Visual Interface of Weather Data of Pakistan

By

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In the name of Allah who is the most Merciful and Compensate.

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DEDICATED TO

My deceased father who gave me the ambition to reach for the stars and the opportunity to do whatever I wanted to do. It is also dedicated to my mother for her love, endless support and encouragement.

DECLARATION

I hereby declare that this report is my own work and effort and that it has not been submitted anywhere for any award. Where other sources of information has been used, they have been acknowledged.

Maryam Rehman

ACKNOWLEDGEMENT

All the praises, thanks and acknowledgements are for the Creator Allah Almighty, the most beneficent, the most merciful, who gave me strength and enabled me to undertake and execute this task. Countless salutations upon the Holy Prophet Hazrat Muhammad (S.A.W.W), source of knowledge for enlightening with the essence of faith in Allah and guiding the mankind, the true path of life. In abeyance of Almighty Allah's order his creature must also be acknowledged. I would like to express my sincere and humble gratitude to Almighty Allah, whose blessings and guidance has been a real source of all the achievements in my life.

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My mother deserves special mention for her inseparable support and prayers, who sincerely raised me with her caring and gentle love. I want to express my sincere thanks to my sisters for more than I could ever repay. Their prayers and words of encouragement meant to me so much, knowing that they always held me in their thoughts and prayers gave me strength to go on. Last but not least, deepest thanks go to all people who took part in making this project completion successful.

Maryam Rehman

Abstract

The system visualization of weather data of Pakistan has been developed to help users to visualize historical temporal weather data in their respective region. This system is designed with the goal to supplement the productivity of already available website of Pakistan meteorological department. The system is flexible enough to visualize current data also, it presents four weather scenarios to visualize weather data: (1) Single place single point in time weather visualization (2) Multi places single points in time weather visualization (3) Single place multi points in time weather visualization (4) Multi places multi points in time weather visualization. The weather data which is visualized is available from 1980 to 2010 from different weather stations of Pakistan, maintained by the Pakistan Meteorological Department. We designed such a system that can present data in user friendly/ comprehensible graphical formats; maps, graphs, attractive icon based and interactive menu.

Contents

Chapter 1

Introduction

This chapter provides an overview of the proposed system and describes why the proposed system is needed and what is in this system. This chapter also describes the motivation for this project. To realize the visualization for weather data sources are provided from Pakistan Meteorological Department. We will focus on visualization of weather data in Pakistan

1.1 Problem Definition

Weather visualization is a difficult problem. As with most complex data, weather data requires a considerable amount of structuring and reasonable visualization to become user friendly. We need to design such a system that can represent these data in formats that users can understand. So weather visualization is about representing weather information in such a way that it becomes understandable for users. This Weather System is required to visualize various weather parameters. The project requires to visualize the weather data and different results can be drawn using this data. The database is required to store all the weather data.

1.2 Objective

The objective of the project is to visualize the weather data of Pakistan. The available data covers four domains related to weather: Humidity, Temperature, Wind Speed and Rainfall. For testing purposes, the data is available from 1980 to 2010 from different weather stations of Pakistan, maintained by the Pakistan Meteorological Department.

1.3 Motivation

Weather is a classic and popular topic. The data that we will visualize are stored for later analysis. Weather depends on a multitude factors such as humidity, wind pressure, rainfall and temperature etc. so everything is prepared to realize the visualization for weather.

1.4 Proposed Solution

A system to visualize weather data should be developed to help users to visualize weather data in their respective region. It will especially help weather analyst to understand temperature trends for one specified place conveniently. The project implementation will be web based, with the goal to supplement the productivity of already available website of Pakistan Meteorological Department.

1.5 Contributions

A website is developed to facilitate user to give user weather information in a very comprehensible and easy to access way, so that user can visualize weather information easily.

- With the purpose of understanding visualization techniques different websites were researched
- In order to understand visualization of weather data a literature survey was conducted to understand basis of visualization of weather
- Visualization of weather data was developed to provide an easy and simple approach to the users. The site contains weather information of different regions the information is presented on google map using weather images and graphs
- SQL Server was used to store historical temporal weather data
- Java Script is mostly used in the system to make most of the things possible
- A website using visualization approach is built to make weather data more understandable

1.6 Overview of Report

An attempt was made to give the reader a view of the whole report. The report is divided into major sections, including the Introduction section as above.

Chapter 1
As in this chapter we have discussed about the proposed system and why the proposed system is needed and what is in this system.

Chapter 2
This chapter describes scope of Visualization of Weather System. It also specifies requirements with different perspectives. In this section we also discuss about the weather scenarios but more emphasis on the visualization.

Chapter 3
This section presents the literature survey of design decisions that we take into considerations to see through the implementation of the Visualization of Weather System.

Chapter 4
This chapter contains detailed design of Weather System in the form of diagrams. Overall, it presents an abstract view of how the system was implemented and also gives readers a generic picture of the complete system.

Chapter 5
This chapter is related to system implementation. This chapter mentions the tools and framework used to develop Weather system.

Chapter 6
System testing considerations are discussed in this section. A test plan and testing strategies are presented. The section is concluded with findings or outcomes of the tests that were done on the system. The section also wraps up the main section of the project report. It describes possible future work and recommendations.

References
At end of this report references of books and sites will be mentioned.

Chapter 2

Software Requirements Specification

This chapter describes Software Requirements Specification (SRS) purpose and scope of proposed weather data visualization system. It also specifies requirements with different perspectives. At the end of the chapter, summary of major functions is provided.

2.1 Introduction of SRS

This section describes SRS purpose and overview of the system.

2.1.1 SRS purpose

Purpose behind developing this SRS is to let other developers understand basic requirements of visualization of weather data.

2.1.2 Overview

This SRS contains system requirements in an organized way to help developers better understand the system functionality. Next sections include overall description of the system from visualization perspective. Also summary of major functions of system is provided under different weather data visualization scenarios.

2.2 Scope of the System

Scope of the system defines the boundaries of the system that what the system can deliver to its users. Visualization of weather system should allow the users to visualize different weather data. Scope of the system also defines the inputs, outputs, functionalities, and constraints, enumerated below:-

2.2.1 Input

Data provided by Pakistan Metrological Department of Pakistan collected by their weather stations.

2.2.2 Output

Visualization of weather data

2.2.3 Functionalities

- User can select weather stations and date according to his/her requirement
- System will show the location of weather station on a map
- Users can view weather data. As we are provided with different times we can visualize weather data according to different scenarios

2.2.4 Constraints

- Minimum screen resolution provided by the system is 800 x 600
- Internet connectivity needed

2.3 Product Perspective

Product perspective contains system interfaces, user interfaces, hardware requirement, software requirement, communication interfaces which are described below:-

System Interfaces

System uses APIs of Google Maps to retrieve geographical location on map.

User Interfaces

Map based interface for browsing weather station on the map.

Hardware Requirement

Minimum hardware requirements is that the hardware that can support Google Maps API's.

Software Requirement

System is for PC. System requires Windows XP, Windows Vista or Windows 7 operating system to run on.

Communication Interfaces

System requires internet connectivity to interact with API's server (Google Maps). (Minimum 256 kbps, Recommended 1 Mbps).

Memory Constraints

System requires memory to manage Google Maps on any compatible browser mentioned in software interfaces.

2.4 Data Characteristics

Following are the data characteristics:-

2.4.1 Data related to Geographical Area

The study area covers different provinces of Pakistan. Data collected from Pakistan Meteorological Department. Stations are located in different cities of Pakistan from where weather data have been collected and recorded.

2.4.2 Data Used

The data obtained from the meteorological stations as given includes:-

- Station identification
- Data time information
- Meteorological information

We have different weather parametric data. The available data covers four main domains related to weather: Humidity, Temperature, Wind Speed and Rainfall. Moreover we have some secondary weather parameters as well which will be discussed later. In the next chapter will go through different visualization techniques of weather afterwards we will conduct a literature survey on these techniques.

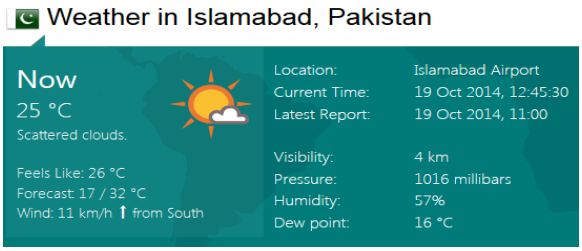
2.5 Weather Visualization Scenarios

We have four different types of weather visualization scenarios:-

- Single place single point in time weather visualization
- Multi places single points in time weather visualization
- Single place multi points in time weather visualization
- Multi places multi points in time weather visualization

2.5.1 Single Place Single Point in Time Weather Visualization

Single place single point in time visualization means that we have single place and we are visualizing weather data of single point in time. Weather data of one place with respect to single point in time can be visualized. As shown in figure below we can visualize weather in Islamabad at 12pm.



Single Place Single Point in Time Weather Visualization
Figure 2.5 a

2.5.2 Single Place Multi Points in Time Weather Visualization

Single place multi points in time visualization opens way to visualize single place with multiple points in time. Weather data of one place concerned with different times can be envisioned as:-

Single Place Multi Points in Time Weather Visualization

Figure 2.5 b

With reference to figure 2.5 c hourly weather is visualized of a certain place. It shows weather data of one single place and we have multiple points in time.

Single Place Multi Points in Time Weather Visualization

Figure 2.5 c

2.5.3 Multi Places Single Point in Time Weather Visualization

In multi places single point in time visualization we have multiple places and we are visualizing data of single point in time. Below the figure indicates that we have weather data of multiple cities and we have only one single point in time to visualize weather data.

Multi Places Single Point in Time Weather Visualization

Figure 2.5 d

2.5.4 Multi Places Multi Points in Time Weather Visualization

Multi places multi points in time weather visualization shows that we have multiple places and we are visualizing data of multi points in time. Weather data of multiple places having multi points in times can be as:-

Multi Places Multiple Points in Time Weather Visualization

Figure 2.5 e

By using the above four scenarios we will be able to do our literature survey. These scenarios will be supportive in survey of weather visualization techniques. Our survey will be based on these scenarios with the accessible weather parameters. This can be defined as:

Single Place Single Point in Time						**Multi Place Single Point in Time**						**Single Place Multi Point in Time**						**Multi Place Multi Point in Time**					
T	R	H	W	C	D	T	R	H	W	C	D	T	R	H	W	C	D	T	R	H	W	C	D

Keywords:-

- **T**: Temperature
- **R**: Rainfall
- **H**: Humidity
- **W**: Wind
- **C**: Clouds
- **D**: Dew point

The literature survey will be accomplished under these weather parameters with mentioned scenarios respectively.

Chapter 3

Literature Survey of Weather Data Visualization Techniques

In this chapter, related knowledge is researched. There are several ideas to visualize weather data inspiring this project. Then some theories for information visualization are discussed. We will discuss about what visualization is, what are the methods and techniques that can be implemented for our system. In the end we will compare the techniques of weather data visualization.

3.1 Visualization

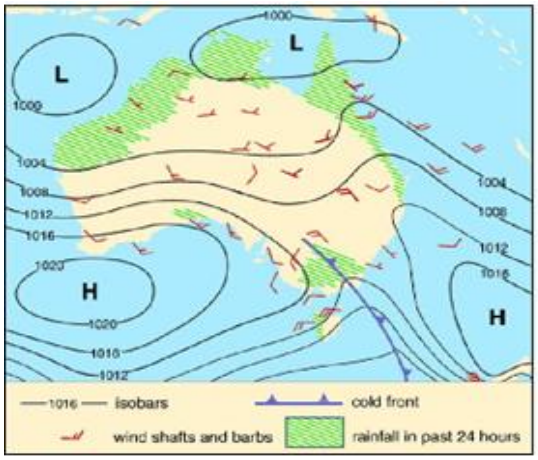
Visualization is any technique for creating images, diagrams, or animations to communicate a message. Visualization through visual imagery has been an effective way to communicate both abstract and concrete ideas since the dawn of man. Visualization is a method of computing by which the enormous bandwidth and processing power of the human visual (eye-brain) system becomes an integral part of extracting knowledge from complex data. Data visualization, as its name indicates, means visualizing data. According to the description of Friedman, the ***"****main goal of data visualization is to communicate information clearly and effectively through graphical means****"*** Graphic representations of data are popular because they open up the way we think about data, reveal hidden patterns, and highlight connections between elements.

3.2 Visualization of Weather

Visualization of weather data is a concept that involves making weather information understandable to users. Weather visualizations are based on meteorological data which are composed of different parameters. Generally speaking weather visualization seems simple. Special icons represent specified weather conditions, such as sun icon means sunny, thunder icon means heavy raining with thunder and so forth.

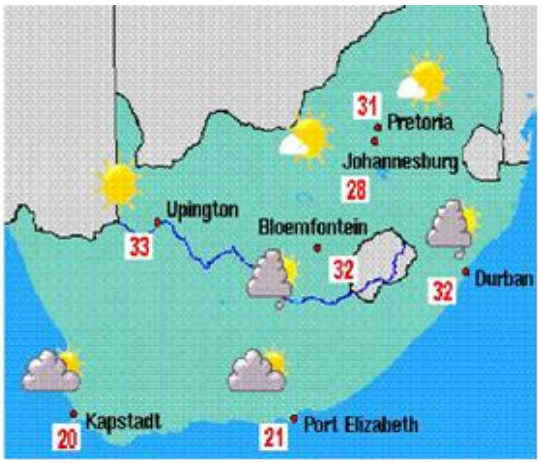
3.3 Background

Weather data can be graphically represented in forms understandable to users in a variety of ways. The two commons forms include weather maps and contour maps.



Weather Information using Contours Plots

Figure 3.3 a



A classic way of representing weather information

Figure 3.3 b

3.3.1 Weather Maps

Weather map is displayed on a map, usually on points representing major cities, and is aided by static images representing the weather conditions predicted for the respective places. Figure 3.3b present weather information for different cities. It is a classic way to present weather information that is easily understood by user.

3.3.2 Contour Maps

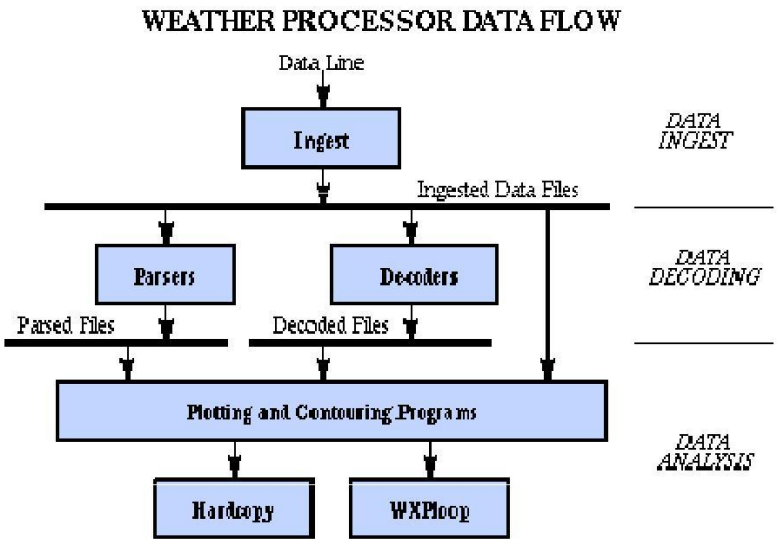
Contour maps are a type of weather maps illustrated with contour lines, i.e. the map is filled with curves connecting points with equal values. With reference to figure 3.3a forms of contour lines include *isotherms* which are contour lines connecting points of equal temperature; *isohyets*, contour lines connecting points of equal precipitation and *isogons*, which are lines along which the wind direction, expressed as an angle, is everywhere the same. It is somehow complex way to present this weather map.

3.4 Weather Visualization Desktop System

There are various desktop tools available for visualizing weather data some of them are discussed as below:-

3.4.1 The Weather Processor (WXP)

The Weather Processor (WXP) can be used for analyzing and representing meteorological data. It is a general-purpose weather visualization tool. The system gets its data from the National Weather Service. It decodes and parses the data, before finally generating graphic representations for visualization. The visualizations come in varying degrees of complexity, with meteorologists as its primary audience. The Weather Processor (WXP) can be logically divided into three data processing sections i.e. ingest, decoding and analysis.



The Weather Processor Data Flow

Figure 3.4 a

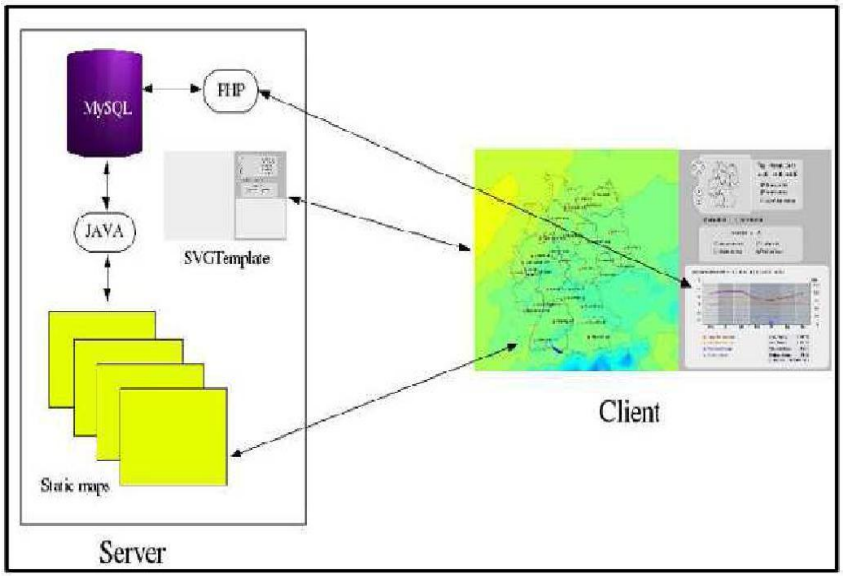
Data input takes place in the ingest stage, and then after is the decoding stage; this stage involves parsing and decoding of the data from the ingest stage. Analysis is the last stage of the process, it

is the where final analysis of the processed data takes place before display. WXP can be used to view and analyze various weather data (e.g. satellite imagery and air data). It also includes routines for Standard Meteorological Analysis.

3.4.2 SVG Weather

SVG Weather is a weather visualization system developed using Scalable Vector Graphics. It uses an SVG frontend to produce an interactive visualization of weather data in different zoom levels. To realize this, a range of techniques is required on both server and client side. The overall structure of the application comprises of the following components:-

- An interactive SVG front-end for visualization and dynamic reload of the weather data
- A number of PHP pages on the server for communication from front-end to server
- A database in which the weather data is stored
- Scripts and applications for updating and pre-processing weather data in the database



SVG Weather Application Design

Figure 3.4 b

3.5 Weather Service Web Sites

Weather service sites are basically websites that provide weather information as a service. Many weather service sites exist on the web. They range from regional weather service sites, provide weather information for the nearby community, to global weather service sites. Some of them are discussed as:-

3.5.1 Weather Bug *(http://weather.weatherbug.com)*

WeatherBug is a weather service web site that provides weather updates. It is a standalone site i.e. it doesn't use weather data from external sources. It monitors multiple decision layers at once for rapid visualization of weather conditions.

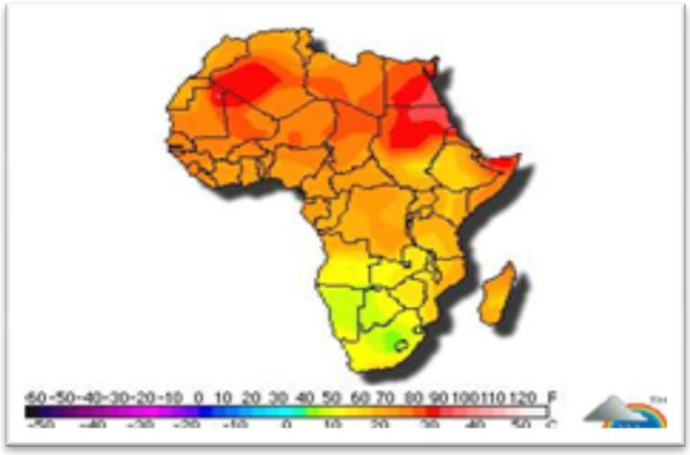
Weather Bug

Figure 3.5 a

3.5.2 Weather Underground *(http://www.wunderground.com)*

Weather Underground is a commercial weather service web site that provides real-time weather information. Weather Underground provides weather reports for most major cities across the

world. The Local Weather Model Visualization system's weather service site will be similar to the ones discussed above, except it will have a narrower coverage, providing weather information for selected points. Below the figure represents Africa temperature. Red portion shows the hot weather in different areas.



Live Africa Temperature from the weather underground site

Figure 3.5 b

3.5.3 AccuWeather.com *(http://www.accuweather.com/en/pk/pakistan-weather)*

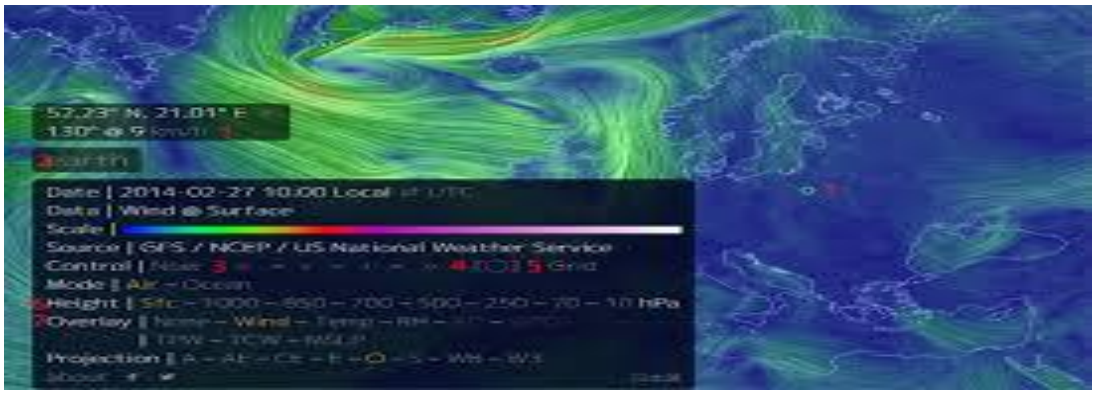
AccuWeather.com created a unified and proprietary apparent temperature system known as "The AccuWeather.com Exclusive Real Feel Temperature" and has used the quantity in its observations. The formula for calculating this value incorporates the effects of temperature, wind, humidity, sunshine intensity, cloudiness and precipitation. In accordance with visualization of this system, it has outstanding graphic look and user can visualize weather of various cities.

AccuWeather

Figure 3.5 c

3.5.4 Earth Null School *(http://earth.nullschool.net/about.html)*

Earth is a browser-based visualization of global weather conditions created by Cameron Beccario. He says that "earth is a personal project I've used to learn JavaScript and browser programming, and is based on the earlier Tokyo Wind Map project." It shows the directions of weather parameters e.g. wind direction around the globe.

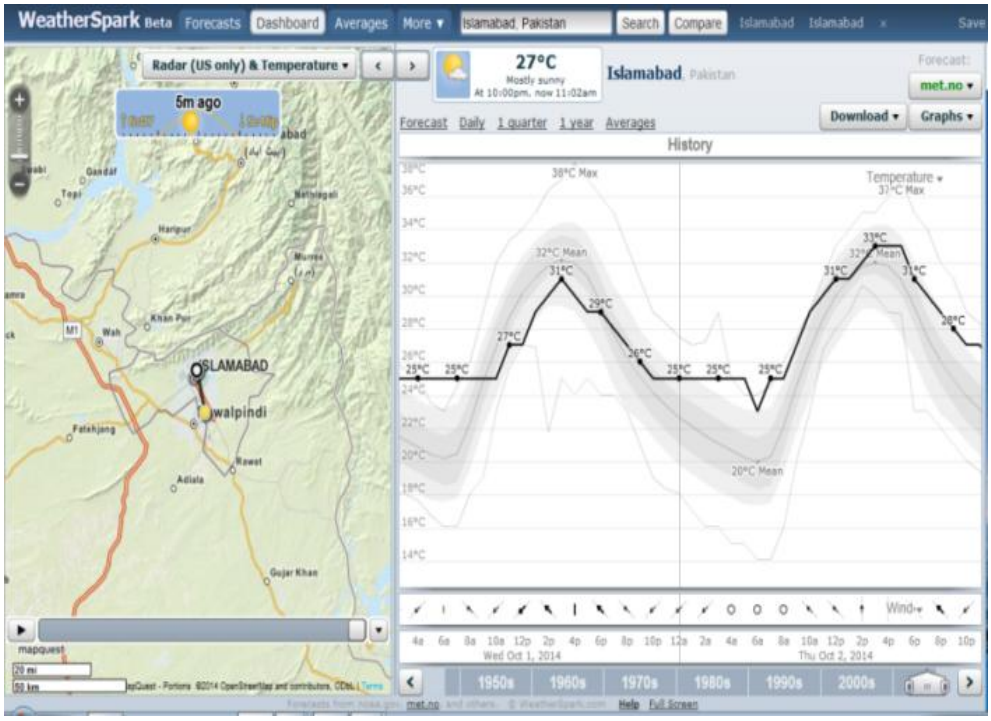


Wind Direction Visualization

Figure 3.5 d

3.5.5 Weather Spark ***(http://weatherspark.com)***

Weather Spark is tapping into a variety of datasets to deliver a different level of weather engagement. The new website, which provides data from more than 4,000 weather stations, lets you interact with full-screen weather graphs to investigate current forecasts and historical weather patterns. Considering visualization of this site map indicates the location of different areas and shows different measurements of a weather parameter, which is selected. On right panel its presents a graph to show various measurements of weather basically one can analyze the weather records.



Historical Weather Pressentation

Figure 3.5 e

3.5.6 Comparison

Here is a summary of the systems we discussed above in comparison to the weather model visualization system.

Weather Service Sites	Features Available For Weather Visualization	Visualization Perception
Weather Bug	Get current temperature and severe weather alerts for your location right in your taskbar, plus current conditions, forecasts, animated radar, maps and more.	Considering visualization perception it is a useful website. Monitor multiple decision layers at once for rapid visualization of weather conditions.
Weather Underground	Weather Underground is committed to delivering the most reliable weather information possible. It also provide a number of specialist weather products such as severe weather alerts, hurricane tracking products, ski and sports weather, a trip planning weather tool.	According to visualization perceptive this website is somehow tricky. Users with great knowledge regarding weather can understand basically it is more useful for weather analyst.
AccuWeather.com	AccuWeather.com offers weather visualization. This offers: Animated, user-centric radar/satellite,15 hours of hourly forecasts, Severe weather alerts, Forecast videos, Lifestyle weather indices, Weather Alarms	This weather system has outstanding graphic look and it provides user an animation map as well. It is beneficial especially during severe weather, when changing conditions require meteorologists to make frequent updates.
Earth Null School	A visualization of global weather conditions forecast by supercomputers, updated every three hours ocean surface current estimates updated every five days ocean surface temperatures and anomaly from daily average (1981-2011) updated daily.	It shows the directions of weather parameters e.g. wind direction around the globe. It is one of the best website for visualizing weather conditions.
Weather Spark	Weather spark prides itself on its attractive graphs, maps, and charts and they definitely deliver on that front. Type in your location and you'll be treated to a beautiful dashboard with a map of current temperatures around your area, along with an interactive, data-driven graph of temperatures in your area, organized by hour, along with a percentile range of accuracy, so you know exactly how likely it is to stray from the projected temperature.	In accordance, to visualization purpose this site is best because at first glance user is able to understand weather data. Moreover, it covers all domains regarding the weather data.

Table 3.5

3.6 Weather Parameter's Visualization

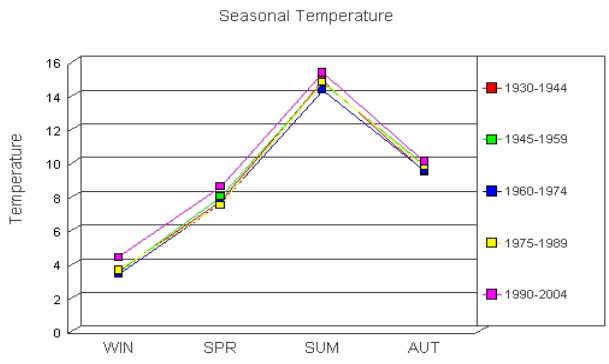
There are several elements that make up the weather of a place. The major of these elements are: temperature, pressure, wind, humidity, and rain:-

- Temperature is a very important factor in determining the weather, because it influences or controls other elements of the weather, such as precipitation, humidity, clouds and atmospheric pressure
- Precipitation is the product of a rapid condensation process (if this process is slow, it only causes cloudy skies). It may include snow, hail, sleet, drizzle, fog, mist and rain
- Humidity is the amount of water vapor in the atmosphere
- Wind is the movement of air masses, especially on the Earth's surface

We will discuss each of these parameters visualization separately.

3.6.1 Temperature Visualization

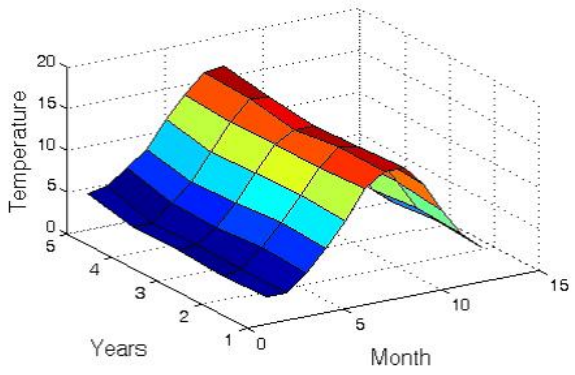
Here different techniques of visualizations that have been used to display the temperature trends. Users will be able to look at temperature graph of any regions. First is the cluster graph in which seasonal temperatures are plotted. From the cluster graph we can see that there is a considerable rise in temperature in last almost 20 years. This increase is incremental in spring, summer and autumn however it has shown a sudden rise in winters in last 20 years.



Seasonal Temperature Graph

Figure 3.6.1 a

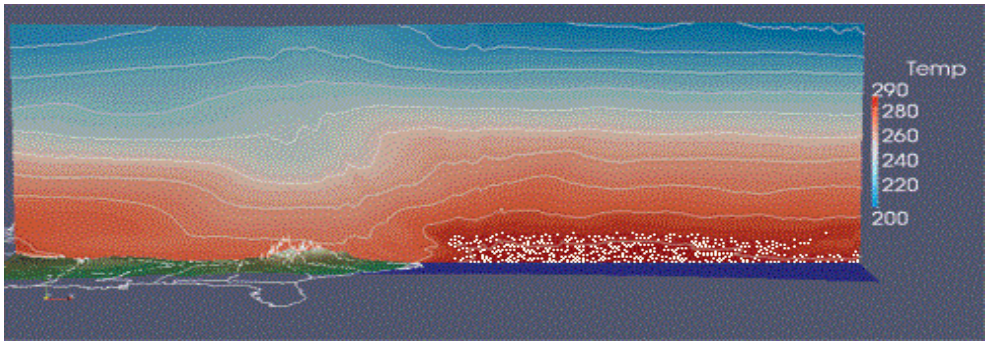
In the second visualization monthly data is plotted on Matlab surface plot. A similar pattern is seen here where the average monthly temperature in last 20 years has increased. We may say that if the same trend continues then the temperature in coming years will be high.



Temperature Graph

Figure 3.6.1 b

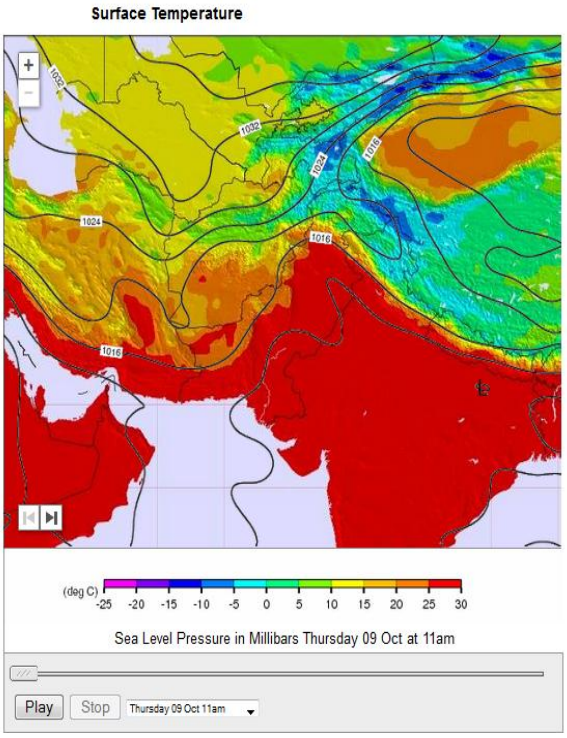
Here is another way of visualizing weather temperature. With temperature contours and shading used to more clearly indicate the vertical temperature gradients. From this figure it is easy to quantify the depth and horizontal dimensions of the warm core, as well as the shape and modification relative to other atmospheric and surface features.



Temperature Gradient Visualization

Figure 3.6.1 c

In this visualization technique animation using the slide bar found beneath the temperature map. You can also get the latest temperature observations from actual weather stations under the live weather section.

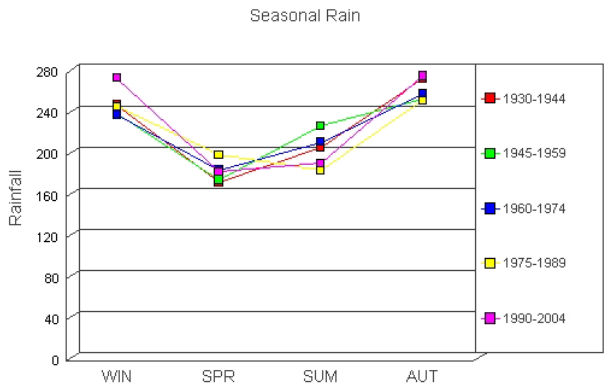


Temperature Map

Figure 3.6.1 d

3.6.2 Rainfall Visualization

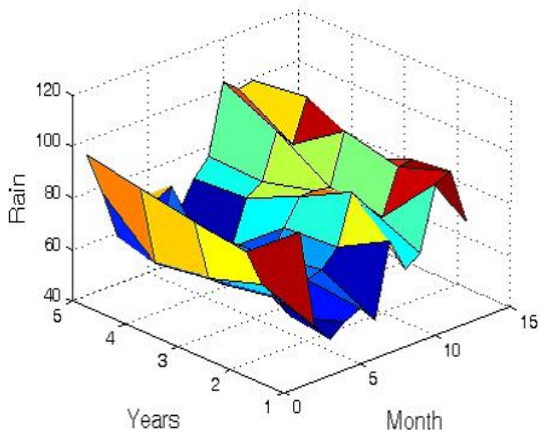
The user will be able to look at rainfall graph (based on historical data) of any region. In the first cluster graph there is an obvious pattern seen during winters and autumn. The rainfall in these two seasons has increased considerably. However it does not show any obvious trend in spring and summer.



Seasonal Rain Graph

Figure 3.6.2 a

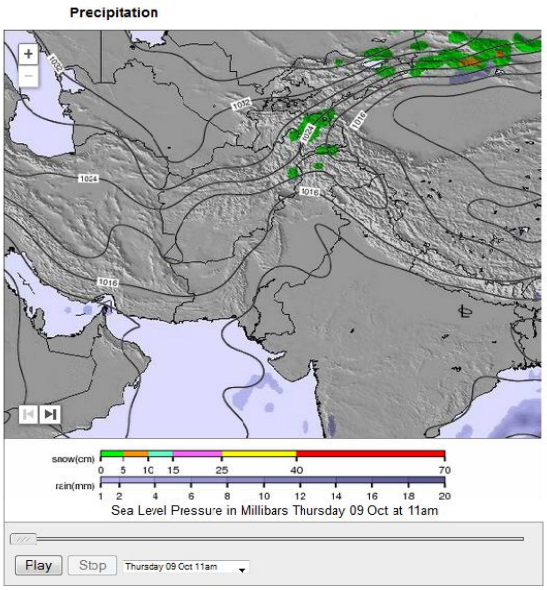
In second surface plot a similar pattern is observed during winter and autumn. In summers during this time block there have been more rains.



Rainfall Graph

Figure 3.6.2 b

In this visualization technique animation using the slide bar found beneath the perception (rainfall) map. You can also get the latest data observations from actual weather stations under the live weather section.

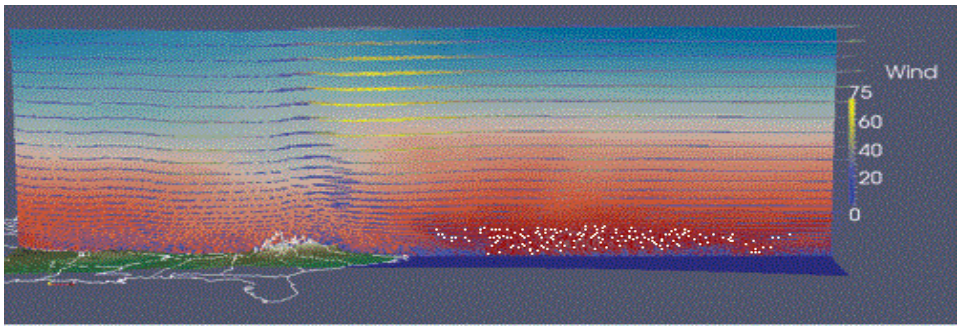


Rainfall Map

Figure 3.6.2 c

3.6.3 Wind Visualization

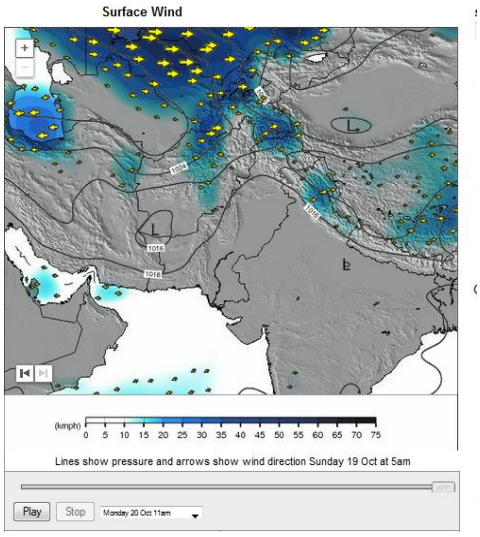
This figure shows wind vectors on the same vertical slice. It provides a rapid identification of the vertical motion within the warm core, allowing for analysis of the vertical extent of the convection within the system. Additionally, by shading and shaping the vectors based on wind magnitude, the location and magnitude of large-scale atmospheric features, such as the jet stream is easily identified.



Wind Vector Visualization

Figure 3.6.3 a

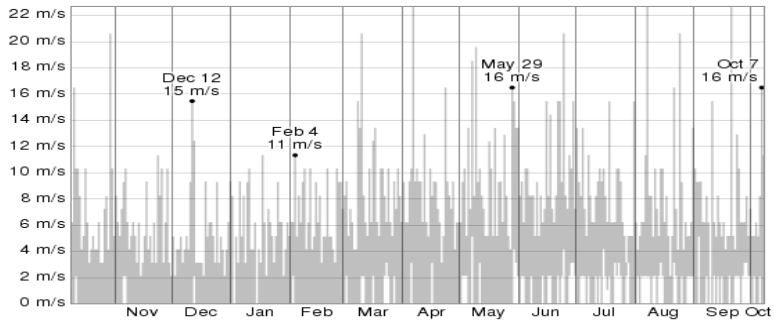
In this visualization technique animation using the slide bar found beneath the wind map. You can also get the latest data observations from actual weather stations under the live weather section.



Wind Map

Figure 3.6.3 b

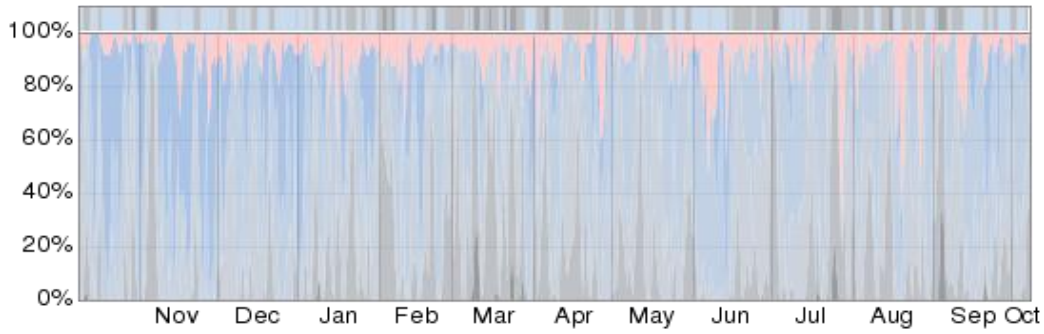
The visualization shows wind direction encoded in line angles, wind speed encoded in line lengths and disk radius, and temperature.



Wind Graph

Figure 3.6.3 c

3.6.4 Clouds



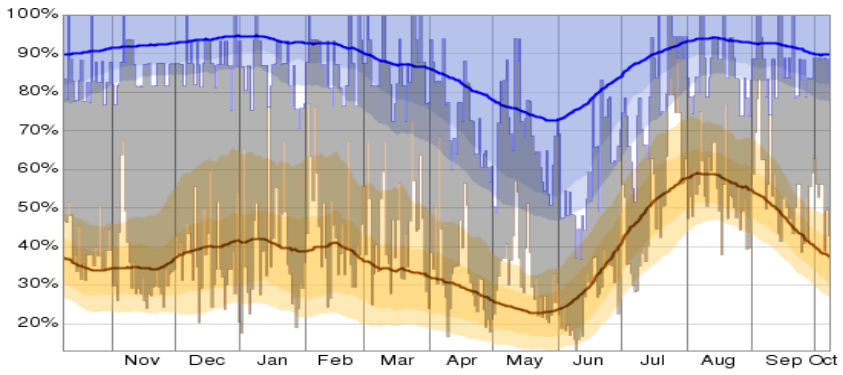
Clouds Coverage

Figure 3.6.4

In this visualization cloud coverage is represented. From top (most blue) to bottom (most gray), the categories are clear. Pink shade indicates missing data. The bar at the top of the graph is gray if the sky was cloudy or mostly cloudy for more than half the day, blue if it is clear or mostly clear for more than half the day, and blue-gray otherwise.

3.6.5 Humidity

Humidity is an important factor in determining how weather conditions feel to a person experiencing them. Hot and humid days feel even hotter than hot and dry days because the high level of water content in humid air discourages the evaporation of sweat from a person's skin. When reading the graph below, keep in mind that the hottest part of the day tends to be the least humid, so the daily low (brown) traces are more relevant for understanding daytime comfort than the daily high (blue) traces, which typically occur during the night.



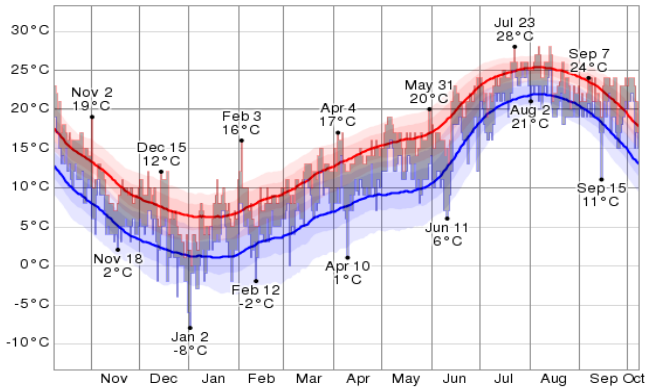
Humidity Graph

Figure 3.6.5

The daily low (brown) and high (blue) relative humidity during the last 12 months with the area between them shaded gray and superimposed over the corresponding averages (thick lines), and with percentile bands (inner band from 25th to 75th percentile, outer band from 10th to 90th percentile).

3.6.6 Dew Point

Dew point is the temperature below which water vapor will condense into liquid water. It is therefore also related to the rate of evaporation of liquid water. Since the evaporation of sweat is an important cooling mechanism for the human body, the dew point is an important measurement for understanding how dry, comfortable, or humid a given set of weather conditions will feel.



Dew Point

Figure 3.6.6

The daily low (blue) and high (red) dew point during the last 12 months with the area between them shaded gray and superimposed over the corresponding averages (thick lines), and with percentile bands (inner band from 25th to 75th percentile, outer band from 10th to 90th percentile).

3.7 Literature Survey

From the above visualization techniques of weather parameters we will take these techniques into consideration for our system. These techniques will be helpful in our system development. This survey is beneficial in development of our system. We will be able to analyze the visualization techniques under the four mentioned scenarios. Underneath the table that depicts our literature survey. In this table visualization of weather websites are evaluated regarding the weather scenarios and weather parameters.

Weather Scenarios / Weather Websites	Single place single Point in time						Multi place single Point in time						Single place multi Point in time						Multi place multi Point in time					
	T	R	W	H	C	D	T	R	W	H	C	D	T	R	W	H	C	D	T	R	W	H	C	D
WeatherBug	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	-	-	-	-	-	-
Weather Underground	✓	✓	✓	-	-	-	-	-	-	-	-	-	✓	✓	✓	✓	✓	✓	-	-	-	-	-	-
AccuWeather.com	✓	✓	✓	-	-	-	✓	-	-	-	-	-	✓	✓	-	-	-	-	-	-	-	-	-	-
Earth Null School	-	-	-	-	-	-	-	-	✓	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Weather Spark	✓	✓	✓	✓	✓	✓	-	-	-	-	-	-	-	-	-	-	-	-	✓	✓	✓	✓	✓	✓
Pakistan Weather Map	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	✓	✓	✓	-	✓	-
Meteorological Data PDF	-	-	-	-	-	-	-	-	-	-	-	-	✓	✓	-	-	-	-	-	-	-	-	-	-
Visualization of Meteorological Data	✓	-	✓	✓	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Historical Weather Data	-	-	-	-	-	-	-	-	-	-	-	-	✓	✓	✓	✓	✓	✓	-	-	-	-	-	-

Table 3.7

Keywords: T: Temperature, R: Rainfall, W: Wind, H: Humidity, C: Cloud, D: Dew point

Chapter 4

System Design

This section discusses the design specifications of the weather visualization system. This system is the user interface part of the Weather Visualization Model project.

4.1 Requirements

Basically, the system should allow users to visualize different daily weather variables i.e. minimum and maximum temperature, wind speed and direction, total rainfall and humidity on map. User will be able to view separately, the weather data of these variables for the corresponding stations or weather points.

4.2 Use Case Analysis

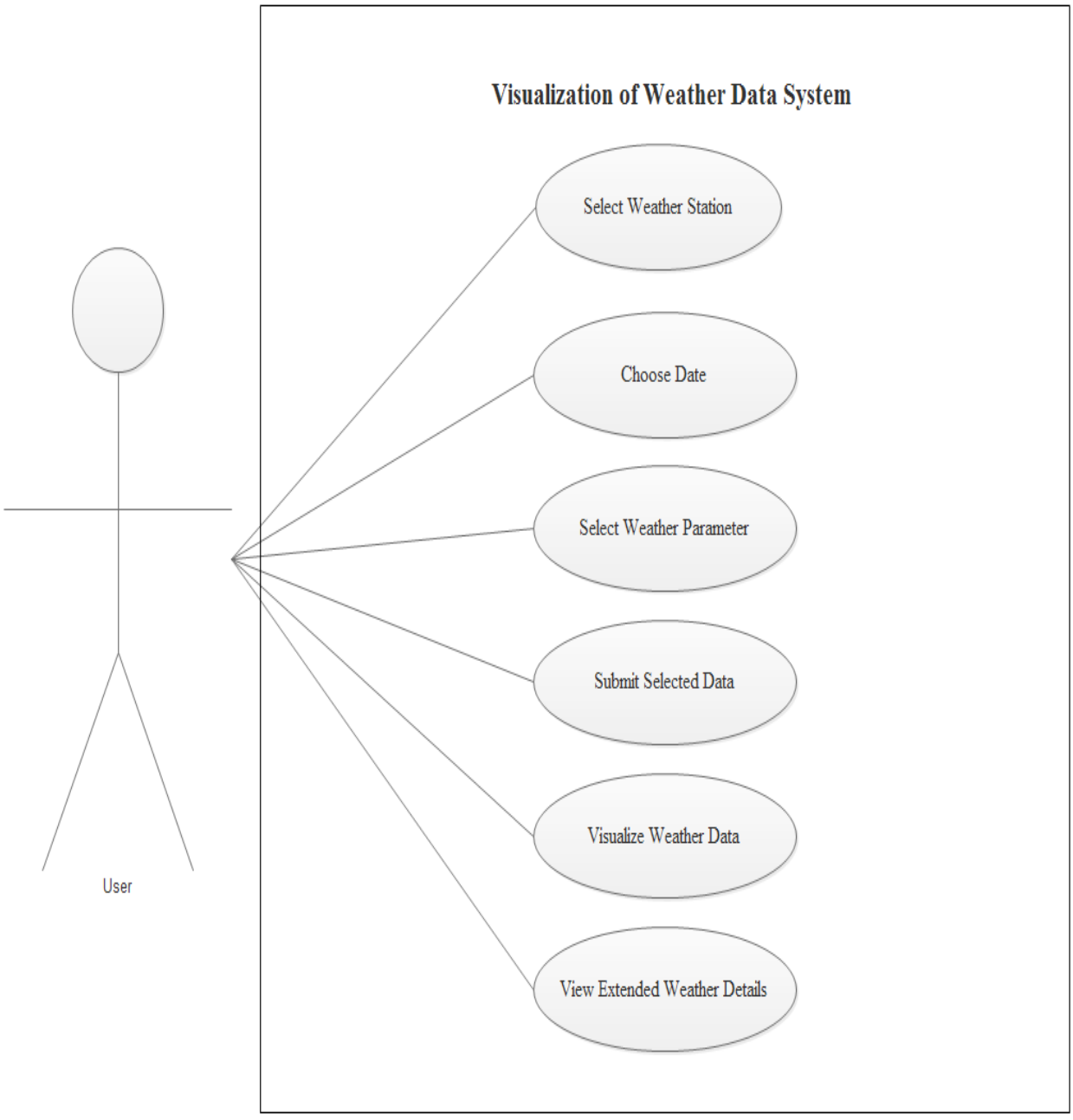
A use case diagram shows all use cases and their interaction with primary actor. After use case diagram, use case description is discussed. Use case analysis is performed in order to identify the use cases of the system.

> *"A use case describes the manner in which an actor (in the context of user interface design, an actor is always person) interacts with system"*
>
> *(Pressman, 2009).*

There are several use cases for the systems, the main use cases include:-
Users using the system can:

- Select weather station, date and weather parameter
- Visualize weather data of a certain location for a specific day
- Visualize weather data of different points in time for a particular station
- Visualize weather data of multiple locations for a specific day
- Visualize weather data of multiple locations for multiple days
- View extended weather details

4.3 Use Case Diagram



Use Case Diagram

Figure 4.3

4.4 Details of Use Cases

All use cases are written in detail where detail includes use cases description, Primary actor, pre-condition, post-condition, success scenario and alternatives.

4.4.1 Use Case 1

Use Case 1	
Use Case Name	**Visualize daily weather data of a specific day**
Scope	This use case allows the user to visualize daily weather data of a specific day for different weather parameters.
Primary actor	User
Pre-condition	Select weather station, date and weather parameter which is to be visualized.
Post-condition	System will display weather data of selected date.
Main Success Scenario	1: User selects weather station 2: User choose single date 3: Afterwards user select required parameter 4: Selected data will be submitted by user 5: System checks whether the data user wants to visualize is available or not 6: If data is available then weather data is displayed
Alternative	If weather data is not available then system will display the message that data is not available

Table 4.4.1

4.4.2 Use Case 2

Use Case 2	
Use Case Name	**Visualize weather data of different points in time for a particular station**

Scope	User can visualize weather data for different days concerned with particular station with respect to selected weather parameter.
Primary actor	User
Pre-condition	Select weather station, date and weather parameter which is to be visualized.
Post-condition	System will display weather data of selected date.
Main Success Scenario	1: User selects weather station 2: User choose a range of dates 3: Afterwards user select a parameter 4: Selected data will be submitted by user 5: System checks whether the data user wants to visualize is available or not 6: If data is available then weather data is displayed
Alternative	If weather data is not available then system will display the message that data is not available

Table 4.4.2

4.4.3 Use Case 3

Use Case 3	
Use Case Name	**Visualize weather data of multiple locations for a certain day**
Scope	This use case allows the user to visualize weather data of multiple locations in accordance with single day.
Primary actor	User
Pre-condition	Select weather station, date and weather parameter which is to be visualized.
Post-condition	System will display weather data of selected date.
Main Success Scenario	1: User selects different weather stations 2: User choose a single date 3: Afterwards user select a single parameter

	4: Selected data will be submitted by user 5: System checks whether the data user wants to visualize is available or not 6: If data is available then weather data is displayed
Alternative	If weather data is not available then system will display the message that data is not available

Table 4.4.3

4.4.4 Use Case 4

Use Case 4	
Use Case Name	**Visualize weather data of multiple locations for multiple days**
Scope	This use case allows the user to visualize weather data of multiple locations in accordance with single day.
Primary actor	User
Pre-condition	Select weather station, date and weather parameter which is to be visualized.
Post-condition	System will display weather data of selected date.
Main Success Scenario	1: User selects multiple weather stations 2: User choose a range of dates 3: Afterwards user select a particular parameter 4: Selected data will be submitted by user 5: System checks whether the data user wants to visualize is available or not 6: If data is available then weather data is displayed
Alternative	If weather data is not available then system will display the message that data is not available

Table 4.4.4

4.4.5 Use Case 5

Use Case 5	
Use Case Name	**Visualize weather extended details**
Scope	This use case allows the user to visualize weather extended data.
Primary actor	User
Pre-condition	Select weather station, date and weather parameter which is to be visualized.
Post-condition	System will display extended weather data.
Main Success Scenario	1: User selects weather station(s) 2: User choose a single date or range of dates 3: Afterwards user select a single parameter 4: Selected data will be submitted by user 5: System checks whether the data user wants to visualize is available or not 6: If data is available then weather data is displayed on map 7: User click on view details 8: Extended weather data will be visualized
Alternative	If details of weather data are not available then system will display the message that data is not available

Table 4.4.5

4.5 Non-Functional Requirements

- Usability: System must be easy to use, i.e. it can be used by any ordinary person having basic knowledge of computer
- Application must be interactive

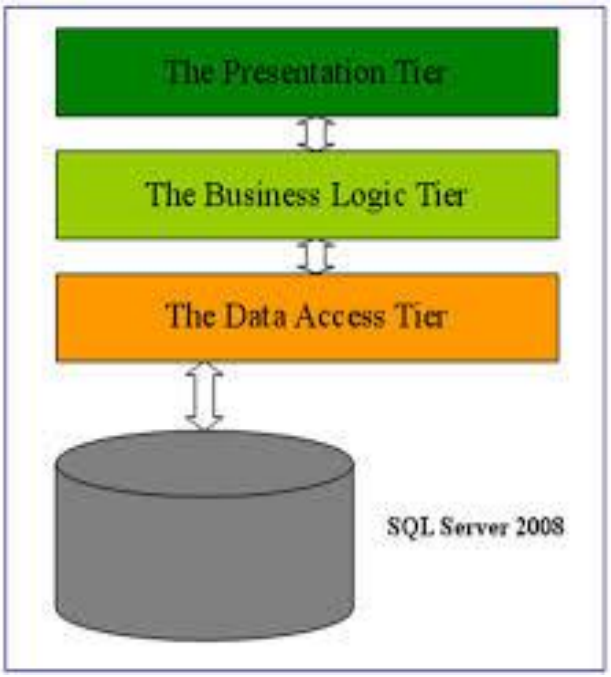
4.6 System Architecture

System architecture defines the infrastructure of the system that is it tells what elements are related to one another. Use of this architecture makes the system more understandable, easy to maintain and easy to modify.

4.6.1 Three-Layered Architecture

Layers differentiate between the different kinds of tasks performed by the components at different layers, making it easier to create a design that supports reusability of components. The three layers are as follows:

- **Presentation Layer:** This is top layer and its main function is to manage user interaction with the system, get input data to send to lower layers for processing and show resulting output to user
- **Business Logic Layer:** This middle layer coordinates the application process commands make visualization logical decisions and evaluations, and performs calculations. It also moves data between two surrounding layers
- **Data Access Layer:** Information is stored and retrieved from database or file system. The information is passed to logic tier for processing and then eventually back to user



Architecture Diagram

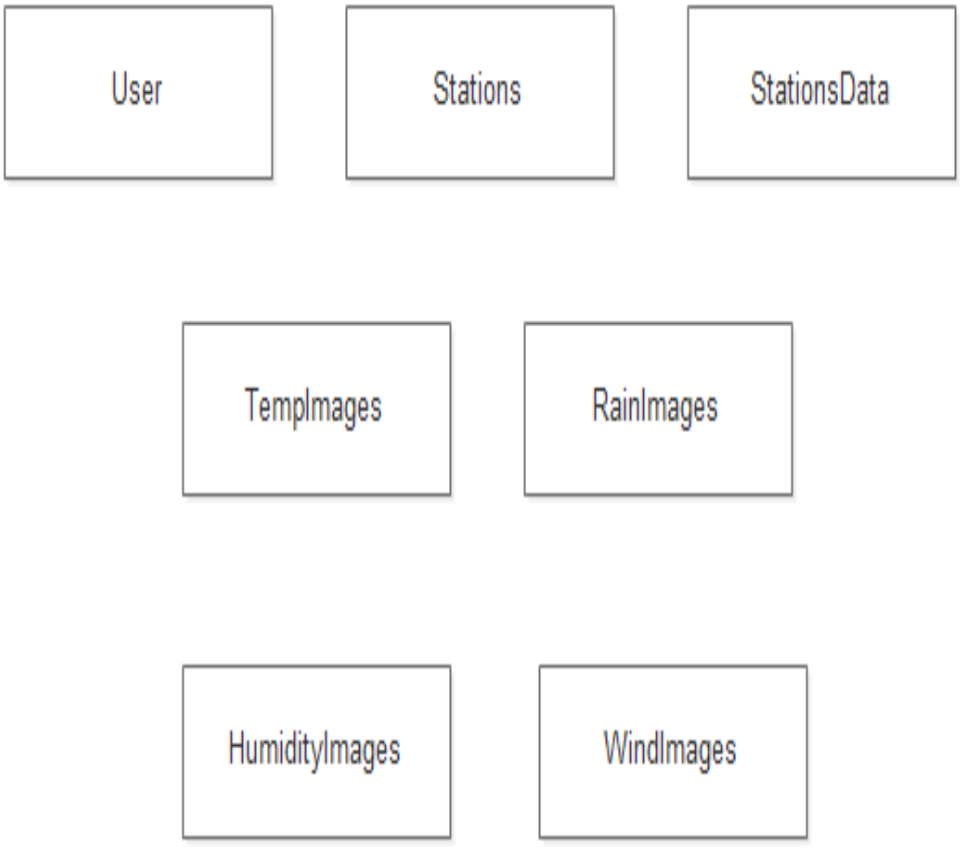
Figure 4.6

4.7 ERD Diagram

An entity relationship diagram is a data modeling technique that creates graphical representation of the entities, and the relationships between entities within an information system. ERD is an abstract and conceptual representation of data.

4.7.1 Entities

An entity is an object of importance about which data must be captured. Entities are key elements of any database system. Entities for this system are:-

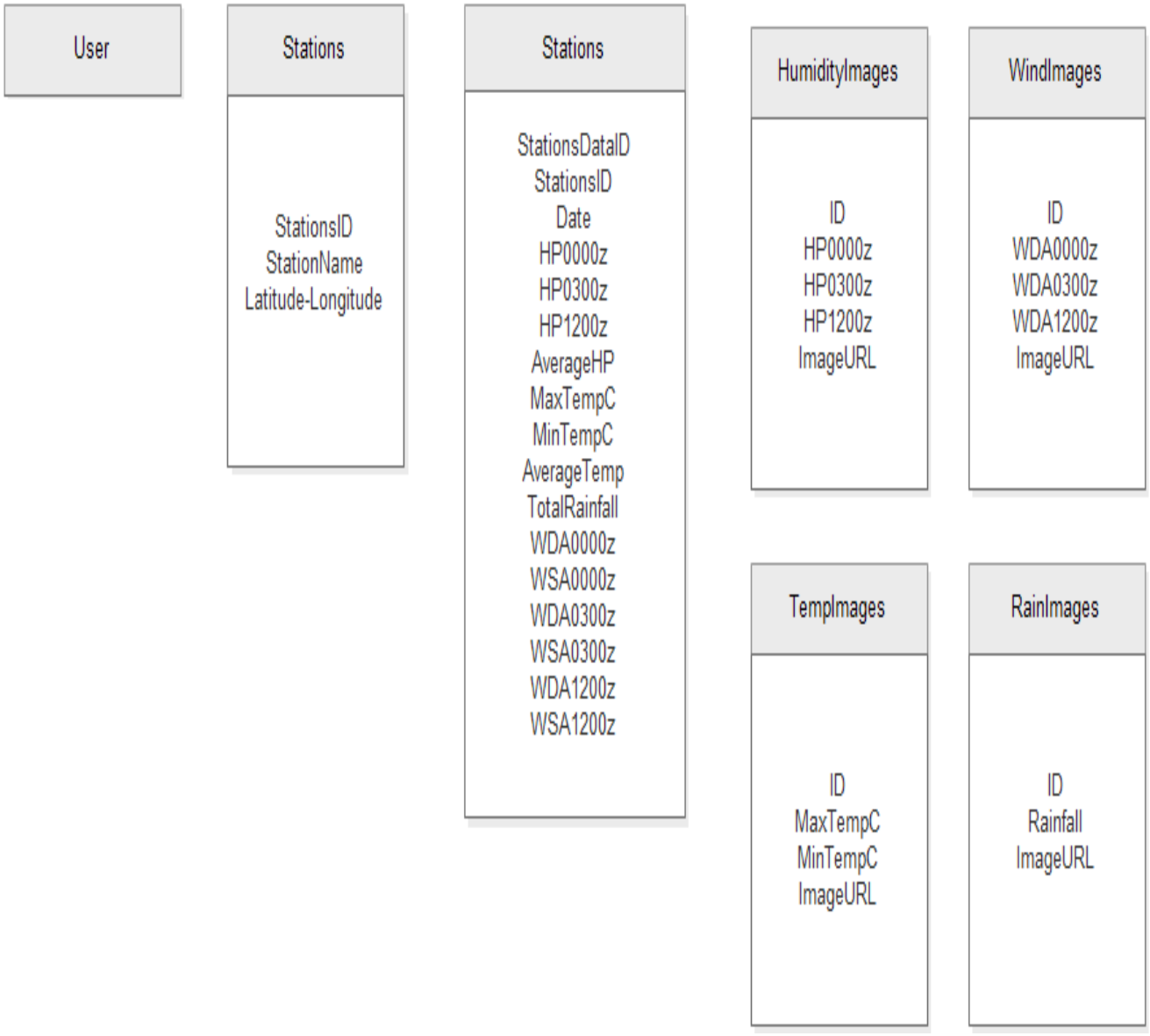


Entities

Figure 4.7 a

4.7.2 Attributes of Entities

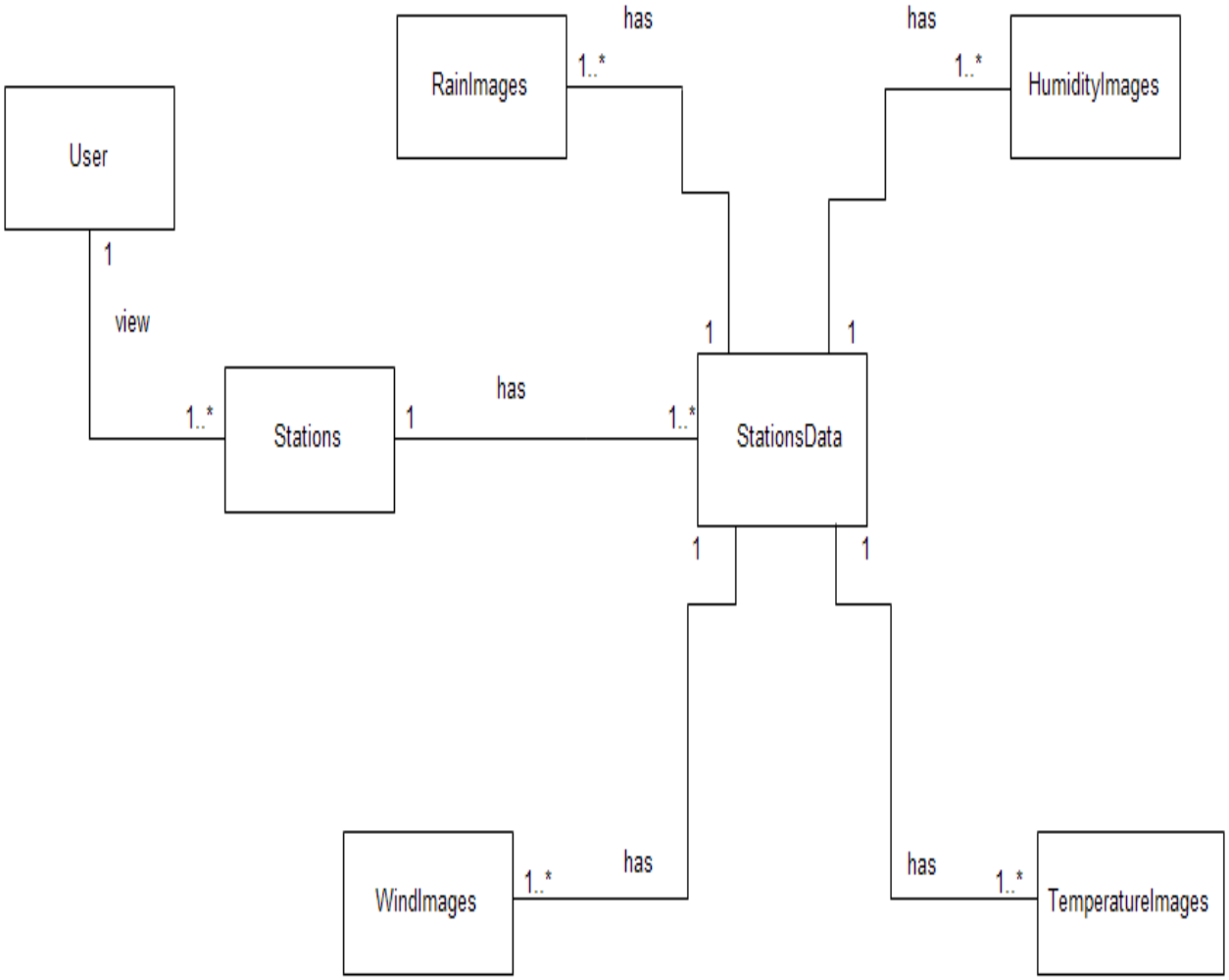
Following are the attributes of the system:-



Attributes of Entities

Figure 4.7 b

4.7.3 Logical ERD



Logical ERD

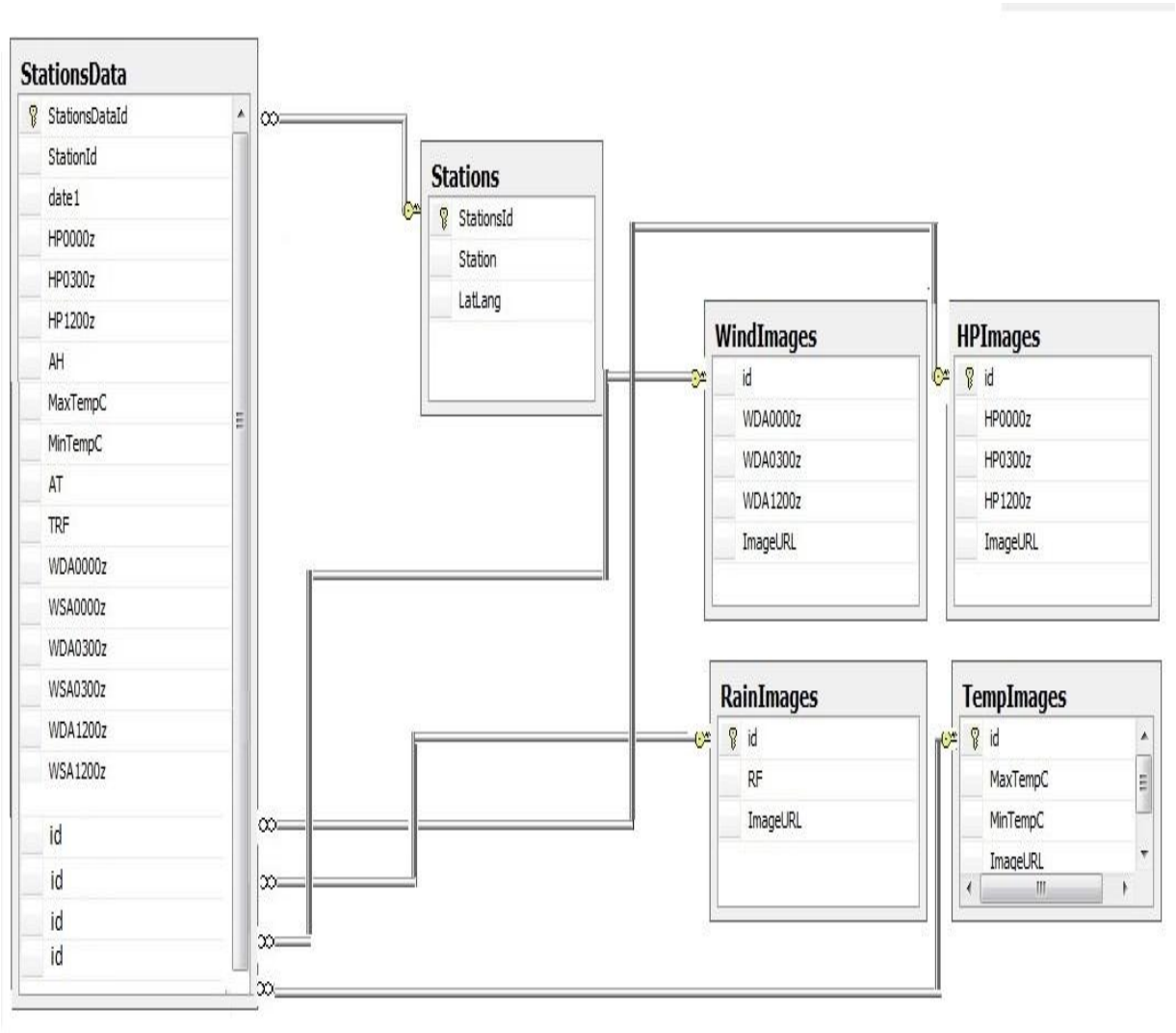
Figure 4.7 c

4.8 Database Design

Database design is an organization of data logically so that data storage and retrieval can be managed easily. Database design contains entities, attributes and their relationship with other entities.

4.8.1 Bachman Diagram/Database Diagram

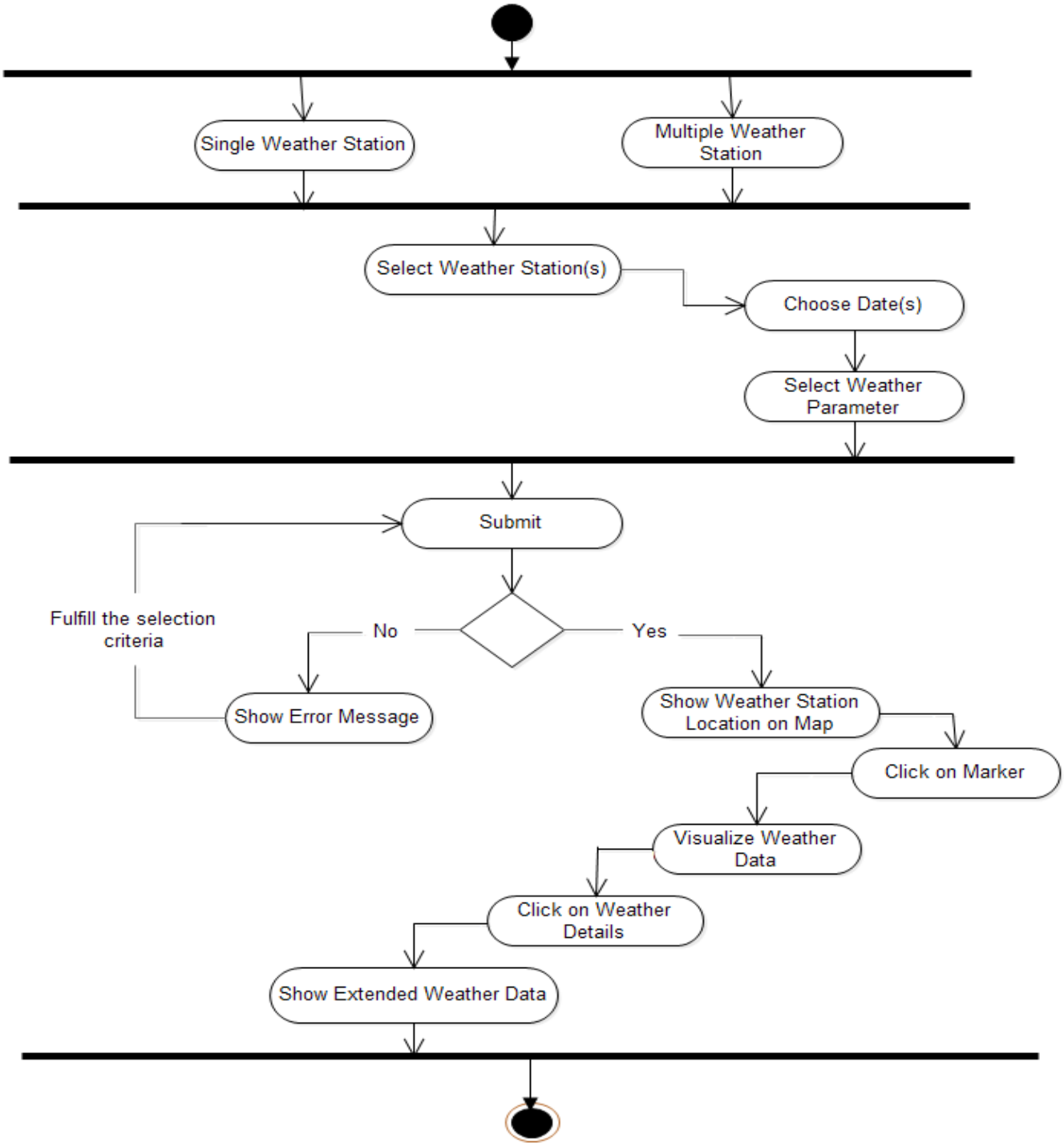
It is pictorial representation of schema, it is named after Charlie Bachman, a generic name for Bachman diagram is linkage diagram.



Bachman Diagram

Figure 4.8 a

4.9 Activity Diagram



Activity Diagram

Figure 4.9

4.10 Interaction Design

It helps in understanding the interaction and functional design of system, with the help of some images of interfaces. Interface design is most often associated with the development of web pages and computer software. The goal of user interface design is to make the user's interaction as simple and efficient as possible, in terms of accomplishing user goals.

4.10.1 User Interface

User can interact with the system by using mouse by moving cursor and by selection. User can also interact with the system by using keyboard.

Interface of Home Page

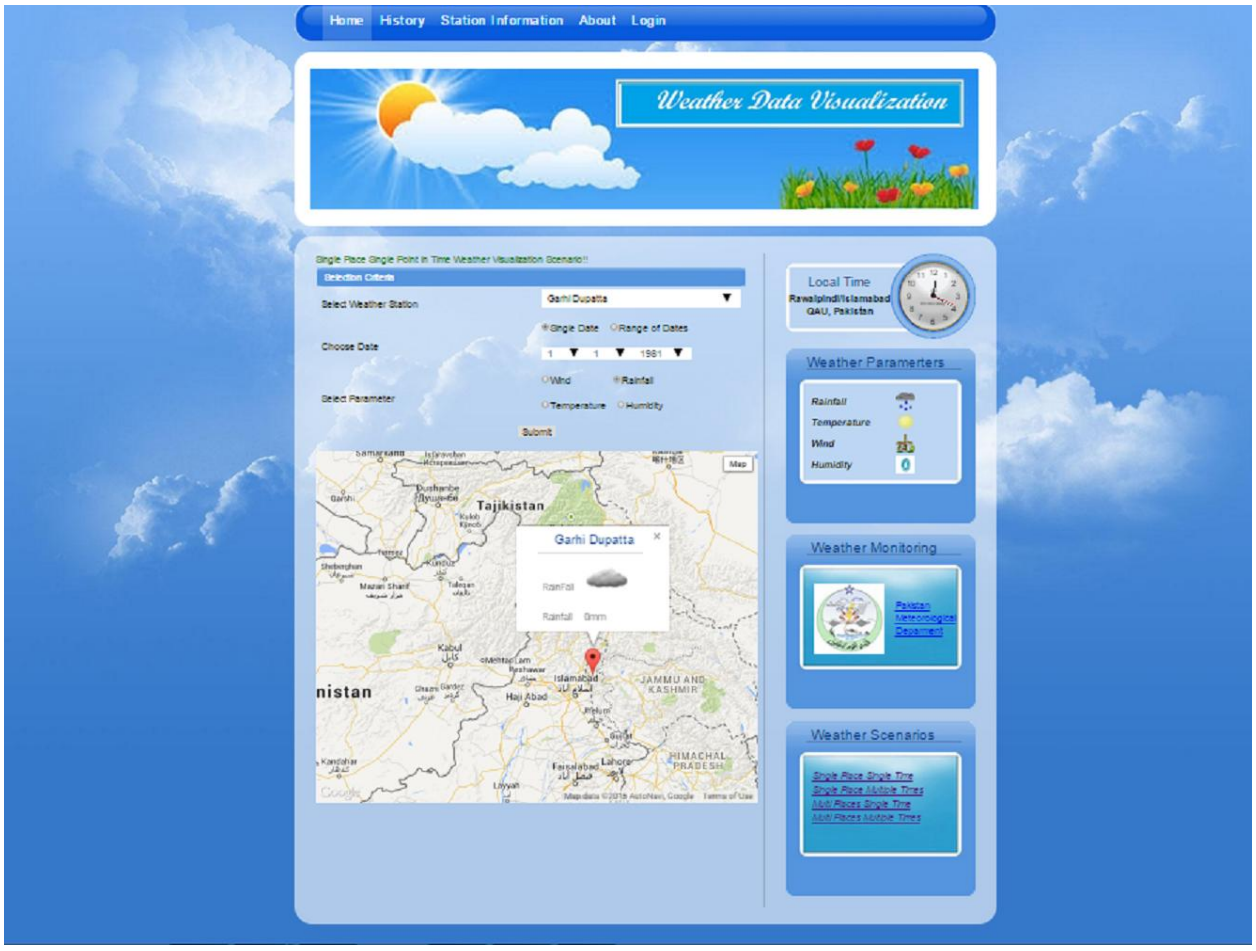
Figure 4.10

4.10.2 Functional Design

A combination of engineering and geometric modeling called “functional design” helps generate digital prototypes early in the design cycle, letting them be continually validated for function.

Interface of Single Place Single Point in Time Weather Visualization Scenario

In the very first scenario weather data is displayed on map. A marker is used to locate the location of selected place on map. User selected his/her desire location and date and then selected rain parameter to visualize its required data.

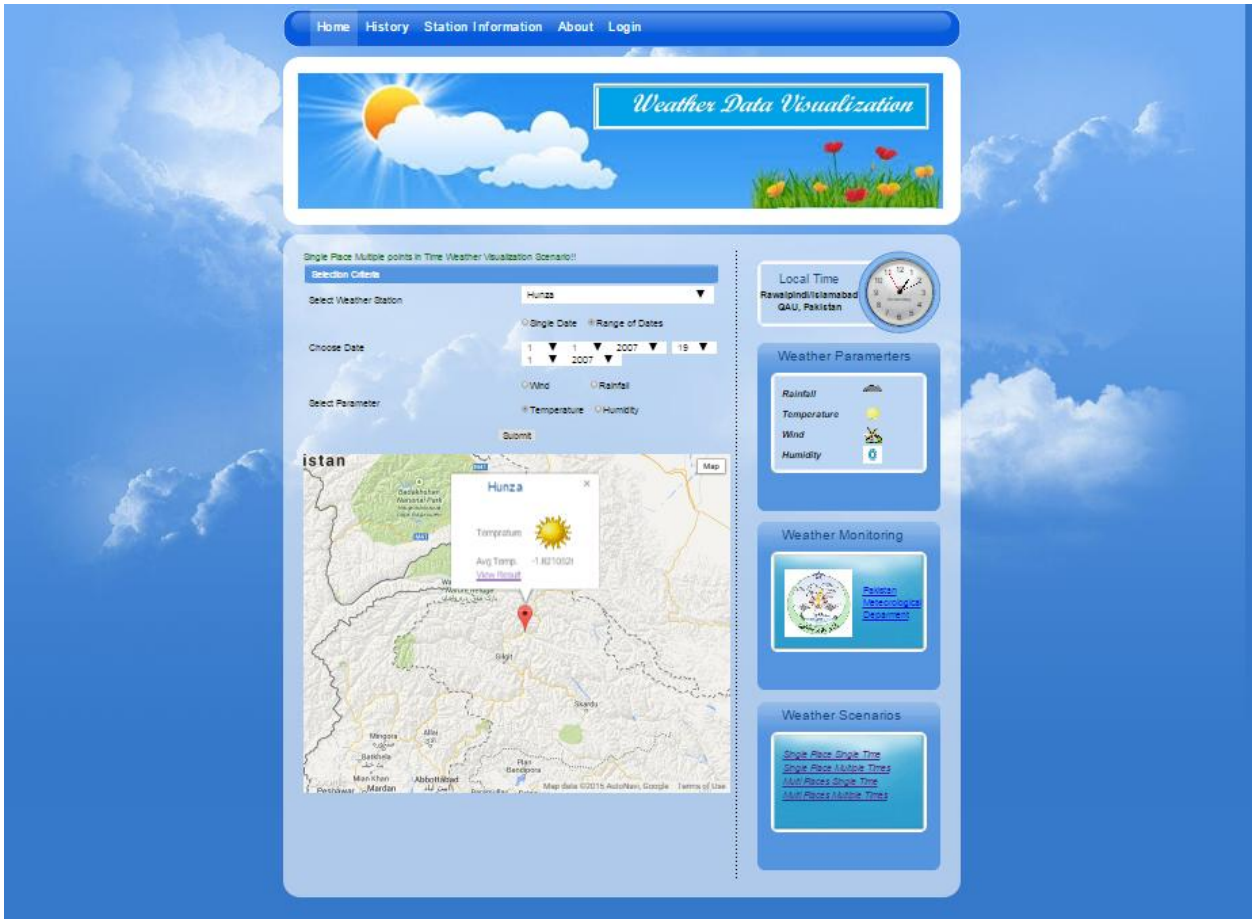


Scenario 1

Figure 4.10 a

Interface of Single Place Multi Points in Time Weather Visualization Scenario

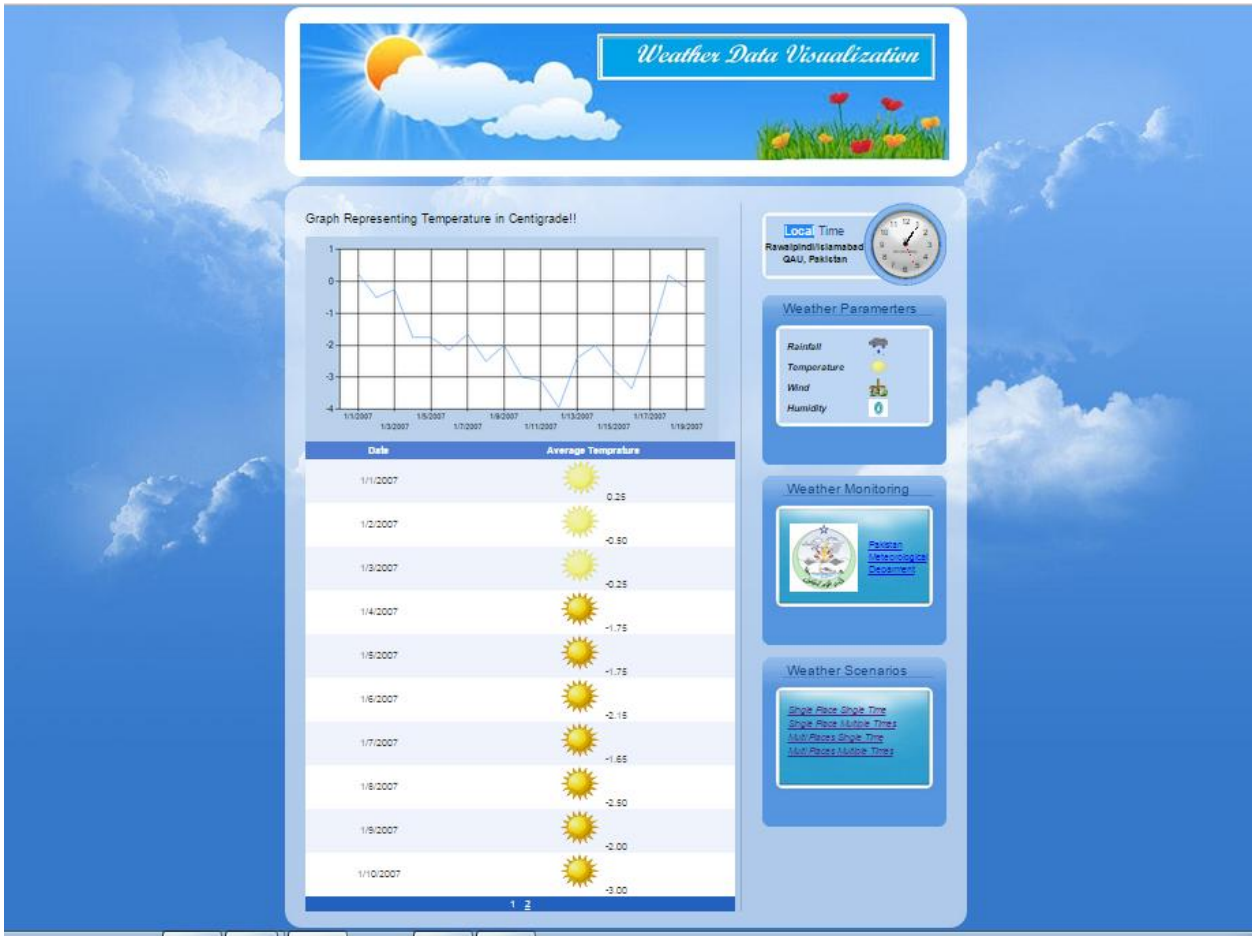
This interface shows the second scenario of weather. Here weather data is displayed on map. User selected a location along with a range of dates and then chooses temperature as weather parameter to visualize data. On clicking view details, individual data for each date will be shown.



Scenario 2

Figure 4.10 b

When user click on view details a new screen will appear with all the details as shown below

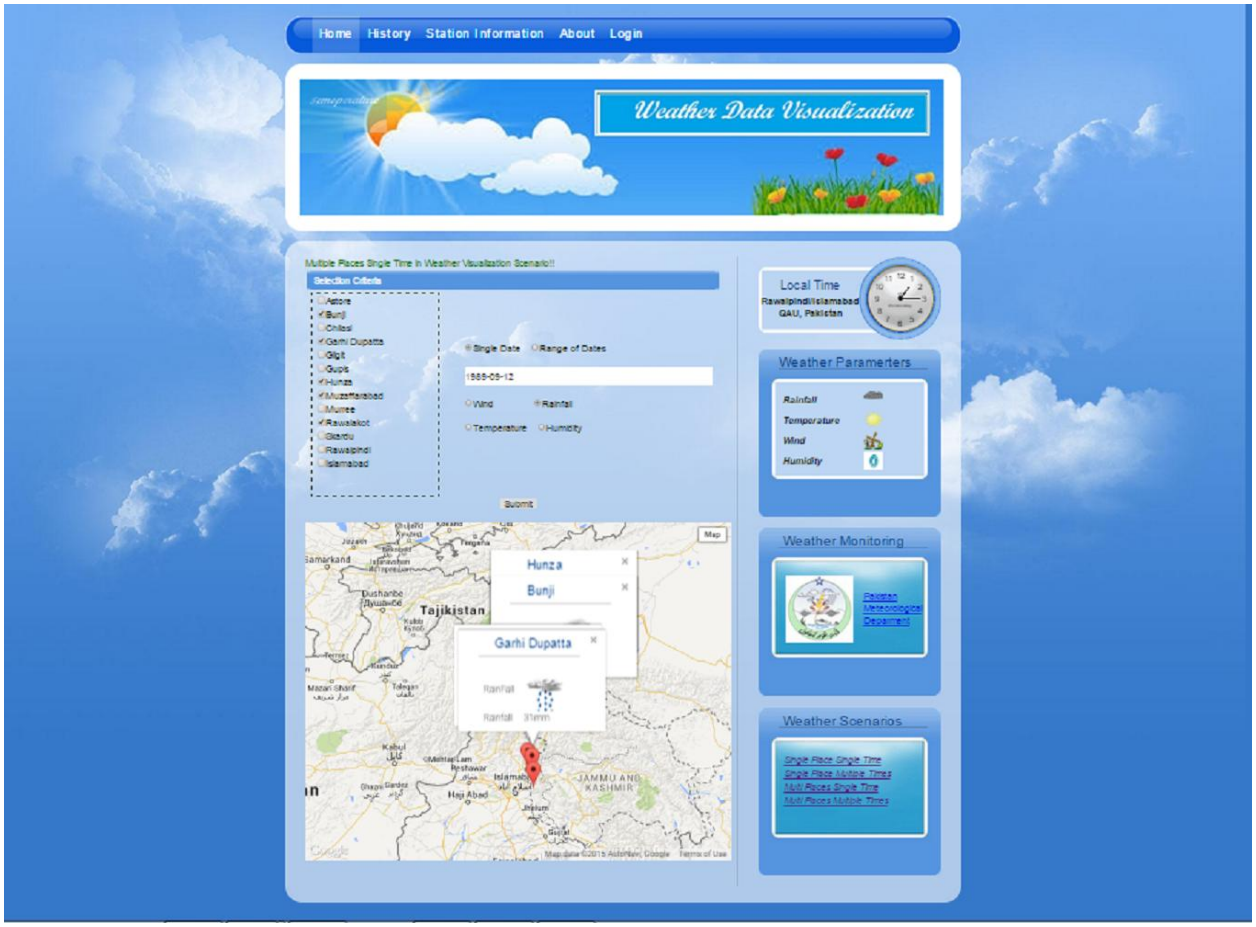


Details for scenario2

Figure 4.10 c

Interface of Multiple Places Single Point in Time Weather Visualization Scenario

This is the third scenario. Here user selects two or more locations accompanied by single date and humidity as weather parameter. After submitting all selected data locations are marked on map. Now on map two markers shows the locations when the marker of a certain place is popped up it shows weather data of that place as soon as next marker is popped up then its shows data of that location. User can choose more weather stations according to his/her need.



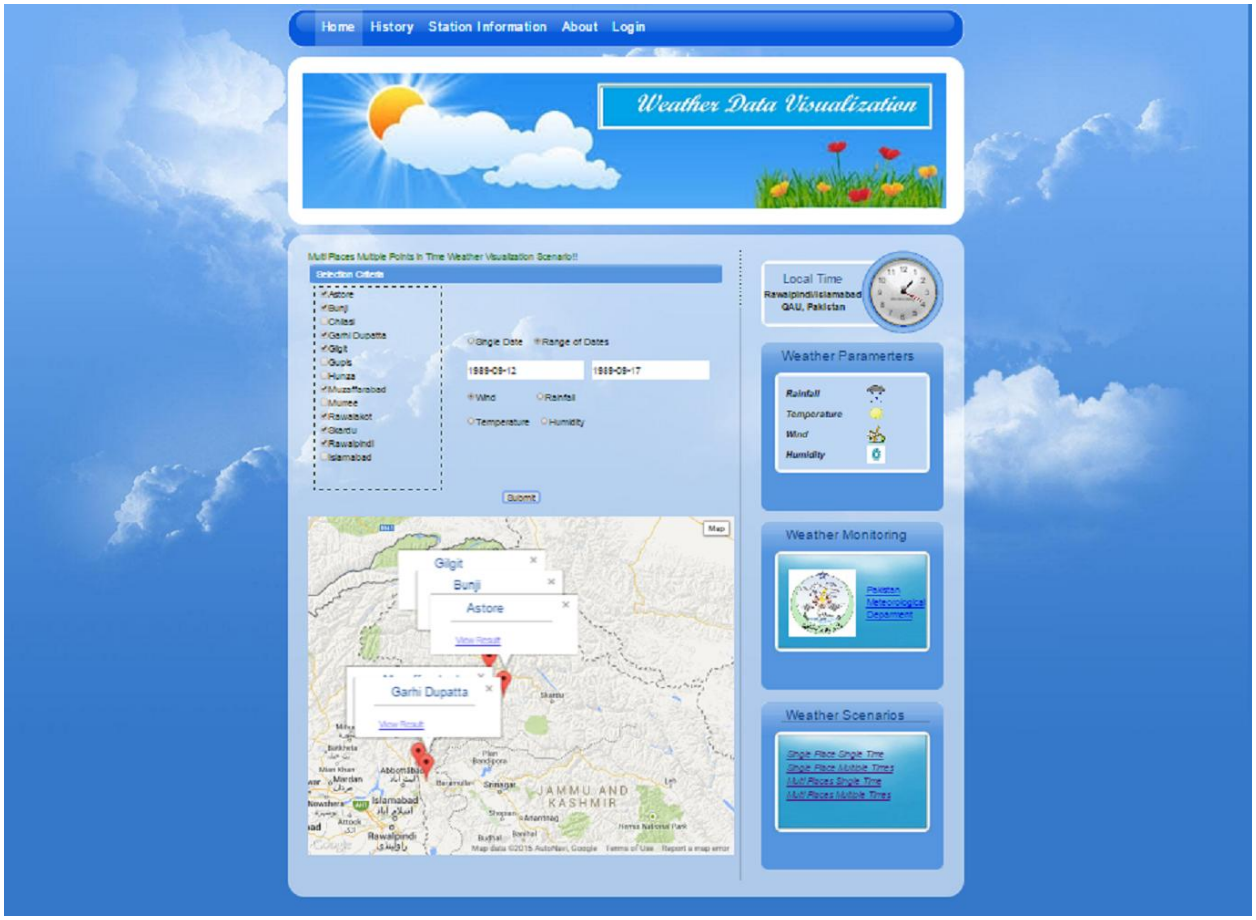
Scenario 3

Figure 4.10 d

Interface of Multiple Places Multi Points in Time Weather Visualization Scenario

Fourth scenario is about multi places and multiple times. User selects two or more locations accompanied by range of dates and temperature as weather parameter. After submitting all selected data locations are marked on map. Now on map two markers shows the locations when the marker of a certain place is popped up it shows average weather data of that place as soon as next marker is popped up then its shows data of that location and clicking on details, will show extended weather details.

In the figure below different weather stations are selected and range of dates are choosen to visualize weather data. So after submitting the selected data weather station locations are shown on map when click on details it will display extended data of the selected parameter.

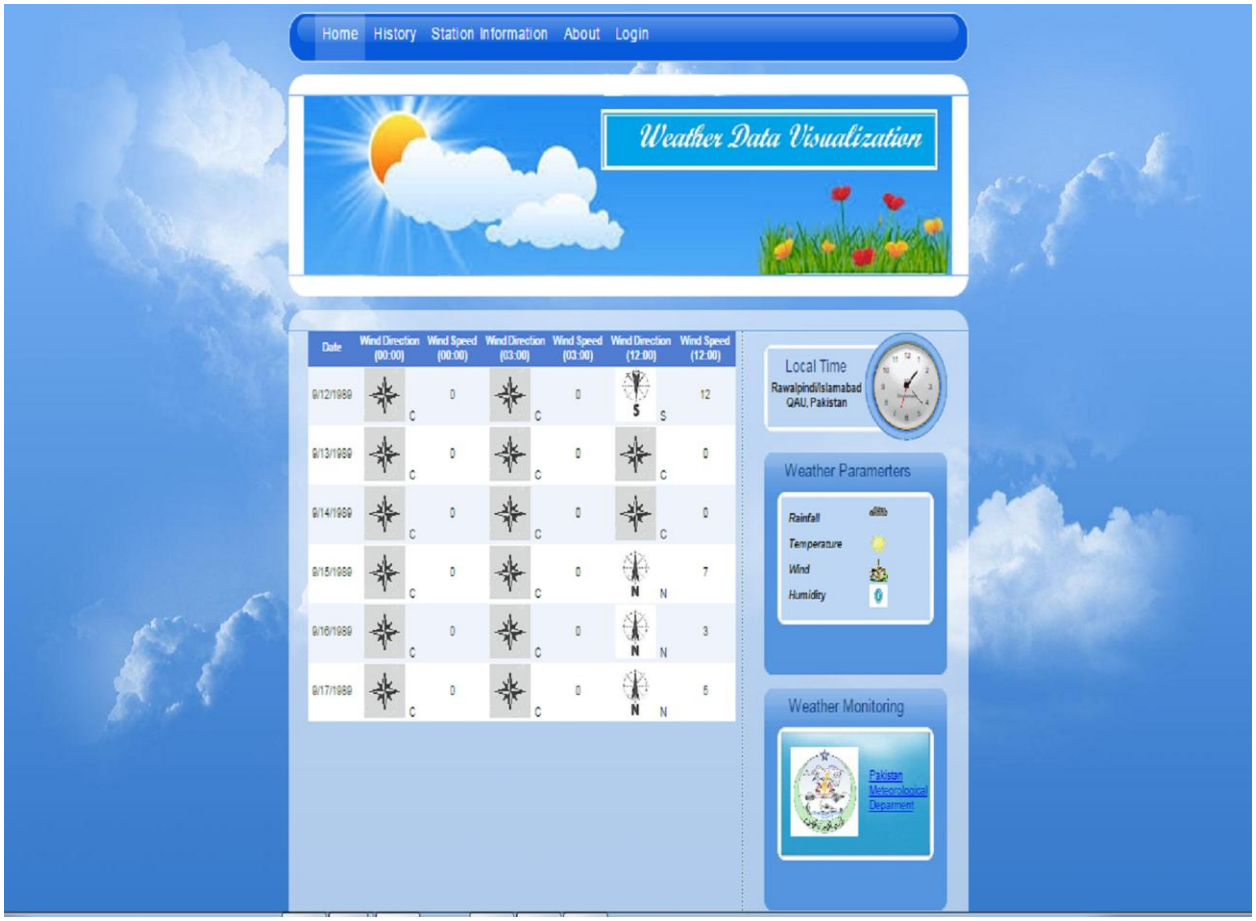


Scenario 4

Figure 4.10 e

Interface for Extended Weather Details

Extended details are shown as below:-



Extended Details

Figure 4.10 f

Extended details for wind parameter is shown above. For each single day wind direction and speed can be visualized.

Chapter 5

System Implementation

This chapter is related to system implementation. After the design phase comes the implementation phase. In this phase we decide how to implement our design and which techniques to use. The purpose of implementation is to transfer the design into executable system software and the system is built to meet the design specification. This chapter describes the implementation phase in detail and also describes the selection of language and software.

5.1 Framework Selection

Dot net framework 4.0 is used to develop system. The .NET framework provides facilities for developing desktop, web applications, web services and mobile applications. It consists of two major components: the common language runtime (CLR) which provides memory management and other system services and an extensive class library which includes tested and reusable code for all major areas of application development.

5.1.1 Language Selection

After the selection of framework the next step in implementation is to decide the suitable language that must be flexible enough to support design. Things that should be taken care of while selecting language:

- Design is object-oriented or structured
- System is web-based or desktop

C# is being used to develop this project. C# is an elegant, type-safe object oriented language used to develop a wide range of applications. C# programs run on .NET framework and are simple and relatively more flexible.

Reason for choosing C# for this project is because it's a desktop application and intended for Windows based Operating Systems. Windows is the dominating Operating System on client

computers today. The best GUI frameworks for Windows applications is .NET Framework and the best suited programming language to work with the .NET Framework and its APIs is C#.

5.2 Database Selection

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. SQL Server aims to make data management efficient by providing the following advantages:

- Dual security models
- Highly scalable enterprise database platform capable of managing petabytes of data while delivery high performance
- Business intelligence: Complex data analysis for managing and forecasting future needs
- Support for structured and semi-structured data (including digital media formats), and spatial data

5.3 Software Used

Following are the software's that are used in developing this system.

5.3.1 Microsoft Visual Studio 2010 IDE

Microsoft Visual Studio is an integrated development environment (IDE) from Microsoft. It is used to develop applications like console applications, desktop applications, windows services, websites, web applications and web services, and mobile applications. Visual Studio uses Microsoft software development platforms such as Windows API, Windows Forms, Windows Presentation Foundation, Windows Store and Microsoft Silverlight.

5.3.2 Microsoft SQL Server 2008 Management Studio

Microsoft SQL Server is a relational database server, developed by Microsoft. It is a software product whose primary function is to store and retrieve data as requested by other software applications. Its tasks include creation, deletion and maintenance of databases, writing and executing queries and stored procedures.

5.3.3 Java Script

JavaScript is the programming language of the Web. JavaScript is an efficiently used scripting language that is used along HTML to create dynamic web pages.

- JavaScript is one of the easy, adoptable, and useful scripting languages that are used to improve functionality among websites
- JavaScript is used for creating visual effects on screen, calculating data and performing processing on web pages
- JavaScript is most commonly used as part of web browsers, whose implementations allow client-side scripts to interact with the user, control the browser, communicate asynchronously, and alter the document content that is displayed
- JavaScript is comparatively faster. This is because JavaScript code is created on user's computer, hence processing is done immediately

5.4 APIs Used

Google Map API is used for the Maps in the System.

5.4.1 Google Map API

The Google Maps APIs give developers several ways of embedding Google Maps into web pages, and allows for either simple use or extensive customization. I have used Google map API to show languages data in a concise way so that user can graphically get the weather station location according to districts of Pakistan. The overlay used to show the location:-

- **Marker:** Markers are used to show all the districts on the maps

Chapter 6

System Testing

Testing is the process of exercising a program with the specification of finding errors prior to delivery to the end user. Testing may also uncover requirement related issues. In testing some or all of the components in a system are integrated and the system is tested as a whole.
System testing should focus on testing component interactions. This chapter contains User Acceptance Test (UAT) specification which is built against use cases stated in Requirement Analysis.

6.1 Objectives

The UAT specification will be helpful to verify requirements finalized in requirement phase and to check whether all the requirements have been fulfilled or not.

6.2 Scope

UAT will cover all requirements specified in the form of use cases:

- UAT will provide test cases against each requirement
- UAT test case will provide actual function, input, expected result, actual result, procedure to perform test case, pass/fail status and date against each test case

6.3 UAT Test Cases

Formal testing with respect to user needs, requirements, and business processes conducted to decide whether or not a system satisfies the acceptance criteria and to allow the user or other certified entity to determine whether or not to accept the system.

6.3.1 Test Case 1

Test Case 1	Visualize weather data for a specific day
Description	User chooses a weather station and a specific date to visualize weather data.
Test Setup	Choose weather station: Hunza
Steps of Instruction	1. Choose weather station: Hunza 2. Select date .i.e. 2007-02-01 3. Choose temperature parameter 4. Submit the selected data
Expected Output	System will display weather data of selected date on map.
Verdict	Pass

6.3.2 Test Case 2

Test Case 2	Visualize weather data of different points in time for a particular station
Description	User chooses a weather station and range of dates to visualize weather data.
Test Setup	Choose weather station: Rawalakot
Steps of Instruction	1. Choose weather station: Rawalakot 2. Select date from .i.e. 2007-02-01 to 2007-02-05 3. Choose humidity parameter 4. Submit the selected data
Expected Output	System will display weather data of selected date on map.
Verdict	Pass

6.3.3 Test Case 3

Test Case 3	Visualize weather data of multiple locations for a certain day
Description	User chooses two or more weather station and a single date to visualize weather data.
Test Setup	Choose weather station: Hunza and Rawalakot
Steps of Instruction	1. Choose weather station: Hunza and Rawalakot 2. Select date .i.e. 2007-06-04 3. Choose wind parameter

	4. Submit the selected data
Expected Output	System will display weather data of selected date on map after user click on the marker location.
Verdict	Pass

6.3.4 Test Case 4

Test Case 4	**Visualize weather data of multiple locations for multiple days**
Description	User selects various weather stations and a range of dates to visualize weather data.
Test Setup	Choose weather station: Hunza, Rawalakot and Astore
Steps of Instruction	1. Choose weather station: Hunza, Rawalakot and Astore 2. Select date from .i.e. 2010-12-04 to 2010-12-07 3. Choose any parameter 4. Submit the selected data
Expected Output	System will display weather data of selected date on map.
Verdict	Pass

6.3.5 Test Case 5

Test Case 5	**Visualize weather extended details**
Description	User chooses a weather station and a specific date to visualize weather data.
Test Setup	Choose weather station: Hunza
Steps of Instruction	1. Choose weather station: Hunza 2. Select date .i.e. 2007-02-01 3. Choose any parameter 4. Submit the selected data 5. Click on view details
Expected Output	System will display weather extended details.
Verdict	Pass

Chapter 7

Conculsion and Future Enhancement

7.1 Conclusion

This report shows complete picture of the visualization of weather system in which all the stages of development of the system was discussed. After a detailed background study and work on the project, it became clear that weather visualization is a challenging and sensitive problem. Weather information can be represented using various techniques. Making clear and understandable visualizations needs careful contemplation and analysis.

7.2 Future enhancements

This project can be further enhanced like visual presentation of future weather predictions/patterns. Secondly, a mobile app can also be developed to support smart phone users for quick navigation of weather in their respective region.

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