OBJECT ORIENTED ANALYSIS AND DESIGN OF FIRE EMERGENCY MOBILE APPLICATION AND CENTRAL SYSTEM (FEMACS)

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Abstract — Fire remains an unannounced outbreak that occurs in our various homes, offices, schools and industries. Without a rapid move, proper control and preventive measures put in place, a destructive effect on both human lives and properties becomes inevitable. During the fire emergencies, speedy response and access to the incident scene is of the highest priority. With the recent exploration of smartphones capabilities and applications, they become more suitable for reporting fire emergencies based on the knowledge of technical know-how and object-oriented analysis and design. In this paper, we have analyzed the associated shortcomings of the manual fire reporting system and as well designed an automated framework; Fire Emergency Mobile Application and Central System (FEMACS). FEMACS is a mobile fire alert app developed based on Software Development Life Cycle (SDLC) that allows users/individuals to report an outbreak in a real-time to the nearest fire emergency department with an indication of a shortest route to follow. A Unified Modelling Language (UML): Use Case, Class Diagram, Sequence Diagram, Collaborative Activity and State-Chart Diagram of the fire reporting application model were developed and used to visualize the design view based on some functional and non-functional requirements. The Graphical User Interface (GUI) prototype for the proposed automated system was also implemented. Our design has shown an efficient way of reporting fire outbreaks with an integration of a central system using Object-Oriented Analysis and Design Approach.

Keywords: *Fire reporting, Fire outbreak, Fire Emergency, Mobile Application, FEMACS, UML, SDLC*

I. INTRODUCTION

Fire emergency can occur anywhere, and at any time, delay in response and support to quench the fire from Fire Department (FD) or volunteers can lead to severe injuries, loss of lives and damage to property. According to the United States Fire Administration (USFA), over 1 million fire incidents occurred between 2008 and 2017, resulting in a loss of 3,400 lives and properties worth $23.0 billion[1]. Fires disaster is unpredictable, commercial and industrial buildings are installing smoke detectors, fire alarms and other suitable sensors as a part of preventive measures to notify occupants earlier in case of fire incident to evacuate from the building immediately. Fire Departments are always on high alert and equipped with firefighting tools to response emergency fire situation 24/7. During emergencies, time, and quick access to the incident scene is the highest priority to the FD. Regardless of how the Fire Department equipped with proper emergency response tools, delay in reporting will make it challenging to respond to emergencies. The main challenges apart from reporting are tracking and monitoring the scene of the fire incident and determining the shortest way to reach incident scene geographically is a significant aspect that prevents the smooth response to an emergency. Traditionally, emergency toll-free call centres are primary contact by the public in case of emergency [2]. Often incident reporters (people) find it difficult to describe the exact scenario in an emergency, which makes it difficult for the Fire Emergency Employee (FEE) to find the scene. The Fire Emergency Department is a vital department delivering first aid services and handling fire incidents, needing a real-time and active support network to coordinate the operations. A quick and reliable emergency response process required to replace the old-fashioned call centres which will improve service delivery and decrease the number of victims of accidents and injuries.

With technology, the proliferation of smartphones has changed the way people communicate and interact, and convergence of networking and computing platforms for mobile consumer devices is evolving to bring interoperability and to leverage the capabilities and functions of every industry[3]. In this convergence phased, entrepreneurs have taken advantages of smartphones and invest heavily in the development of advanced applications in entertainment, education, business automation and for the rest of the industries. Smartphones, as leading devices in this era, can play a vital role in emergency communication.

In recent years researchers have become increasingly interested in exploring smartphone capabilities and applications in emergency areas[4]. The emergence of the 5G network and new smartphones integrated with high-speed processors, accelerometer, compass, gyroscope, GPS, and high-end camera[5] make it suitable and practical to join the use of smartphone application as a way of reporting emergencies. Thought development of such kind of emergency application depends on the technical know-how of programming and knowledge of object-oriented analysis and design.

Object-oriented analysis and design (OOAD) is the fundamental aspect of developing any business application, OOAD is a structured approach for analysing and designing software systems by applying the object-orientated concepts[6]. It develops a set of graphical system models during the development life cycle of the software.

The OOP framework allows the team to develop and test a mobile fire alert app that allows users to report an incident immediately so that the department can take necessary action. The term OOP used to describe an object and a class-based approach to programming. The object-oriented model allows us to organise software as a collection of objects made up of data and behaviours—this contrast to conventional functional programming practice, which connects data and behaviour only loosely.

In this paper, we want to use OOAD concept to develop a mobile fire emergency reporting application and central response system that will provide a quick and correct reporting platform while enhancing the fire reporting business process.

II. RELATED WORKS

Several papers on emergency reporting and response system published, we selected and presented the most relevant literature relates to our proposed system.

In[7], the authors developed mobile disaster management using android technology known as MyDisasterDroid. The Application uses a genetic algorithm to guide volunteers and rescuers to determines the best shortest route to reach the disaster incident location. The Application is also versatile because it allows the prioritisation to be changed or extended with minimal effort. It can be used during the disaster response process, especially when time is crucial.

In[8], the authors implemented GIS-Based Fire Emergency Response System for Mandalay Road Network using the Dijkstra routing algorithm. The paper emphasises the selection of the best route between two locations on the road network data and then finding the nearest emergency service providers and fire stations to an accident site based on traffic conditions.

In [9], the authors designed and developed a mobile android application to report an incident easily in Manila city. The Application helps to get essential details on the incident report in real-time from citizens to Barangay officers and the designated department. Fire, road accident and crime are part of the incident. The mobile App uses GIS and geo-mapping to show the incident status in an area. Red shows incidents reported, while green shows incidents resolved in an area.

A Mobile Fire Emergency Application (FEAP) has been analysed and designed by [10], which enable the public to report fire incidents to the Fire Department and guide the Fire department to locate the reported incident to take action quickly. Software Development Life Cycles (SDLCs) and Unified Modelling Language (UML) used in the analysis phase, and Figma software used to develop the GUI of the prototype application.

In [11], the authors presented SOS-based Android Platform called SOSerbia for citizens in Serbia to send emergency messages. The SOSerbia App is helpful to people that are in dangerous situations of security, safety or emergency. Once the user presses the correct programmed combination buttons on the cell phone, the App will automatically send a message to the Serbian Police containing the user's location. The App uses the Google location API to acquire the user's location and the Media Player broadcast receiver to read the pressed buttons on the phone.

In [12], the authors proposed A Mobile-Based Emergency Reporting Application for the Philippine National Police Emergency Hotline 911, the mobile Application maximises response time during emergency calls and reduce the process of data collection. The user must register and granted authorisation to uses their location before using the Application. If help is required, the dispatcher can immediately retrieve the caller data and location. The work supports the existing 911 platform.

In [2], the authors developed an Emergency Accident Alert Mobile Application(EAAMA) that used to send an accurate alert and accident notification to the emergency call centre. It helps bystander and eyewitness to report any accident to the emergency call centre, including the victim's condition details. Rapid Application Development (RAD) approach, Phone gap HTML, CSS, JavaScript, JQuery technology used to develop Mobile apps. The application usability assessed, and the feedback was positive from users under ten Heuristic Principles.

In [13], the authors developed the Emergency Management System (EMS): Android Based Rescue Application Using Vertical Partitioning For Data Security implemented an Adhoc smartphone communication platform that can use when other communication media fail during a disaster. The mobile App helps the users to set up an ad-hoc network for communicating with the police, ambulances or fire brigades through an EMS server over Wi-Fi in case of a disaster. Compared to other services, the Application provides a quick response to the victim at free cost.

III. PROPOSED SYSTEM

To overcome the shortcomings of earlier studies outlined above, we proposed and developed the system using the principles of the OOAD. The system will make the business process more straightforward. It will also enhance monitoring of fire accidents, provide visual feedback to FEE, save accident reporting, which will help government and relevant agencies to make better decisions on FED equipment and deployment. The central system will be physically and logically secured from hackers and intruders while the client application at the end-user will be guarded using authentication and authorisation mechanism.

We also focused on simplifying the application operation by reducing user inputs; the user location will be automatically synchronised from GPS satellites, the reporter will have an option to record video as evidence, user can also view incoming rescue team in real-time via the Application. FEE employees will use the location to track and reach the incident's destination via the map, thus minimising distance can be accomplished by the Minimal Congested Traffic Algorithm (MCTA). The system will also allow top FEE personnel to manage fire accidents, FEE teams, facilities and users. The primary value will be provided to the enterprise by FEMACS is to enhance the entire business cycle, from semi-manual to automated with the following benefits.

- Timely and faster reporting of fire accidents.
- Easy management and supervision of Fire Department staff.
- Quick, timely and straightforward location incidents monitoring.
- Offers alternative means of reporting accidents to users (via SMS or free toll in the FEMACS app) in the event of unreliable internet connections.
- Provide comprehensive automated reporting generating system.
- Provide a general overview and status of the system.

A. REQUIREMENTS GATHERING

Requirement gathering is a statement of what the system must have and the characteristics that it must possess[14, 15]. The requirement can be a business user system, functional or non-functional requirement. The criterion is one of the successful fact-finding methods used to check for requirements using specific collection techniques. It helps us to understand the current business process and the need to improve the proposed system. The Application of this method is, therefore, essential and recommended in the study of any system development. Analysts are expected to use several techniques to get requirements. In order to access the project business requirements, an interview conducted to understand the existing system boundary, framework, and the challenges faced.

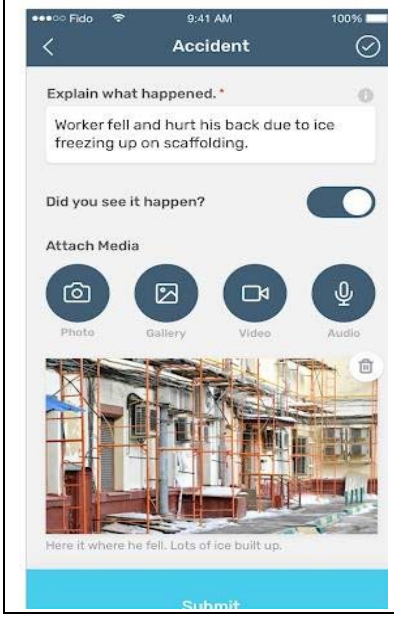
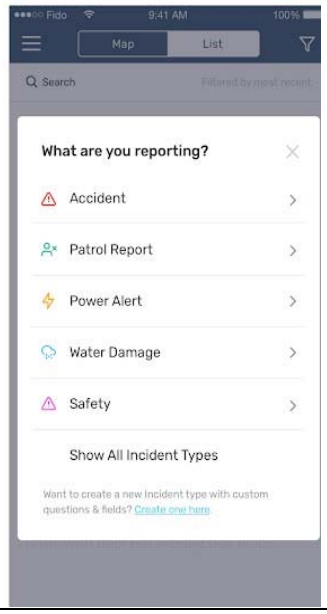
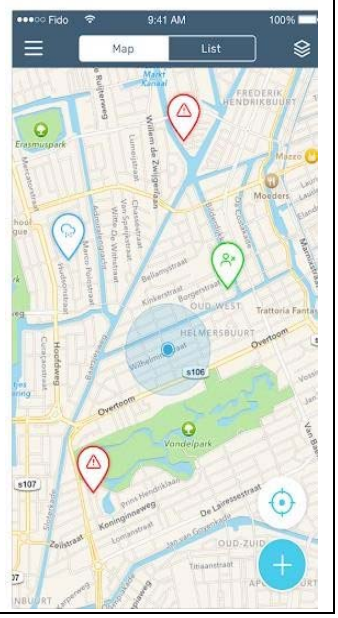
1. Document Analysis

As part of the collection of requirements, a document reviewed to gather the business requirements of the system.

2. Informal Bench-Marking

Informal benchmarking used to study how other organisations perform their business processes. The project adopts specific processes that add value to the analysis of the system. 1ST Incident Reporting mobile application[16] was benchmarked. This Android mobile App is an incident reporting system that allows users to quickly report the location, time, date, accident time data and other information and to submit it for confirmation and actions to the designated department or operations[9].

TABLE 1 1ST REPORTING APP INTERFACE

A. APP Home	B. Reporting	C. Tracking
		

The above table contains 3 figures demonstrated how the 1st incident reporting App built to handle various types of emergencies. The system indicates how the system can be compiled and modelled. We also adopt some architecture of design philosophy and usability.

B. BUSINESS ANALYSIS/ STATEMENT

The business statement of the project is that when a fire incident occurs, any user with the App can report the incident to the FEE by sending out an alert via the App comprising the incident, geo-location and other necessary information. If required, the user can make or receive a phone call from the FED. Once the central system is alerted, the location of the fire incident to be pinned to the map and the FED will decide which team will be sent to quench the fire.

REQUIREMENT ANALYSIS

1. *FUNCTIONAL REQUIREMENT*

Functional requirements are considered as what a system is expected to do or the characteristics it must have. Functional requirements define the necessary requested behaviour or functionality of a particular system in terms of methods of operations, functions, responses to inputs and exceptions[17]. The system actors can be classified into two major groups: users and the FEE.

Users;

1. Regular User
2. Top Manager
3. Area Manager

FEE

1. FEE Admin
2. FEE Field

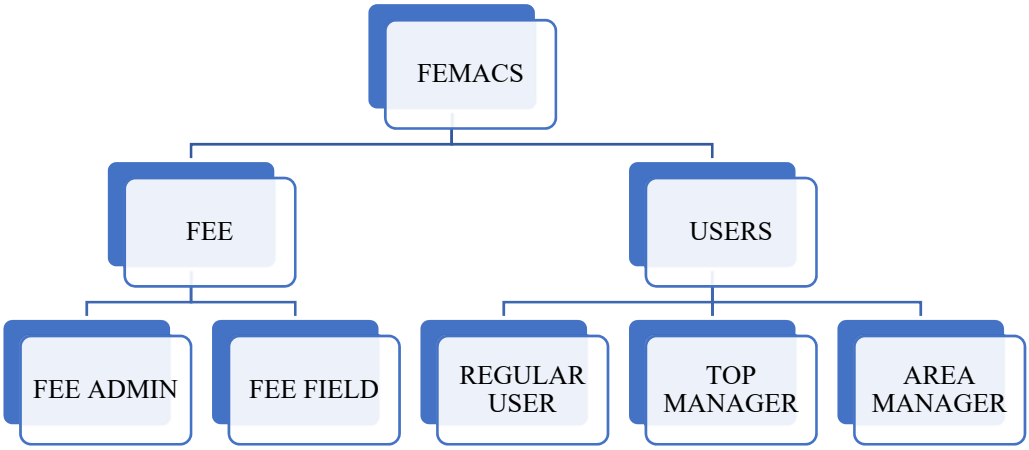


Figure 1 Femacs Organisation

TABLE 2 FUNCTIONAL REQUIREMENT

S/n	Requirements	Description	Basic Sequence	Priority
1	Login	All users must log in to gain access	1. Register 2. Enter valid username and password	High
2	Report Fire Incident	User reports a fire incident to the central system through the App.	1. Place a call and select-fire type 2. Capture incident Scene (Optional) 3. Report	High
3	Manage Regular User	allows the area manager to manage user registration.	1. Manager select registered user. 2. Click manage registration 3.Perform intended action via; A. Approve/ Disapprove registration B. Block user temporarily/Delete Account	High
4	Generate Incident Report	allows FEE top admin officers to view & generate necessary incidents report.	1. Select Report Type; Daily/Weekly/Monthly 2. Click generate and Save	High
5	Track Team Location	allows regular users to view the status of the discharged teams such as count-down time to the incident location and real-time GPS location of theFEE	1. Select Sent/acknowledge “Report Fire Incident.” 2. Click Track Team via Display; A. Real-time FEE team location B. Display time count-down to the incident location	High
6	Confirm Incident Report	allows FEE admin to acknowledge the receipt of the report sent by the user via the App.	1. Select incident report 2. Confirm incident report receipt	High
7	Assign Schedule	allows FEE admin to assign a schedule to various FEE field staffs.	1. Select teams or FEE employees 2. Assign schedule	High
8	Dispatch Team	allows FEE admin to dispatch Field FEE to attend to the reported fire incident.	1. Select FEE teams 2. Map Team(s) to the incident report 3. Map Teams to location 4. Dispatch	High
9	View Report Status	allows Users that report fire incident to view the status of the sent report.	1. Select Incident report 2. Click 'View Status' 3. Display Status; 3A. Received/Confirmed 3B. Processing/Pending 3C. Team not Available 3D. False Alarm Report	High

10	Manage Organization	allows the top managers to manage the organisation by mapping, listing & updating details of sensitive areas in the organisation	1. Click Manage Organization 2. Select Add New Sensitive Area 3. Display Sensitive Area Added Successfully	High
11	Manage Area Manager	allows the top managers to manage area managers by adding/updating/mapping manager to an area.	1. Click Manage Area Managers 2. Select or search from the existing list to update details/ Click Add New Manager 3. Display Area Manager Added/Update Successfully	High
12	Track Incident Location	Allow FEE Field officers to track the incident location via the particular FEMACS mobile app.	1. Select Reported Fire Incident Mapped by FEE Admin to the Team. 2. Select View Route Directions 3. Take Minimal Congested Traffic Route	High
13	View Schedule	Allow FEE Field officers to view their daily schedule as individuals or as a team.	1. Click on view schedule. 2. Display schedule	High
14	Change Location	Allow all actors to edit their profile, especially residential address or location in case of future changes.	1. Click on profile. 2. Select Change location 3. Click on Automatically Detect Current Location 4. Display Location Updated Successfully	High
15	Log out	All users must log out to exit	1. Click on profile 2. Exit app	Low

2. NON-FUNCTIONAL REQUIREMENTS

The non-functional requirement is one types of requirements that have to do with the design, quality features and constraints and external factors that may influence the system. It also includes vital communicative features that the system must have, such as security usability and efficiency. Such types of requirements are primarily in the design phase before the final choice of interface hardware and software[15]. The FED needs a new integrated fire emergency reporting system that collects monitors and processes fire incident reports, which will be simpler, quicker, more accurate and give both employees and users with technical and operational needs. However, other requirements can help to meet the general business requirements of the project which includes;

TABLE 3 NON-FUNCTIONAL REQUIREMENTS

S/n	Requirements	Description	Priority
1	Security	The security mechanism is in place to make sure unauthorised access to the FEMACS.	High
2	Privacy	User data will be kept confidential via encryption mechanism and legal policies that govern the use of third-party data or information.	High
3	Usability	FEMACS System will be flexible to be explored by different categories of users.	Average
4	Performance	The performance will ensure that the request is processed and responded to on time.	High
5	Reliability	Software systems should be able to authenticate users and ensure the reliability of all processes.	High
6	Availability	24/7 availability should in case of any Emergency.	High

C. OBJECT ORIENTED ANALYSIS AND DESIGN OF FEMACS

1. USE CASE DIAGRAM

Use case diagram is a dynamic UML model that models the system/sub-system of an application. It includes the functionalities represented as the use case, actors and the relationships between the actors and the use cases. We identified 5 actors with their roles and functionalities in the system

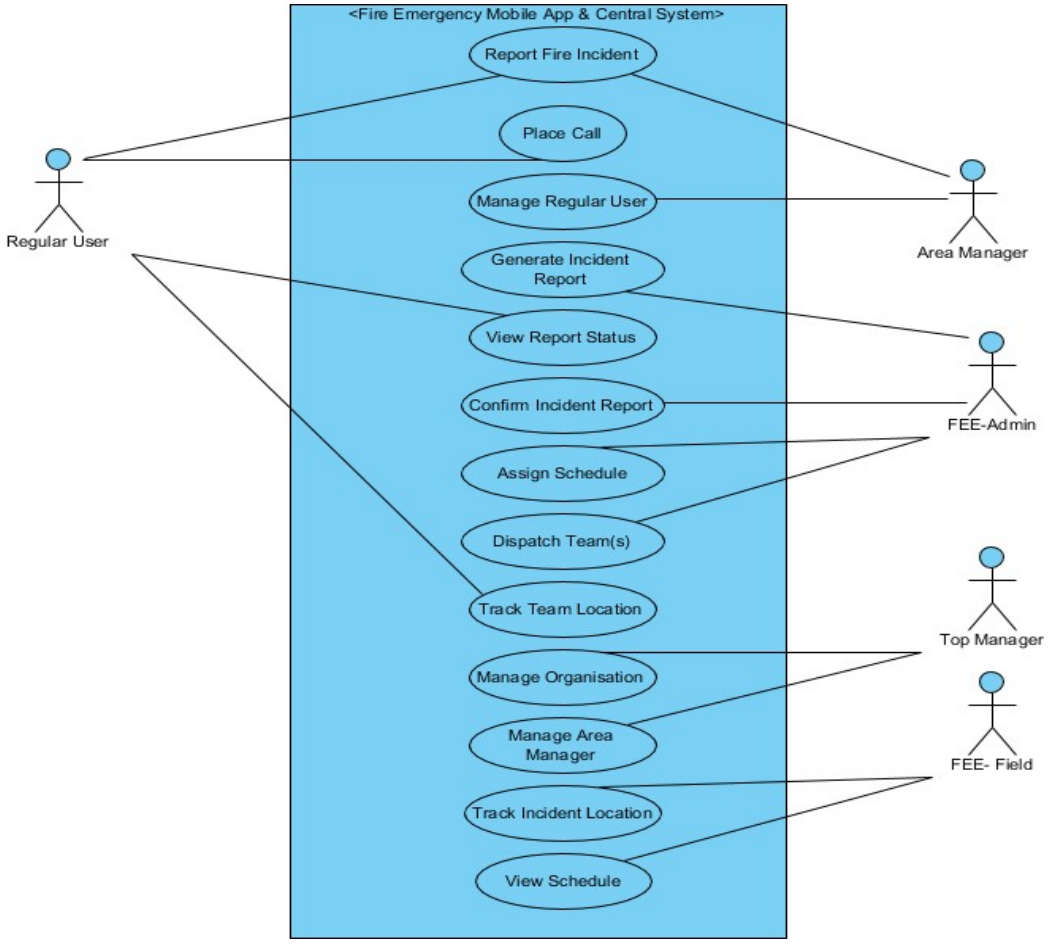


FIGURE 1 USE CASE DIAGRAM

2. *SEQUENCE DIAGRAM*

The sequence diagram captures the time sequence of the message flow from one object to another. It shows how the object in a system interacts with each other and gives a sequence of events with lifelines, call messages, return messages, alternative frames, activation boxes, etc. The objects involved in the operation shown from left to right according to what they take part in the message sequence.

Report Fire Incident Sequence Diagram

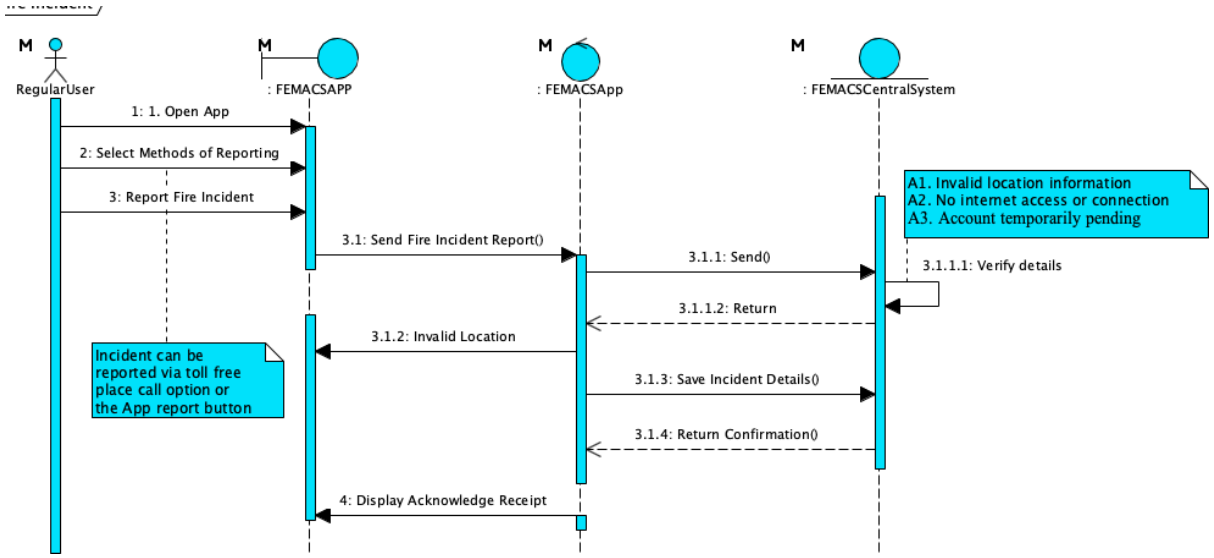


FIGURE 3 SEQUENCE DIAGRAM

3. CLASS DIAGRAM

A class diagram describes the objects in the system and the various kinds of static relationships that exist among them[18]. It shows the classes and relationships that exist between the various classes available. The class diagram depicts a set of classes that includes ***attributes, behaviours and function***, state or operation. The primary and most essential elements of the class diagram are the class which refers to the people, events, places and other things about which the system will store or capture information.

Class diagram plays a vital role in modelling; this includes describing the responsibilities of a system, a background for deployment and component diagrams, used in forward and reversed engineering, describes the basic functionalities of a system, building a software application using the concepts of object-Oriented Programming. We identified the class objects of the project through analysis; our system comprises of 14 classes as shown in the figure 4 below

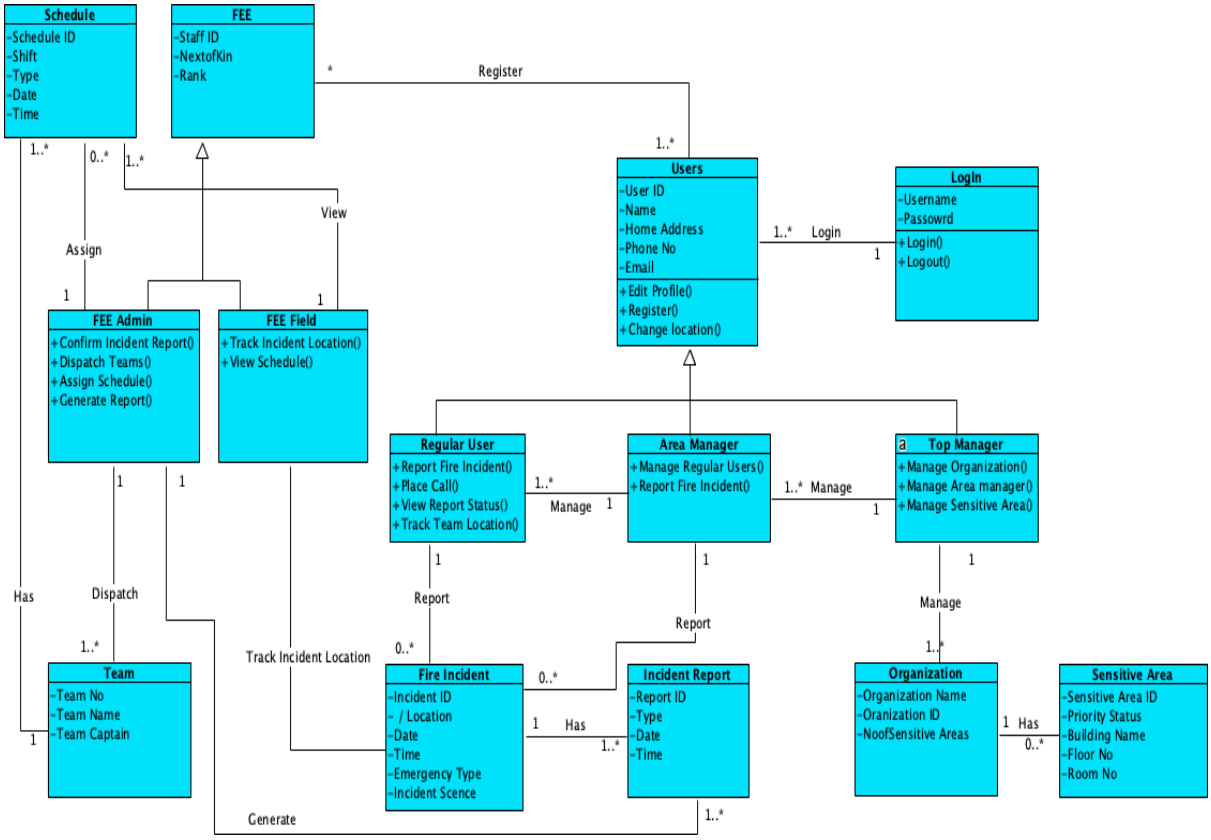


FIGURE 2 CLASS DIAGRAM

4. COLLABORATION DIAGRAMS

Collaboration diagrams are a unified modelling language tool that allows system designers to be collaborative describe the sequence of messages sent between objects. The layout of the diagram focuses on the relationships that exist between objects in contrast to the sequence. It helps in visualising the way an object collaborates to complete a specific task and used in comparing dynamic and static models.

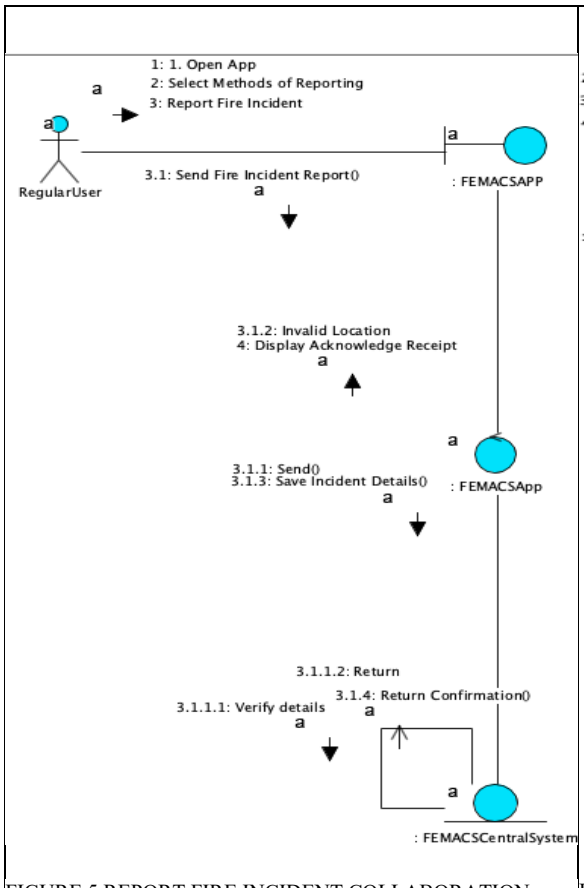


FIGURE 5 REPORT FIRE INCIDENT COLLABORATION DIAGRAM

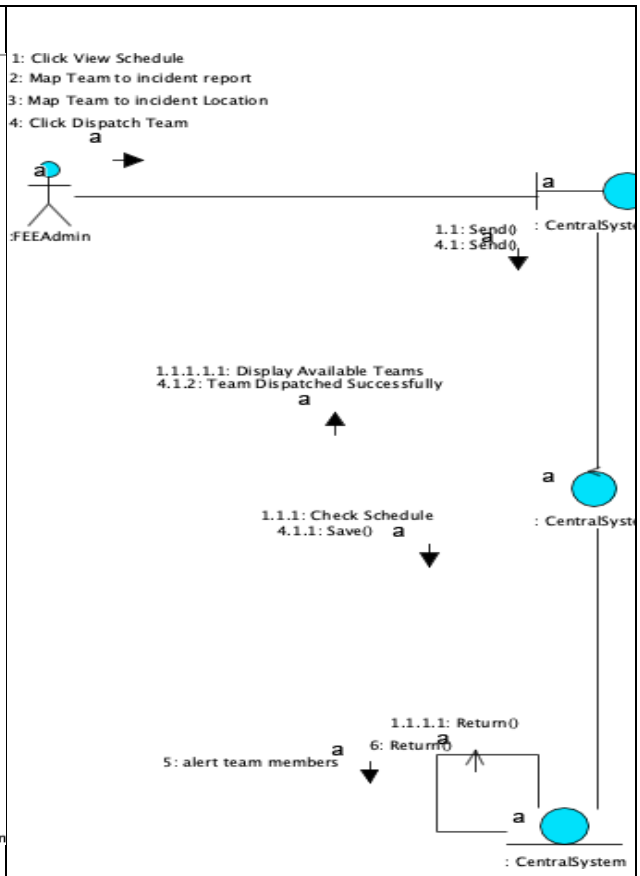


FIGURE 6 DISPATCH TEAM COLLABORATION DIAGRAM

5. *ACTIVITY DIAGRAMS*

The activity diagram is one of the critical UML diagrams that describe the dynamic aspects of a software system or sub-systems. It describes a sequence of activities from one activity to another. The control flow drawn from one operation to another this flow can be sequential, parallel branched, or concurrent. The figures below illustrate some vital activities of the system.

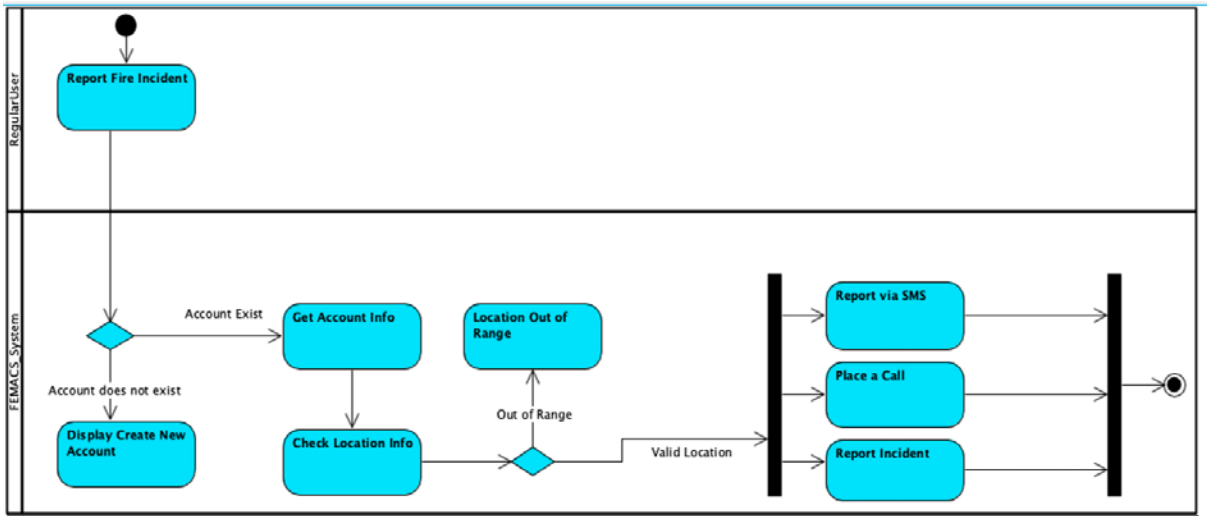


FIGURE 7 REGISTRATION ACTIVITY DIAGRAM

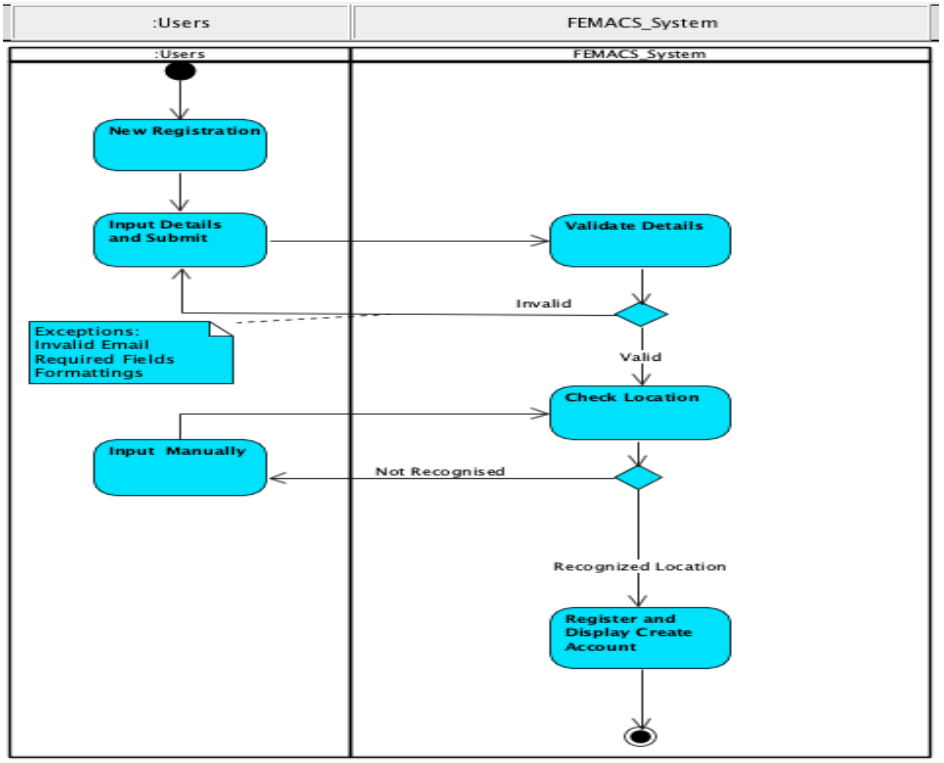


FIGURE 8 REPORT FIRE INCIDENT ACTIVITY DIAGRAM

6. *STATE CHART DIAGRAM*

Statechart diagram defines different states of an object, and the states defined as a condition in which an object exists and changes when some event (external or internal) triggered. It demonstrated the model a lifetime of an object from creation to termination. Figure 9 and 10 demonstrated the chart the system chart diagrams

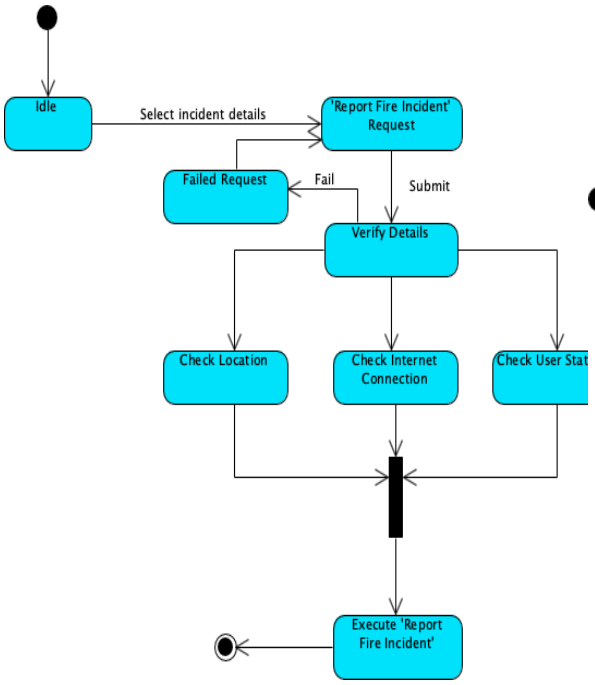


FIGURE 9 REPORT FIRE INCIDENT STATE CHART DIAGRAM

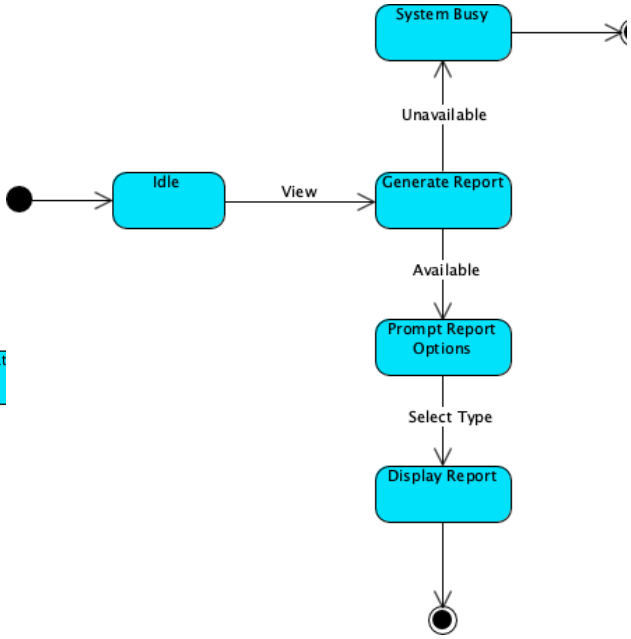


FIGURE 10 TRACK TEAM LOCATION STATE CHART DIAGRAM

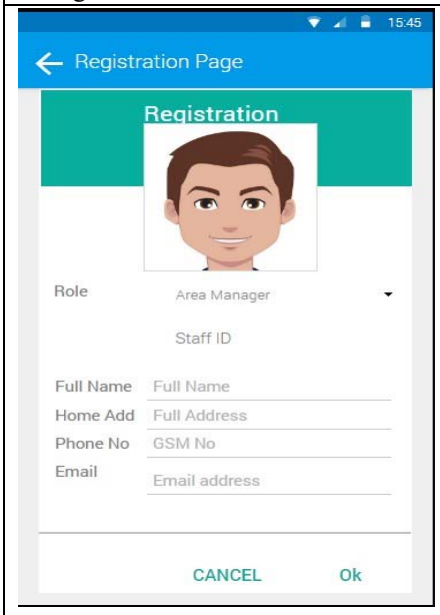
D. GRAPHIC USER INTERFACE DESIGN

1. FEMACS MOBILE APPLICATION:

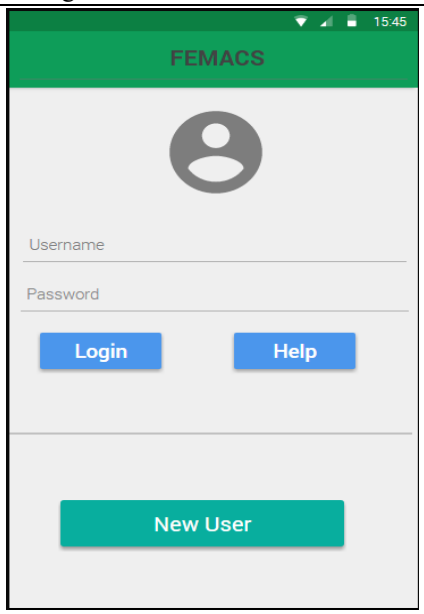
Protype of an Android mobile application was designed and built with the following operation steps, which include registration, login, reporting and tracking. We focused on improving usability and simplicity while designing the graphical application interface.

Table 4 FEMACS APP GUI

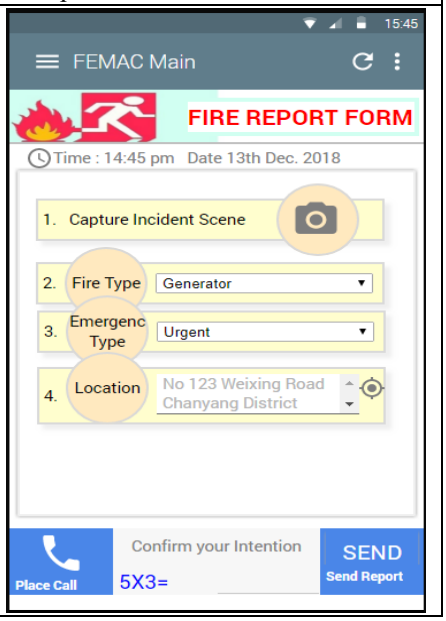
a. Registration



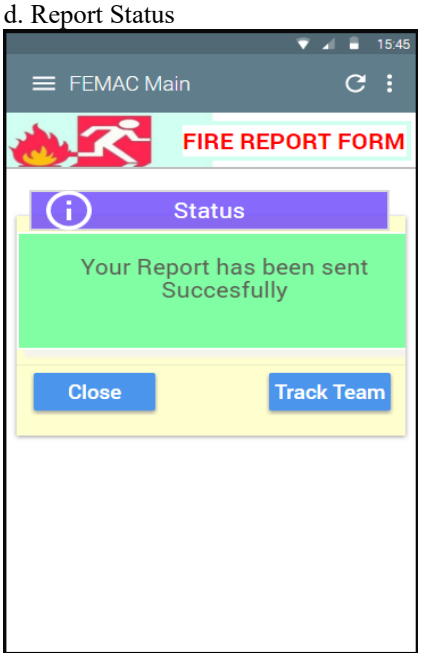
b. Login



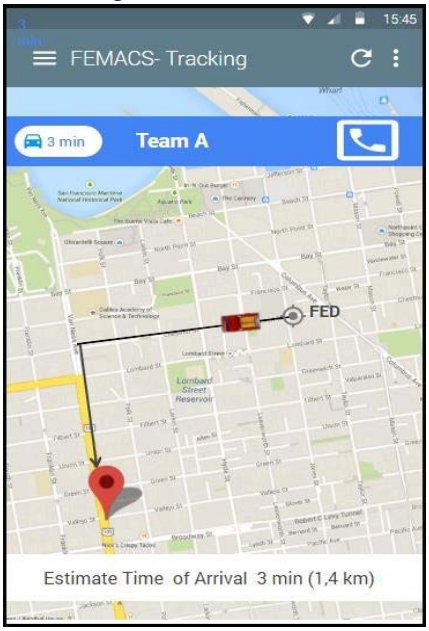
c. Report Fire Incident



d. Report Status



e. Tracking Rescue Team



f. Calling Rescue Team

The application simplicity in operation will make it faster to report an emergency incident on time

a. Registration: -The new user must register with the FEMACS APP before he/she can report an incident, few steps are required to complete the registration. Name and phone number are the only fields required while the user address and e-mail are left optional to speed up the registration process. Upon completion of the registration process, the user must fill in the username and password for subsequent login.

b. Login – Existing user can log to the application by supplying the correct details

c. Report Fire Incident: -Incident reporting consists of only 4 steps; select options are included to help the reporter speed up the reporting process. The first step after successful registration or login is to capture the incident video/ photo; this will allow the fire department to see the location of the incident and how severe the incident is. Then pick the type of incident and the priority level. The application built to synchronize the location via the GPS device and, alternatively, the user can fill in the incident address. The reporter has two options to report an incident, either by submitting a report or by placing a call directly to the Emergency Operations Centre; the confirmation code is required to complete the action.

d. Report Status- After the incident has been reported, the application will notify the status of the report, and will also give an option to track the incoming rescue team.

e. Tracking Rescue Team: user can track the incoming team in real-time, additional information such as team name, distance and estimated time of arrival is also provided.

f. Call Option: - FEMACS APP gives flexibility to the incident reporters to call and communicate with the incoming rescue team

2. FEMACS Central System

The central system designed to serve the fire department; the system provides real-time reported incident to the department. Also, assist the department in dispatching and tracking rescue teams.

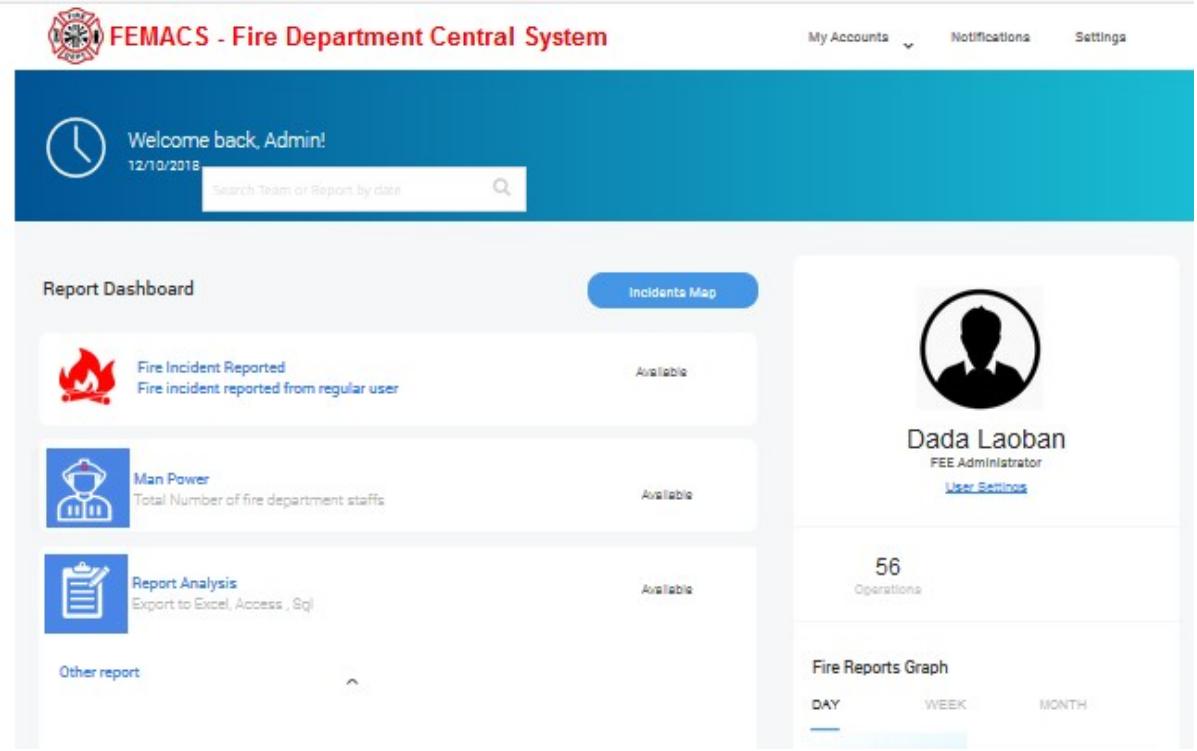


FIGURE 11 MAIN PAGE CENTRAL SYSTEM

Figure 11 depicted the Central System Dashboard. The Dashboard provides Administrators with tools to track activities, reports metrics and provide flexibility to export report.

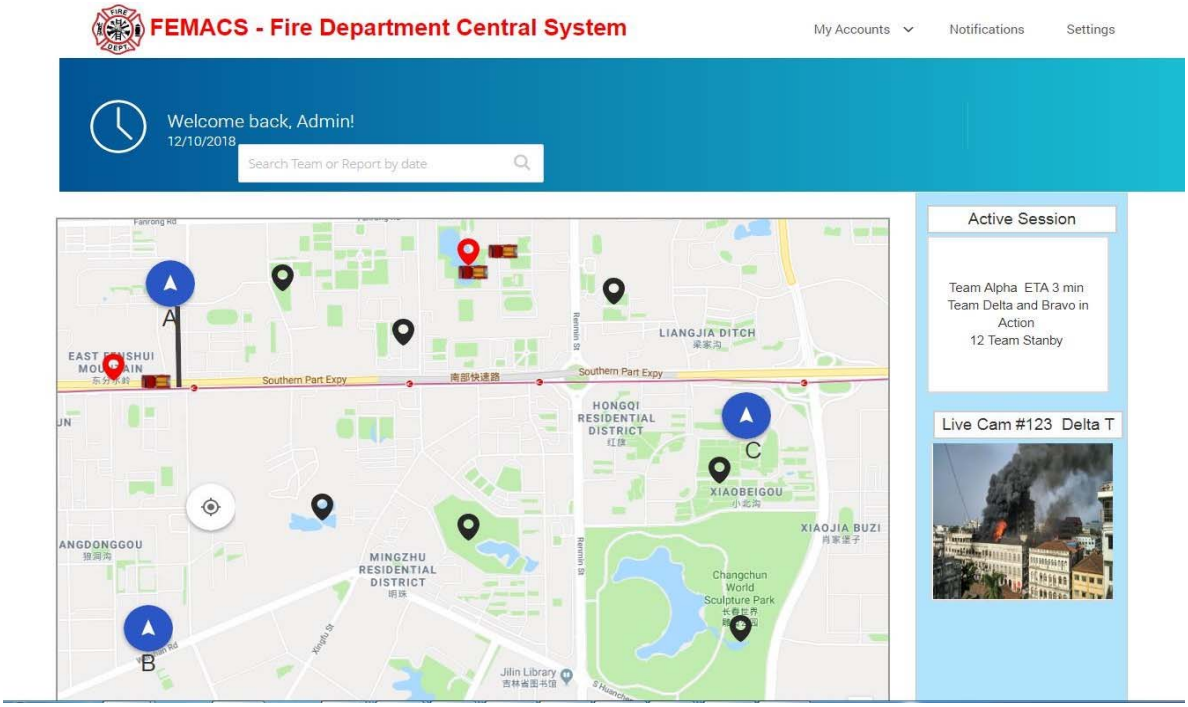


FIGURE 12 CENTRAL SYSTEM ACTIVITY PAGE

Figure 12 Shows the Central System Activity page, updates on concurrent emergency incidents, deployed teams, live incident streaming via the rescue team cam, and much more to the fire department admin.

CONCLUSION

In this paper, we have developed a fire reporting application with an integration of a central system using Object-Oriented Analysis and Design Approach. Prior to the development of FEMACS mobile app, the manual fire reporting system has been analysed with their shortcoming stated, and the functional and non-functional requirements have been investigated to build and improve on the unified modelling language (UML) for an automated system (FEMACS). The designed FEMACS prototype allows an individual with the mobile App to rapidly report all cases of fire outbreaks to a nearby fire emergency department (FED) via call or SMS. It as well gives a route preference to the fire emergency employee (FEE), thereby choosing the possible shortest distance to the scene of the incident. While the UML was used to demonstrate the application view, the GUI gives the prototype with simple usability. We concluded our work by proposing and recommending a practical implementation of this prototype in our various community.

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