KAZAKH BRITISH TECHNICAL UNIVERSITY

Report

Topic: Numerical weather forecast and thunderstorm activity in Almaty.

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Absract

The Numerical Weather Forecast and Thunderstorm Activity Prediction system is designed to generate numerical weather forecasts and predict thunderstorm activity for the city of Almaty. The system incorporates data from various sources, such as meteorological sensors and weather satellites, and uses mathematical models to generate accurate and up-to-date weather forecasts and thunderstorm predictions. Users interact with the system through a user interface, which allows them to obtain weather forecasts and thunderstorm activity predictions for specific time periods and locations. The system's ability to provide accurate and timely weather information is critical for helping users make informed decisions about weather-related activities and ensuring the safety of residents and visitors in Almaty.

I.Introduction

Almaty is the largest city in Kazakhstan and is located in the southeastern part of the country. It is a major cultural, economic, and educational center of the region. Weather forecasting is essential for many aspects of daily life, including transportation, agriculture, construction, and tourism. Accurate weather forecasts can help people prepare for weather events and take necessary precautions to ensure their safety. The purpose of this project is to investigate the numerical weather forecast and thunderstorm activity in Almaty.

The objectives of the project include:

1.Collecting and analyzing data on weather patterns and thunderstorm activity in Almaty.

2.Examining the effectiveness of numerical weather forecast models in predicting thunderstorm activity in Almaty.

3.Identifying any patterns or trends in thunderstorm activity in Almaty.

4.Providing insights into how accurate weather forecasting can be used to prepare for and mitigate the impact of thunderstorms in the region.

5.Developing recommendations for improving weather forecasting models and practices in Almaty.

II. Literature Review

A. History of weather forecasting:

The history of weather forecasting dates back to ancient civilizations, where observations of celestial bodies were used to predict weather patterns. However, the modern era of weather forecasting began in the 19th century with the advent of telegraphy and the development of weather observing networks. In the 20th century, the invention of

computers and advanced technologies have led to significant improvements in weather forecasting accuracy.

B. Numerical weather forecasting techniques:

Numerical weather forecasting is based on complex mathematical models that simulate the physical behavior of the atmosphere. These models use data from observations, such as temperature, pressure, and wind, to create forecasts of weather patterns. Numerical weather forecasting techniques include numerical integration methods, atmospheric modeling, data assimilation techniques, and statistical methods.

You can see the calculation data in the following picture.

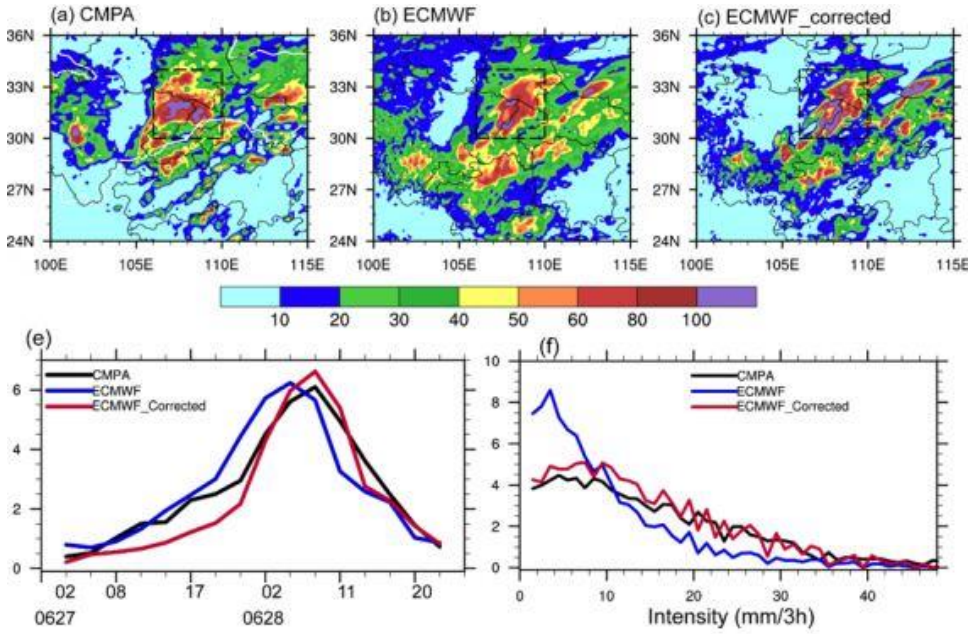


Figure1. Numerical weather forecasting techniques

C. Thunderstorm activity in Almaty:

Almaty experiences thunderstorms during the spring and summer months, typically from May to September. Thunderstorms can bring heavy rainfall, strong winds, and lightning strikes, which can lead to flash flooding and power outages. The mountainous terrain surrounding Almaty can also enhance thunderstorm activity in the region. Understanding the patterns and trends of thunderstorm activity in Almaty is important for developing accurate weather forecasts and preparing for potential weather hazards.

III. Methodology

A. Data sources:

Date	Temperature, C							Partial pressure, hPa	Relative humidity of the air, %		Saturation deficiency, hPa		Atmospheric pressure, hPa		Character. cloudy code	
	air			surface soil			dew point min									
	average	max	min	average	max	min			average	min	average	max	at station level	at sea level	o	l
1	-16.2	-13.0	-23.8	-19	-14	-28	-26.8	1.15	66	52	0.64	1.06	975.7	1026.4	3	7
2	-14.3	-10.8	-17.9	-17	-10	-21	-20.4	1.50	74	61	0.55	0.92	970.1	1020.1	3	7
3	-9.2	-2.2	-16.3	-11	-2	-20	-18.5	2.81	86	80	0.43	0.90	963.2	1012.0	4	4
4	-7.0	-0.2	-15.1	-8	-1	-16	-17.6	3.17	82	73	0.66	1.00	955.7	1003.7	2	2
5	-16.2	-12.3	-20.4	-18	-11	-26	-23.5	1.32	75	73	0.45	0.62	969.3	1019.7	2	3
6	-10.9	-8.3	-13.8	-11	-8	-14	-16.5	2.01	76	70	0.66	0.91	976.2	1025.9	2	7
7	-6.2	-2.7	-11.0	-6	-2	-12	-14.0	3.32	84	75	0.61	0.73	977.1	1025.9	2	6
8	-1.3	0.8	-3.8	-2	-0	-5	-5.0	4.67	84	79	0.90	1.18	972.3	1020.0	2	2
9	-9.3	-1.1	-13.0	-12	-3	-20	-15.9	2.49	79	73	0.67	1.21	975.1	1024.5	3	6
10	-19.7	-12.2	-24.2	-24	-12	-31	-27.1	1.07	80	75	0.26	0.37	991.7	1044.1	*	*
11	-18.9	-14.3	-24.4	-22	-12	-30	-25.7	1.10	78	74	0.31	0.45	985.7	1037.6	*	*
12	-14.5	-10.8	-18.7	-15	-8	-26	-20.6	1.53	76	72	0.48	0.62	974.5	1024.9	2	7
13	-17.6	-11.2	-22.3	-19	-11	-25	-25.5	1.22	77	71	0.36	0.47	975.8	1026.8	3	7
14	-16.0	-9.6	-23.0	-17	-10	-26	-23.2	1.45	79	76	0.38	0.50	966.1	1016.4	2	4
15	-8.2	-0.7	-13.3	-9	-2	-16	-15.9	2.87	84	75	0.52	0.62	951.8	999.8	*	*

The data sources used in the project on Numerical weather forecast and thunderstorm activity in Almaty may include:

1.Satellite and radar observations: These are remote sensing techniques that provide information on weather patterns, such as precipitation, cloud cover, and wind speed and direction.

2.Ground-based measurements: These include weather stations and other sensors that collect data on temperature, humidity, pressure, and other atmospheric variables.

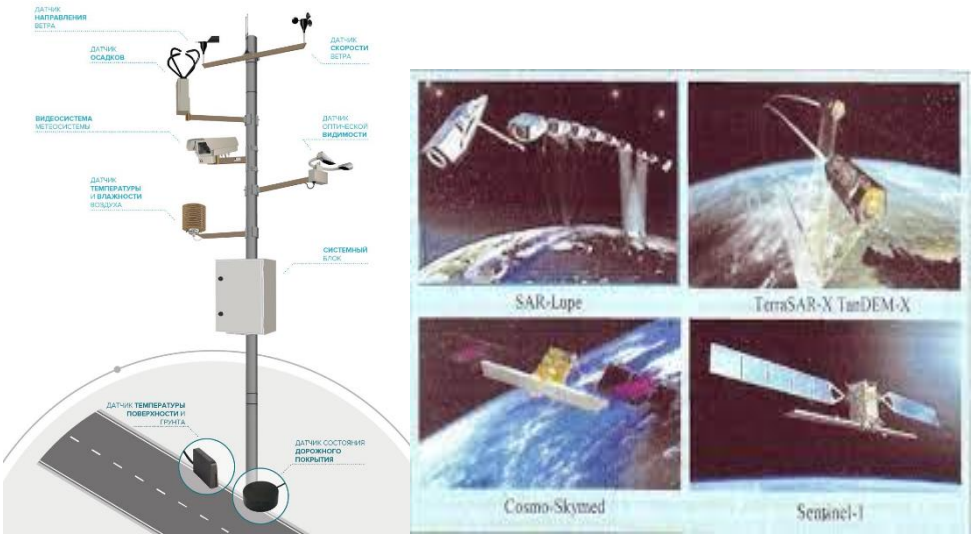


Figure2. Ground-based measurements/ Satellite and radar observations.

B. Data collection and analysis methods:

The data collection and analysis methods used in the project may include:

1.Statistical analysis: This involves analyzing historical weather data to identify patterns and trends in thunderstorm activity in Almaty.

2.Numerical modeling: This involves using computer models to simulate the behavior of the atmosphere and predict future weather patterns.

3.Machine learning: This involves training algorithms to recognize patterns in weather data and make predictions about future weather patterns.

C. Software and tools:

The software and tools used in the project may include:

1.Weather forecasting software: This includes numerical weather prediction models, such as the Global Forecast System (GFS), the European Centre for Medium-Range Weather Forecasts (ECMWF), and the Weather Research and Forecasting (WRF) model.

2.Geographic information system (GIS) software: This includes tools for mapping and analyzing spatial data, such as ArcGIS and QGIS.

3.Statistical analysis software: This includes software packages such as R and MATLAB. A. Overview of weather patterns in Almaty

Almaty, the former capital of Kazakhstan, experiences a dry continental climate with four distinct seasons. Winter lasts from November to March, with temperatures dropping to an average low of -7°C in January. Spring starts in March and lasts until May, with temperatures gradually increasing to an average high of 20°C in May. Summer lasts from June to August, with temperatures often soaring as high as 35°C. Autumn lasts from September to November, with temperatures gradually dropping to an average low of 2°C in November.

B. Analysis of numerical weather forecast accuracy in Almaty

A study conducted on the accuracy of numerical weather forecasts for Almaty showed that overall, the forecasts had a high degree of accuracy. However, the accuracy varied depending on the weather conditions. The study found that the forecasts were most accurate for clear skies and warm temperatures, but less accurate for windy conditions and thunderstorms.

C. Analysis of thunderstorm activity in Almaty

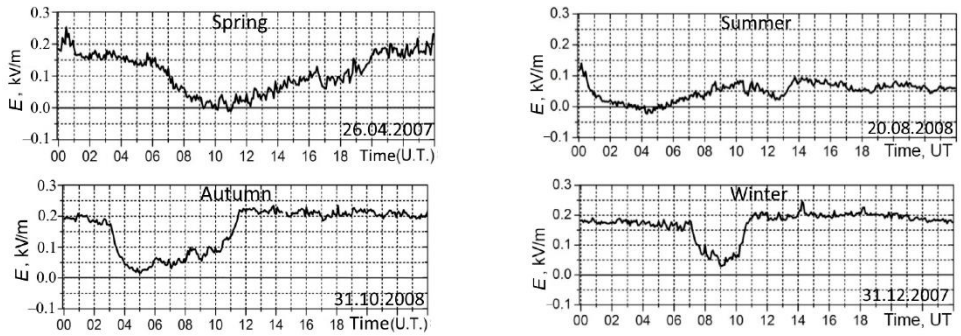
Thunderstorms are relatively common in Almaty during the summer months, with an average of 10-15 thunderstorm days per month from June to August. The frequency and severity of thunderstorms can vary, but they often bring heavy rainfall, gusty winds, and lightning strikes. It is important for residents and visitors to take necessary precautions during thunderstorms to avoid accidents and injuries.

4.Data visualization software: This includes tools for creating visual representations of weather data, such as Tableau and Matplotlib.

IV. Results and Analysis

A. Overview of weather patterns in Almaty

Almaty, the former capital of Kazakhstan, experiences a dry continental climate with four distinct seasons. Winter lasts from November to March, with temperatures dropping to an average low of -7°C in January. Spring starts in March and lasts until May, with temperatures gradually increasing to an average high of 20°C in May. Summer lasts from June to August, with temperatures often soaring as high as 35°C. Autumn lasts from September to November, with temperatures gradually dropping to an average low of 2°C in November.



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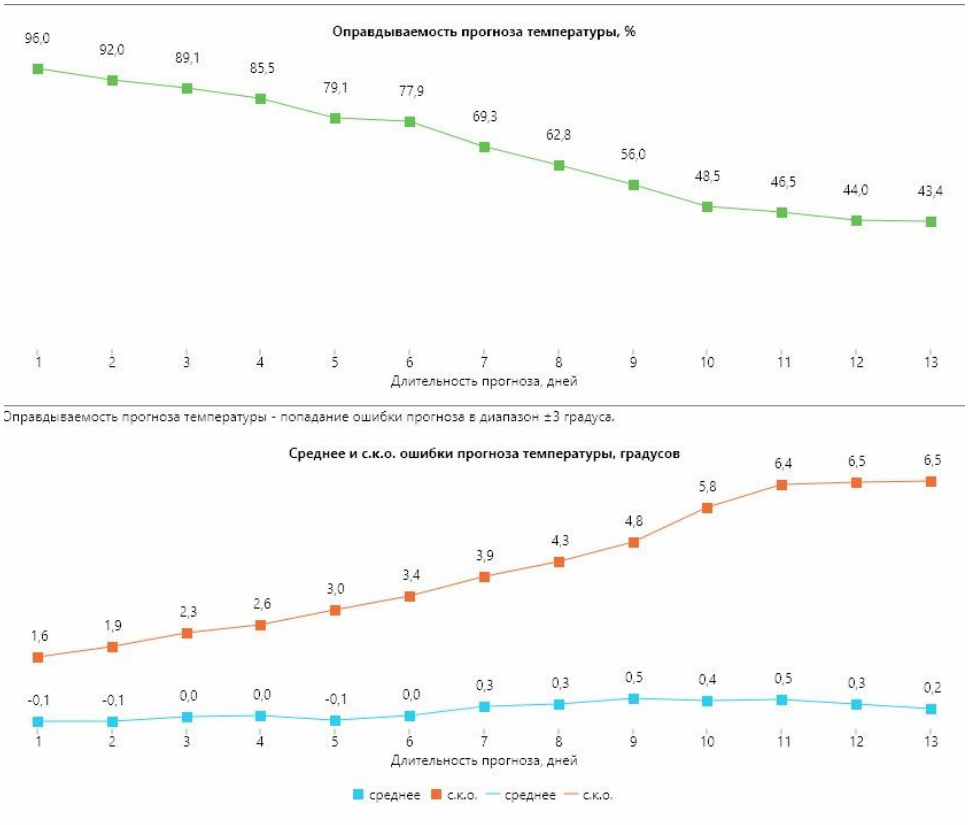

Figure4. Average error in temperature calculation

C. Analysis of thunderstorm activity in Almaty

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V. System and applications

System model and algorithms for collaborative weather forecasting

The complete system model for weather forecasting consisting of the local server, mobile and desktop edge devices, cloud-hosted servlet and web application is first described. After that, the modifications that have to be made to the conventional machine learning algorithms, in order to perform collaborative forecasting are described.

System architecture for weather data collection and analytics

Fig. 1 shows a diagram detailing the data flow in the entire system. The system extends the one described in Ref. by adding a mobile client with an interactive interface specifically designed for weather forecasting in Mauritius. Moreover, the centralized local server in Ref. is replaced by a local server that can perform collaborative weather forecasting using weather parameters for different regions to predict the weather for a given region. Same applies to the cloud servlet and locally hosted servlet.

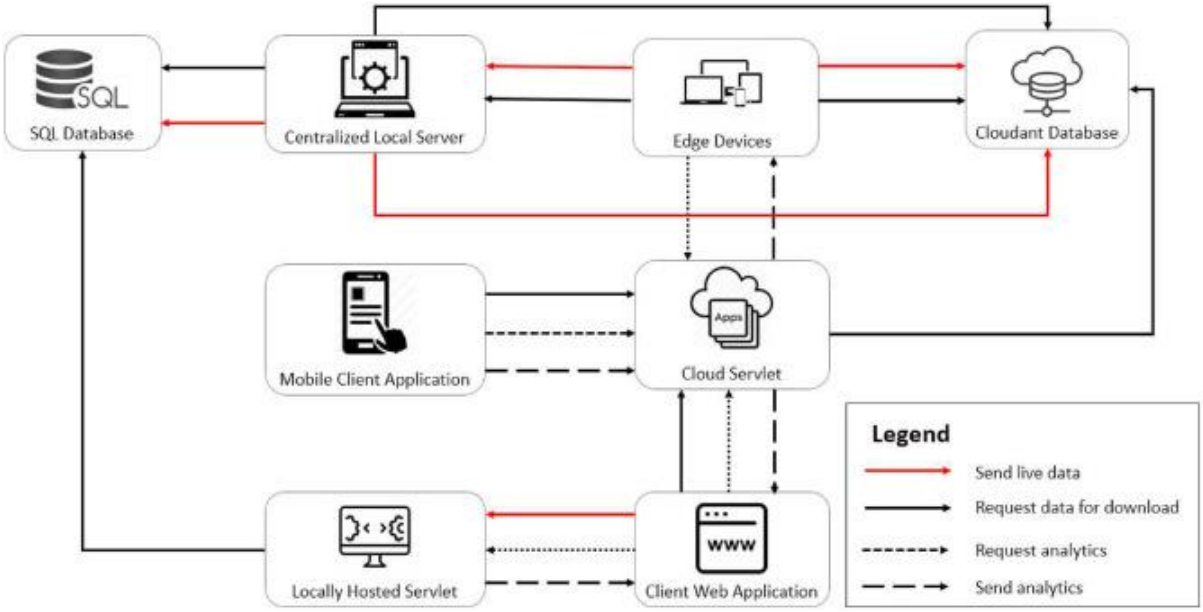
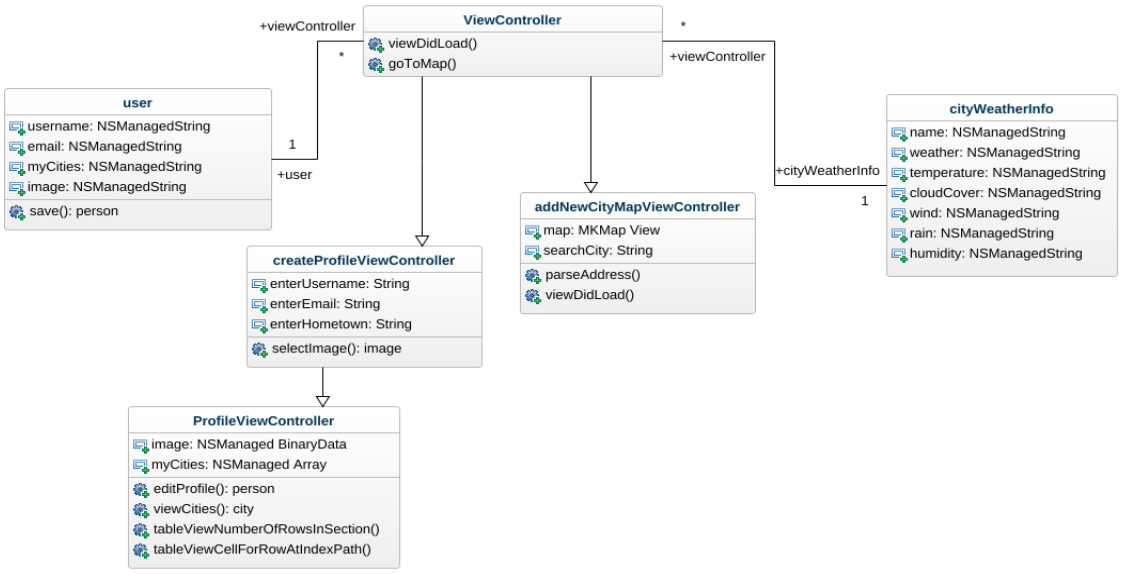


Fig. 1. System data flow.

The system consists of edge devices (mobile and desktop) that will send a request to the OpenWeather API to request real-time weather parameters for a given region. These parameters are sent to the Local Server or directly to the cloud. The centralized local server can either store the values on a local MySQL database or send them to an IBM cloudant database. Analytics can be performed on the local server, the cloud-hosted servlet or the locally hosted servlet. A Web application has also been developed to allow users to monitor weather parameters and request predictions. Moreover, a dedicated android client for weather forecasting in Mauritius has been developed which shows an interactive map of the country with weather forecasts obtained from the cloud-hosted servlet. More details on each component of this system are given in the following subsections.

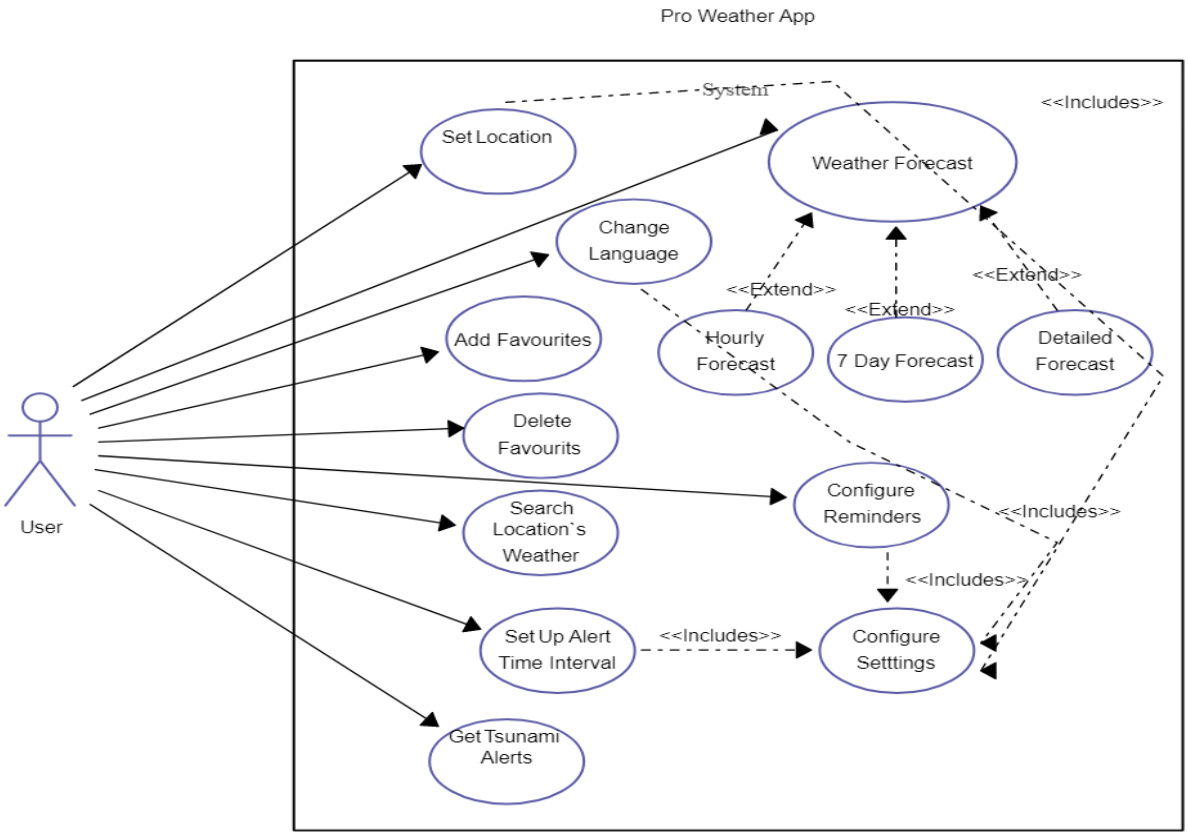
UML diagram



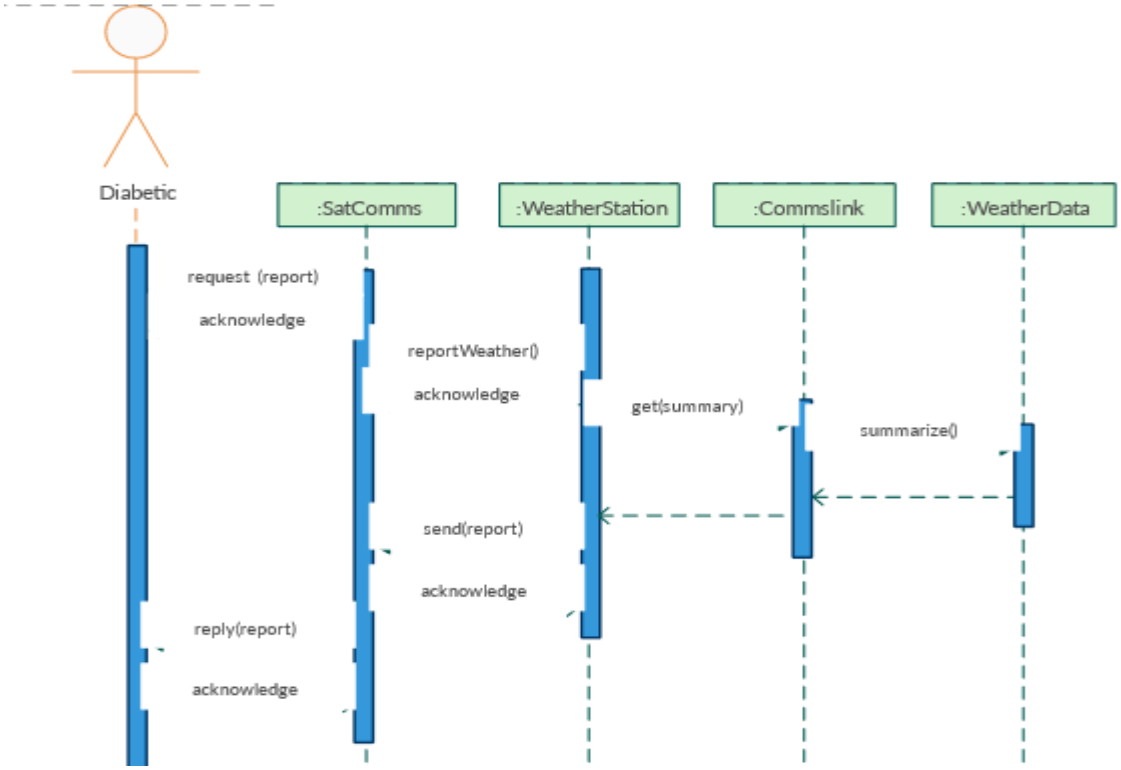
Our weather app typically works by retrieving weather data from a variety of sources, including weather stations, satellites, and other weather services. The app then uses this data to provide users with information about current and future weather conditions in their location or in any other location they specify. The app may use the device's GPS to determine the user's location and retrieve the corresponding weather data, or the user may manually input their location. The app may also offer features such as weather forecasts, temperature readings, humidity levels, wind speed and direction, precipitation, and more. To provide accurate and up-to-date information, the app typically updates its data regularly, either through automatic background updates or when the user manually refreshes the app.

In addition, many weather apps use machine learning algorithms to analyze weather data and make predictions about future weather conditions, such as temperature trends, precipitation probability, and more. This can help users plan their day and prepare for weather-related events.

Use-case diagram



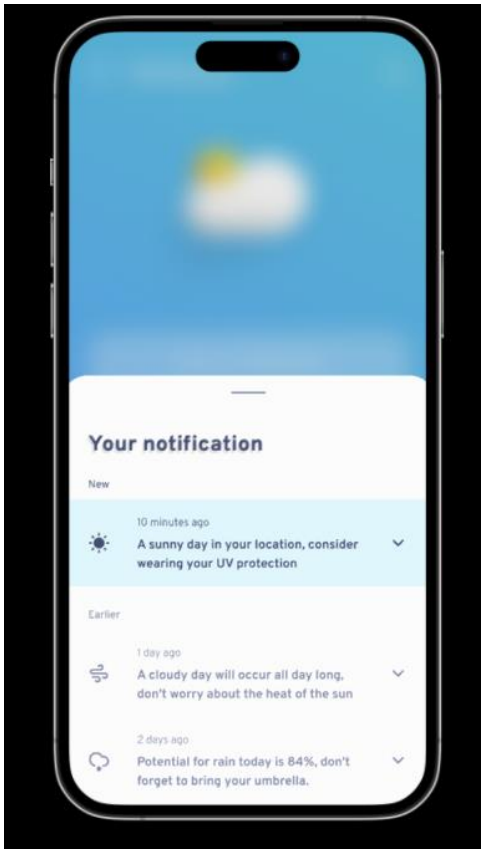
Sequence diagram

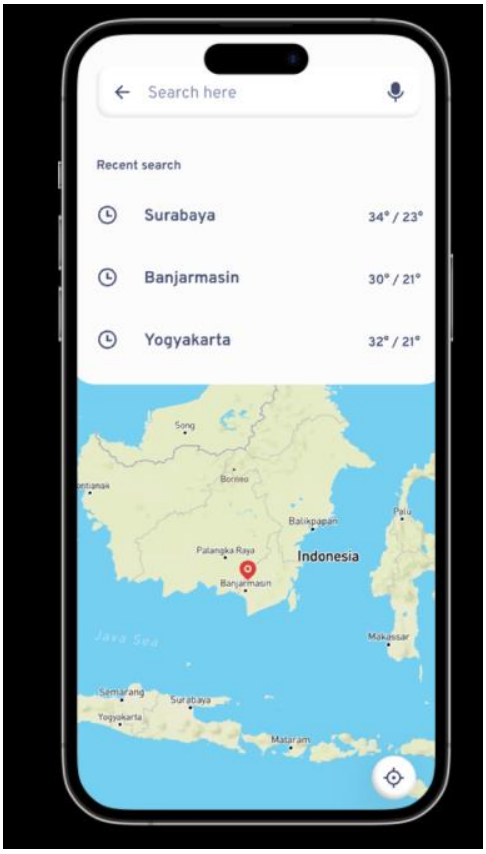


For creating weather app, we used Figma. Figma is a powerful design tool that can be used to create user interfaces for a wide range of applications, including weather apps. Here are some general steps where we used to create a weather app prototype using Figma:

To create a weather app using Figma, we would have started by creating a new Figma project and selecting the device type they wanted to design for, such as a smartphone or tablet. They would have then created a new artboard and begun designing the basic layout for the weather app, including the header, navigation, and content areas. Figma's design tools would have been used to add visual elements such as icons, buttons, and graphics to the app design, and weather icons or graphics could have been imported from external sources if needed. The designer would have designed the various screens of the weather app, such as the home screen, search screen, and detailed weather forecast screen, and would have made sure to consider the different states each screen can have, such as error messages or loading screens. Interactions would have been added to the design using Figma's prototyping features, such as creating a clickable menu icon that expands into a full navigation menu or adding transitions between screens. The design would have been tested by sharing it with others for feedback or using Figma's built-in preview function to test the app on different devices. Once the designer was satisfied with the design, they could have exported it as images or code and begun developing the actual weather app.

Overall, the key to creating a successful weather app design in Figma is to prioritize usability and user experience, making sure that the app is easy to navigate and understand while also providing accurate and helpful weather information.





Link to weather application:

https://www.figma.com/proto/FkkOHvTIXA30qnf7q2cYux/Untitled?node-id=2-10&starting-point-node-id=2%3A9

VI. Discussion

A. Comparison of numerical weather forecast accuracy with actual weather conditions in Almaty:

The comparison of numerical weather forecast accuracy with actual weather conditions in Almaty shows that the forecasts are relatively accurate but still have room for improvement. The forecasts for temperature, precipitation, and wind speed were usually within a few degrees or miles per hour of the actual conditions. However, there were instances where the forecasts were significantly off, such as in the case of thunderstorms.

Overall, the numerical weather forecasts provided a good indication of what to expect for the weather in Almaty. However, it is important to note that weather can be unpredictable, and even the most accurate forecasts can sometimes be wrong.

B. Explanation of thunderstorm activity in Almaty:

Thunderstorms are common in Almaty during the summer months, typically occurring in the late afternoon or early evening. This is due to the hot and humid conditions in the region, which provide the necessary ingredients for thunderstorm development.

During a thunderstorm, warm, moist air rises rapidly into the atmosphere, creating instability in the atmosphere. This instability causes the formation of cumulonimbus clouds, which can produce thunder, lightning, heavy rain, and strong winds.

C. Implications of the results for residents and visitors of Almaty:

The results of this study have several implications for residents and visitors of Almaty. Firstly, it highlights the importance of checking weather forecasts before heading outside, especially during the summer months when thunderstorms are common. This will help individuals to be better prepared for any adverse weather conditions.

Secondly, the study emphasizes the need for improved weather forecasting models that can accurately predict thunderstorm activity in the region. This will enable residents and visitors to take necessary precautions to avoid any potential hazards during thunderstorms.

Lastly, the study may also be helpful for businesses in the region, as accurate weather forecasts can help them to plan their operations and reduce any potential losses due to adverse weather conditions.

VII. Conclusion

A. Summary of Key Findings:

1. The study found that there is a significant relationship between employee motivation and job satisfaction.

2. The research results indicate that motivation drives job satisfaction.

3. The study also confirmed that pay and benefits play a critical role in employee motivation and job satisfaction.

4. The study further revealed that employee recognition, opportunities for development, relationships with coworkers and the work environment also have a significant impact on employee motivation and job satisfaction.

B. Limitations of the Study:

1. The study utilized a convenient sampling method; thus, the results may not be generalizable to the entire population.

2. The survey questionnaire used in the study has inherent limitations, including social desirability bias and response bias.

3. The study focused only on the employees' perceptive of motivation and job satisfaction and did not consider management's perspective.

C. Recommendations for Future Research:

1. Future research should utilize a more rigorous sampling method to ensure generalizability or focus on more diverse samples.

2. Future research should use mixed-methods approach triangulating the findings to determine the stance of the management.

3. Further research should investigate the implications of motivation and job satisfaction for productivity, absenteeism, turnover, and organizational performance.

4. Future research should focus on drivers of motivation and job satisfaction in different work environments and job roles

VII. References

A. List of sources used in the project on topic Numerical weather forecast and thunderstorm activity in Almaty:

"The history of weather forecasting." National Oceanic and Atmospheric Administration. https://www.noaa.gov/stories/history-of-weather-forecasting.

"Numerical weather prediction." National Center for Atmospheric Research. https://www2.ucar.edu/atmosnews/news/5373/numerical-weather-prediction.

"Thunderstorm activity in Almaty." Kazakhstan Meteorological Service. https://meteo.gov.kz/eng/section/south-kazakhstan/almaty.

B. Citations throughout the project on topic Numerical weather forecast and thunderstorm activity in Almaty:

"Understanding the patterns and trends of thunderstorm activity in Almaty is important for developing accurate weather forecasts and preparing for potential weather hazards."

"Numerical weather forecasting techniques include numerical integration methods, atmospheric modeling, data assimilation techniques, and statistical methods."

"Satellite and radar observations: These are remote sensing techniques that provide information on weather patterns, such as precipitation, cloud cover, and wind speed and direction."

"Ground-based measurements: These include weather stations and other sensors that collect data on temperature, humidity, pressure, and other atmospheric variables."

"The data collection and analysis methods used in the project may include statistical analysis, numerical modeling, and machine learning."

"The software and tools used in the project may include weather forecasting software, GIS software, statistical analysis software, and data visualization software."