Bilkent University

Department of Computer Engineering

CS-452

PROJECT REPORT

Group-1 Project Members:

- Ahmet Burak Savlu
- Cemal Kılınç
- Cüneyt Erem
- Mehmet Mustafa Demir
- Mert Gürcan
- Rıdvan Çelik

1.IDENTIFYING BUSINESS DRIVERS

The Ministry of the Environment has long been forecasting the weather conditions. Despite the advances in the techniques supporting the weather forecasts, there are still errors in the forecasts, in particular to large cities. One technique that is proposed by the Department of the Weather Forecasting to minimize the errors is the usage of the small-scale sensor networks. The Ministry charges the IT department to make a research on the usage of the sensor-network if the technique is found useful and feasible, the Department of the Weather Forecasting is going to use sensor-networks on the weather forecasting. The IT department is going to contact with several companies for the rental of the small scale sensor-networks for the prototyping of the project. In addition to this, the IT department is going to make a market research on the acquisition of the necessary equipment of the sensor-network that is required for the installation of the sensor-network prototype. If the budget constraint fails, the project will be terminated.

1.1 The Business Need

The business need is to provide Ministry with the data acquired from the small scale sensor-networks. Each sensor in the network will be responsible for a small region and will have geotagging. That way, the Ministry will be able to make forecasts more locally. The forecasts based on the satellite images on large cities are not enough for forecasting. Therefore, the Ministry needs additional information to forecast weather. In an abstract point of view, the business requirements of the project are the acquisition of the data from the sensor-network and providing the Ministry access to sensor data.

1.2 The Business Value

Better weather forecastings and very small error rates will increase customer satisfaction, in this case, the citizen’s satisfaction. The overall reliability of the Ministry will increase. Also, there are plenty of mobile applications which provide weather forecasts to the users. The apps may pay for accurate weather forecasts. That way the Ministry may make revenue from the investment they make in the sensor network project.

2. FEASIBILITY ANALYSIS

Since this is software-related the IT department of the Ministry is given the task of analyzing the feasibility and implementing a prototype using one sensor-network from another organization and one installed for this prototype. The analysis will be from the technical, organizational and economic perspectives.

2.1 Technical Feasibility

Technically, this project has a middle level of risk. The IT department has never developed a similar project for the Ministry. However, as stated in the case description some other departments in the Ministry work with weather related data from a sensor-network and IT department participated in the development of this system. Although the project size might become bigger in time as the project may include a huge sensor-network, the project size can be considered as a medium risk since the size of the project team can be kept the same since the project team can work on one sensor-network area at a time. There will be intensive user involvement since the department of the Weather Forecasting and IT department is going to work very closely. It will increase the possibility of the acceptance of the project, thus the acceptance will be low risk.

2.2 Economic Feasibility

Since the overall reliability of the weather forecasts will rise in time with the help of the new system, the ministry may be able to make revenue from the new system by selling out the weather forecasts to the mobile and desktop app developers and channels. Anyways, since this project is conducted at a non-private sector company, in this case, the Ministry of the Environment, it may not be a really big objective for the project to make revenue immediately. The project is related to a public service and may have a great impact on the national economy and life quality of the society

Income per region with sensor network	2017	2018	2019
From the companies of mobile applications	15 000$	20 000$	23 000$
From the TV channels	35 000$	40 000$	40 000$
Total Benefits	50 000$	60 000$	63 000$

Development Cost	**2017**	**2018**	**2019**
Labor: Analysis	60 000$	0	0

and design			
Labor: Implementation	100 000$	0	0
Office space and equipment	3 000$	0	0
Software	15 000$	0	0
Hardware	35 000$	0	0
Total Development Cost	213 000$	0	0

Operational Cost	2017	2018	2019
Computer Operations	45 000$	47 000$	48 000$
Maintenance Operations	30 000$	33 000$	35 000$
Connectivity/Communication charges	30 000$	30 000$	30 000$
Total Operational Cost	105 000$	110 000$	113 000$

2.3 Organizational Feasibility

The project, if it succeeds, is going to contribute considerably good to the business conducted by the department of the Weather Forecasting. Also, the Ministry of the Environment is going to acquire a great amount of credit for this project since the overall prestige of the Ministry of the Environment will rise with quite accurate weather forecasts. The test of the project is straightforward with the installation or rental of a prototype of the sensor-network. The fact that the Ministry is not a private-sector company is a great advantage for the project. In the case of a successful project, the project champion will be the Department of the Weather Forecasting since they proposed the system that includes a new technique for more accurate weather forecasts.

3. NON-FUNCTIONAL REQUIREMENTS

1. *Operational Requirements*

   1.1 System should integrate with the current weather forecasting system.

   1.2 A healthy network connection should be provided.

   1.3 Ensure that a continuous electrical connection is provided for the system.

2. Performance Requirements

2.1 The system must be available 24 hours daily

2.2. The system must be able to utilize alternative sources of electrical power to ensure continuous electrical connection.

2.3. Sensors should send information per minute in order to get an accurate forecast.

3. Security Requirement

3.1 Ensure that the system is safe against physical effects(rain, wind, lightning).

3.2 The security of the network must be ensured so that the network connection is not sabotaged.

4. Cultural and Political Requirements

4.1 The system must be installed in accordance with the regulations of the Ministry of Environment.

4.2 The national resource rate of the system must be at least 50%.

4. IDENTIFICATION OF KEY PERFORMANCE MEASURE

Since this project is applied in large cities and aims to observe meteorological events, it is important to identify key performance measures.There are seven key performance features determined for this project.

4.1 Size and Scale

Size and Scale is one of the important performance measures. Each network contains individual sensors which gather information.The atmospheric processes that are to be observed, and the size and morphology of the area being covered, will impact on the physical arrangement of the network – such as the distance between the sensors, the sensor heights, and the precise location of the sensor – and thus the network scale.

4.2 Location

The location is another important performance measure. Selecting appropriate location provides better communication on the sensor network. Finding suitable sites and secure locations in large cities are important against the threat of vandalism. We need to locate them very carefully so vandalism risk is reduced, thus small sensors and network work continuously. Also surrounding the aesthetics or visual appeal of instruments in urban areas can create challenges. The system might be located very well but it is not applicable to the people of the region for aesthetics reasons. The aesthetic concerns of people should be considered when establishing such systems.

4.3 Communication an Internet Accessibility

Communication is an essential component of any network. Since this project consists network, it becomes important performance measure. Communication of the project consists of the data flow from the sensor to initial analysis, data management, data display, and usage. Since it has so much task to handle, internet connection becomes very critical. Also project consists of computer systems, instrumentation, data acquisition, data storage systems and repositories, visualization systems, management services and technicians, linked by software and communication networks. Communication and Internet accessibility should be considered key performance measures.

4.4 Energy

Since the project is sensor based, Power is needed in order to run the system.The options available to small sensor networks depend on the location of the sensors, the specific power requirements and the nature of equipment involved. Where possible electricity from the main power grid can be utilized. This may involve utilizing the local electricity infrastructure, such as available on lampposts and traffic lights onto which sensors may be installed. However, when mains electricity is unavailable, renewable option solar energy is a viable alternative. Solar panels are efficient, capable and environmentally friendly to powering sensor equipment

4.5 Data Management and Collection

Vast amounts of data are generated by dense sensor networks which may present a challenge to manage them well so Data management and collection should be the key performance measure. Each sensor should be calibrated at a well enough. This ensures the reliability of data collection and allows for comparison with other sensor calibrated to the same level.

4.6 Sustainability

Sustainability should be one of the key performance measures because there is considerable difficulty in obtaining funding to maintain an already established network to produce the data. Any distress on the network must be resolved or repaired quickly in order to provide an efficient result. The unsustainable system means a waste of money, therefore, the system fails.

5. DATABASE SELECTION AND DESIGN

In order to forecast weather in specific areas, the system has to collect sensor data (from temperature, pressure, humidity and wind sensors in related regions) and use past data too. That means our database should have significant importance for the system to make some statistics as well. Therefore, the ideal design pattern is MVC (Model View Controller) type. Our design will be in three-tier architecture as expected.

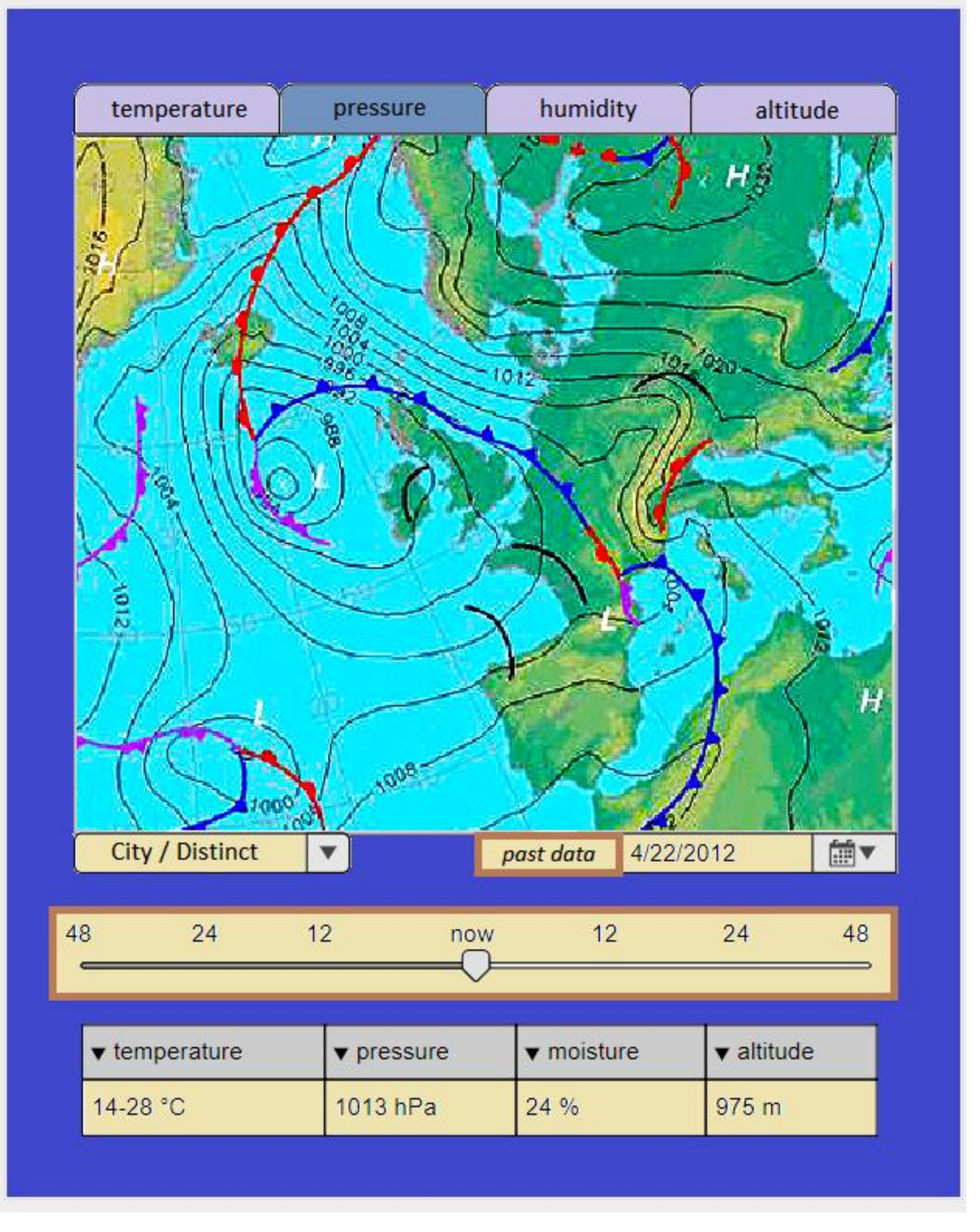
In the model tier, we are planning to use MySQL database, since it is sufficient for our system and free to use. There will be such data from sensors. Each sensor will have a unique data table. By the way, each region (distinct) have their three types of sensor data. In other words, a region will have three variable as rows (temperature, pressure, humidity) and time as a column. The temperature will be stored as lowest and highest Celsius degree, the pressure will be hectopascal (hPa), and humidity will be stored as a percentage. Since satellite images do not make sense for small areas, their storage will not be specific for distinct.

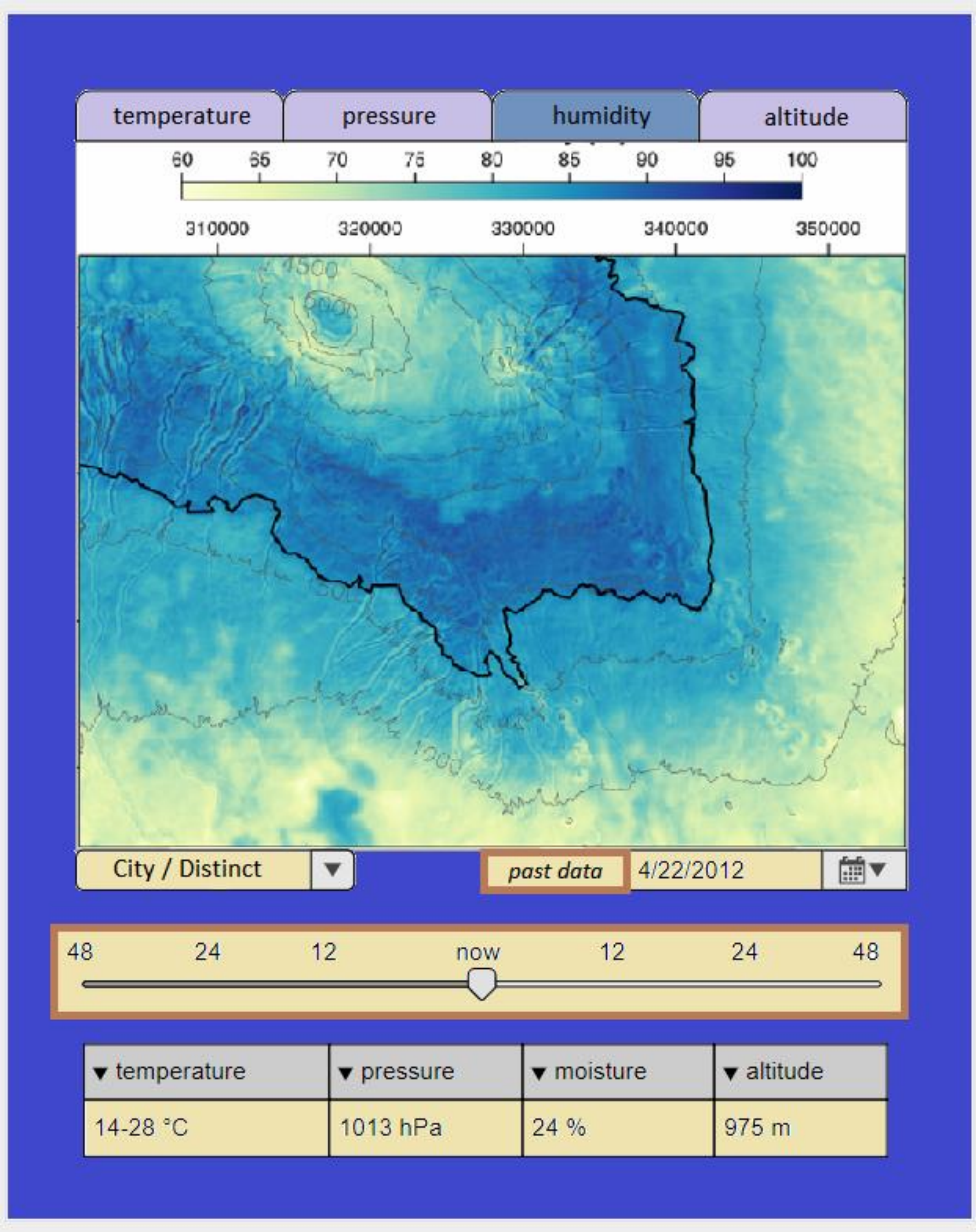
In the controller, we have to consult weather forecasting specialists and their experiences in order to design best algorithms and use the data wisely. Because, our system will not only determine current weather conditions, also will forecast for a few days later. In addition, gathering data from the sensor will not be sufficient without linking up satellite images. That is mean, there will be also imaged analysis function of the logic tier. These show how much importance controller has.

In the view tier, there will be a user interface that shows past, present and near future values. There are four significant factors that can affect the weather conditions. They are temperature, air pressure, humidity, and altitude. In addition, altitude in a region is constant in time scale. That means, after we measure the altitude, we do not need to update it later. On the other hand, temperature, pressure, and humidity should be frequently updated from the database.

6. USER INTERFACE DESIGN

In order users to provide with ease of use, the application should not be much complicated in view tier. In the UI, Users will select the city and distinct from the combo box, and also they will reach past data by choosing a date from the calendar. There will be a slider from 48 hours before to 48 hours later. The user can see related values from the map by choosing the tabs (temperature, pressure, humidity, and altitude) and sliding the bar. After the user chooses the City / Distinct from the combo box, the bottom table demonstrates the values for that region.




temperature
pressure
humidity
altitude
60 65 70 75 80 85 90 95 100
310000 320000 330000 340000 350000
City / Distinct
past data
4/22/2012
48 24 12 now 12 24 48
▾ temperature
▾ pressure
▾ moisture
▾ altitude
14-28 °C
1013 hPa
24 %
975 m

7. SECURITY DESIGN

Although sensor network is an efficient and low-cost solution in unreliable environments, it faces some security issues. These issues are caused by the restriction of using low-cost hardware, the environmental condition and the use of wireless networks. As pointed out in the security requirements, we need to ensure the safety of the hardware against environmental conditions and the security of wireless network against sabotage attempts.

7.1 Network Security

In some sensor networks such as military applications, network security becomes a major concern since the low-cost hardware is unable to use the traditional security protocols to pass information. Therefore, various protocols and encryption algorithms have been specifically developed for sensor networks. Although it is hard to think of a reason for a sensor network collecting weather data to become a target of malicious attacks, it is still important to make sure it is secure enough in the event of one. Even if a few nodes become malicious, the data can easily be altered along the transmission. To ensure security, sensor network specific protocols such as TinySec and MiniSec should be implemented with encryption algorithms. However, because the sensors are obtained from another department for prototyping, we may not have the option to choose during prototype stage. Since weather condition tracking likely needs less security than the average department sensor networks are used in, the prototype should have decent security assuming the other department did their due diligence.

7.2 Hardware Security

The sensors should not be harmed in the case of rough environmental conditions. Since the system's primary use is to monitor weather, it might be expected to perform under extreme weather conditions. To make sure the sensors are durable, they must be tested under various temperature and humidity values. Other than this, the hardware might also become a target of malicious attacks through methods such as jamming or tampering. Since these methods usually require the attacker to be present in the field, camera systems could be an immediate solution. Alternatively, a more cost-effective and elegant method could be to use spread-spectrum communication to contest jamming and various tamper-proof methods.

8. HARDWARE SELECTION

To forecast the weather we need a sensor that is capable of measuring temperature, humidity, wind speed, wind direction, and rainfall. Also, those sensors should have solar panels on them in order to provide energy to operate.

SPECIFICATIONS:

Wind Speed	0 to 159 kph
Wind Speed Accuracy	+/-1 kph below 10 kph +/- 2 kph from 10 to 50 kph +/- 3 kph from 50 to 100 kph +/- 5 kph from 100 to 159 kph
Temperature Range	-40 to 70 degrees Celsius
Temperature Accuracy	+/- 1 degrees Celsius
Humidity Range	1% to 99% Relative Humidity
Wireless Range	1000 meters
Rainfall Capacity	0.25 mm and up
Rain Gauge Accuracy	+/- 0.05mm per centimeter of rainfall
Data Reporting	Every minute
Solar Power	Solar Panel minimum 10 Watt, and run time is 15 days without direct sunlight, needed is 2 hours daily of direct sunlight to maintain battery charge.

9. SOFTWARE/SYSTEMS CONSTRUCTION

9.1 Managing Programming

All of the projects will be done by the IT department. However, they get help from other departments in the Ministry for installing sensors and investigating weather data. Since the prototype includes a sensor network that was already deployed in other departments, the implementation part mainly consists of small changes to database and network. Both of them will be divided into three areas: development, testing, and production to increase organization.

Most of the software work will be done on testing since we already have a working prototype that needs small alterations for our specific functional and non-functional requirements. Scope creep is likely since this is a government project with large funding and no immediate time constraints. The ministry may add new functional requirements as the project progresses. Finally, Turkey is considered to be a society that lives in the past/present more than the future so it is important to hold project meetings regularly and demonstrate short-term progress when possible. Both of these suggest an agile software development approach which can handle scope creep well and can generate rapid results with continuous improvement.

9.2 Documentation

We will use three different documentations. System documentation for hardware(sensors etc.), system documentation for data collecting system and user documentation. The system documentations will focus on how the system works and be a guideline to programmers, whereas the user documentation will help users make sense out of the data in front of them.

10- INSTALLATION AND OPERATIONS PLAN

As in all organizations, cultural issues are very important in terms of the future of the project. Cultural influences have been examined at the national level in terms of the better definition of the project.

10.1 CONVERSION

The first step is to rent the sensor-network. Small scale sensor network needs to be used and one prototype will be prepared. Sensor network will be provided by another organization. Necessary servers, client computers, and networking equipment will be used. To obtain those necessary tools, we will be in contact with vendors. After we install the hardware and testing are done, we will set up software integrated with the hardware without showing any major problem. To clarify being operational, software tests will be checked. The next step is to make sure that as-is data system will be converted to the to-be system properly so that formal test plans are required for data conversion. After running the software with hardware for two months without crashing the program in the city center, the system will be approved.

The conversion system will be parallel conversion because the ministry of environment already tracks the weather conditions and we will use their current system as a prototype and we will set up new devices to the new areas of the city. After some period, systems will be changed with new ones, during this time major bugs can be detected and fixed. With the pilot conversion, one main location will be selected within a city. Because different locations have different versions of the system and business processes, data exchange could be different but to see the effects of the system, it will show the result how the prototype will work for the specific area.

The conversion module is another issue. Whole-system conversion is most common one that will be used for this project because we need to establish one time for the prototype. The system will have conversion strategies such as risk, cost and time required. As expected, different strategies have different risks, costs and time requirements. The parallel conversion has low risk, high cost and takes a long time. The pilot conversion has low risk, medium cost and time required. The whole-system conversion has a medium risk, high cost and requires long time that is reasonable conversion method for the project.

10.2 CHANGE MANAGEMENT

In the change management system, the sponsor is the Ministry. Change agent will implement and plan the change and he will be outside like an inspector. Potential adopter will be the minister that decide the actual change for the system. A management plan has four steps. The standard operating procedure will be done in order of the IT department's wishes. If hardware and software system integrated well and the system works fine after two months which provides significant data for meteorology and obtain goals, we can get to resource allocation. If engineer staff needs more men, other departments of meteorology can send their available engineers. Infrastructure will be supported by the head of the meteorology minister and the project will be funded properly. Potential adopters such as employee and supervisors will set the costs and benefits related to the change. By using informational strategy, sponsors will be convinced that new system will help us to collect necessary data in the more efficient way. If they do not convince, the political strategy will be used by convincing politicians because this system is very useful for Meteorology's purposes.

10.3 Training

Users must know not how to use the system only but accomplish their jobs well. So, training for the IT engineer and other involved staff will focus on what the users need to do with the system. Teaching the entire system is not their business, they need to understand only their job. A first training technique that will be used is classroom training. If some personal have obstacles, they will learn on the one-on-one way that facility will be provided for them. Also, because it is IT business, people who will work on software part can learn by computer-based training. Its cost is different from each other so that as long as funds are adequate, these facilities will be provided to the IT engineers and other users to learn the system.

10.4 POST-IMPLEMENTATION ACTIVITIES

Providing assistance is important for the flow of the system and encourage users to contact it. Members of the operational group are involved because they need to know how the system works. Helping users to use the system can be done with lots of things. FAQs, online support, help desk, problem report, level-1 and level-2 support are some of them. A staff member will learn how to use the system and they will be supported at any time by these features. System maintenance is needed to make sure business needs are made. Small scale sensor networks are already used by other departments so that we already know how to maintenance should be done. But still it is implemented into the city, therefore problem reports and change request will be prepared and send to the project manager. Then change request with feasibility, cost and benefits are prioritized, system analysts are responsible for analyzing and design the system which includes interviews with users. After the test, program change will be applied to the system. So, by doing this sequence, most common problems and bugs will be fixed and the program will run in safe. Project team review focuses on the performance of development team. Project manager selects the qualified engineers and they deploy the proper version (v1 to v2) for the system. The systematic review is conducted after two months. If the program runs without a big problem and pilot statement is not disappointed, performance will be increased as planned.

11- TEST DESIGN

Developer team tests the system by considering the functional model, structural model, and behavioral model as well as their consistency check. Actual testing part continues on unit testing, integration testing, system testing and lastly acceptance testing. Unit testing will be black-box to focus on class meets requirements in the specification like CRC cards, class diagrams and contracts will be tested. When the system performs data processing, class diagrams, sequence diagrams and communication diagrams will be tested whether data is displayed correctly with interaction testing. For the system testing, performance testing will be used by system proposal and it will be checked functional and non-functional requirements are met.

Security testing is highly important because that system will be established into city center so that infrastructure analysts will be assigned to this task. An acceptance test is a final part for the accuracy of the system. Alpha testing will be the first step for the first one month that theoretical measurements are satisfied. The beta testing for system requirements using real data will be conducted that sensors work fine in real life. Those are the core testing methods that will be used after those tests are done, other tests may be used such as documentation testing for tutorials. During the tests, rainfall and wind speed will be simulated parameters. In the field testing, device’s communication range is 1 mile at the line. In the high rise buildings, the range will be 300m to 400m at the city.