Design of a Hybrid Aircraft Tracking System for Developing Countries

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Abstract - *Aircraft crashes are always accompanied with monumental loses. Other than the very high mortality rate involved, the grand scale destruction of property and the attendant socio-economic costs have made air crashes one of the most feared event in the world today. Guaranteeing a hundred percent safety during flight is impossible. We present, the design of an aircraft tracking system with a view to enhancing the effective tracking of aircrafts in flight, thereby ensuring air safety and preserving public trust and belief in the safety of air travel.*

Keywords: *Aircraft, tracking, Aircraft-simulator, database, location-chart crashes, safety.*

I.   INTRODUCTION

Since the birth of airplanes, several crashes have occurred, often with serious consequences. September 17th, 1908 recorded the first fatal crash in a powered airplane piloted by Lieutenant Thomas E. Selfridge who was flying with Orville Wright.

Although it was in 1925 when the first plane landed in Lagos, South-West Nigeria, the first fatal aviation mishap in Nigeria occurred precisely on November 20, 1969, several plane crashes have since then been recorded, with some of them been very fatal. Unfortunately, development in the aviation industry has not been reciprocated with growth in safety regulation, thus leading to unnecessary air disaster accompanied by unimaginable lapses in disaster response.

A well respected Entrepreneur and Business mogul in Nigeria vowed never to fly any Nigerian airliner but the foreign airliners in our country; he said he prefer travelling by road in his jeeps. He was about to take a flight to Lagos, South-West Nigeria, one evening from the International Airport in Port - Harcourt, South-South Nigeria, when he aborted the trip after a call from his boss that there was a message he had to take along. The following morning, he learnt that the plane he had wanted to board a night before had crashed into a lagoon [5]. This is not surprising, as the Nigerian aviation history has recorded black days of plane crashes which have led to severe loss of lives and property.

The first major air crash in Nigeria's aviation history was that of a Federal Government owned DC-10 aircraft, which crashed as it prepared to land at the Ikeja Airport on the 20th of November, 1969. All eighty-seven (87) passengers and crew on board were killed.

Another unforgettable crash was that of the ADC Airline passenger plane, with more than 100 people on board that crashed near Abuja the capital of Nigeria, killing ninety-six (96) passengers including the then Sultan of Sokoto.

Yet another one was the Bellview Airline Flight 210, which crashed on 22nd October 2005 at about 8:38pm, 3minutes after take-off in Lisa, Ogun State and claimed the lives of all 117 passengers and 6 crew members on board. In fact their bodies were never recovered [3].

In the same 2005, precisely, December 10th, another plane, Sosoliso Airline, Flight 1145 crashed killing 109 people on-board mainly children of a particular high school in Nigeria's capital city. This left many families devastated, as their wards were all killed [3].

Nigeria was hit with yet another tragedy on September 17, when an 18-seater Dornier 228 Air Force transport plane, carrying fifteen (15) senior army officers(15 NATIONAL SENIOR ARMY OFFICERS) and three crew members crashed leaving only three survivors that sustained serious injuries.

The most embarrassing of all, is the Arik private jet chartered by people and heading for Obudu Ranch in Calabar, in the South-South region of Nigeria. The remains of the plane have not been located till date.

A.   *The Causes of Flight Accidents in Developing Countries*

It is generally believed that, flight accidents, especially in some developing countries are caused by certain factors, among which are; use of old sub-standard planes, stress on pilots, corruption and mismanagement in the aviation industries, as well as use of obsolete substandard equipments.

The objectives of this work therefore are (1) to examine, evaluate and analyze modern aircraft tracking systems, causes of flight accidents and

lapses in aviation management in developing countries, (2) design an aircraft flight scheduling and tracking system.

B. *Methodology*

The existing records of air crashes in Nigeria and other developing countries were examined with a view to knowing their remote causes. In order to facilitate the design of the aircraft tracking and scheduling system, an object-oriented analysis of the requirement specifications was carried out, the detailed structure of the problem was examined. The various objects that occur in the problem domain and the solution domain were first identified, and the different relationships that exist among these objects were identified.

This is followed by an object-oriented design activity. During this step, the results of object-oriented analysis are transformed into the software design by further refining the object structure to obtain the detailed design.

II. OVERVIEW OF THE PROPOSED SYSTEM MODEL

The System model described in Figure 2.1 pictures the tracking systems as one consisting of three separate entities namely; (1) aircraft(s), (2) a Web Service, and (3) a Control Room Tracking Application. The major activities and intents of each entity are described below;

1) *The Aircraft(s)* – this represents a single aircraft or a set of aircrafts under surveillance. In this model, each aircraft carries a wireless device capable of determining the location (in terms of longitude and latitude) of its carrier aircraft via satellite communication and one also capable of transmitting such data to a host server. This communication could be performed in two modes. Firstly, in order to utilize the ubiquitous telecommunication system in the country, the data could be transmitted via the nearest telecom mast server to their regional system. Secondly, we could also have each device to be an intelligent node that could connect to the internet via communication satellites and then go on to consume a dedicated tracking web service. These methods are both viable, only cost and the ease of implementation determines the choice. For the sake of demonstration the later is chosen here, and implemented using a Windows-based application.

2) *The Web Service* – this component is very important for the proposed model to be complete. The web service provides a remote means of communication between disparate communicating devices or applications. With the aid of this, each aircraft communicates its dynamic location data with it, which then logs such data, reports and updates in the right database. The architecture of web services and how they work are described shortly below.

3) *The Tracking System* – this is essentially the user end of the entire system. This is the interface linking the flight control officers with the system. From within this interface control could view the dynamic location of each aircraft in flight. This interface is highly volatile (dynamic) as it is based on a database that is constantly been updated almost every second. This component is modeled as a web-based application interface.
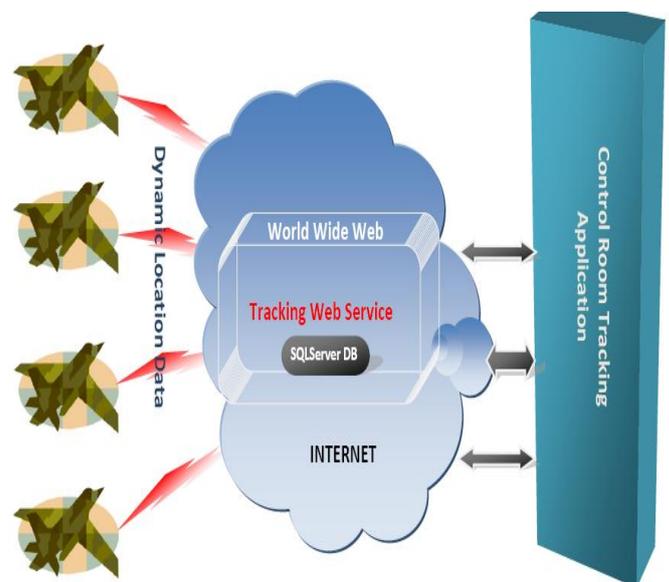

Figure 2.1: Aircraft tracking system model

This Aircraft Tracking System Model is formalized as in equation 2.1 below;

$$\left(\bigcup_{I=1}^{n} A_I \right) \leftrightarrow W_S \leftrightarrow T_R \dots\dots\dots\dots\dots\dots\dots.2.1$$

Where A_I denotes the Aircraft(s) been monitored.

W_S denotes the Tracking Web Service.

T_R denote the control room tracking application

↔ denotes the direction of flow of information

A. *System Architecture.*

The system architecture is a simple, three layered model that supports the client/server model of the World Wide Web. It is made up of three major components. Though these components have been described at the application level earlier in section 2.0, the following sub-section highlights the technical implementation of each of these components.

1) *Windows Client* –According to the architecture, this module is implemented as a Windows-based application. This is to give the model the capability to be able to create several instances of it depicting several aircrafts in flight. Each instance generates dynamic location data such as rapidly changing longitude and latitude of the aircraft. Location data so generated are transmitted via the web service published by the Tracking Web Service Portal module.

Figure 2.2: The Tracking System Architecture

2) *Tracking Web Service Portal* – this is a major component of the system model. It is essential to the operation of other components or modules and the system in its entirety. It exposes a Tracking Web Service through which the two other disparate application (i.e the windows application and the web application) communicate in an open and secured mode using web service technologies such as SOAP RPC. This module serves as the intermediary between the other modules and the database. It is implemented as a web-based .NET Web services.

3) *Web-based Tracking Portal* – This is implemented as an ASP.NET web application with C# as the server programming language. It serves as the tracking end to the patrol officer at the control towers. It is a platform used to view the dynamic location of any

aircraft and to carry out other task. As a web-based component, it supports the client/server model. It is however a 3-tier system, made up of *the Front End layer* - which is the web user interface that users interact with via a web browser; *the Middle Layer* – which represent the code body of the module made up of C# classes, libraries and interfaces; *the Back End* – which encompasses the database and other code libraries used in communicating with the database. The database is implemented using Microsoft SQL Server 2005.

B. *Technology Platform*

The system is designed to run on specifically the Windows platform and all other operating system with internet capability. The system sits on top of the Microsoft.NET platform with Microsoft SQL SERVER database management system, Microsoft Internet Information Server and ASP.NET web server technology.

The relationship between ASP.NET, C# and the SQL Server database in our .NET web application; is as shown in the figure below;
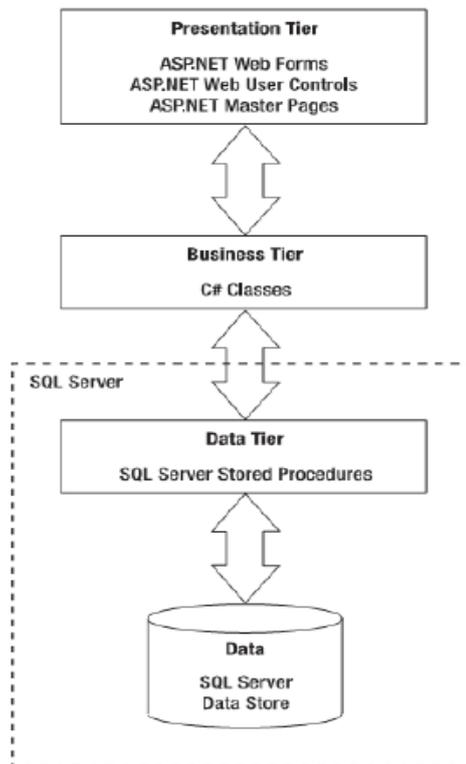

Figure 2.3: Interaction between .NET web technologies

Microsoft Internet Information Server (IIS) fulfills the role of the Web server, responding to requests for files from Web clients such as IE, and logging activity. IIS maintains information about the

location of content files, what security identities have access to those files, how content files are separated into applications, and what URLs are mapped to those applications.

C. Database Design

A database was designed to service the information needs of this work. There are classes of information needs and these are:

- Reliable information storage that allows retrieval at a later date.
- Up-to-date information; which requires well defined functions for updating the information
- Analytical functions

The database for this work is made up of tables such as *the tracking table,* which stores dynamic tracking information; *the places table,* which stores location information (village, river, city or any landmark) which could be used to locate missing aircrafts, and *the aircraft table,* which stores information such as the model and capacity of a particular aircraft.

We present below, class diagrams showing the static structure and class components of the proposed system.
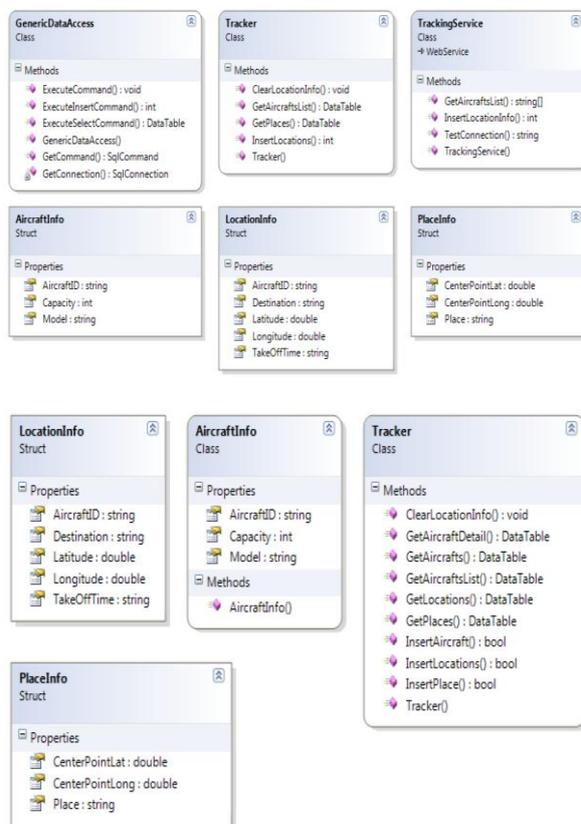

Figure 2.4: Class Diagrams

III. SYSTEM IMPLEMENTATION AND DOCUMENTATION

All program codes, classes and modules are implemented with the Microsoft.NET C# language alongside ASP.NET. While the entire system is built upon the Microsoft.NET Framework (v2.0 and later), the implementation of this work also involves other tools such as the Microsoft Ajax Library, and Microsoft Visual Studio.

To enhance the usability and maintainability of this system, we present both the user manual and the technical manual. While the former contain installation and configuration information, the latter is meant to enable technical users like the developers and maintainers, manage the system.

We hereby present a module by module documentation of how this aircraft tracking system works.

A. How To Run

To get the application started, the following tasks are performed.

- Open Internet Information Service Manager
- To publish the web service, start the Tracking Service application
- Start the TrackingWebClient application (ensure the web service is running before this task)
- Run the TrackingWindowsClient module of the application (ensure the web service is running before this task).

1. Aircraft Model (Windows Client): How to Run

The windows-based module in this system models an in-flight aircraft, hence, the name Aircraft Flight Simulator. When this application is started, the first window interface shown is as shown in Fig. 3.2. It automatically connects to the Tracking web service to load all aircrafts objects under observation. To simulate an aircraft select an aircraft ID from the list provided on the interface and click *Start* to continue. This action produces another interface as shown in Fig. 3.3a and Fig. 3.3b. These interfaces are as a result of simulating several different aircrafts at the same time. Each aircraft model displays the dynamically generated longitude and latitude values experimentally representing the spatial location of an aircraft at a particular time. At the same time, this information is then communicated to the web-based Tracking Portal application via the Tracking Web Service which dynamically updates information displayed to the

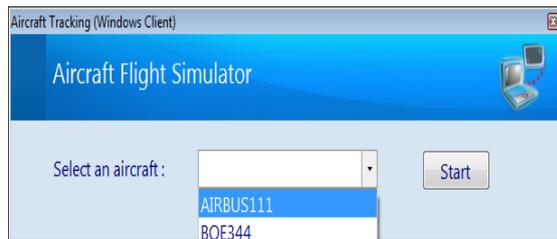control officers. Once the simulation expires the interfaces can be closed in any order of choice.

Figure 3.2 Aircraft Selector Interface

Figure 3.3a: Aircraft Model of BOE344

Figure 3.3b: Aircraft Model of AIRBUS111

.2   Aircraft Tracking Portal (Web Client): How to Run

Fig. 3.4 is a snapshot of the portal showing the Home page. The home page contains navigational links through which related tasks can be performed. These include *Locator*, *Settings* and *About* links. Clicking any of the links helps one to perform the corresponding task as depicted by the name.

Figure 3.4: Tracking Portal Home Page

3.4   3.   *Aircraft Location Chart*

Fig. 3.5 below shows a table chart depicting the location of each aircraft via the Tracking Web Service. The page automatically refreshes to update and display latest information. The chart displays information in tabular format for easy location. The table contains fields like; *AircraftID*, *Longitude*, *Latitude*, *Destination*, and *TakeOffTime*. The table is paged to give room for easy viewing scope.

Figure 3.5: Aircraft Location Chart

The AircraftID column in the chart is displayed as hyperlinks. Clicking any of the IDs navigates to the page shown in Fig. 3.6 displaying more information about the aircraft selected.
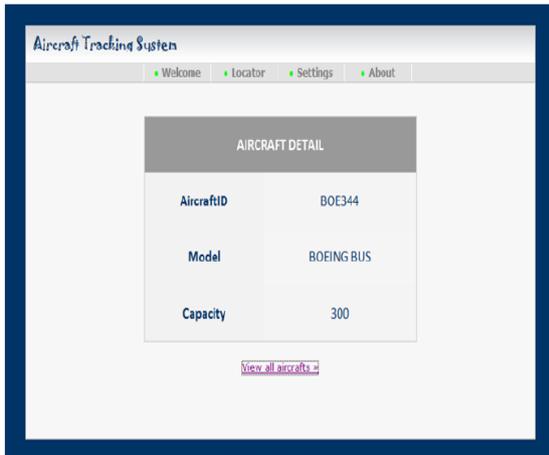
Figure 3.6: Aircraft Detail Page

Fig 3.6 as shown above does not only show detailed information of a particular aircraft but provide a link to a page that displays all aircrafts under observation. This page is shown below;
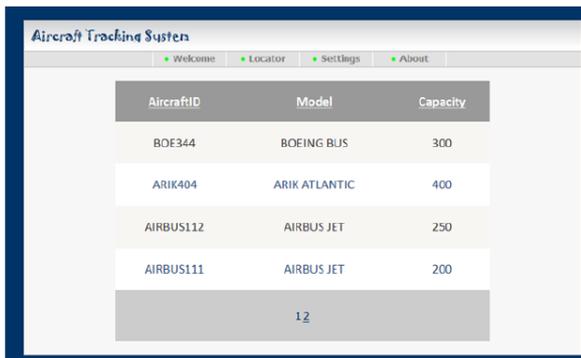

Figure 3.7: All Aircrafts Information

4.   *Creating New Aircraft Record*

The steps to add a new aircraft record is straight-forward. From any page click the **Settings** link from the menu bar. The page as shown in Fig. 3.8 is displayed. This page presents the *Create New* form. User must supply all necessary fields and click the Submit button to save. This can be performed many more times to register more aircraft.
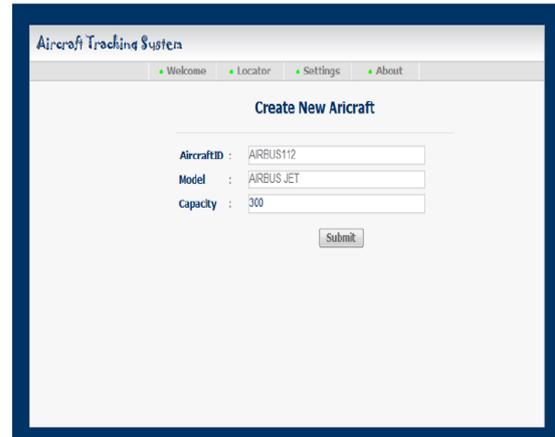

Figure 3.8: Create New Aircraft Page

IV.   CONCLUSION and RECOMMENDATION

With great assurance, we conclude that, improvement and implementation of this work, together with current developments in Information and Communication Technologies (ICT), will not only guaranty prompt tracking but also to a great extent, allay the fears in the hearts of people that travels through the air.

An aircraft tracking system like this present numerous benefits for developing countries like Nigeria, and should not be ignored or thrown into the waste bins. The Aviation Industry and/or Airport Authorities should take a very deep look into this, with a view to providing lasting solutions to the ever-nagging air crashes facing developing countries.

Collaboration between the Airspace Management Agencies and Telecommunication Companies would go a long way in achieving the goal of ensuring safety of our air spaces.

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