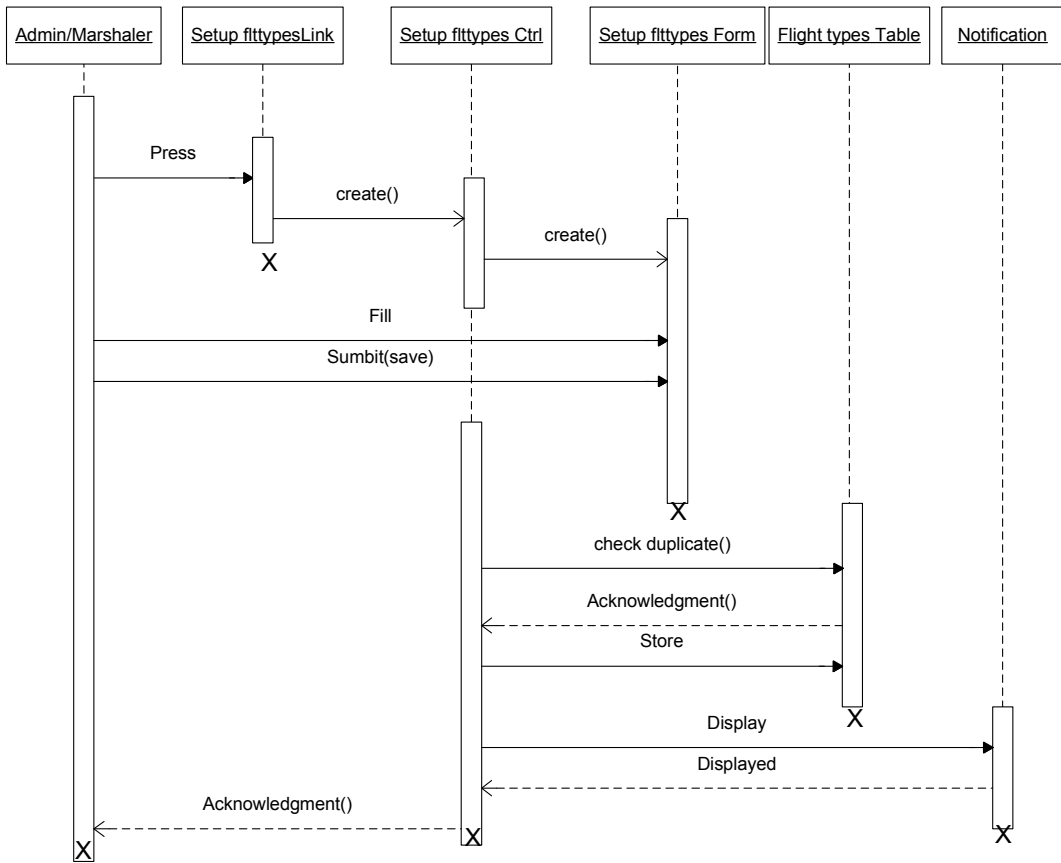


Figure A.7: Setup Flight types sequence diagram

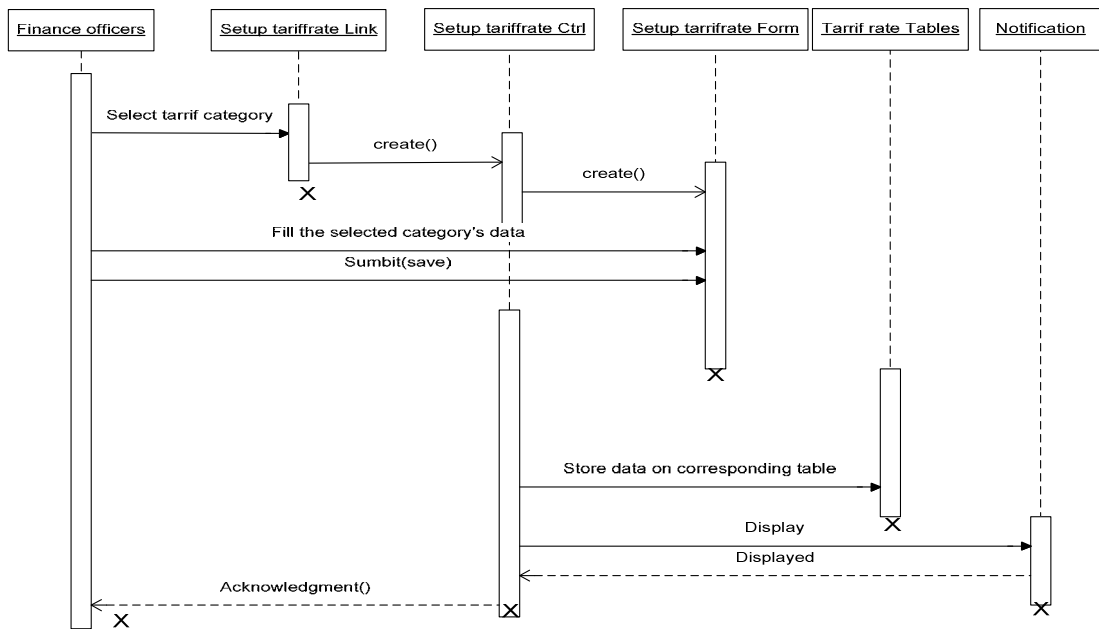


Figure A.8: Setup Tariff rates sequence diagram

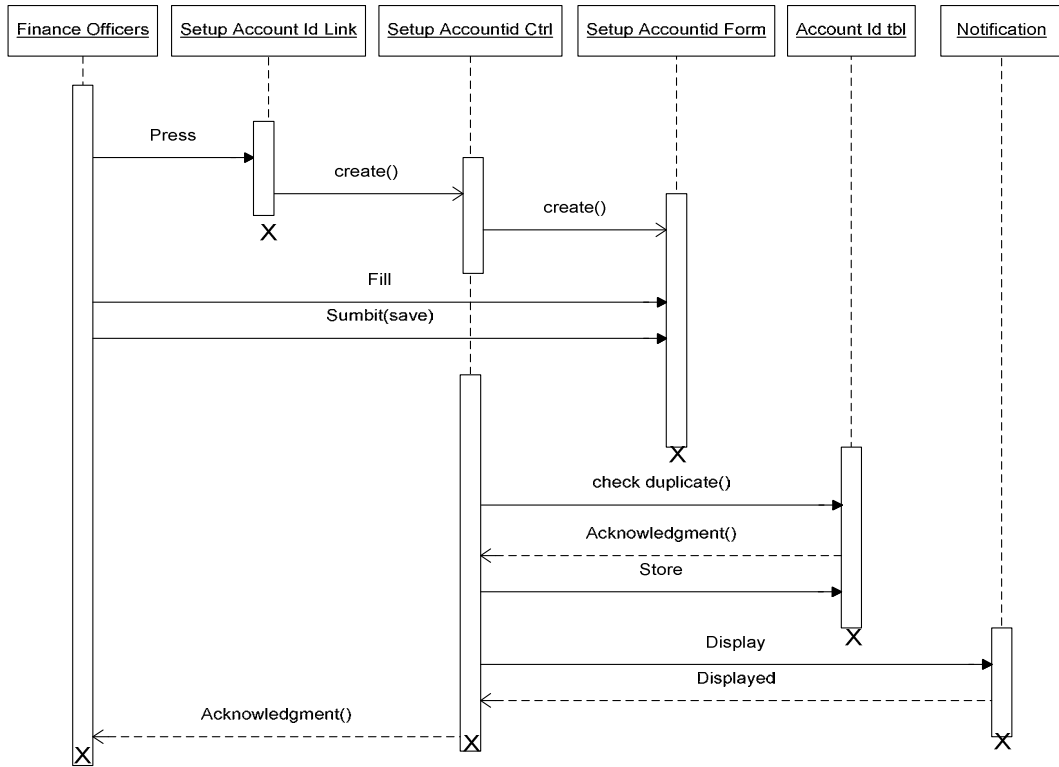


Figure A.9: Setup Finance Account Id sequence diagram

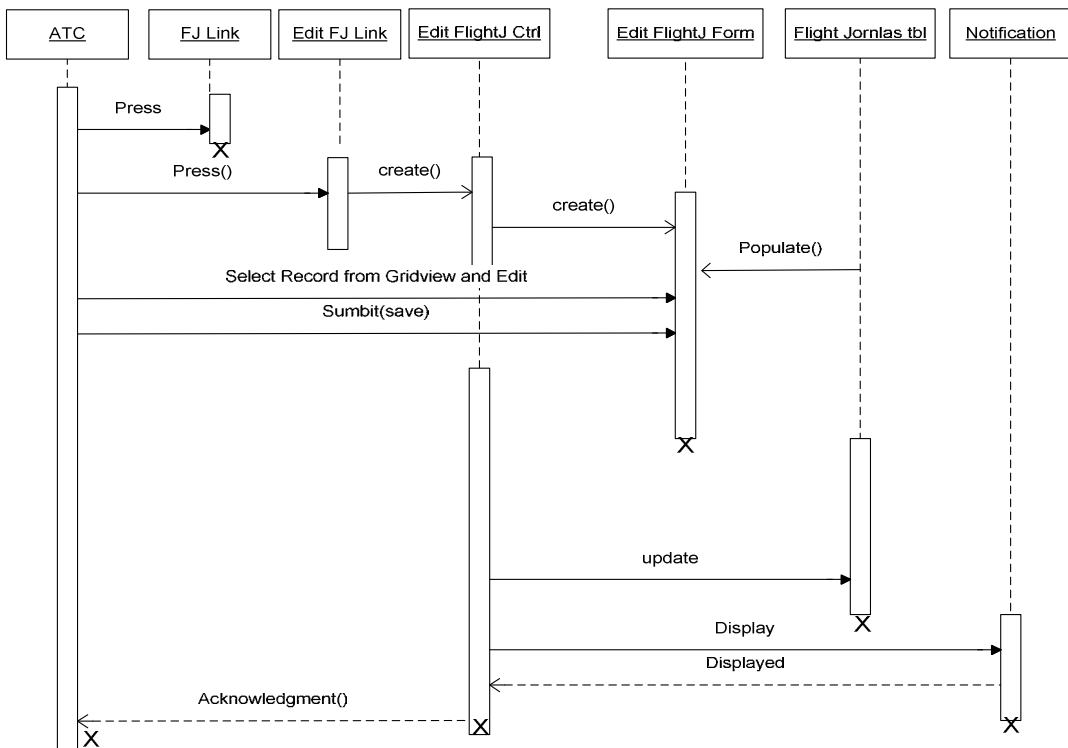


Figure A.10: Edit Flight Journals sequence diagram

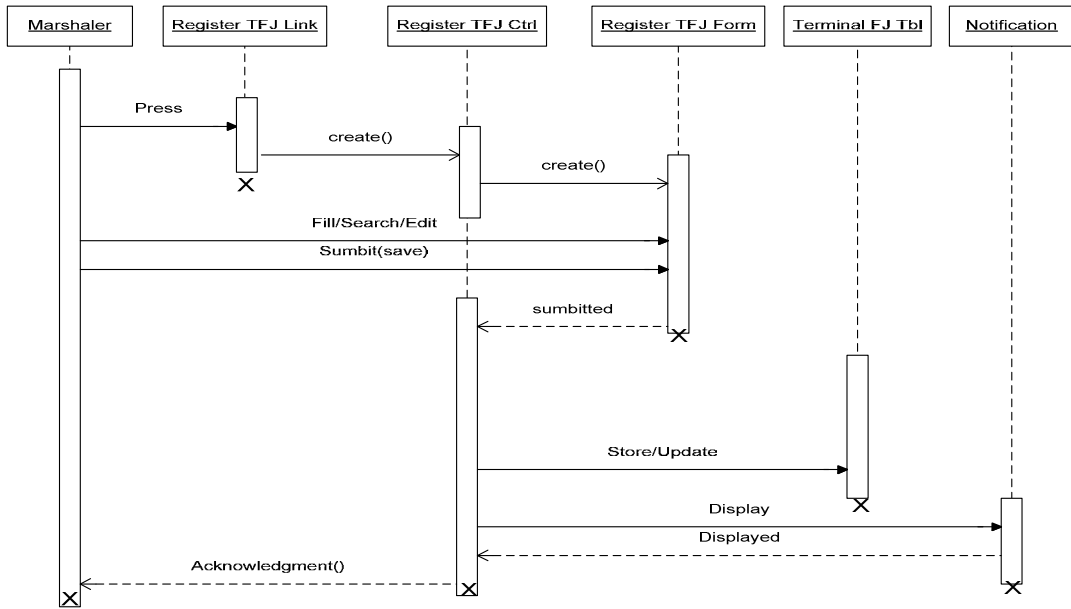


Figure A.11: Register Terminal Facility Journals sequence diagram

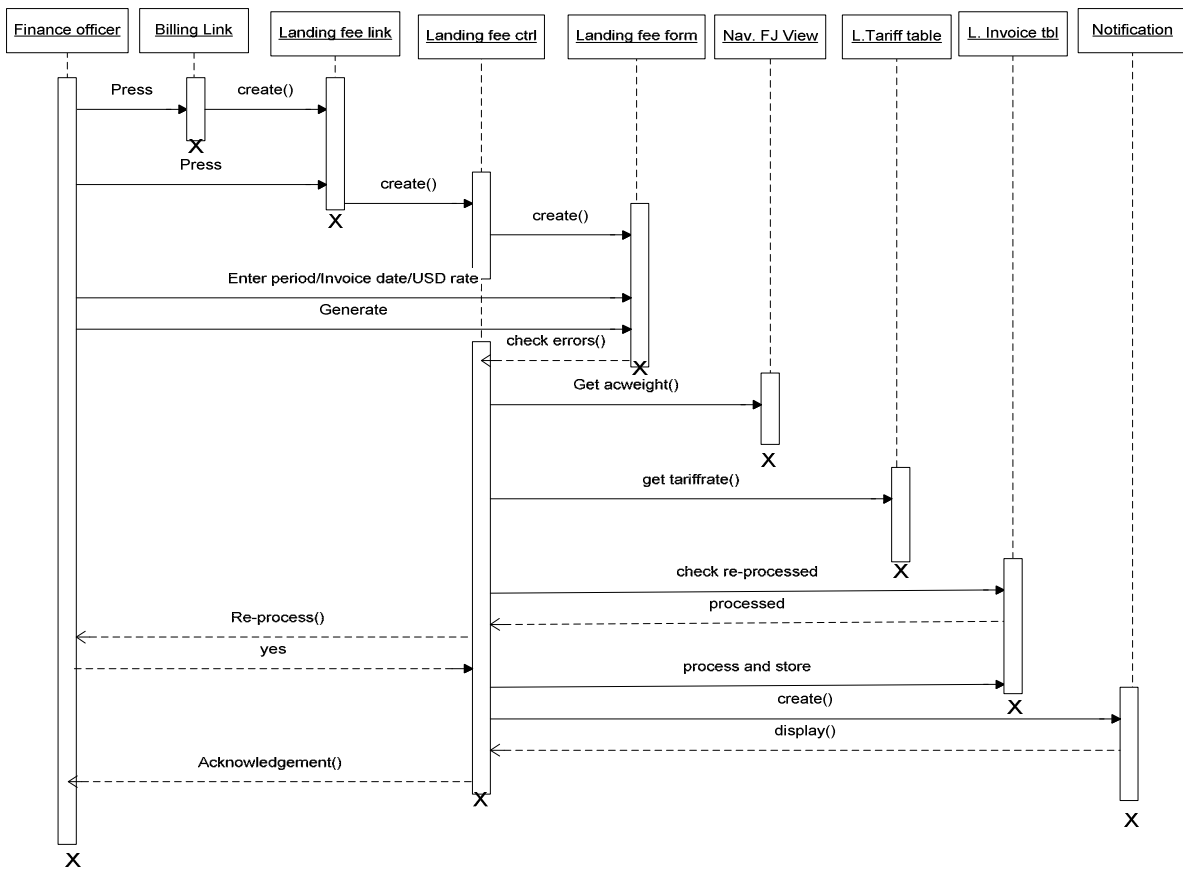


Figure A.12: Process Landing Billing sequence diagram

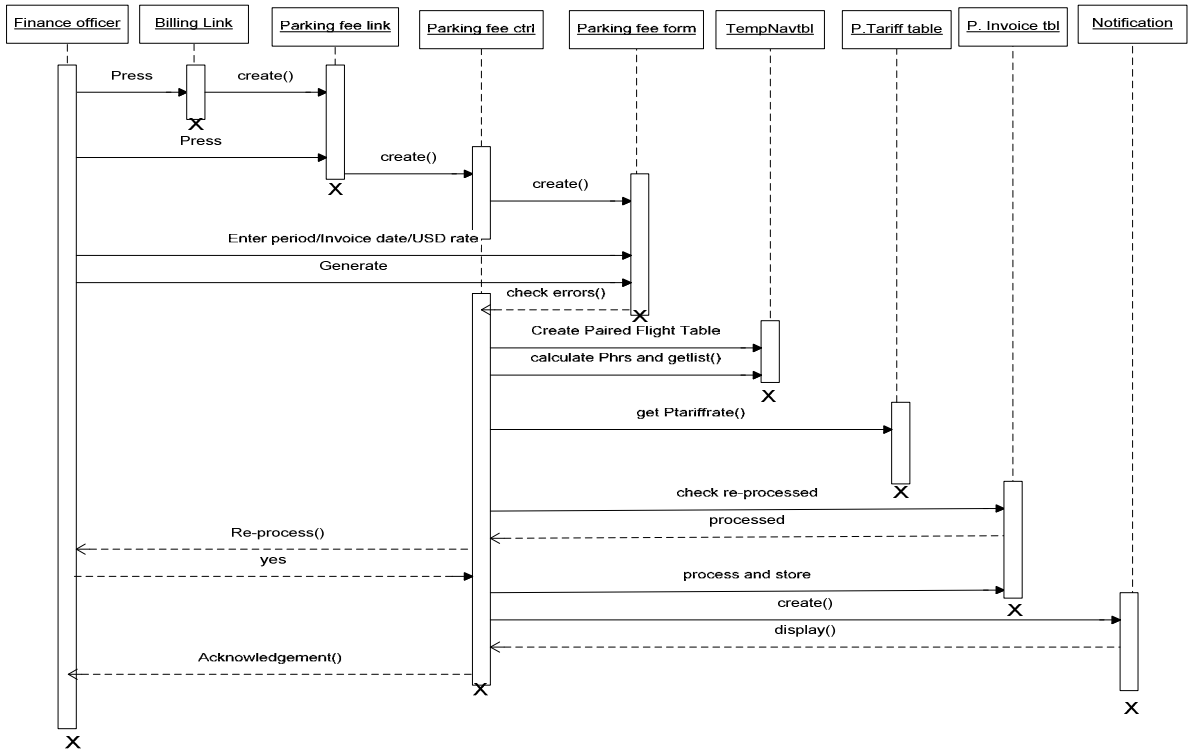


Figure A.13: Process Parking Billing sequence diagram

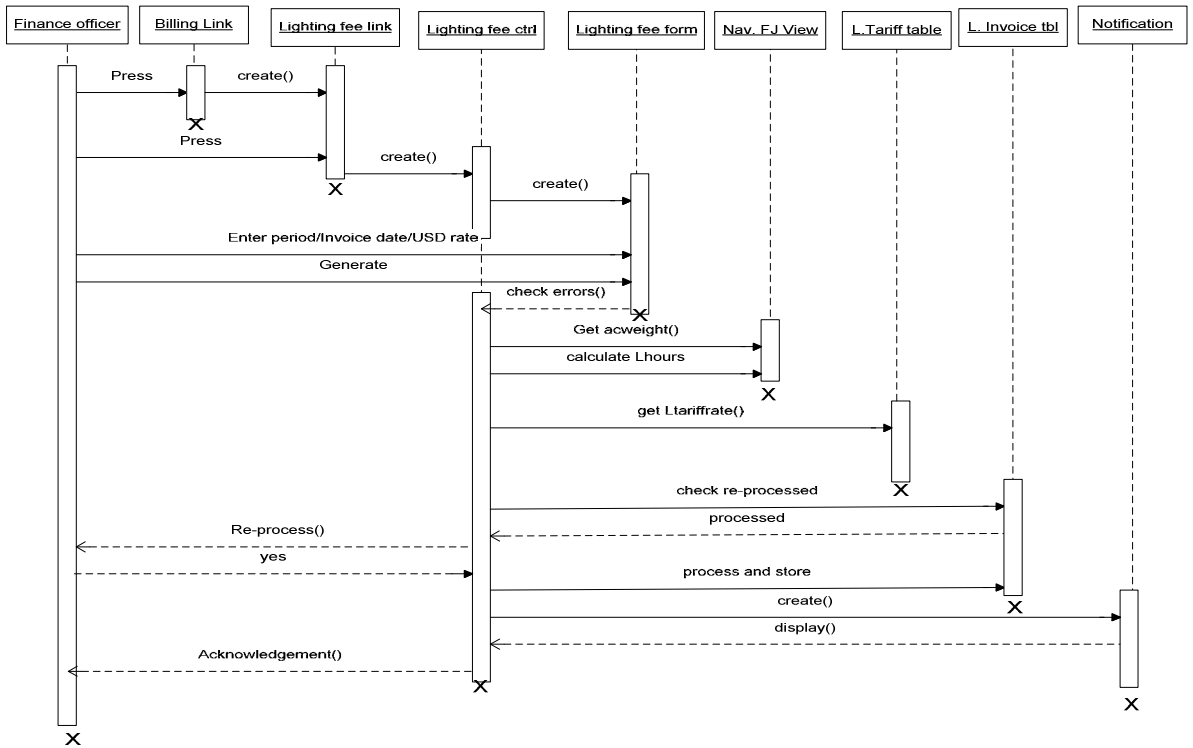


Figure A.14: Process Lighting Billing sequence diagram

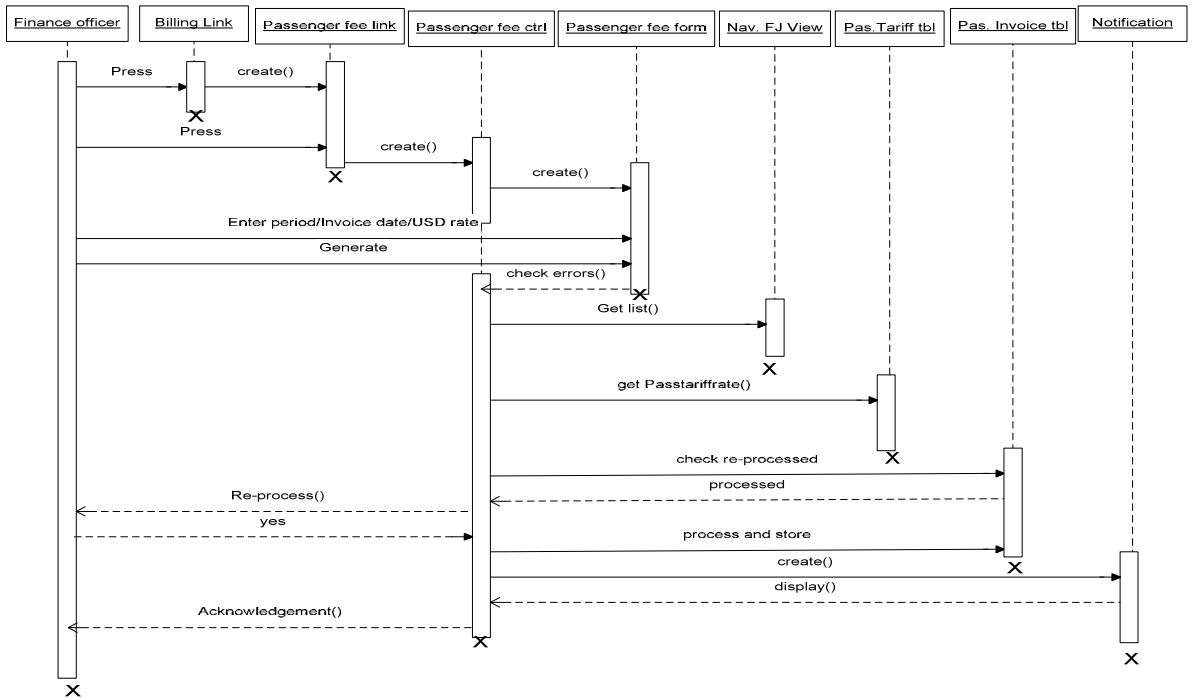


Figure A.15: Process Passenger Billing sequence diagram

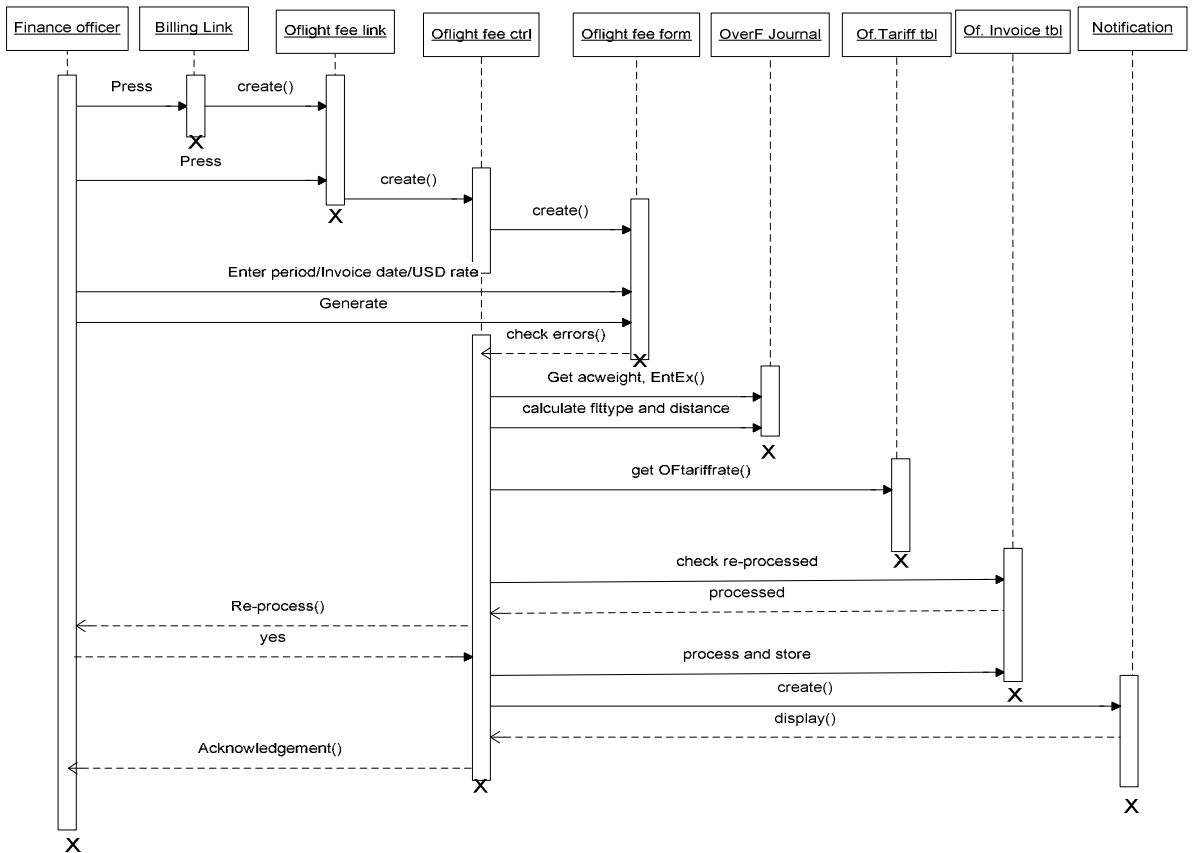


Figure A.16: Process Over-Flight Billing sequence diagram

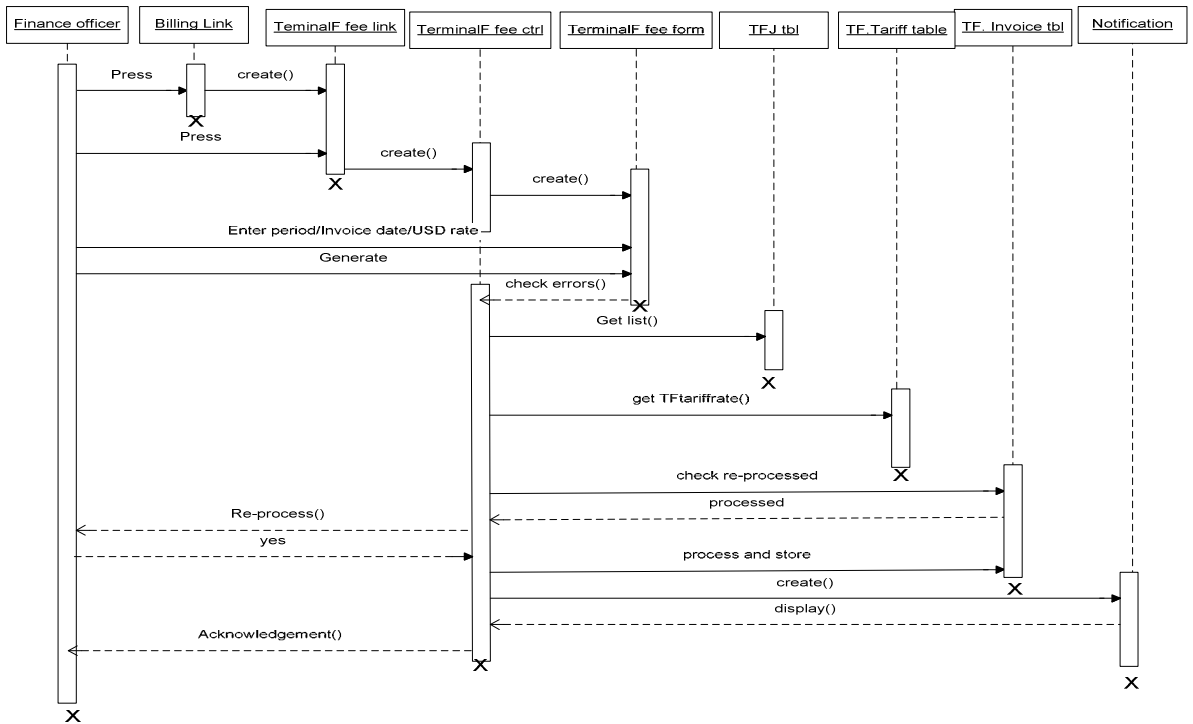


Figure A.17: Process Terminal Facility Billing sequence diagram

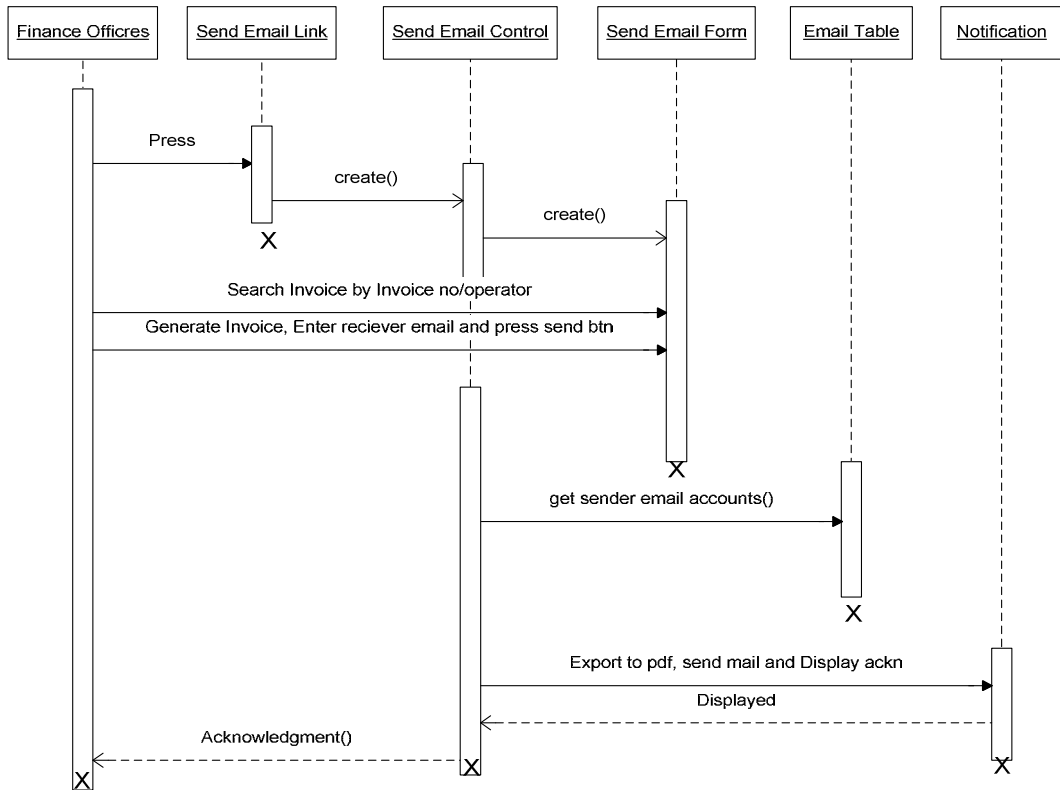


Figure A.18: Send Invoice by Email sequence diagram

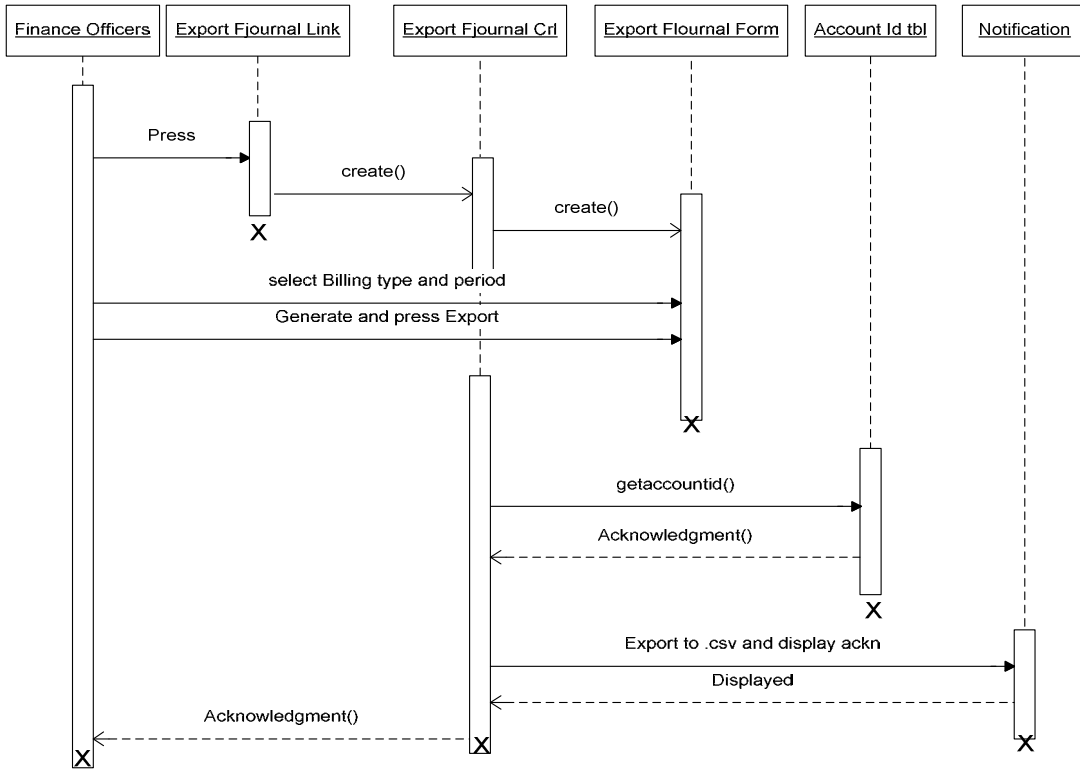


Figure A.19: Export Finance Journal Entry sequence diagram

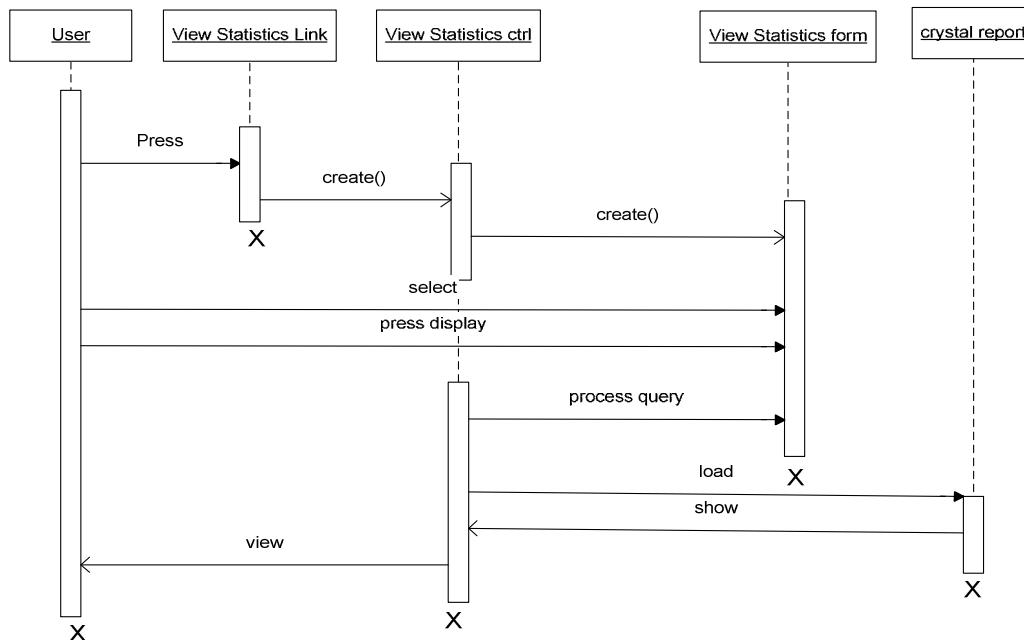


Figure A.20: Generate Aircraft movement statistics sequence diagram

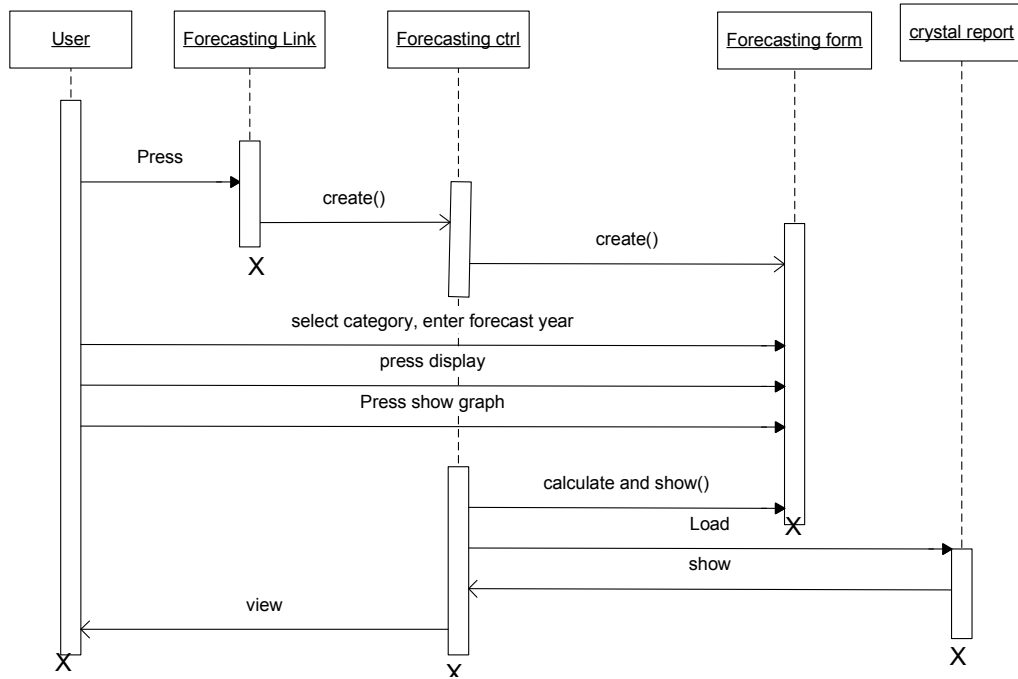


Figure A.21: Generate Traffic Forecasting sequence diagram

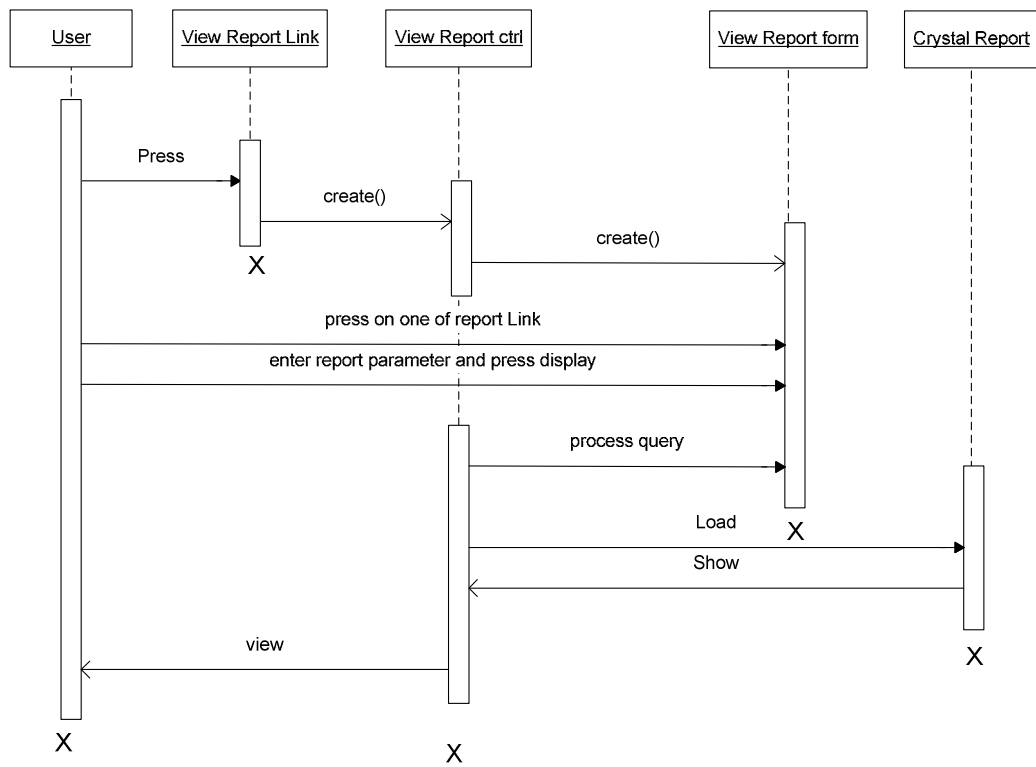


Figure A.22: View Report sequence diagram

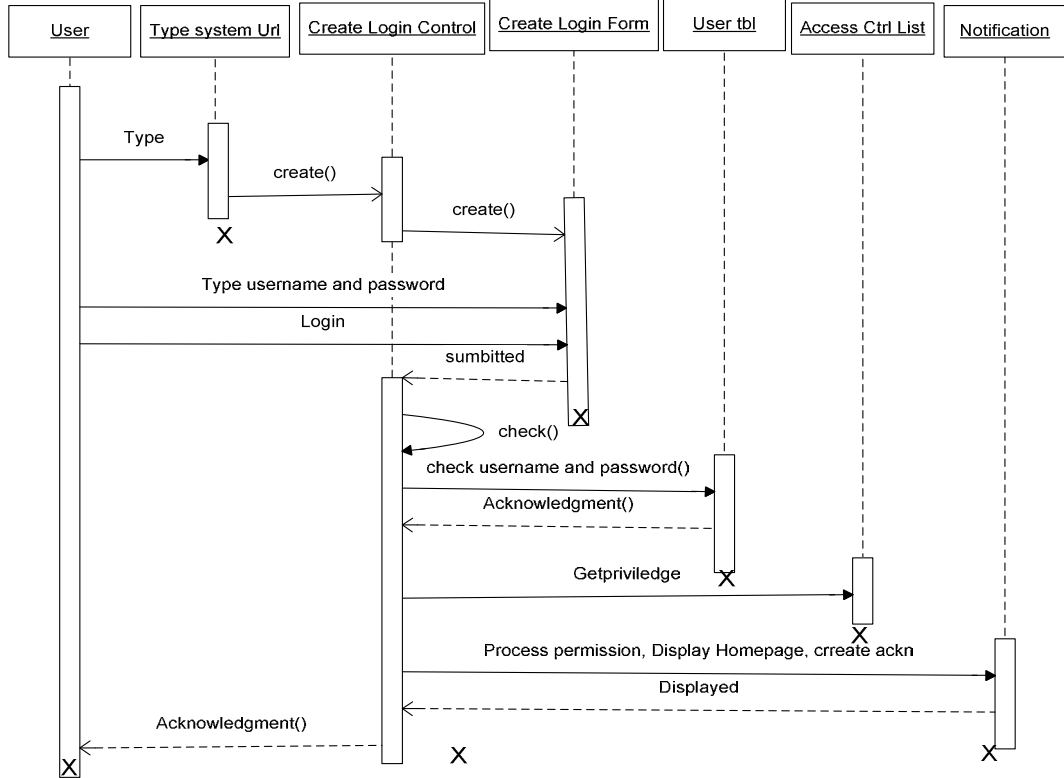


Figure A.23: Login sequence diagram

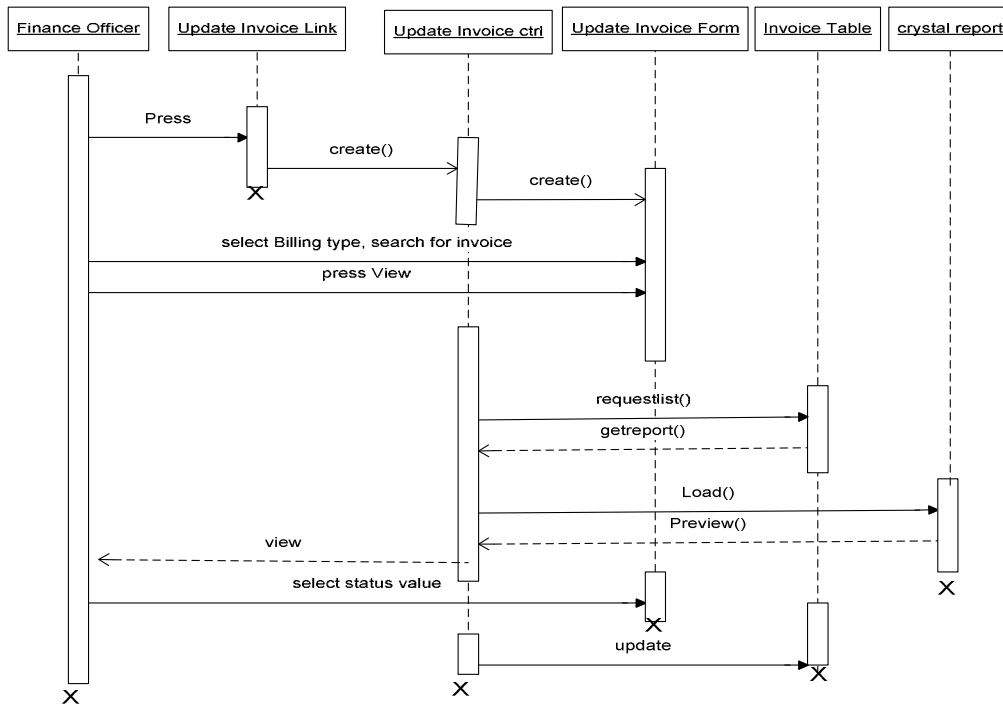


Figure A.24: Update Invoice Status sequence diagram

ANNEX B

Web based Flight Journals, Billing, and Forecasting Management System (FJBFMS)

Usability Testing Questionnaire

User category 1- Finance officers

This questionnaire is intended to know the users satisfaction related to the main functionalities of the FJBFMS. Please indicate your agreement by making ✓ in the boxes.

No	Question	Strongly agree	Agree	Neutral	Disagree	Strongly disagree
1	Do you think the terminology used in the prototype related to Billing and Invoice management is consistent					
2	Are you satisfied with the user interface of the system?					
3	Do you think the system prototype can be used easily?					
4	Do you think the system can produce the invoices correctly without errors for each customer according to the given tariff rate and billing calculation					
5	Does the system enable you to search an invoice for each category of billing easily?					
6	Do you think the developed system can save your time in sending an invoice to customer via email from the system screen?					
7	Does the system totally avoids the burdens and challenges you faced by entering flight data from manual journals to your old access billing system					
8	Do you think the response time for process billing and other invoice management is fast enough					
9	Does the system give enough description when the error occurs?					
10	Do you think the menu items and links allowed to you to access are consistently located and work without failure?					
11	Does the flight analysis report provided by the system helps you in identifying flight data errors and leads you to take appropriate actions					

Please write any other comments about the FJBFMS

ANNEX C

Web based Flight Journals, Billing, and Forecasting Management System (FJBFMS)

Usability Testing Questionnaire

User category 2- Air Traffic Controllers (ATC)

This questionnaire is intended to know the users satisfaction related to the main functionalities of the FJBFMS. Please indicate your agreement by making ✓ in the boxes.

No	Question	Strongly agree	Agree	Neutral	Disagree	Strongly disagree
1	Do you think the terminology used in the prototype related to Flight Journals management is consistent					
2	Are you satisfied with the user interface of the system					
3	Do you think the system prototype can be used easily					
4	Do you think the system can successfully import the flight plan records and helps in saving time wasted by daily flight registration and validation process					
5	Does the system enables you to search for a given flight data both in flight plan and flight journal database					
6	Do you think that the setup journal parameters provided by the system helps you to populate and manage common parameters in journal screen for data entry problem avoidance					
7	Do you think the response time for import flight plan and flight journal preparation is reasonable					
8	Does the system give enough description when the error occurs					
9	Do you think the menu items and links allowed to you to access are consistently located and work without failure					
10	Does the flight analysis report provided by the system helps you in identifying flight data errors and leads you to take appropriate actions					

Please write any other comments about the FJBFMS

ANNEX D

Web based Flight Journals, Billing, and Forecasting Management System (FJBFMS)

Usability Testing Questionnaire

User category 3- Statisticians and planners

This questionnaire is intended to know the users satisfaction related to the main functionalities of the FJBFMS. Please indicate your agreement by making ✓ in the boxes.

No	Question	Strongly agree	Agree	Neutral	Disagree	Strongly disagree
1	Do you think the terminology used in the prototype related to statistics and forecasting subsystem is consistent?					
2	Are you satisfied with the user interface of the system?					
3	Do you think the system prototype can be used easily?					
4	Do you think the system can produce the enough and useful statistical information					
5	Do you think the forecasting model can predict traffic information that best fits the actual data?					
6	Does the system totally avoids the burdens and challenges of you faced in statistical data preparation and collections					
7	Do you think the response time for producing the statistical information and generating forecasted data is fast enough					
8	Does the system give enough description when the error occurs?					
9	Do you think that capturing of passenger, freight, and mail transfer data along with flight journals helps in avoiding time					
10	Do you think the menu items and links allowed to you to access are consistently located and work without failure?					

Please write any other comments about the FJBFMS

Declaration

I, the undersigned, declare that this thesis is my original work and has not been presented for any degree in any other university, and that all source of materials used for the thesis have been duly acknowledged.

Declared by:

Name: Doji Wordofa Bedane

Signature: _____

Date: _____

Confirmed by advisor:

Name: Dr Mulugeta Libsie

Signature: _____

Date: _____

Abstract

The availability of precise and exact flight data is crucial to effectively manage aircraft operator's billing, air transport business operations and also to ensure flight safety. This project work has aimed to design and implement systems that can efficiently manage flight journals, aircraft operators invoicing, and produce traffic Statistics and Forecasting for Ethiopian air transport industry.

System requirements have been rigorously collected from Ethiopian Civil Aviation and Ethiopian Airports Enterprises. Review of literatures and related works which are used in the transport industry are also conducted. The design and implementation of the system is done in accordance to the identified functional and non functional requirements. Object oriented software engineering and ASP.NET 2.0 platform is employed to develop the system. The system is designed in such a way to be accessible via the Internet. Users have access based on their privilege level. The system has different subsystems to meet its core functionalities. The Flight plan subsystem imports planned flights from Flight Plan database to the main database so as to enable Air Traffic controllers to produce actual flight journals. The Flight Journal Management subsystem manages registration and preparation of different flight journals. The Billing Management subsystem is in charge of processing different aircraft operator's charges. This subsystem also manages different invoice operations including sending the specified invoice to the customer via email. The System Utility Management subsystem manages user account management tasks and sets up different system parameters used by the system. The Statistics and Report subsystem generates different statistics and standard reports whereas the Forecasting subsystem enables users to generate aircraft movement traffic forecasting using the designed forecasting model.

The system has been tested with seven years actual data and it has been observed that the system successfully meets the entire requirement identified. In addition, we evaluated our system through a questionnaire which is prepared by considering the ISO 9241-11 usability test standard attributes. The results of the evaluation have shown that our system is easy to use, efficient, effective, accurate, and can save time of professionals.

Keywords: Flight Journal Management, Flight Journal and Billing Management System, Airport Revenue Management, Flight Journal Statistics and Forecasting System, Aircraft Operators Invoicing System, Aircraft Movement Statistics and Forecasting.