"Smart City and Data Visualization"

A PROJECT REPORT

Submitted by

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CERTIFICATE

This is to certify that the project entitled *Smart City and Data Visualization* has been carried out by Anish K. Virani (110420107016), Jay A. Patel(110420107021), Mohit C. Gandhi (110420107026), Ujjaval S. Prajapati (110420107034), students of B.E.IV (CO), Semester-VII, under my guidance in fulfillment of the degree of Bachelor of Engineering in Computer Engineering of Gujarat Technological University, Ahmedabad for the academic year April-2015.

Signature of	**Signature of**
Guide	**Head of the Department**
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Prof. Vaikhari Deodhar	**Prof. (Dr.) Keyur Rana**

Signature of Jury Members

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Acknowledgements

We have taken efforts in this Project. However, it would not have been possible without the kind support and help of many individuals and organizations. We would like to extend our sincere thanks to all of them.

We are extremely grateful to our guide Prof. Vaikhari Deodhar for her unforgettable support and expert guidance without which the success of this project would have been impossible.

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Abstract

Urban performance currently depends not only on the city's endowment of hard infrastructure, but also on how intelligently and efficiently city's overall management is carried out. It will help to improve superiority of life and increase involvement of citizens in the governance of cities.

Even developed cities are facing many problems like poor management of street lights, drainage, fire safety, traffic management, etc. Authorities often take measures to prevent against all these problems but they are not able to overcome all of them completely. So to get rid of all these problems, we come up with a concept of Smart City which can offer possible solutions to the above mentioned problems.

Smart City refers to the city automated in various aspects. These aspects could be traffic analysis, street light control, fire detection, drainage-overflow detection, gas-leakage detection, temperature measurement etc.

Live Visualization involves the visual representation of data received from the sensors in real time. Live visualization of traffic, drainage, fire, weather etc. can be done. It can be used to visualize the real time data of sensors and can be used to take appropriate measures.

Data Visualization involves the creation and study of visual representation of data. Its main goal is, to communicate information clearly and effectively through graphical means. We will develop the system as a platform to connect key services like traffic analysis, street light control, fire detection, drainage-overflow detection, gas-leakage detection, temperature measurement, etc. to give the graphical view of city for all these aspects to authorities.

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1. Problem Summary

Developing cities are currently facing many problems like poor management of street lights, drainage, fire safety, traffic management, etc. Authorities often take measures to prevent against all these problems but they are not able to overcome all of them completely. Cities don't have centralized data management centers for maintaining the data of the above mentioned aspects. The data currently stored is in textual form which is quite difficult to analyze, so we need graphical representation to analyze the data in comprehensive manner.

Street lights are ON at daytime and OFF at night when they are actually needed which is not acceptable. Some of the drainage overflows for many days due to lack of information to the authorities which causes chaos. Information about fire is not received by the authorities immediately, so sometimes it becomes difficult to control the fire. Different facilities like Electricity, Gas, Telephone Lines, etc. come from different channels which are termed as grids. So it becomes very difficult to maintain it. If all the grids are arranged in a single tunnel then it will be very easy to maintain.

Traffic is a very big problem that is currently faced by most of the cities. People get stuck in traffic due to lack of information about traffic on different roads. Ambulances and fire fighter vehicles also get stuck in traffic due to this. All these problems of traffic can be handled if correct information about traffic is visually available.

The Environment-related data about humidity, temperature, dust, rain, etc cannot be currently visualized properly due to which prediction of weather is difficult. Similarly, the data about population and crime rate currently stored is in textual form which is very difficult to analyze.

2. Aims and Objectives of the Work

The feasible solution to the problem mentioned in problem summary can be to use sensors to detect fire, drainage overflow and perform temperature measurement, pressure measurement, etc. at publicly important places; we can have better management of city. Software can be designed to show the map of the city. It can demonstrate the visual representation of received data on the equivalent map of the city. It can have functionality to control street lights, visualize the data received from the above mentioned sensors, record this data and visualize it when needed.

1. Street Light Management:

Street lights can also be controlled manually using the software and can be controlled by time i.e. switching the street light ON at night time and switching it OFF at day time depending on the season. BH1750FVI can be used for measuring the intensity of light around the street light and it can be used to turn OFF or turn ON the street light. A relay named contactor can be used to control actual street lights using low voltage microcontroller.

2. Live Visualization:

Live Visualization involves the visual representation of data received from the sensors in real time. Live visualization of traffic, drainage, fire, weather etc. can be done. It can be used to visualize the real time data of sensors and can be used to take appropriate measures.

3. Traffic Analysis:

Traffic can be analyzed by processing the captured video of the road and the visual representation of it can be shown on the map publicized in the software.

4. Data Visualization:

Data Visualization involves the creation and study of visual representation of data. Its main goal is, to communicate information clearly and effectively through graphical means. The data about crime can be crime and population can be stored in the data base and can be visualized. This provides ease of analysis of crime in different area of city and it can be used for making appropriate decisions for authorities.

3 Usefulness of Project to the Industry/society/User

This project is mainly focused to improve the quality of life of the society. A smart city uses digital technologies to enhance performance and wellbeing, to reduce costs and resource consumption, and to engage more effectively and actively with its citizens. Key 'smart' sectors include transport, energy, health care, water and waste. A smart city should be able to respond faster to city and global challenges than one with a simple 'transactional' relationship with its citizens. It helps the society by providing traffic information so that they can select the route with less traffic. Ambulances can use traffic information to reach the emergency situations quickly. Municipal Corporation can plan new road by analyzing the traffic density on particular route.

The management of street light becomes very effortless to the municipal corporation as the street lights can be operated manually, by time or by light intensity. Light detectors are used to ensure the intensity of light of the surroundings and are used to control the street lights. This also reduces the wastage of electricity.

Live visualization of data like temperature, pressure, humidity and other environmental aspects assist the weather forecasting department in their work. Fire detecting sensors which are placed at public places provide quick notification about the fire to the authority so that more dangerous situations can be avoided. Rain detecting sensors provide notification about rain in particular areas.

Data visualization of pre-recorded data like temperature, pressure, humidity and other environmental aspects can be visualized on a graph. It assists the work of weather forecast department. Zone-wise data visualization of population, crime, etc helps the authorities to take necessary actions for the future.

4 Brief Literature review

a. IBM's concept of Smart City

Smarter cities of all sizes are capitalizing on new technologies and insights to transform their systems, operations and service delivery. Competition among cities to engage and attract new residents, businesses and visitors means constant attention to providing a high quality of life and vibrant economic climate. Forward-thinking leaders recognize that although tight budgets, scarce resources and legacy systems frequently challenge their goals, new and innovative technologies can help turn challenges into opportunities. These leaders see transformative possibilities in using big data and analytics for deeper insights. Cloud for collaboration among disparate agencies. Mobile to gather data and address problems directly at the source. Social technologies for better engagement with citizens. Being smarter can change the way their cities work and help deliver on their potential as never before.

Table 1 IBM's concept[1]

Concepts	Description
Intelligent transportation	Citywide visibility across entire transportation network and city services to improve incident response
Traffic	Analyzing patterns of traffic conditions, traffic flow graphs and event reports.
Energy and Utilities	IBM is helping utilities add a layer of digital intelligence to their grids.
Public safety	Unified view across crime, emergency management, terrorism, etc. data sources to protect citizens, business and government.

Water solution	Visibility across the water network to improve operational planning and prioritization and to monitor water quality.
Education	Analytics, cloud computing and early warning prediction can make education system smarter

b. Microsoft's Launches 'Smart Cities' Initiative

CityNext is “a people-first approach to innovation that empowers government, businesses, and citizens to shape the future of their cities,” .Microsoft's CityNext initiative puts people first and builds on this new era of collaborative technology to engage citizens, business and government leaders in new ways. In theory, this system can be put to use in emergency situations: When critical information is allowed to flow seamlessly between government, businesses, and citizens, people will more readily get the resources they need to be prepared. New York City, for instance, would likely have benefited from such a program last fall, during Hurricane Sandy.

CityNext aims to connect functions like energy, water, infrastructure, transportation, public safety, tourism, recreation, education, health and social services, and government administrations.

If CityNext succeeds, cities will improve efficiency by installing Microsoft products that harness the cloud and big data. Mobile access to big data tools and cloud-powered enterprise apps could give workers on-demand access to advanced analytics, with sources ranging from vast databases to real-time data culled from environmental sensors. In theory, these technologies should allow workers to more quickly derive insights, collaborate with one another and come to decisions. This sort of efficiency could

not only save lives during an emergency but also drive day-to-day savings that total millions, and perhaps even billions, of dollars over time.

Microsoft announced eight other CityNext customers: Zhengzhou and Hainan Province, both in China; Auckland, New Zealand; Buenos Aires, Argentina; Hamburg, Germany; Manchester, England; Moscow, Russia; and Philadelphia, the only U.S. city to sign up so far.

5 Plan of our Work

5.1 Requirement Analysis

Urban performance currently depends not only on the city's endowment of hard infrastructure, but also on how intelligently and efficiently city's overall management is carried out. It will help to improve superiority of life and increase involvement of citizens in the governance of cities. Even developed cities are facing many problems like poor management of street lights, drainage, fire safety, traffic management, etc. Authorities often take measures to prevent against all these problems but they are not able to overcome all of them completely. So to get rid of all these problems, we come up with a concept of Smart City which can offer possible solutions to the above mentioned problems.

Poor management of street lights is a problem that should be solved to use the electricity effectively and efficiently. Street lights are ON at daytime and OFF at night when they are actually needed which is not acceptable. Information about fire is not received by the authorities immediately, so sometimes it becomes difficult to control the fire. Different facilities like Electricity, Gas, Telephone Lines, etc. come from different channels which are termed as grids. So it becomes very difficult to maintain it. If all the grids are arranged in a single tunnel then it will be very easy to maintain.

Figure 1: Street Light on at day time[14]

Traffic is a very big problem that is currently faced by most of the cities. People get stuck in traffic due to lack of information about traffic on different roads. Ambulances and fire fighter vehicles also get stuck in traffic due to this. All these problems of traffic can be handled if correct information about traffic is visually available.

Figure 2: vehicle stuck in traffic[15]

Drainage management needs some improvement for better management of city. Some of the drainage overflows for many days due to lack of information to the authorities which causes chaos. This problem needs to be solved efficiently and effectively.

Figure 3: Drainage Overflow[16]

Fire control department currently faces many problems due to lack of information about fire. Information about fire is not received by the authorities immediately, so sometimes it becomes difficult to control the fire. Quick notification system is required for solving the above mentioned problem.

Figure 4: Fire at public place[17]

The Environment-related data about humidity, temperature, dust, rain, etc cannot be currently visualized properly due to which prediction of weather is difficult. Similarly, the data about population and crime rate currently stored is in textual form which is very difficult to analyze. These problems are needed to be solved efficiently and effectively using software that can show the visualization of the above mentioned data on the equivalent part of the map.

5.2 Design

Architecture Diagram

The figure below shows the architecture diagram of the project. The zone server receives data about its zone from various sensors. The Main server receives data about streetlights, traffic, environment, etc. from the zone servers. The main server stores these data to the database. This data can be used for data visualization.

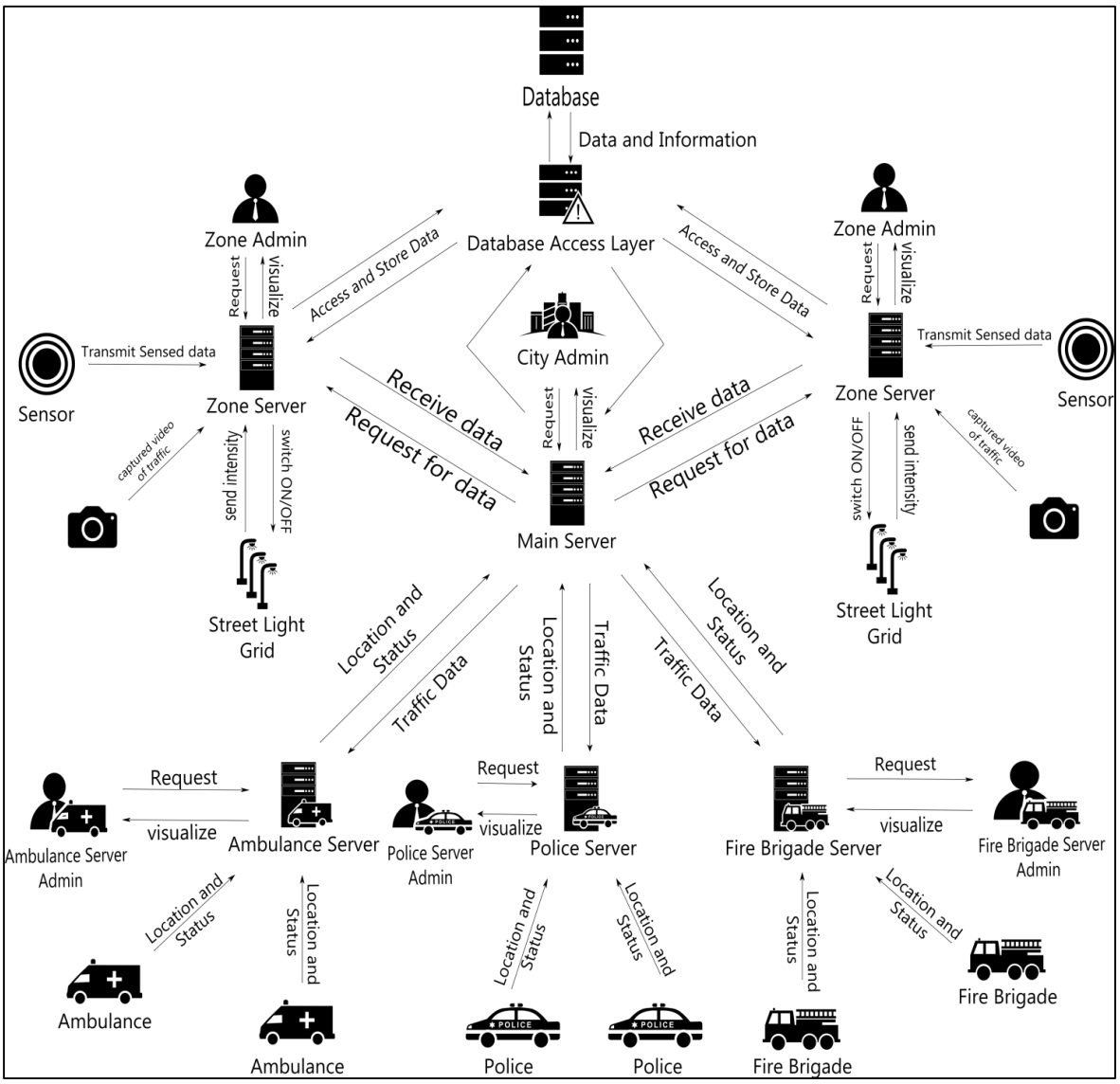

Figure 5: Architecture Diagram

Database Diagram

The Figure shown behind represents the database diagram for the project. The tables for the administrators store the data about various administrators like zone admin, city admin. The tables of the sensors stores the data about different sensors. The data may be its id, location, status, etc

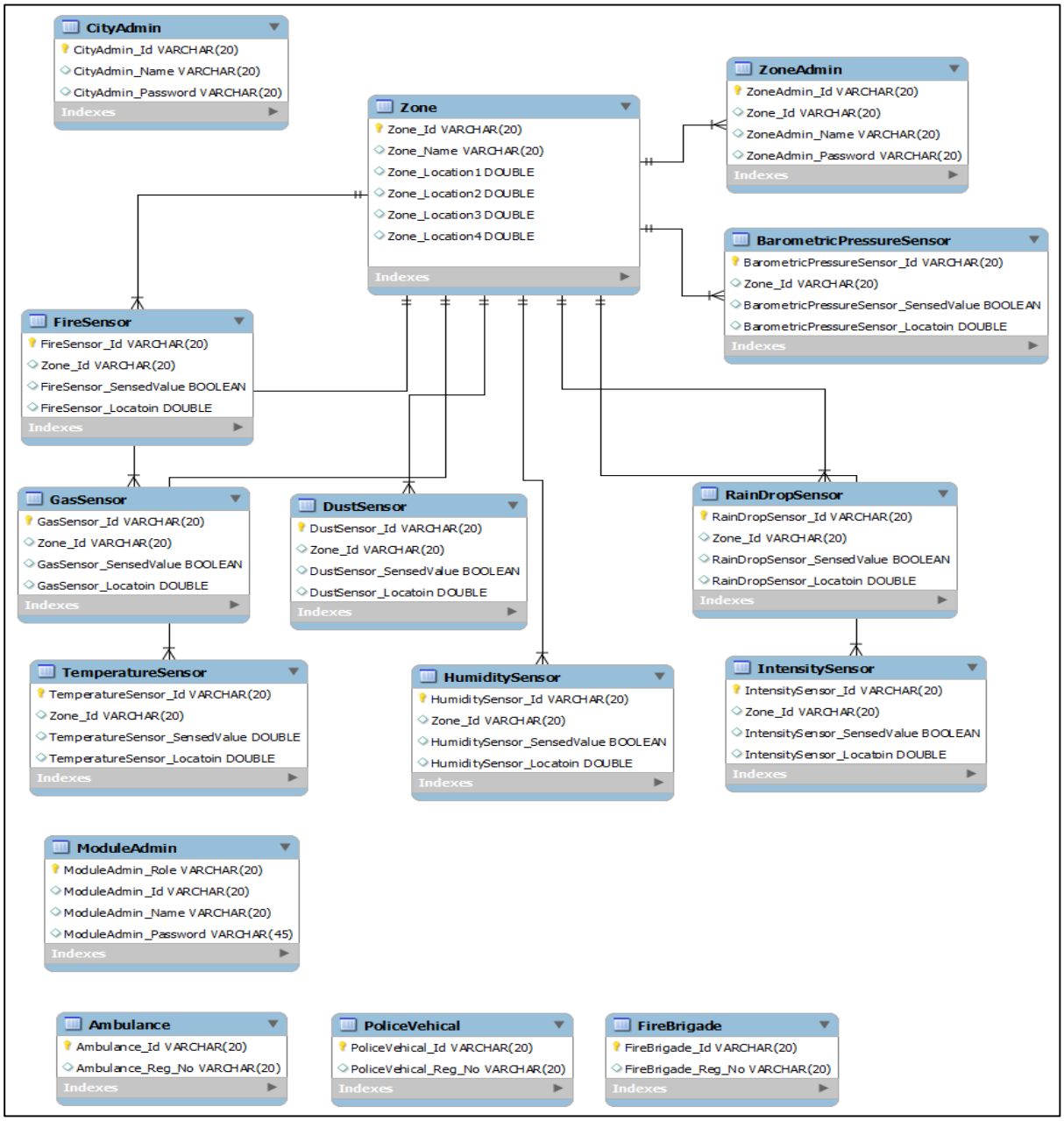

Figure 6: Database Diagram

Class Diagram:

The figure shown behind represents the class diagram of the project. Various classes

of the project are administrators, sensors, servers, etc. The city administrator is connected to the main server which is in turn connected to the various zone servers. The zone server receives data from different sensors and the data is stored in the database by the main server.

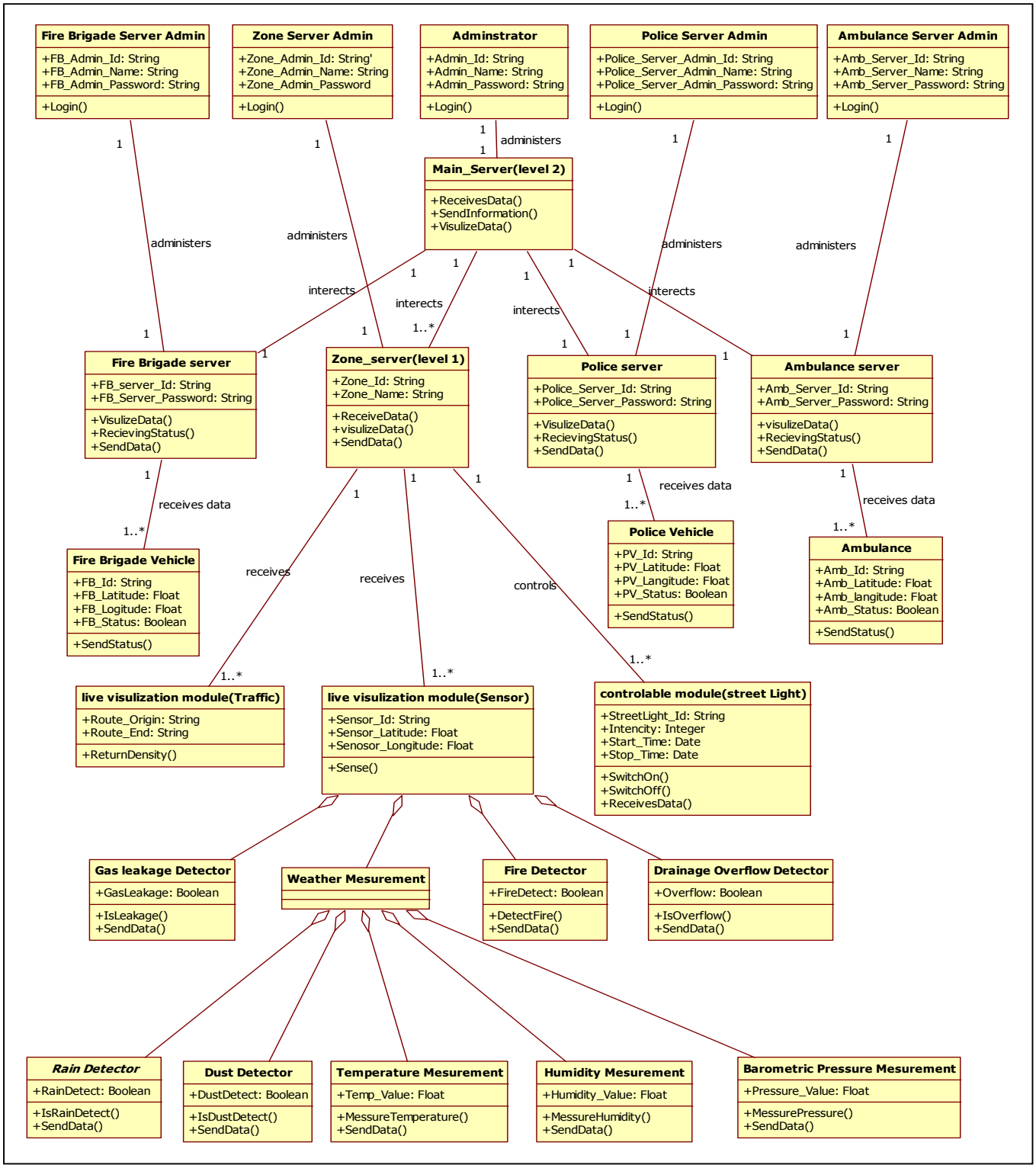

Figure 7: Class Diagram

Use-case Diagrams:

- The figure shown below represents the use-case diagram for the system. It represents how the administrator does the login and visualizes data received from the zone servers.

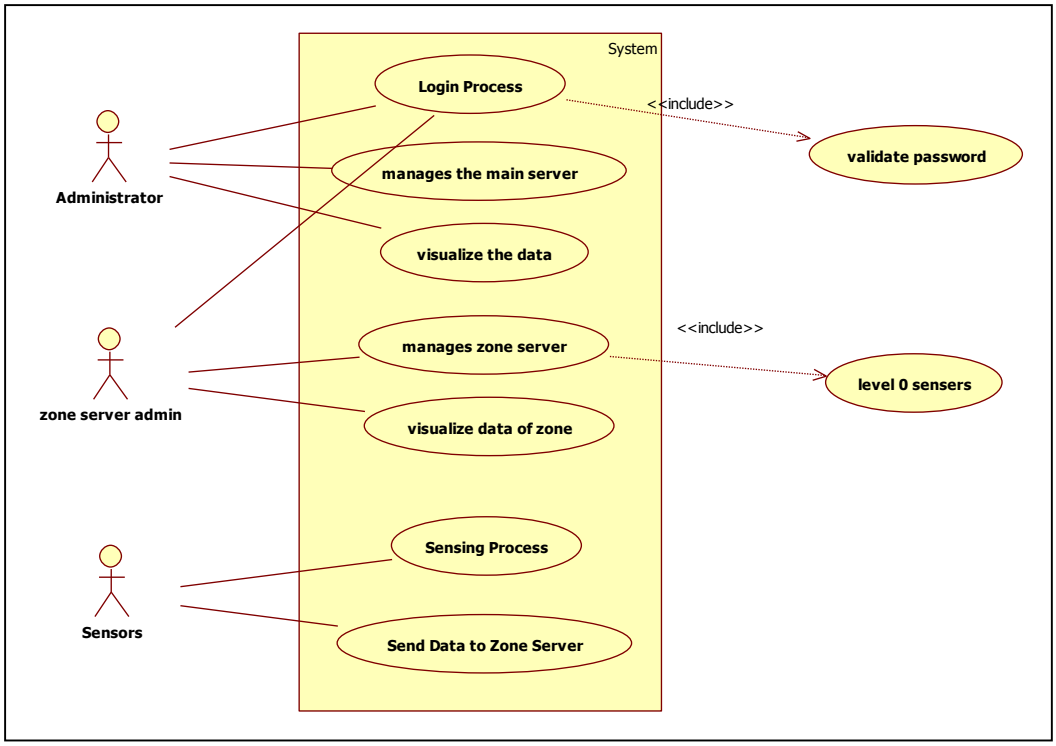

Figure 8: Usecase Diagram for system

- The figure shown below represents the use-case diagram for the individual modules. It represents how the specific admin does the login and control the module provided to him.

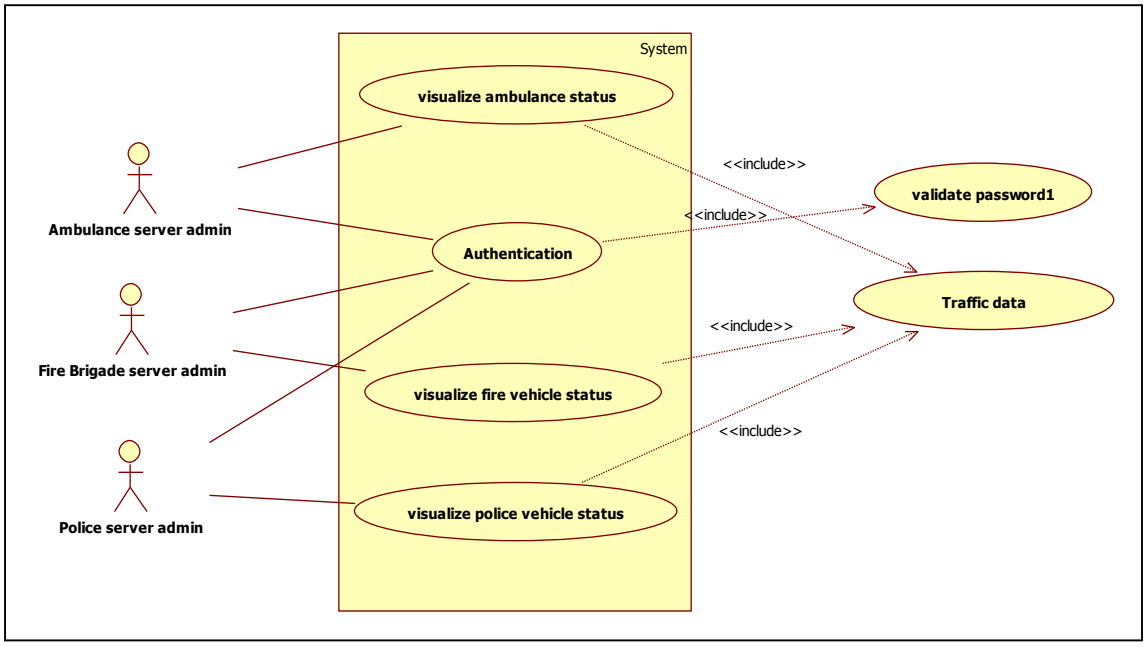

Figure 9: Usecase Diagram for modules

Activity Diagrams:

- The figure shown below represents the activity diagram for the administrator. It represents how the administrator does the login to the system.

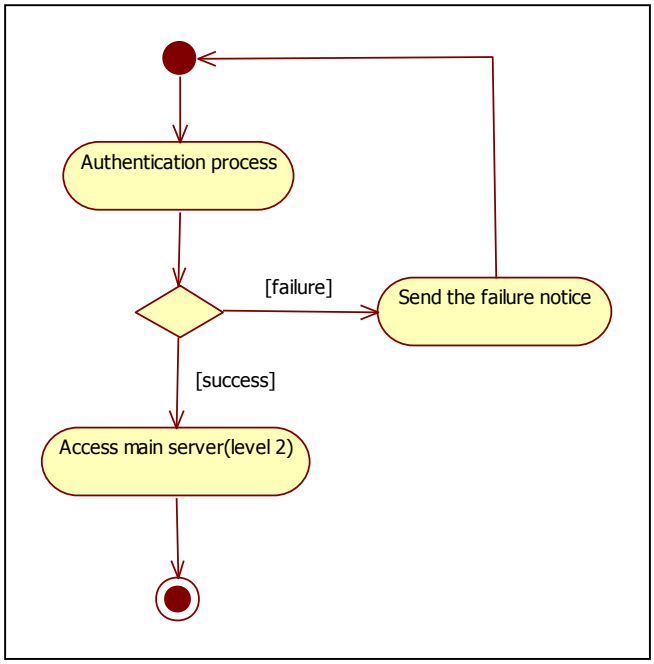

Figure 10: Activity Diagram for administrator

- The figure shown below represents the activity diagram for the zone administrator. It represents how the administrator does the login to the system and visualizes the data received from the sensors.

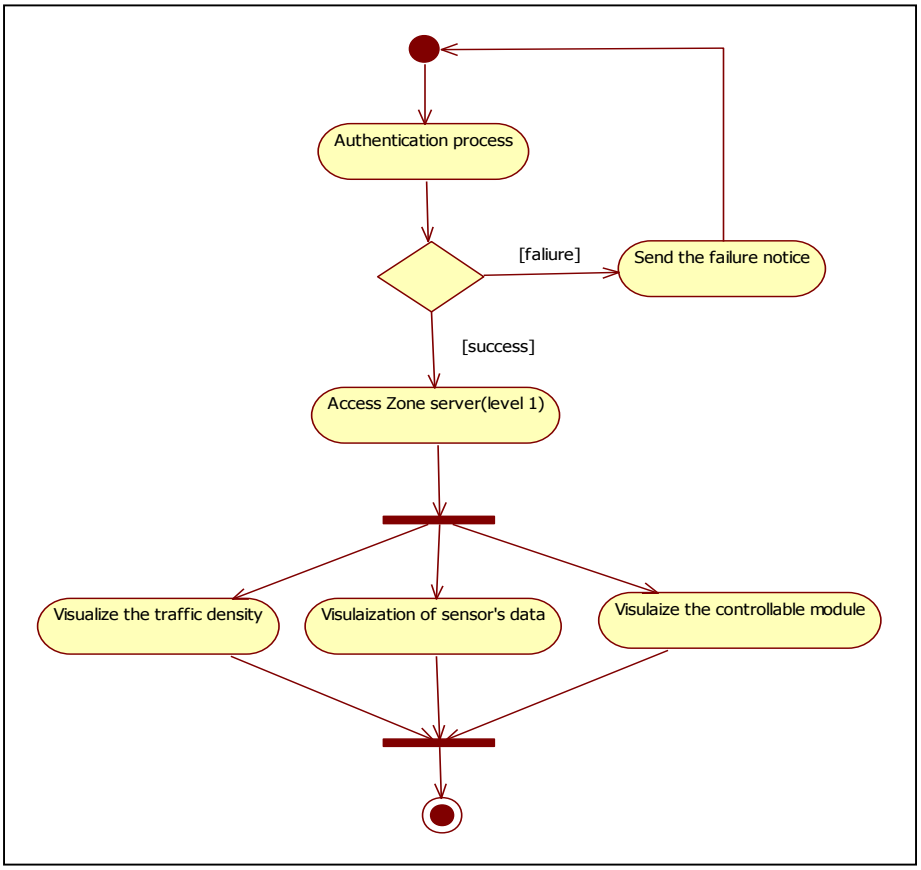

Figure 11: Activity Diagram for Zone Administrator

- The figure shown below represents the activity diagram for the sensor. It represents how the sensor sense the data and send it to the zone.

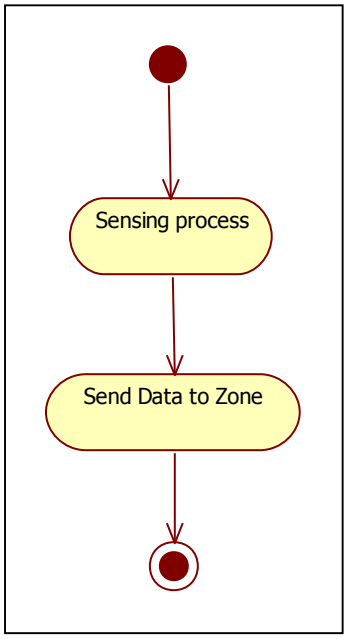

Figure 12: Activity Diagram for sensors

- The figure shown below represents the activity diagram for the ambulance administrator. It represents how the administrator does the login to the system and receives the data about the status of the ambulance.

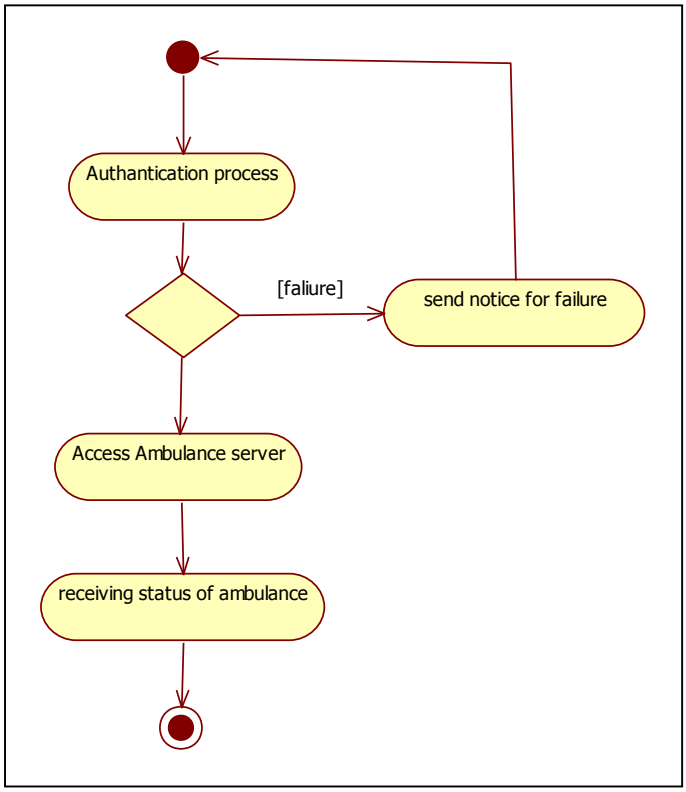

Figure 13: Activity Diagram for ambulance administrator

- The figure shown below represents the activity diagram for the police server administrator. It represents how the administrator does the login to the system and receives the data about the status of the police vehicle.

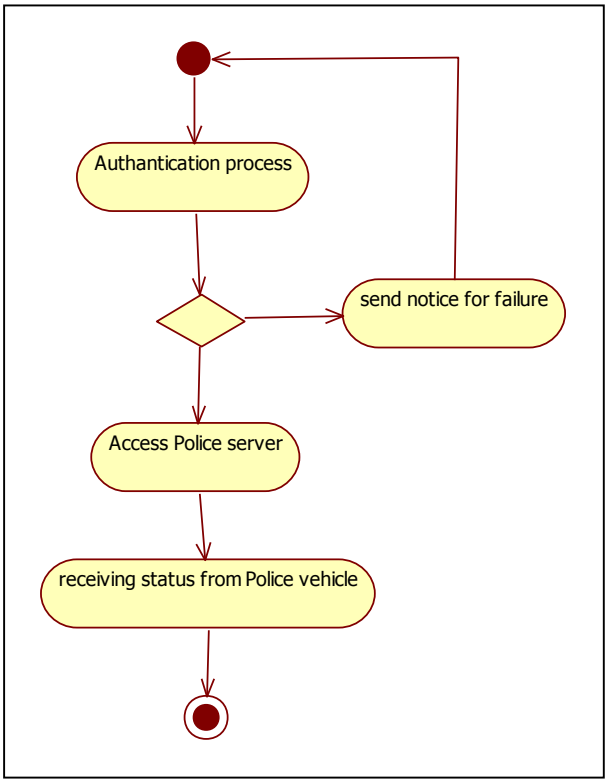

Figure 14: Activity Diagram for police administrator

- The figure shown below represents the activity diagram for the fire brigade administrator. It represents how the administrator does the login to the system and receives the data about the status of the fire brigade.

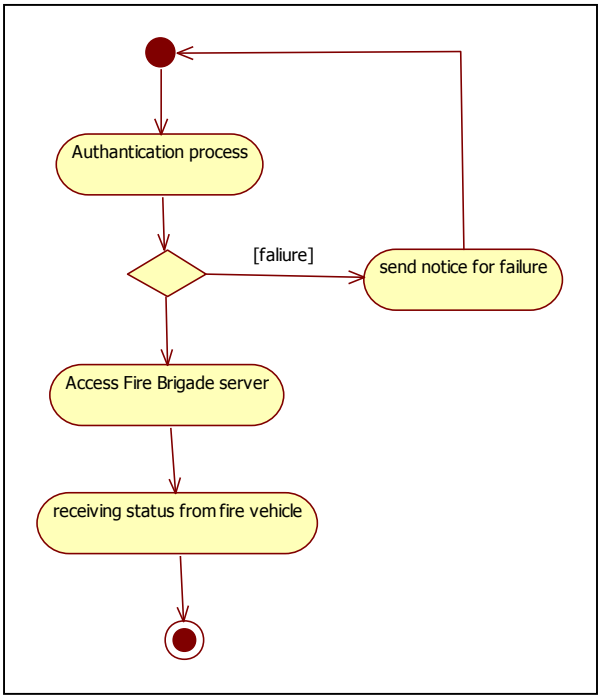

Figure 15: Activity Diagram for fire brigade administrator

Sequence Diagram:

- The figure shown below represents the sequence diagram for the administrator. It represents how the administrator does the login to the system, requests data to the zone server and receives the data about the sensors and visualizes the data.

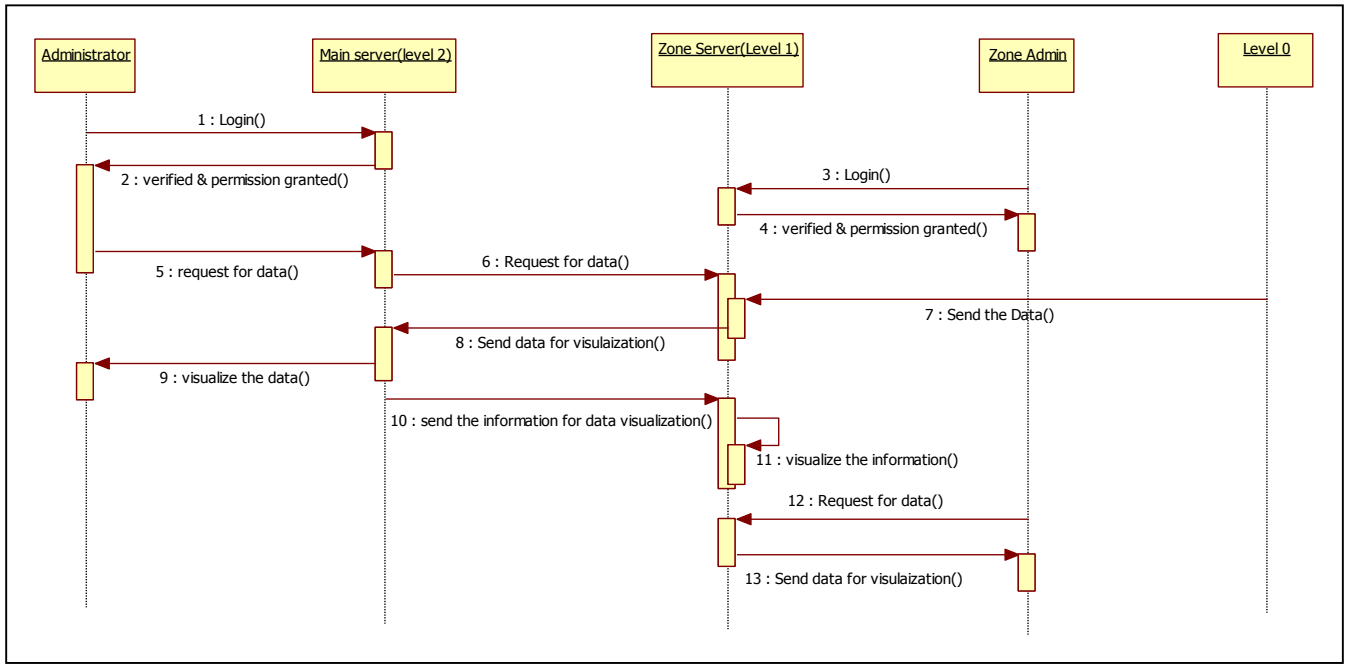

Figure 16: Sequence Diagram for administrator

- The figure shown below represents the sequence diagram for the ambulance administrator. It represents how the administrator does the login to the system, requests data to the zone server and receives the data about the ambulances and visualizes the status.

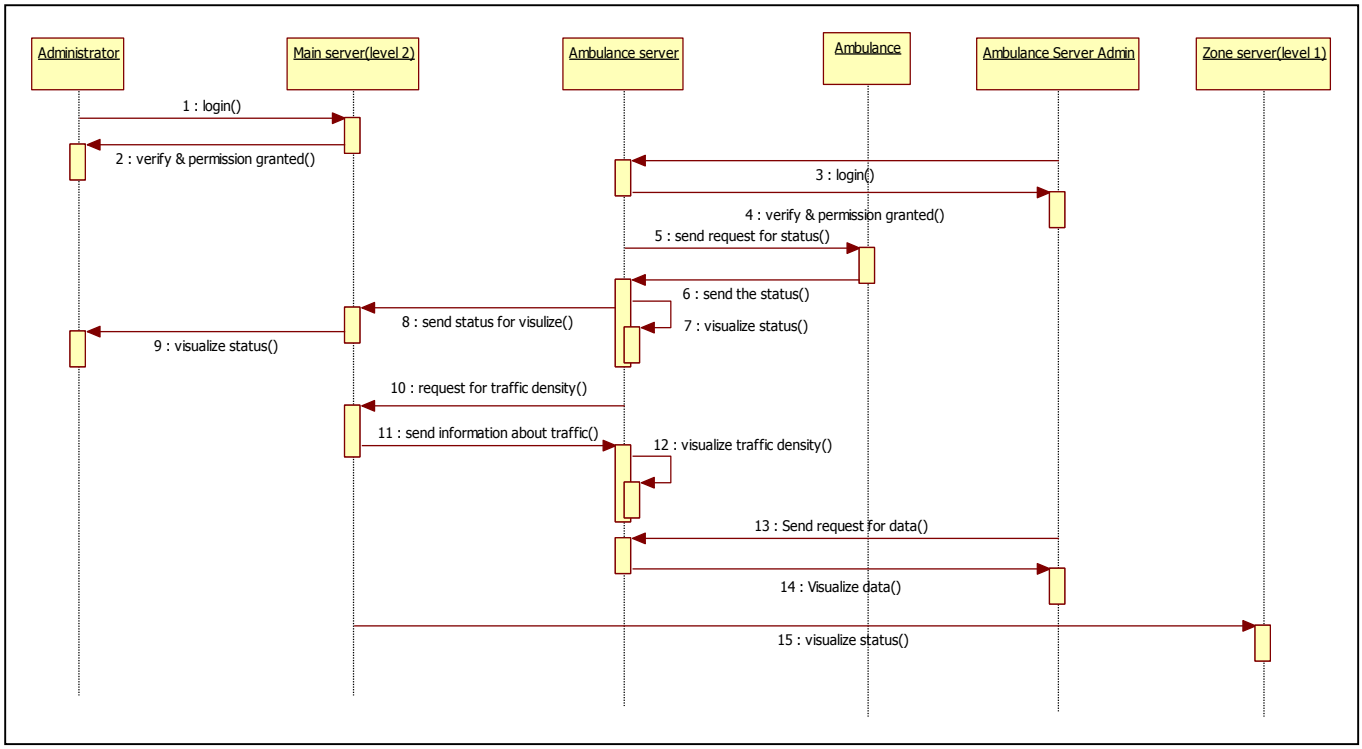

Figure 17: Sequence Diagram for ambulance administrator

- The figure shown below represents the sequence diagram for the police server administrator. It represents how the administrator does the login to the system, requests data to the zone server and receives the data about the police vehicles and visualizes the status.

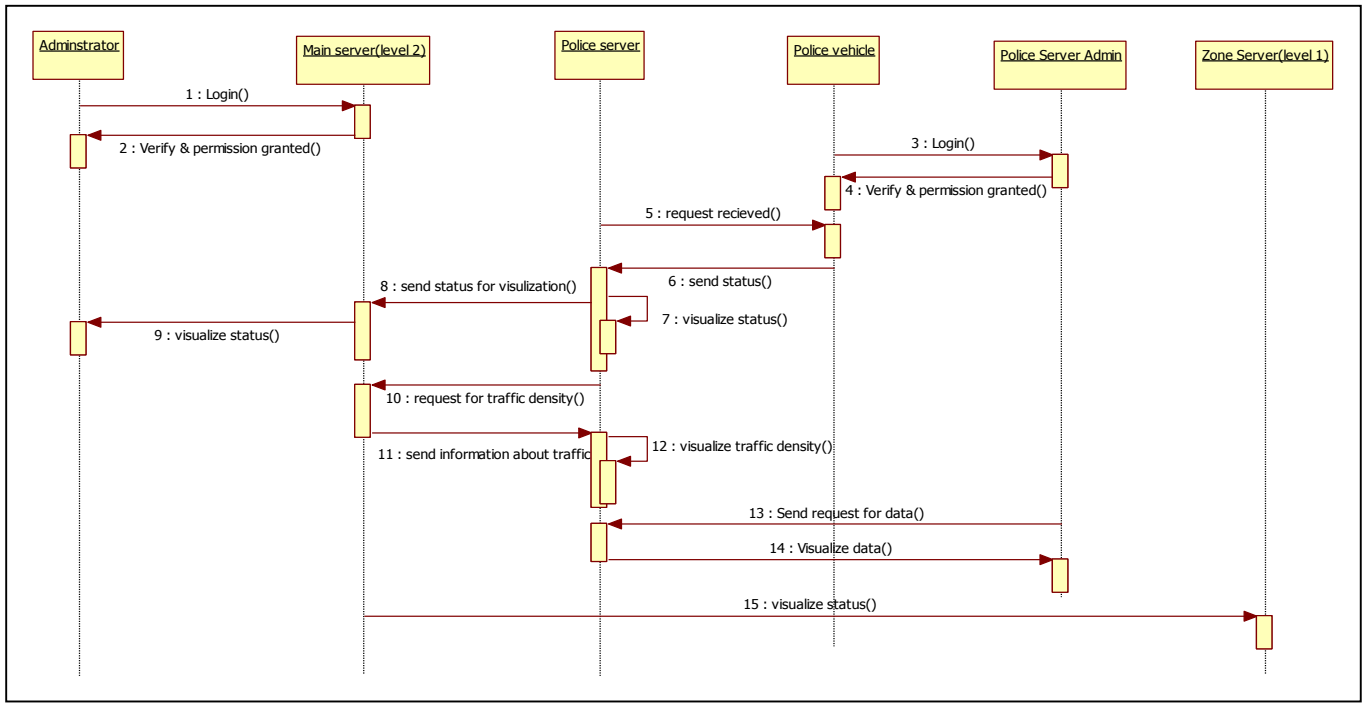

Figure 18: Sequence Diagram for police administrator

- The figure shown below represents the sequence diagram for the fire brigade administrator. It represents how the administrator does the login to the system, requests data to the zone server, receives the data about the fire brigade and visualizes the status.

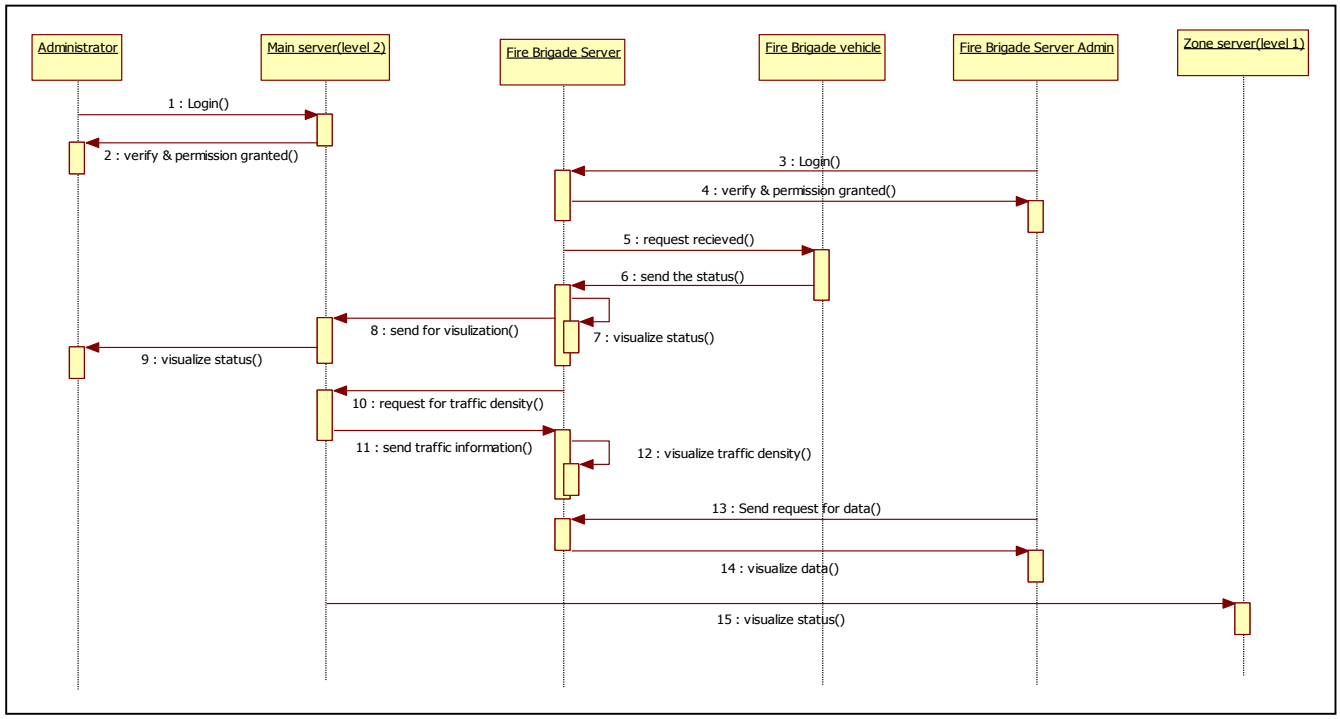

Figure 19: Sequence Diagram for fire administrator

5.3 Data Dictionary

Table 2: Data Dictionary of City Admin

Field	Type	NN	PK	FK	Comment
CityAdmin_Id	VARCHAR(20)	Yes	Yes	-	Identity of City Admin
CityAdmin_Name	VARCHAR(20)	-	-	-	Name of City Admin
CityAdmin_Password	VARCHAR(20)	-	-	-	Password of City Admin

Table 3: Data Dictionary of Zone

Field	Type	NN	PK	FK	Comment
Zone_Id	VARCHAR(20)	Yes	Yes	-	Identity of Zone
Zone_Name	VARCHAR(20)	-	-	-	Name of Zone
Zone_Location1	DOUBLE	-	-	-	Geographic Location of specified Zone
Zone_Location2	DOUBLE	-	-	-	Geographic Location of specified Zone
Zone_Location3	DOUBLE	-	-	-	Geographic Location of specified Zone
Zone_Location4	DOUBLE	-	-	-	Geographic Location of specified Zone

Table 4: Data Dictionary of Zone Admin

Field	Type	NN	PK	FK	Comment
ZoneAdmin_Id	VARCHAR(20)	Yes	Yes	-	Identity of Zone Admin
Zone_Id	VARCHAR(20)	-	-	-	Identity of Zone
ZoneAdmin_Name	VARCHAR(20)	-	-	-	Name of zone admin
ZoneAdmin_Password	VARCHAR(20)	-	-	-	Password of zone admin

Table 5: Data Dictionary of Fire Sensor

Field	Type	NN	PK	FK	Comment
FireSensor_Id	VARCHAR(20)	Yes	Yes	-	Identity of Fire Sensor
Zone_Id	VARCHAR(20)	-	-	-	Identity of Zone

FireSensor_SensedValue	TINYINT(1)	-	-	-	Fire sensed by Fire Sensor
FireSensor_Locatoin	DOUBLE	-	-	-	Location of Fire Sensor

Table 6: Data Dictionary of Intensity Sensor

Field	Type	NN	PK	FK	Comment
IntensitySensor_Id	VARCHAR(20)	Yes	Yes	-	Identity of Intensity Sensor
Zone_Id	VARCHAR(20)	-	-	-	Identity of Zone
IntensitySensor_SensedValue	TINYINT(1)	-	-	-	Sense the Intensity of light
IntensitySensor_Locatoin	DOUBLE	-	-	-	location of Intensity Sensor

Table 7: Data Dictionary of Barometric Pressure Sensor

Field	Type	NN	PK	FK	Comment
BarometricPressureSensor_Id	VARCHAR(20)	Yes	Yes	-	Identity of Barometric Pressure Sensor
Zone_Id	VARCHAR(20)	-	-	-	Identity of Zone
BarometricPressureSensor_SensedValue	TINYINT(1)	-	-	-	Value of Barometric Pressure
BarometricPressureSensor_Locatoin	DOUBLE	-	-	-	Location of Barometric Pressure Sensor

Table 8: Data Dictionary of Gas Sensor

Field	Type	NN	PK	FK	Comment
GasSensor_Id	VARCHAR(20)	Yes	Yes	-	Identity of Gas Sensor
Zone_Id	VARCHAR(20)	-	-	-	Identity of Zone
GasSensor_SensedValue	TINYINT(1)	-	-	-	Sense Gas leakage
GasSensor_Locatoin	DOUBLE	-	-	-	Location of Gas Sensor

Table 9: Data Dictionary of Dust Sensor

Field	Type	NN	PK	FK	Comment
DustSensor_Id	VARCHAR(20)	Yes	Yes	-	Identity of Dust Sensor
Zone_Id	VARCHAR(20)	-	-	-	Identity of Zone
DustSensor_SensedValue	TINYINT(1)	-	-	-	Proportion of sensed dust
DustSensor_Locatoin	DOUBLE	-	-	-	location of Dust Sensor

Table 10: Data Dictionary of Temperature Sensor

Field	Type	NN	PK	FK	Comment
TemperatureSensor_Id	VARCHAR(20)	Yes	Yes	-	Identity of Temperature Sensor
Zone_Id	VARCHAR(20)	-	-	-	Identity of Zone
TemperatureSensor_SensedValue	DOUBLE	-	-	-	Sense the temperature
TemperatureSensor_Locatoin	DOUBLE	-	-	-	Location of Temperature Sensor

Table 11: Data Dictionary of Humidity Sensor

Field	Type	NN	PK	FK	Comment
HumiditySensor_Id	VARCHAR(20)	Yes	Yes	-	Identity of Humidity Sensor
Zone_Id	VARCHAR(20)	-	-	-	Identity of Zone
HumiditySensor_SensedValue	TINYINT(1)	-	-	-	Sense the Humidity
HumiditySensor_Locatoin	DOUBLE	-	-	-	Location of Humidity Sensor

Table 12: Data Dictionary of Module Admin

Field	Type	NN	PK	FK	Comment
ModuleAdmin_Role	VARCHAR(20)	Yes	Yes	-	Role of Module admin
ModuleAdmin_Id	VARCHAR(20)	-	-	-	Identity of module admin
ModuleAdmin_Name	VARCHAR(20)	-	-	-	name of module admin
ModuleAdmin_Password	VARCHAR(45)	-	-	-	Password of module admin

Table 13: Data Dictionary of Rain Drop Sensor

Field	Type	NN	PK	FK	Comment
RainDropSensor_Id	VARCHAR(20)	Yes	Yes	-	Identity of Raindrop Sensor
Zone_Id	VARCHAR(20)	-	-	-	Identity of Zone
RainDropSensor_SensedValue	TINYINT(1)	-	-	-	Sense the rain
RainDropSensor_Locatoin	DOUBLE	-	-	-	Location of Raindrop Sensor

Table 14: Data Dictionary of Ambulance

Field	Type	NN	PK	FK	Comment
Ambulance_Id	VARCHAR(20)	Yes	Yes	-	Identity of Ambulance
Ambulance_Reg_No	VARCHAR(20)	-	-	-	Registration number of ambulance

Table 15: Data Dictionary of Fire Brigade

Field	Type	NN	PK	FK	Comment
FireBrigade_Id	VARCHAR(20)	Yes	Yes	-	Identity of Fire brigade
FireBrigade_Reg_No	VARCHAR(20)	-	-	-	Registration number of Fire brigade vehicle

Table 16: Data Dictionary of Police Vehicle

Field	Type	NN	PK	FK	Comment
PoliceVehical_Id	VARCHAR(20)	Yes	Yes	-	Identity of police vehicle
PoliceVehical_Reg_No	VARCHAR(20)	-	-	-	Registration number of police vehicle

6 Materials and methods used in project work

6.1 Methods

Arduino Framework[13] : Arduino is a family of single-board microcontrollers, intended to make it easier to build interactive objects or environments. This framework allows writing programs for the arduino board in higher level programming language and uploads these programs to the board and gets output from the board.

OpenCV (**Open Source Computer Vision)** is a library of programming functions mainly aimed at real-time computer vision, developed by Intel Russia research center in Nizhny Novgorod, and now supported by Willow Garage and It is free for use under the open-source BSD license. The library is cross-platform. It focuses mainly on real-time image processing. If the library finds Intel's Integrated Performance Primitives on the system, it will use these proprietary optimized routines to accelerate itself.

Bing Maps: Bing Maps (previously Live Search Maps, Windows Live Maps, Windows Live Local, and MSN Virtual Earth) is a web mapping service provided as a part of Microsoft's Bing suite of search engines and powered by the Bing Maps for Enterprise framework.

.Net Framework[11]: The .NET Framework is a development platform for building apps for Windows, Windows Phone, Windows Server, and Microsoft Azure. It consists of the common language runtime (CLR) and the .NET Framework class library, which includes classes, interfaces, and value types that support an extensive range of technologies. The .NET Framework provides a managed execution environment, simplified development and deployment, and integration with a variety of programming languages, including Visual Basic and Visual C#.

C#.Net[12]: C# syntax is highly expressive, yet it is also simple and easy to learn. The curly-brace syntax of C# will be instantly recognizable to anyone familiar with C, C++ or Java. Developers who know any of these languages are typically able to begin to work productively in C# within a very short time. C# syntax simplifies many of the complexities of C++ and provides powerful features such as nullable value types, enumerations, delegates, lambda expressions and direct

memory access, which are not found in Java. C# supports generic methods and types, which provide increased type safety and performance, and integrators, which enable implementers of collection classes to define custom iteration behaviors that are simple to use by client code. Language-Integrated Query (LINQ) expressions make the strongly-typed query a first-class language construct.

WPF(windows presentation foundation)[10]: The core of WPF is a resolution-independent and vector-based rendering engine that is built to take advantage of modern graphics hardware. WPF extends the core with a comprehensive set of application-development features that include Extensible Application Markup Language (XAML), controls, data binding, layout, 2-D and 3-D graphics, animation, styles, templates, documents, media, text, and typography. WPF is included in the Microsoft .NET Framework, so you can build applications that incorporate other elements of the .NET Framework class library.

Sql Server: Microsoft SQL Server is a relational database management system developed by Microsoft. As a database, it is a software product whose primary function is to store and retrieve data as requested by other software applications, be it those on the same computer or those running on another computer across a network (including the Internet). There are at least a dozen different editions of Microsoft SQL Server aimed at different audiences and for workloads ranging from small single-machine applications to large Internet-facing applications with many concurrent users. Its primary query languages are T-SQL and ANSI SQL.

6.2 Materials:

Arduino[13]: The hardware consists of an open-source hardware board designed around an 8-bit Atmel AVR microcontroller or a 32-bit Atmel ARM. Current models feature a USB interface together with six analog input pins and 14 digital I/O pins that can accommodate various extension boards.

Figure 20: Arduino UNO

Sensors: By using sensors to detect fire, drainage overflow and perform temperature measurement, pressure measurement, etc. at publicly important places, we can have better management of city. Software can be designed to show the map of the city. It can demonstrate the visual representation of received data on the equivalent map of the city. It can have functionality to control street lights, visualize the data received from the above mentioned sensors, record this data and visualize it when needed.

Table 17: List of Sensors

Sensor	Description
BH1750FVI	Intensity Digital Light Sensor Module
BMP180	Digital Barometric Pressure Sensor
DHT-11	Digital Temperature and Humidity Sensor
LM393	IR Flame Fire Sensor Module
M3AO	Soil Hygrometer Humidity Detection Module
MQ-2	Smoke Gas LPG Butane Hydrogen Sensor

Above mentioned sensors can be used for better management of various aspects of the city. These sensors should be packaged appropriately for using it in the city and can be used as follows:

- **BH1750FVI:** It can be used for measuring the intensity of light around the street light and thus becomes helpful to decide whether the street light should be turned OFF or turned ON.

- **BMP180:** It can be used to measure the pressure, temperature and altitude of a location. This data can be used for visualization and can be used for better weather forecasting.
- **DHT-11:** It can be used to measure temperature and humidity. This data can be used for visualization and can be used for better weather forecasting.
- **LM393:** It can be used to detect fire at a place. The data about fire can be visualized on the map and the authorities can take measures as quickly as possible.
- **M3AO:** It can be used to measure the humidity of the soil. It can be used to visualize the humidity in the soil and can be used to determine as to which crop should be planted on that land.
- **MQ-2:** It can be used to detect gas at a place. The data about gas-leakage can be visualized on the map and the authorities can take measures as quickly as possible.

6.3 A brief description about method/protocol going to be adopted for Problem solving

Software development life cycle:

Incremental development

The primary objective of incremental model is to reduce inherent project risk by breaking a project into smaller segments and providing more ease-of-change during the development process.

The basic principles are:

- A series of mini-Waterfalls are performed, where all phases of the Waterfall are completed for a small part of a system, before proceeding to the next increment, or
- Overall requirements are defined before proceeding to evolutionary, mini-Waterfall development of individual increments of a system.

- The initial software concept, requirements analysis, and design of architecture and system core are defined via Waterfall, followed by iterative Prototyping, which culminates in installing the final prototype, a working system.

In this project, the risk of developing all the modules together is very high so we have selected this SDLC cycle to reduce the risk of the project. It also reduces the complexity of the project.

Components to be used in project:

Front-end:

- Arduino framework
- .Net framework
- Windows presentation foundation(WPF)
- C#.Net
- Bing Maps

Back-end:

- Sql server
- Client-server communication

7 Outcome

Various modules created by us are:

1. **Controllable**
    a. The street lights are controlled manually using start and stop buttons.
    b. Light detectors (BH1750FVI) are used to check the intensity of light of the surroundings and are used to control the street lights.
    c. Street lights are controlled on the basis of time i.e. daytime or nighttime.
2. **Visualization**
    a. Live Visualization
        - **Fire Detection:** Fire sensor (LM393) is used to sense the fire and if detected, then it symbolizes the area where it is detected.
        - **Temperature Measurement:** The sensor (DHT11) is used to sense the value of temperature and the value is shown on the map.
        - **Pressure Measurement:** The pressure sensor (BMP180) is used to sense the value of pressure and the value is shown on the map.
        - **Humidity Measurement:** The sensor (DHT11) is used to sense the value of humidity and the value is shown on the map.
    b. Data Visualization
        - **Temperature visualization:** The data of temperature received during the live visualization phase is recorded in the database and is visualized on the graph later.
        - **Pressure visualization:** The data of pressure received during the live visualization phase is recorded in the database and is visualized on the graph later.
        - **Humidity visualization:** The data of humidity received during the live visualization phase is recorded in the database and is visualized on the graph later.
        - **Population visualization:** Zone-wise population-rate is stored in the database and is visualized on the map with different colours for high, medium and low population.

- **Crime visualization:** Zone-wise crime-rate is stored in the database and is visualized on the map with different colours for high, medium and low population.

3. Communication

Two zone servers are created with above mentioned functionality. The communication module connects the zone servers with the main server and data of various zone servers can be visualized simultaneously on the main server.

4. Traffic Analysis

Recorded video of a road is provided to the software and the software detects the amount of traffic on the road and it shown as percentage in the command prompt window.

8 Gantt Chart

No	Task Name	Start	Finish	Duration
1	Problem Identification	16-06-14	02-07-14	17
2	Requirement Analysis and Design	03-07-14	16-07-14	14
3	Identification of Suitable SDLC	17-07-14	21-07-14	5
4	Identification of feasible of solution	22-07-14	05-08-14	15
5	Study of Arduino framework	06-08-14	26-08-14	21
6	Study of C#.Net and WPF	27-08-14	17-09-14	22
7	Serial Communication Arduino and C#.Net	18-09-14	30-09-14	13
8	Implementation of Controlable Module	01-10-14	12-10-14	12
9	Study of Inskape,MySQLWorkBench	12-10-14	18-10-14	7
10	Implementation of Live Visualization	19-10-14	15-11-14	28
11	Client-Server Communication in C#.Net	06-12-14	17-12-14	12
12	Study of OpenCV Framework	25-12-14	13-01-15	20
13	Implementation of traffic Module	16-01-15	25-01-15	10
14	Study of SQL Server	26-01-15	06-02-15	12
15	Implementation of Data Visualization	07-02-15	28-02-15	22
16	Implementation of Police, Fire and Ambulance Modules	01-03-15	30-03-15	30
17	Testing	01-04-15	30-04-15	30

9 Results

We have formulated a model of a miniature of an area. The model has been incorporated with different types of sensors like light detectors, fire detectors, temperature detectors, pressure sensor, humidity sensor, etc.

Smart city software has encompassed an implemented API of map. It demonstrates the visual representation of data received on the equivalent map of the area. It has functionality to control street lights, visualize the data received from the above mentioned sensors, record this data and visualize it when needed.

Functionality:

1) Controllable

1.1)Street lights

Light detectors are used to ensure the intensity of light of the surroundings and are used to control the street lights. Street lights are controlled on the basis of time i.e. daytime or nighttime.

2) Visualization

2.1)Live Visualization

2.1.1) Traffic Analysis: Traffic is analyzed by processing the captured video of the road and the visual representation of it will be shown on the command prompt publicized in the software.

2.1.2) Fire Detection: Fire sensor senses the fire and if detected, then it symbolizes the area where it is detected.

2.1.3) Environment Measurement: Different sensors of temperature, pressure, and humidity etc. sense the respective values and those values are visualized on the map.

2.2) Data Visualization

2.2.1) Traffic Density: The data recorded from the above functionality of traffic analysis is used to visualize the traffic density of different routes.

2.2.2) Population Density: The data about population in different areas is entered and is used to visualize the area-wise population.

2.2.3) Crime Rate: The data about crime-rate in different areas is entered and is used to visualize the area-wise crime-rate.

2.2.4) Environment Measurement: Previously recorded data of temperature, pressure, and humidity etc. of different areas is visualized on the map.

Implementation snapshots

The snapshot shown below is **the login page for zone administrator**. It has two text boxes, one for username and other for password. It also has link for forgot password. The administrator can do login to the system using it.

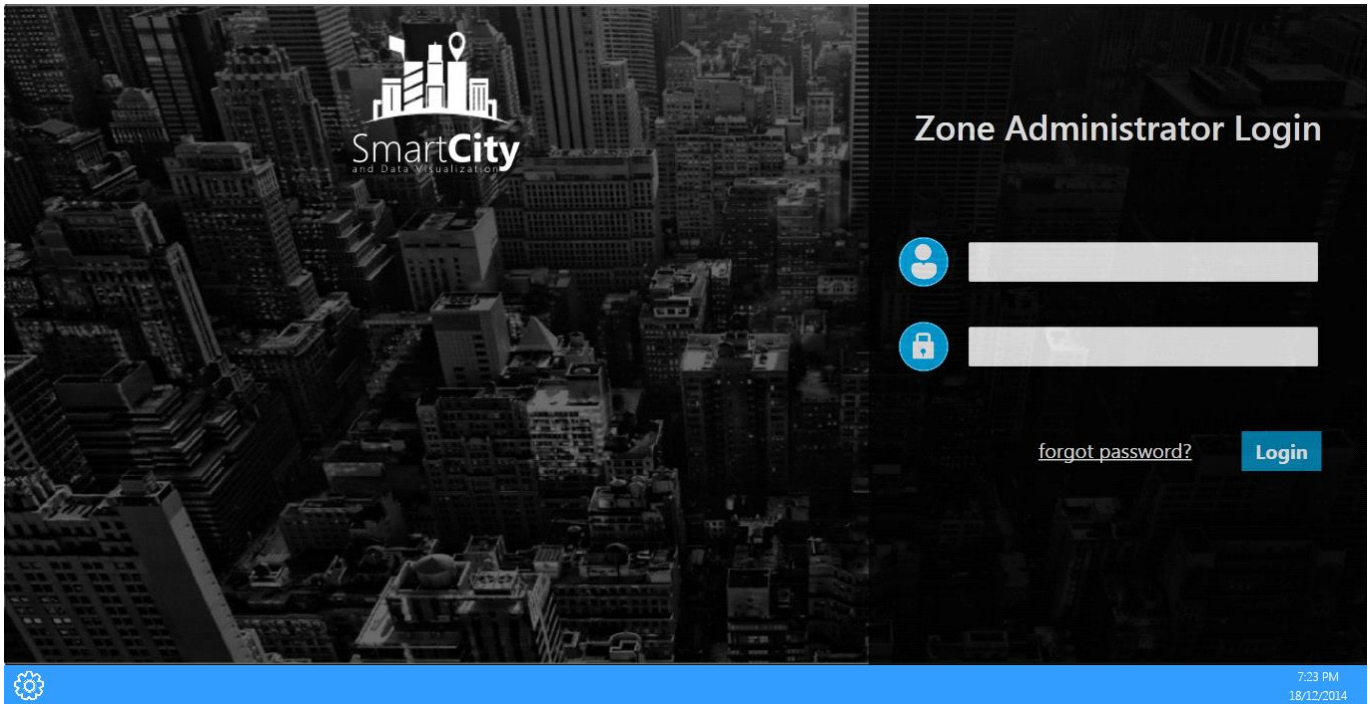

Figure 23: snapshot of login page for zone administrator

The snapshot shown below is **the live visualization page for city administrator**. It has two tables, one for zone 1 status and other for zone 2 status. It also shows map for zone 1. The map provides visualization for rain and fire in zone 1.

Figure 24: snapshot of live visualization page for city administrator

The snapshot shown below is the **street light management page for zone administrator**. It has three options, first to control the street lights by time, second to control the street lights by time, and the third button to control the street lights by intensity of light in the surrounding

Figure 25: snapshot of street light management page for zone administrator

The snapshot shown below represents **miniature model** for our project. It contains arduino nano to which different sensors are connected through bread board. Arduino nano sends the received data to the computer on the COM port.

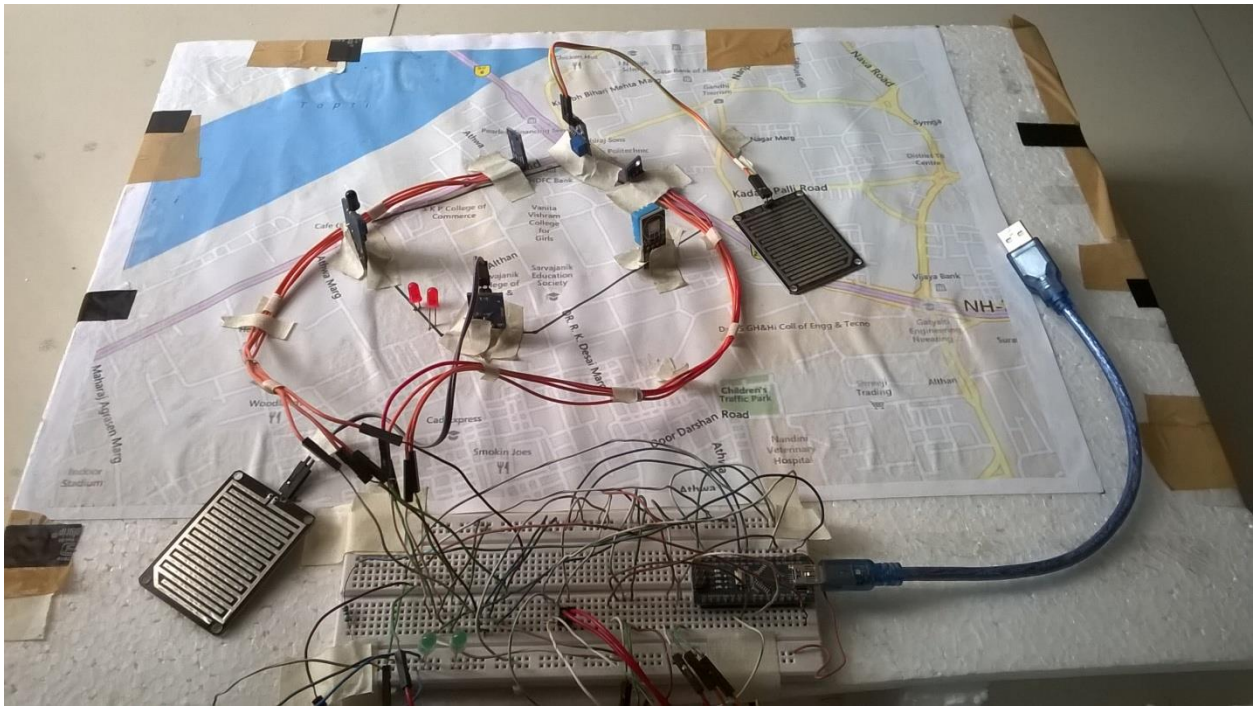

Figure 26: snapshot of miniature model of an area

The snapshot shown below represents **traffic analysis module** for our project. It contains video in which vehicles are passing on the road and the other video detects the vehicles from the video. The command prompt video shows the percentage of road covered by the vehicles.

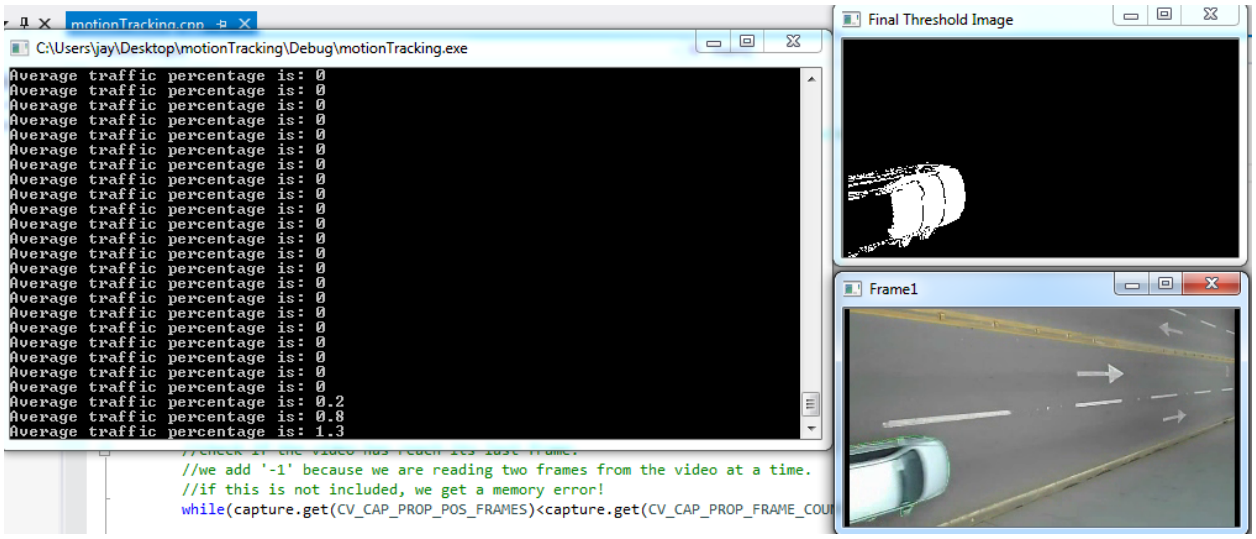

Figure 27: snapshot of traffic analysis

The snapshot shown below represents **Environment Data Visualization** for our project. It contains graph in which data of temperature pressure and humidity are shown on x-axis and the recorded time on y-axis.

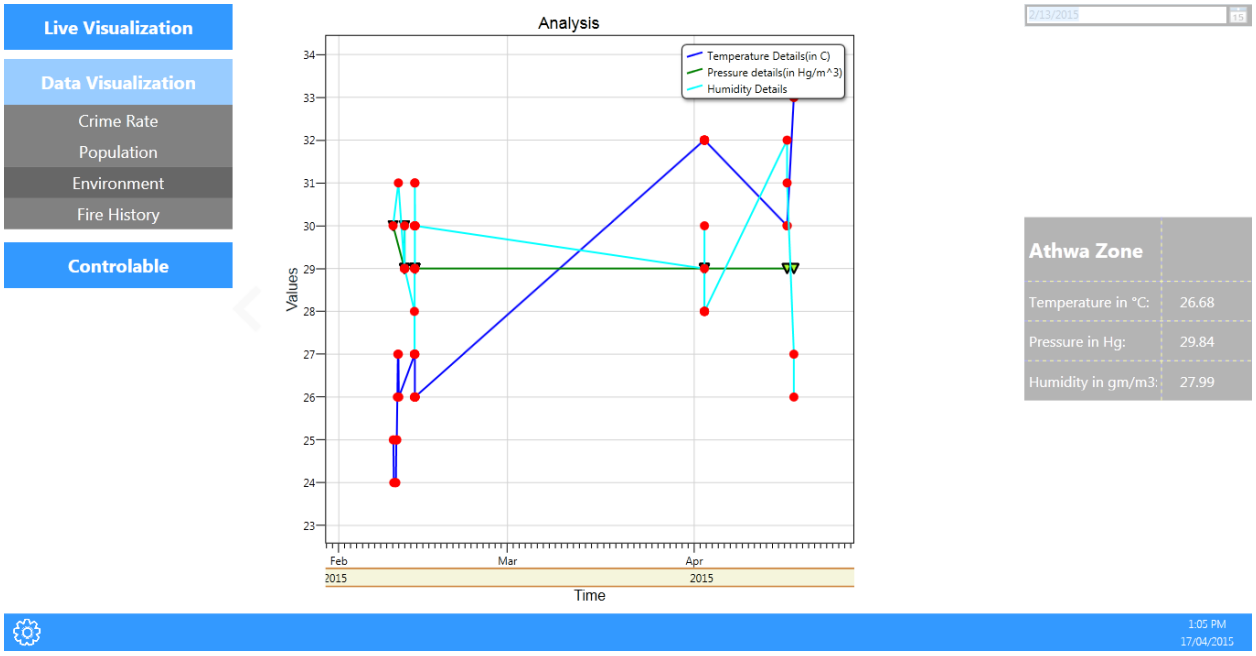

Figure 28: snapshot of environment data visualization

The snapshot shown below represents **Zone wise Population Visualization** for our project. It contains map in which population rate for different zones is represented by different colors accordingly.

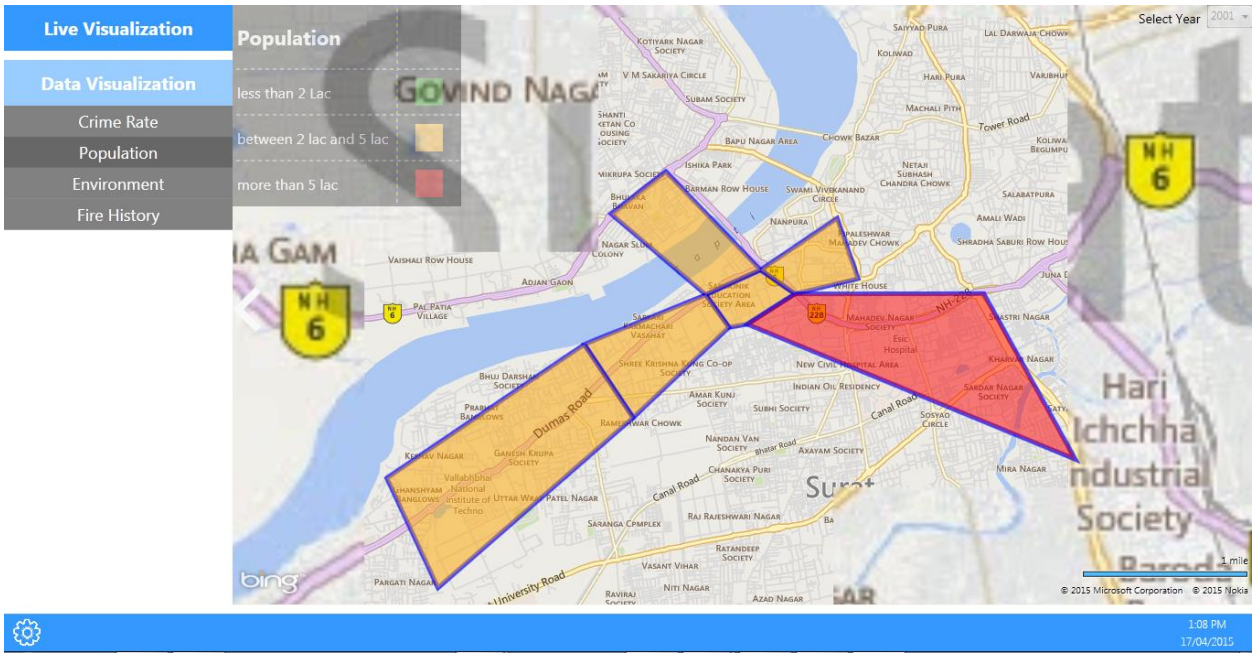

Figure 29: snapshot of zone wise population

10 Conclusion

Cities should be developed to meet the future requirements efficiently and effectively. So cities should be automated in various aspects like fire management, environmental measurement, traffic analysis, street light management, etc. Information about places under fire can be quickly obtained using sensors and stable communication systems. Data about environmental factors like temperature, pressure, humidity, etc. can be sensed using various sensors and can be visualized on map for making future decisions and predictions. Street lights can be controlled on the basis of intensity of light of the surrounding or on the basis of time. Traffic can be analyzed and can be visualized on the map to provide stable information about traffic to the citizens. Thus the above mentioned data and functionality can be used to make the cities smarter.

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