



INF – 3996  
MASTER'S THESIS IN  
TELEMEDICINE & e-HEALTH

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**INTERACTIVE DISEASE MAPS FOR THE SNOW AGENT SYSTEM**

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3<sup>rd</sup> June 2009

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## **DEDICATION**

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**To  
My PARENTS**

## ACKNOWLEDGEMENTS

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I would like to thank my supervisor Johan Gustav Bellika for his encouragement, support and productive discussion, without whose expertise, guidance and support the project would never have been success as it is this day. His remarkable guidelines and recommendation on solving problem inspired to produce this report. He was always inspiring me for independent research and writing scientific work. His feedback, support, comments were always valuable for me during project work.

A special thank to Gunnar Hartvigsen for his support and the rest of the MI&T research group also deserve my thanks. I would like to thank the people who helped me during my project work. Most of the people are from MI&T research group at University of Tromsø and Snow Agent System team from NST.

I also thank Bernt Ivar Olsen, Taridzo Chomutare, Tom Arild Jakobsen, Hjørdis Solstand, Shiva Amgai & Keshab Pudasaini who consistently offered tips and information related to my research. I would like thank Jan Fuglesteg for his administrative support.

Finally, I thank my parents Ghan Prasad Dhakal & Tika Devi Dhakal, my brother Sanjeev Dhakal and sisters Sangita Dhakal & Reeta Dhakal for their moral and financial support.



## ABSTRACT

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The aim of this research was to develop an interactive disease map framework and integrate Silverlight map support for the research project developing the Snow Agent System. The interactive disease map can be used for visualizing information on the map during disease outbreak situations. An engineering approach was used for system design, development and testing. Three different inputs, Microsoft Virtual Earth, population data and epidemiological data formed the interactive map system.

The interactive disease map framework extract data from database and was integrate with geo-spatial information and presented as an interactive map system. The system integrates population data and epidemiological data with virtual earth and is present in a Silverlight presentation. The system user can interact with the system during run time and search zip code area of Norway, once the system match the zip code of Norway, the area is located on a map. The interactive maps integrate the population and epidemiological data with zip code and presents it as a Silverlight presentation.

We have demonstrated the interactive disease map by integrating the population and epidemiological data with Microsoft Virtual earth and present it using a Silverlight presentation. The Microsoft .NET framework was used to implement a prototype. The interactive disease map framework may be used as a generic framework to create interactive maps in other areas with heterogeneous data sources.

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## Notations / Abbreviations

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TTL	- Tromsø Telemedicine Laboratory
NST	- Norwegian Centre for Telemedicine
API	- Application Programming Interface
EHR	- Electronic Health Record
SVG	- Scalable Vector Graphics
ESRI	- Environmental Systems Research Institute
SARS	- Severe Acute Respiratory Syndrome
SOAP	- Simple Object Access Protocol
CGI	- Common Gateway Interface
WHO	- World Health Organization
BBC	- British Broadcasting Corporation
GIS	- Geographic Information System
UTM	- Universal Transverse Mercator
MGRS	- Military Grid Reference System
SPCS	- State Plane Coordinate system
WMS	- Web Map Service





# CHAPTER - 1

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## INTRODUCTION

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### 1.1 Background & Motivation

This thesis is about visualization of interactive disease maps, which allow its user to visualize information and interact with the map. This thesis research focused on existing interactive map solution in different representation, compare the solutions, and a choice of a suitable presentation and implement for the Snow Agent System. The project focused on the XML based language SVG (Scalable Vector Graphics), ESRI ArcGIS and Microsoft Silverlight presentation. The interactive mapping solution can be used widely in different area of researches like health care, environmental, geography or business world. The thesis work covered the healthcare perspective; a mapping application within the diseases surveillance scenario in the Snow research project at NST (Norwegian Centre for Telemedicine). This research has generated a generic framework for interactive map, which can be adopted and applied within other areas as well. Our solution can be adopted for developing interactive map for different purposes.

The objective for a disease surveillance system is to identify disease outbreaks in the early phase. Both public and private healthcare organization has been threatened from different kinds of disease outbreaks everywhere in the world such as Bird Flu, Avian Influenza, and SARS. In 2001 an Anthrax attack was identified in the United States, which was an example of a bio-terrorism act. The SARS outbreak in 2003 was also a threat to the global public healthcare system. (Bellika, Hasvold et al. 2007; Bellika, Sue et al. 2007)

The symptom-based disease surveillance system collects diseases outbreak data in early phase and reports to the National Public Healthcare System. Getting disease outbreak data in an early phase increases the efficiency of the public healthcare system to handle the disease outbreak situation. The disease surveillance information can support the clinical decision support system's decision-making procedure. The clinical decision support systems are developed to assist the healthcare professionals to make the right decision. Information from the disease outbreak can be applied in the decision-making procedure in a particular community.

Another usage area of a disease surveillance system is make travel alerts for travellers to different destinations. The surveillance system can be used to create such travel alerts according to the disease outbreak information. Travellers can face common medical illness in different destinations according to climate condition, drinking water and other factors. The traveller can get information about serious outbreaks like SARS, Avian Influenza on their destination. This is one of the fruitful benefits of disease surveillance system. The Google health map give alerts about *global disease outbreaks* in different location according information abstracted from *local news agencies and local health authority information*(HealthMap 2008).

The Tromsø Telemedicine Laboratory (TTL) project “Symptom Based Diseases Surveillance” focus mainly on the following objectives; the main objective is identifying possible outbreak in an early phase. The other main objective of research is developing methodology and models for calculating risk at incubation period. Finally the project focus on communicable diseases and develops an open source software solution with both a national and an international perspective. The system methods and application can be used for global perspective for outbreak alert in different areas like research, public health authorities, private care and travel alerts. This master project is the small part of this research project at Tromsø Telemedicine Laboratory. The main objective for this master thesis was to create a prototype system for producing interactive disease maps. The system is producing interactive disease map files according to the different information in the system. The input to the system is map data, population data and epidemiological data to produce interactive disease maps.

## 1.2 Scope & Research problem

The master thesis project aims at developing interactive generic map files using the Symptom Based Disease Surveillance Information as input. The input to the system is digital maps; epidemiology data and population data. The input should be used to create interactive diseases maps. The above-mentioned inputs should be integrated and transformed to interactive disease map. The main research problem addressed in this master thesis is therefore how interactive disease map can be constructed?

**Main Question1:** How can the variable information sources be integrated and represented with the constant input to the interactive disease map file production system?

A great challenge of interactive disease map research is how should we extract the epidemiological and population data from heterogeneous data source. We required to create data model to integrate with geo-spatial information, the challenge of interactive disease map is how should we define relation among population and epidemiological data with geo-spatial data. How can our data model adopt standards and presented to the end-user?.

**Sub Question 1.1** How can input information be modelled ?

A great challenge of interactive disease map is how should we create the population and epidemiology data model. The population and epidemiological data varies in time period by different causes death, birth or migration, how should we create a data model to address changing population. How can we create data model for different age group population?

**Main Question 2:** How can the input be transformed into interactive diseases map files?

A great challenge of interactive disease map is how should we create map interactive ?. How can we define relationship between digital map and data model , which allows the interaction with map during run time?

**Sub Question 2.1** What layers of information element are needed in the interactive disease map file ?

The digital map has different geo-spatial layers and information , a challenge of interactive diseases map is how can we make relation between map layers. How system can match different map layers?.

**Sub Question 2.4** how can epidemiology and population data be visualized?

A challenge of interactive disease map system, how can we create relation between the epidemiological and population data with digital map ?. How can we present population and epidemiological data on the map screen?.

**Main Question 3:** What functionality is needed in the interactive map files?

A great challenge of interactive disease map is how can we create interactive map. What functionalities are required by user to interact with the system?. how can the system support map navigation, scrolling , zooming functionalities? . How can we create zip code search functionality on the map?

**Sub question 3:** How should this functionality be supported?

A challenge of interactive disease map system , how can system support interactive functionality?. How should we integrate different technologies to support interactive functionality? How can we choose best programming framework to support functionality of system?.

## 1.3 Methods

We used an engineering approach as described by *Denning*, to developed the prototype based on the problem statement and demonstrate the interactive map solution (Denning Peter Douglas, David et al. 1988). The prototype has user interface tool for interaction with the map. After implementing the application, we evaluate the system and discussed usability and critique the solution.

The main focus of the system is to provide mapping solution for the disease surveillance scenario by integrating the population and epidemiology data with geo-spatial data. The system development focused on data modelling and applied some existing data from Snow Agent system, Norwegian Statistics data and Norwegian Public Health care sample data. The system is inspired by web data sample from *NIPH, WHO* and *CDC*. (WHO 2008; CDC 2009; NIPH 2009)

The system used an engineering approach to modelling the system, formulating logic for problem statement and finally implementing the problem statement. The system could not be to implemented in real healthcare organization and use real patient data due to many circumstances like legal restrictions, research time limit etc. This is the main drawback for system for not getting real system feedback from a real situation.

### 1.3.1 Method Applied and Evaluation

We used an engineering approach to build the prototype. During development period, we used methods from the following sub areas.

- a. Analyse the problem statements
- b. Modelling the problem statement in engineering scenario
- c. Implementing the prototype
- d. Experiments and Evaluating the prototype

The health care professionals are the end users of system. It is important to get feedback from them about prototype, whether our approach can help them to provide better care or not, whether the functionality of the system is working properly or not, whether they require some additional functionality?

### **1.3.2 Data Collection**

The quality and reliability of the prototype is depending on the input to the system. The prototype is aiming to assist and improve clinical setting. To get real patient and real disease data is extremely difficult in Norway because of patient rights and legal issues. We used some previously collected data from Snow Agent System and Norwegian Statics to collect population data and World Health Organization (WHO 2008) for epidemiological data studies.

### **1.4 Contribution**

The main contribution of this master thesis project is that it provides an overview on how to produce an interactive mapping solution by integrating different data input with geo-spatial data. The research introduces the modelling technique, formulating logic to develop interactive map and deploying mapping solution in Microsoft .NET framework.

From our research, we have showed how to integrate population and epidemiological data in interactive disease maps. The interactive map system can play important role in co-ordinating different public health authorities actions during an outbreak situation.

### **1.5 Main Results**

The testing and experiments of prototype demonstrated the interactive diseases map in Silverlight presentation as described in problem statement. Chapter 6 provides details of implementation. Chapter 7 gives an analysis of the advantages and drawbacks for the system. Interactive map can be small part of a diseases surveillance system, which will co-ordinate for alerting of disease outbreak situation. Similarly, interactive map project can be utilized for other kind of telemedicine & e-Health projects and applied in non-healthcare industry as well.

## **1.6 Outline**

The structure of the thesis is as follows:

Chapter 2: This chapter present the theoretical background of interactive maps, available technology and theory required to develop system.

Chapter 3: This chapter present the requirement specification of interactive diseases map.

Chapter 4: This chapter present the design models of requirement specification.

Chapter 5: This chapter present the how the system is implemented.

Chapter 6: This chapter describes the result of system and interpret the results.

Chapter 7: This chapter describes conclusion of thesis and potential future work of interactive diseases map.

## **1.7 Summary**

This chapter has given overview of this project, background, problem definition, methods and main results achieved by thesis. This chapter also list the outline of following chapters of this thesis.

## CHAPTER -2

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### THEORETICAL FRAMEWORK

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#### 2.1 Introduction

This chapter describes the state of the art in interactive disease map systems and theory which is applied during this thesis work. This chapter covers epidemiology, co-ordinate systems and Open Source solutions. The theoretical framework was produced based on literature review, and our own ideas applied in this thesis work.

#### 2.2 Epidemiology

Epidemiology is the study of disease distribution in a population. This study covers the area of diseases and illness in the population, in other word we can say that epidemiology and population research are related to each other. The research of disease information, geographical information and time could be sub research area that related to the diseases surveillance and epidemiology.(Bellika, Sue et al. 2007). The epidemiology and diseases surveillance research could be used in the public healthcare to improve clinical settings. The major study area of disease surveillance are collecting data, interpreting data and analyzing and reporting to the authority for decision making(Fu- Chiang Tusi 2003). This study may be used for health services, better handling situation before and after diseases outbreak. (Bellika, Hasvold et al. 2007; Bellika, Sue et al. 2007)

The World Health Organization (WHO) is the main international organization for conducting studies, continuously analyzing and monitoring epidemiology globally. After analyzing and calculating risk factors, the WHO issues warning message globally (WHO 2008). The recent cholera outbreak in Zimbabwe showed the level of disaster in public healthcare system by disease outbreak. The epidemiology study always provides supportive information for public health organization to support better decision, handling before and after outbreak situation and warn people in such geographical area. In Zimbabwe outbreak, *In February 2009, 8000 cases were reported every week but the number of reported cases was decreased in mid of March, only 2076 cases were reported after taking good decision by the public health authority.* The above study showed that epidemiological analysis is the

backbones for handling the outbreak situation globally. The rapid updated of the epidemiology studies could help to improve public health services during an outbreak situation. The recent outbreak of *swine flu* also showed how quick a virus can spread globally (WHO 2008) and how quick public health authorities are required to take action in co-ordinating with other organizations. (CDC 2009; NIPH 2009)

The impact and results of epidemiological studies could be evaluated by the public health authority and validation studies. The main question for our research is how to analyze the epidemiological data in a disease surveillance scenario and how to apply epidemiological data in a productive way to improve decision-making.

The research field in this arena are developing methodologies for collecting data, analyzing data, calculating risk factors of diseases outbreak and how to utilize such report for clinical decision making procedure. Epidemiology studies are used not only for preventing diseases outbreak but the physician can use such studies to improve his clinical setting.

### 2.2.1 Modern Epidemiology studies

In 1854 the British doctors John Snow investigated the epidemiology data to identify the Cholera outbreak. He is well known as the father of modern epidemiology (BBC 2009) . At that time, doctors, researchers and people assumed that the main causes of Cholera death were polluted air. However, Dr. Snow strongly opposed that view. He presented successfully the relation between drinking water and cholera death. In *August 1854* there was a cholera outbreak in the Soho area, and he found people that lived near the broad street water pump died during the cholera outbreak(BBC 2009). Finally he made a relation between the drinking water and death and visualized it on map.

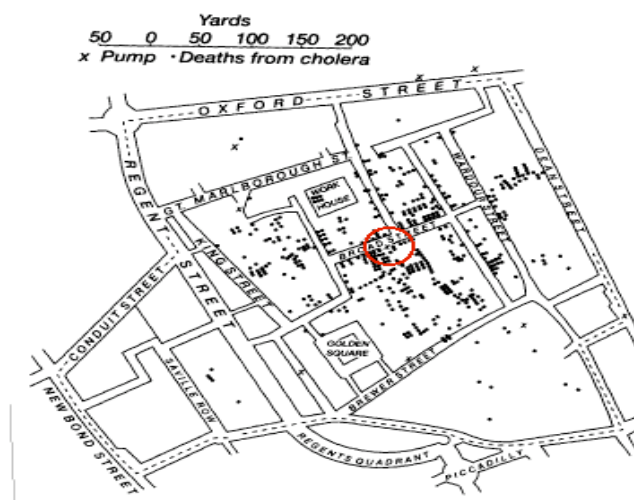


Figure 1: John Snow Map

(<http://users.rcn.com/jkimball.ma.ultranet/BiologyPages/E/Epidemiology.html>)



Figure 1 shows the Snow map, which was used by John Snow to identify Cholera outbreak at Broad Street area of London. He identified that people living near the water pump and using water from that pump died most frequently. He visualized the number of death in map and made relation cholera outbreak (BBC 2009).

Epidemiological data analysis is one major indicator to identify diseases outbreaks. In our research the epidemiological data analysis, design and develop models are the major challenges.

### 2.2.2 Prevalence and Incidence Rate

Prevalence is defined as total number of cases of the diseases in population at a particular time. The prevalence can be illustrate mathematically as well, suppose x is the total number of individuals in population having a diseases within a time frame and y is the total numbers of individuals in a population that do not have the disease, prevalence can be calculated by the following equation.

$$\text{Prevalence} = x/(x+y)$$

This calculation can formulate total number of infected population within a time frame. The statistics can be changed with time frame, if new infected individuals come into the population it is called incidence(Enrico 2003).

A proper analysis of prevalence and incidence helps to identify a disease outbreak situation. If the incidence rate is higher with in a time frame, then the doctor could suspect a diseases outbreak within a geographical area.

The incidence rate can be calculated by the following illustration

*Number of new infected individuals in a specific time period*

$$\text{Incidence Rate} = \frac{\text{Number of new infected individuals in a specific time period}}{\text{Size of Population}}$$

If there are more new suspected cases come within a certain time frame force to think about diseases outbreak scenario so that validity of those data is also very important before alerting the disease outbreak. There are some probability theories for validating epidemiological statics. They are

- ❖ *Sensitivity(Enrico 2003)*
- ❖ *Specificity (Enrico 2003)*

Sensitivity is the probability of positive test result, which is calculated by the following formula:

$$\text{Sensitivity} = \frac{\text{Number of True Positive}}{\text{Number of T.P+ Number of False Negative}}$$

Specificity is the probability of negative test result and which is calculated by following formulas.

$$\text{Specificity} = \frac{\text{Number of True Negatives}}{\text{Number of T.N+ number of False Positives}}$$

We can define relation of sensitivity and specificity by following relation tables

	Outbreak	Not Outbreak
True	True Positive	True Negative
False	False Negative	False Positive
	Sensitivity	Specificity

Table 1: Sensitivity and Specificity

Above table defines consequences of diseases outbreak relationship with sensitivity and specificity. The following condition is the disease outbreak condition

*True Positive = True*

*False Negative= True*

If there are more validate incidence rate then there is possibility of diseases outbreak(Enrico 2003).

We are going to describe the epidemiological studies in population by following diagram.

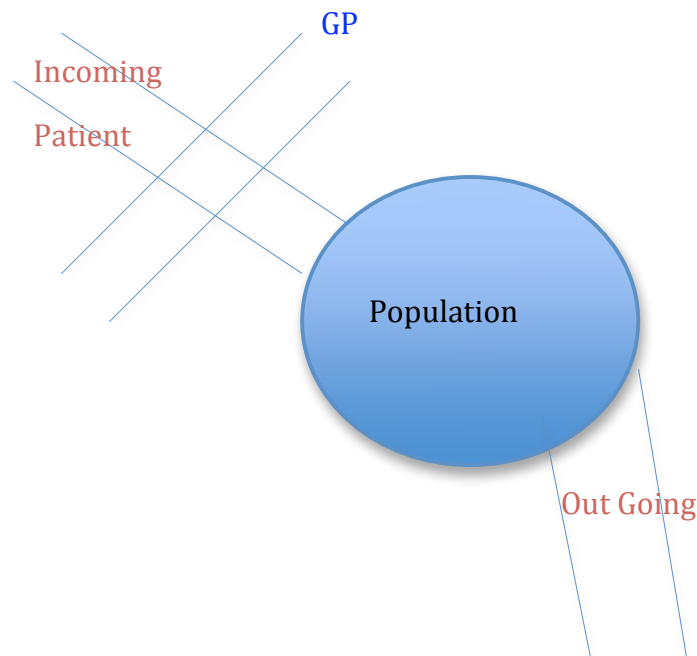


Figure 2: Epidemiology study among Population

Above figure 2 is illustration of epidemiological studies in a population. It describes how hard it is to get real epidemiological data and analyze them. Above figure is analysis of epidemiological studies comparing with river and lake. The river comes from mountain and ending at the lake. We can assume the river is the new disease infected people who are coming to the population and the GP office has a record of it. The rate of infected people coming into the infected population is the incidence rate. We can assume the lake as community of infected population.

The total number of infected people in population is called prevalence. Identifying the exact number of infected among population is still challenging task, when people got sick then they will visit doctor office. The doctor can keep track of infected people coming to his office but he does not have updated information about the patient if he died or go away from infected population after getting well.

The doctor has information about incoming infected but do not have information about out going patients, which is one major challenge for epidemiological analysis of populations.

Once infected patient came to the doctor office, there is some chance of getting false negative test, which means patient is infected but the test result showed that the patient is not infected and moved to population. Those factors are affecting the real epidemiological studies among population. (Enrico 2003)

### 2.3 Electronic Map and Layering

Electronic maps are tools for displaying geographical information to its users. The electronic map has been widely used in web-based applications to provide interactive interface to the users as well as geographical information system. By using electronic map, the application can facilitate to its user resizing the map screen, changing map format and searching entire geographical location. Because of the electronic maps interactive and dynamic features enables integration of other information with maps. The Symptom Based Diseases Surveillance research project benefited by using electronic map to display the geographical location information as well disease information on a map. Technically map has different layers like zip code, municipal code, county code and country code, the map layers can be varies according to mapping standards. (ESRI 1969; MapServer 2008)

### 2.4 ArcView Presentation

The Environmental System Research Institute (ESRI) develops and provides the Geographic Information System (GIS) with geo database management application. This research institute was founded in 1969 and providing mapping application globally. The product of ESRI are Desktop GIS, Server GIS, Mobile GIS, Online GIS, Developer Tools, Specialized GIS and Data. All of the products of ESRI are used to develop mapping application. The Desktop GIS application is mainly for the analysis of spatial maps, modelling and visualizing the map at end. There are different kind of Desktop GIS application like *ArcInfo*, *ArcEditor*, *ArcView*, *Desktop Extension*, *ArcGIS engine*, *ArcGIS Explorer* and *ArcReader*. (ESRI 1969)

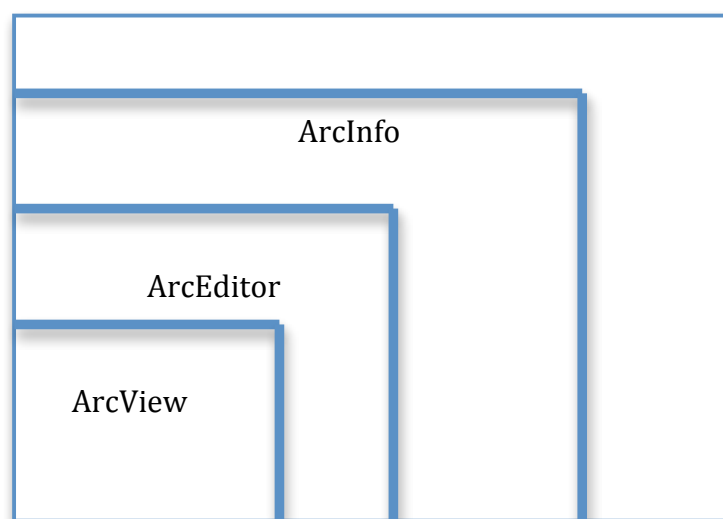


Figure 3: Desktop GIS

The figure 3 is describing the how Desktop GIS is organizing with its application. The ArcView lies in the bottom stack of application, which is using for visualizing the geographical data and analysis them for modelling. The map information is stored in shape file, the ArcView is able to open shape file and convert it into ArcView file format. (ESRI 1969)

The shape file .shp is used to store the geo spatial, geo vectors and information in a point, polylines and polygons. The shape file was introduced by *ESRI* in 1990, ArcGIS version 2.0. The map files are arranging the different zip code area by using point to draw the polygons so each zip code are is the one full polygons. The shape file itself can coming geo spatial data in a database file having extension .dbm . The shape file is the collection of .shp, .dbm and .shx file format in map files. The ArcView application is used to read and write and visualize the shape files. (ESRI 1969)

## 2.5 Scalable Vector Graphics (SVG) Presentation

The SVG (Scalable Vector Graphics) is the specification introduced by the W3C (World Wide Web Consortium) bringing rich, compelling high-resolution interactive map to the web based applications. The major research areas of the W3C are defining *specifications, guidelines, software and tools* for the web applications. For web based multimedia applications, the W3C introducing XML based Scalable Vector Graphics. This specification is for embedding multimedia application on the web applications. In the SVG specification, the graphics is drawing by vectors, which can be scalable. The main applied areas of SVG presentation are mapping system, visualization of different kind of data and structure, Graphical User Interface for the web applications. Because of those applied area, this format has been adopted in different kind mapping and visualization data applications. (SVG 2001; W3C 2004)

The SVG specification is based on XML, which lets developers use rich interactive visualization specification, which lead to a strong position for SVG in web applications design user interface and interactive maps. The SVG specification for two-dimensional graphic, where XML is used to write API for graphics that is main reasons to achieve interactive intelligent graphics application by using these specifications. The SVG specification is an *open standard*, so it is platform independent the among different vendors. (SVG 2001)

The Scalable Vector Graphics (SVG) supports three different types of graphics objects. They are as following

- ❖ Vector Graphics Shapes (*point, line and polygons*)
- ❖ Text
- ❖ Raster graphics (*Images*)

The SVG developer can *group, styled, transformed* above mentioned graphics objects and present and used on the SVG based applications. To present SVG object in web base application, the web browser required to install plug-in *SVG viewers*. The *Adobe SVG browser* plug-in is widely accepted and used to view SVG application on web pages.

Some of the advantage of using SVG application mentioned by W3C on web-based application is as follows

- **Open standard:** - SVG is developed by the W3C; it has open standards for multi industry consortium.
- **Scalable:** - The SVG is vectors graphics so that it support high quality image in different resolutions. This is one of the main advantage of using SVG presentation instead of any JPEG, PNG image presentation. System cannot achieve high-resolution image presentation.

- **Animation:**- The animation feature can be implanted in SVG based application.
- **Styles:** - The W3C's Cascading Style Sheets (CSS) can be applied for SVG different style presentations. The Cascading Style Sheet is used to make attractive presentation by using different texts; colours and many other features can be applied in SVG.
- **Zooming:** -The zooming feature applied can be applied in SVG map presentation. The zooming feature is one of key feature of map presentation so that SVG enables opportunity for zooming feature in applications.
- **Interactive:** -We are allowed to use scripting language within an SVG application so that it is possible to create interactive application for its user in web-based applications.

**XML Based:** - SVG supports the full features of XML, so that developer can apply XML feature in its application. The XML create unlimited opportunity to create and present application on the web. The application can achieve full phased search capability in the SVG based applications. We could enable to achieve Interoperability from this feature because XML is a platform independent mark up language. Interoperability is very important feature for any computing application; it will improve the usability of the system.

- **Open Source Solution:** - The SVG is specification of W3C, so that this specification can be used for different open source applications.

The above-mentioned are the some of the feature of SVG described by the W3C. We are going to present some of the applied industry of SVG application described by the W3C.

- **Web Application:** - Web application is the one main applied industry of SVG. The developer can present high quality SVG presentation over cross browser platforms. The SVG supports multiple scripting languages so that developer could achieve high quality, attractive Graphical User Interface (GUI).
- **Mapping:** - Mapping industry is also one of the applied areas of SVG presentation. SVG support Vectors graphics so that shape files can be exported into SVG presentations. Many Geographical Information Systems present its mapping presentation over Internet through SVG presentation.

- **Mobile:** -Telecom and mobile industry is the one of applied industry of the Scalable Vector Graphics (SVG). The SVG presentation is used for MMS technology in mobile phones. The *Nokia, Motorola and Ericsson formed SVG (W3C) working group* for mobile specifications.
  
- **Printing and Design:** - The SVG specification is also widely applied in printing and graphic design industry. The SVG support rich graphical features so that it creates a platform for creating high quality graphics and printed it in hard copy.

The SVG has been adopted by above-mentioned industry.

### 2.5.1 SVG Document Structure

One objective for this master thesis project is to create interactive disease maps. The interactive map is required to present web-based presentation so that we are interested in how to create SVG documents on Internet. The following structure is used to create document for web-based application

```
<?xml version="1.0" standalone="no"?>
<!DOCTYPE svg PUBLIC "-//W3C//DTD SVG 1.1//EN"
"http://www.w3.org/Graphics/SVG/1.1/DTD/svg11.dtd">
```

```
<svg xmlns="http://www.w3.org/2000/svg"
width="100%" height="100%" x="0" y="0">
<!-- SVG Content -->
</svg>(W3C 2004)
```

The above mentioned structure is the standalone for the Scalable Vector Graphic in web based application.

**<?xml version="1.0" standalone="yes"?>**, this line include XML in the application. This line enables the XML on the application so that developer can use extensible mark up language on the application.

**<!DOCTYPE svg PUBLIC "-//W3C//DTD SVG 1.1//EN" "http://www.w3.org/Graphics/SVG/1.1/DTD/svg11.dtd">** this line specifies the DTD (Document Type Definition). This specific rule for defining rule, so that developer can use DTD elements in the program. It is essential to define document type in DTD to use in application later. In other word DTD is used to validate structure of SVG documents.

**<svg xmlns= <http://www.w3.org/2000/svg> width="100%" height="100%" x="0" y="0">** This line described the starting of SVG documents, we can specifies the size



of canvas by following attributes **width="100%" height="100%"**, It described size of canvas, if we required to increases the size of canvas, we can do by changing its values. The x and y co-ordinate described the position of canvas in the browsers. We can place canvas in left, right, bottom as our application demand.

**<!-- SVG Content ...>** We can define content in this place, whatever is content which can adjust in this area.

**</svg>** this is the closing tag of SVG documents.

### 2.5.2 Geography Mark-up Language (GML)

The Geography Mark up Language (GML) is xml-based specification defined by the Open Geospatial Consortium (OGC), applied for specifies geo-spatial information as well non-spatial information and store them. The SVG specification is also widely applied very promising for the Mapping and GIS applications, because of its open standard specification adopt the GML (Geography Markup Language) specification format with in mapping application. The Geography Markup Language can play promising roles in mapping application by following features.

- *Specification*
- *Storage*
- *Transportation*
- *Interoperability*

The Geography Markup Language is also widely used for mapping applications.

## 2.6 Silverlight Presentation

The Microsoft Corporation developed and launched new generation of multi-browser including Microsoft Internet Explorer, Mozilla Firefox, Apple Safari and Opera, strong .NET Framework implementation of Rich Interactive Applications (RIA) for the web based application. The user is required to install a small plug-in of Silverlight with its browser open dynamically, new generation media file over Internet.

The web based media file has been presented by using different technology like Adobe Flash, W3C SVG, and ESRI ArcView for map presentation. The new technology Silverlight opens a door for future generation of media presentation in web based applications. The Microsoft widely used and accepted .NET framework is used to develop and present Silverlight. The developer use the .NET framework with existing scripting solution ASP.NET AJAX and JavaScript for high definition media presentation on the internet. We are going to present some features of Silverlight presentation in web based applications, described by Microsoft and during project development of this master thesis. (Silverlight 2009)

- **High Quality:** - Silverlight is developed for the new generation media file presentation in browser-based application. High Definition media file can be streamed using a Silverlight presentation, high quality Virtual earth can be also be presented using Silverlight.
- **Interoperability:** -The silverlight presentation is among multi –running platform. Silverlight is currently working for both MAC OSX and Windows platform and promised has been done for Linux platform as well. Almost all browser including safari, Internet explorer, Firefox and opera also supports Silverlight.
- **Extremely Fast Development Environment:** - The Silverlight presentation is developed in Microsoft .Net framework. This framework has been renowned for fast and effective developing environment and .NET developers can use this Silverlight presentation for web based media applications.
- **Easy to Streaming:** - Silverlight presentation can stream through windows ISS server as well as Microsoft Virtual Earth server for the Silverlight Virtual Earth presentation.

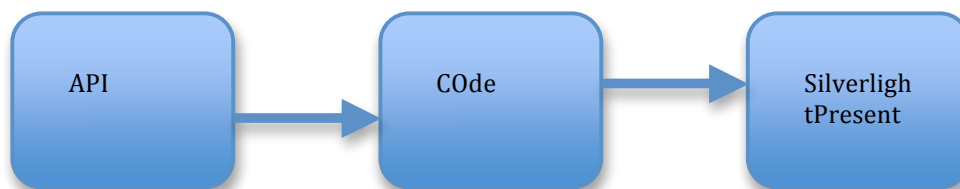
Above mentioned are the main features of Silverlight presentation. Silverlight is still in development phase all versions that are available now are not stable versions.

### 2.6.1 ArcGIS API for Silverlight Presentation

ESRI is the leading organization for GIS and mapping solutions globally. Its products has been used globally and accepted in mapping applications. The ArcGIS and Microsoft Virtual Earth open a new door for a new generation of interactive media applications in Silverlight. The API of ArcGIS open boundless opportunities to integrate the ArcGIS Sever and Microsoft Virtual Earth Server for Silverlight presentations. This integration enables following facility

- *Create Map with different data*
- *Present data in Virtual Earth or ArcGIS*
- *Allow to add Graphics and markup interactively*
- *Locate address and display results*
- *Create mashups (ArcGIS)*

The following diagram illustrates how to use ArcGIS API for Silverlight presentation.



**Figure 4: ArcGIS for Silverlight Presentation**

The figure 4 above describes how to make Silverlight presentation

### 2.6.2 Development Framework

To present Silverlight presentation in a browser based application the following are the basic requirements for application development.

- ❖ *Visual Studio 2008 SP1 or Visual Web Developer Express with SP1*

### ❖ *Silverlight Tools for Visual Studio SP1 (add-on)*

The silverlight presentation can be developed by the above-mentioned framework. To create mapping application, we required to integrate ArcGIS API with application. The following API'S are required to develop map presentation in silverlight.

- *ESRI.ArcGIS.dll* :- This is main library required for mapping application, which includes map, ArcGIS Service Layer, Graphics and Geometry.
- *ESRI.ArcGIS.VirtualEarth.dll* :-This library contains the Virtual Earth which support virtual earth mapping services as well.
- *ESRI.ArcGIS.Widgets.dll* :- This library is for different interactive tool for application like navigation and tool bars.

The above mentioned library is required to add in project to enable Silverlight presentation. The user view required to implement XAML. The following structure is used to create the map for silver light presentation.

```
<UserControl x:Class="SilverlightApp.Page"
xmlns="http://schemas.microsoft.com/winfx/2006/xaml/presentation"
xmlns:x="http://schemas.microsoft.com/winfx/2006/xaml"
xmlns:esri="clr-namespace:ESRI.ArcGIS;assembly=ESRI.ArcGIS">
<Grid x:Name="LayoutRoot" Background="White">

<esri:Map x:Name="MyMap" Extent="-120, 20, -100, 40" >
<esri:Map.Layers>
<esri:ArcGISTiledMapServiceLayer ID="StreetMapLayer"

Url="http://server.arcgisonline.com/ArcGIS/rest/services/ESRI_StreetMap_World_2D
/MapServer" />
</esri:Map.Layers>
</esri:Map>

</Grid>
</UserControl>
(source:http://resources.esri.com/help/9.3/arcgisserver/apis/silverlight/help/index.h
tml)(ESRI 1969; Sliverlight 2009)
```

## 2.7 Co-ordinate System

The geo-spatial information of the map are stored in either vector or raster format. The co-ordinates of map are used to refer specific geographical location. The map co-ordinate systems are the standards that are used to create and elaborate maps.

The main objective of using co-ordinate system in the map is assigning code to the particular location of the earth so that single code can be represent that particular location on the map. We are going to present some of the well defined and adopted mapping co-ordinate system.

- ❖ *Latitude, Longitude and Height*
- ❖ *Universal Transverse Mercator (UTM)*
- ❖ *Military Grid Reference System (MGRS)*
- ❖ *World Geographic Reference System (GEOREF)*
- ❖ *State Plane Co-ordinate Systems (SPCS)*

### 2.7.1 Latitude, Longitude and Height

The term latitude and longitude are the key important term in any mapping application. If we required describing any location of earth then we needed longitude and latitude to specify particular location. The term latitude is defined as, "horizontal lines that are running east-west on maps are called latitude". The term latitude is denoted by the Greek symbol phi, which can specify the particular location in the earth from North Pole to South Pole.

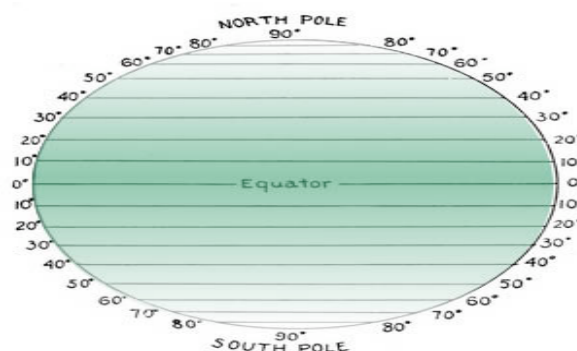


Figure 5: Latitude

Figure Src: <http://www.mrdowling.com/images/601latitude.jpg>

From the figure above described, the earth is divided by the horizontal lines from 0 degree equator to 90 degree north and the 90 degree south. The longitudinal lines are parallel to each other.

Longitudes are vertical projection lines on the earth surface. The following figure describes the longitude in detail.



Figure 6: Longitude

Figure src :[http://www.timegenie.com/latitude\\_and\\_longitude/](http://www.timegenie.com/latitude_and_longitude/)

The figure 6 described how vertical lines are projected on the earth, which is called longitude.

### **2.7.2 Universal Transverse Mercator (UTM)**

The Universal Transverse Mercator (UTM) map co-ordinate system was developed and adopted by U.S Army (Ekale L Wade 1988),for the rectangular military maps. The UTM system has been widely adopted and implemented, this co-ordinate system is based on the concept of dividing earth in different zones. The earth is divided in the

60 different zones and every zone is 6 degree longitude wide (Ekale L Wade 1988). The zones are dividing from 84-degree north to 80-degree south, which exclude the Polar Regions. The following diagram described the Universal Transverse Mercator in details.

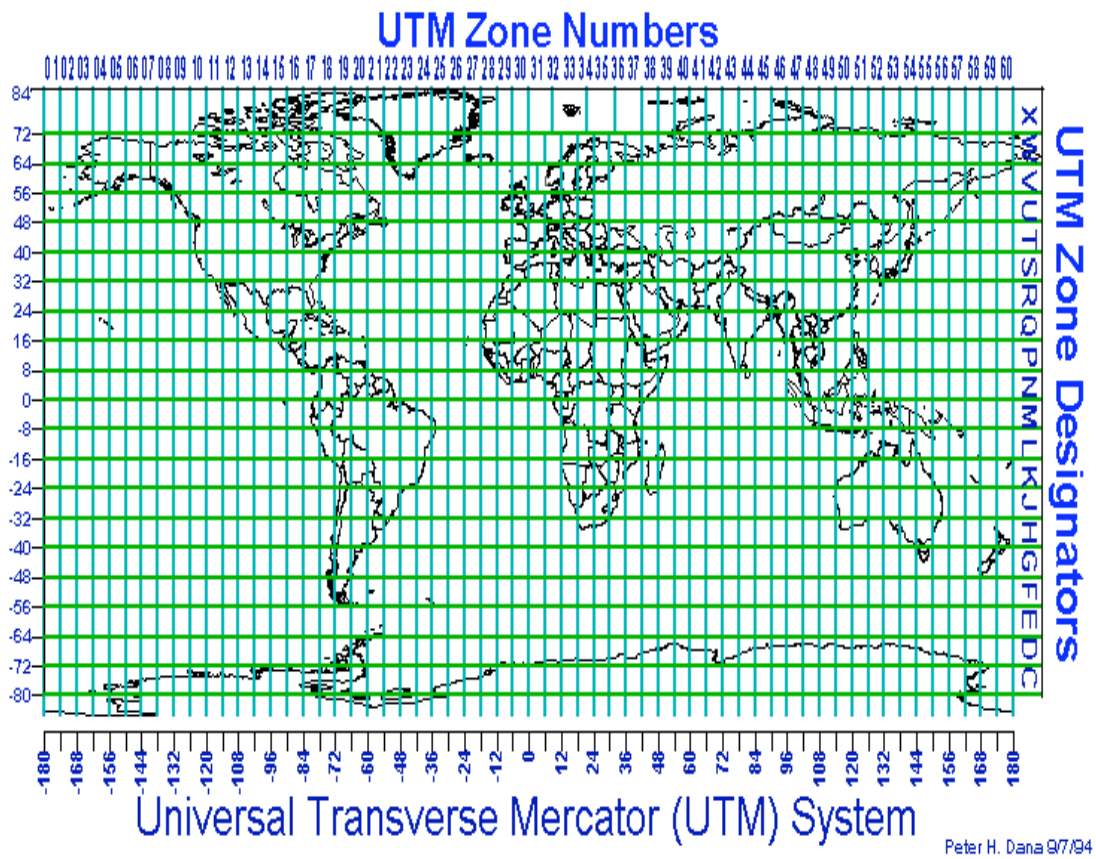


Figure 7 : UTM zone

Fig src: <http://w3.impa.br/~pcezar/cursos/GIS/mapproj/mapproj.gif/utmzones.gif>

The figure 7 described the how UTM zones are diving and using it in referring maps. The UTM zone number start from 1 , from above figure zone one is covering 180 degree to 174 degree west longitude.

### 2.7.3 Military Grid Reference System (MGRS)

The mapping system which is used for military purposes are required to have 100 % accuracy of pointing location during military operations. From history, military has great contribution for developing mapping standards. The Military Grid Reference system (MGRS) is one outcome of military research.

The Military Grid Reference system is similar to the Universal Transverse Mercator (UTM) System. We can say this standard is a modified UTM version and extension of the UTM co-ordinate system. The main difference between Universal Transverse Mercator and military grid reference system are on labelling convention. The

military grid reference system are also locating point from 80 degree south to 84 degree north , for polar region this system used another standard which is called Universal Polar Stereographic system.

#### 2.7.4 World Geographic Reference system (WGRS)

The world geographic reference system is the grid based co-ordinate system, which is used for reference positioning on the earth location. This co-ordinate system also developed and implemented on longitude and latitude concept. The earth surface is dividing in to quadrangles of latitude and longitude with co-ordinate pair. This co-ordinate system is a grid based system so that the longitude and latitude are presenting in a grid chart.

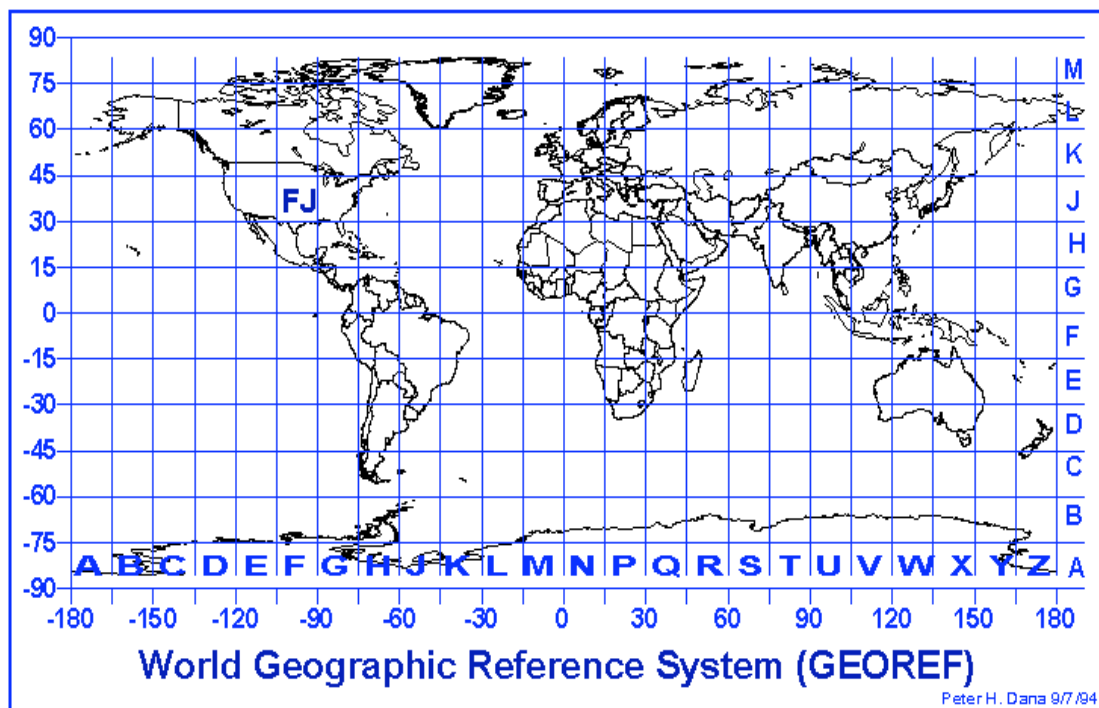


Figure 8: world Geographic Reference System

Fig Src :-<http://earth-info.nga.mil/GandG/coordsys/images/georefA.gif>

The figure 8 is described the World Geographic Reference System.

#### 2.7.5 State Plane Co-ordinate Systems (SPCS)

The state plane co-ordinate system was developed at United State at 1930s, which was based on North American Datum. This co-ordinate system are mainly intra state planning in the united states, the state plane co-ordinate system are based on 126 geographic zones and the foot.



## 2.8 Diseases Map Systems

The map is used to represent and visualize geographical areas by using different objects, data structure and information. Disease map systems could visualize diseases and information related to diseases on the map.

### 2.8.1 Survey of existing Diseases map system

The Google earth and mapping system is promising technology in new era of web based mapping application. The Google map can be used in any kind of web based application without cost, for any purpose. The Google mapping technology is also used for disease mapping applications. There are many advantages of using Google map in a disease map system. Google map is free to use in any application, Non-profitable organization can therefore benefit by using free Google mapping system. Google mapping system is used to develop based application so it is compatible with any kind emerging technology. The Google map API is required to embed Google map into web-based applications. Google provides free API by signing up, but the developer has to follow the terms and conditions set by the Google. (HealthMap 2008)

The Non-profitable organization *Health Map System* used Google maps to create disease map system to alert global disease outbreak. The organization developed the web based interactive disease map application for outbreak alerts. Different kinds of information sources are using to collect global disease outbreak and combine them with Google map system to create a health map. The sources of information are

- a. *ProMed Mail*
- b. *World Health Organization*
- c. *Euro Surveillance*
- d. *Google News*
- e. *Moreover(HealthMap 2008)*

The disease outbreak information are collecting from above mentioned sources and combine them with Google map, which is one of the promising examples of using Google maps for disease outbreak alerting. The Health map system can warn traveller about infectious disease outbreak according to real time data information. Currently the Health Map System has branch at some cites of *USA, UK, Canada,*

*China and India*. They are planning to elaborate the different domains all over the world (HealthMap 2008).

The Linux platform has been used to implement health map system; the other software toolkits are Apache, MySQL and PHP. The Health map web page alert the disease outbreak globally (HealthMap 2008). In the health map organization the source of data cannot be fully trusted so that public healthcare unit cannot fully trust and rely on such results. The validation of information is one of the limitations of such kind of disease map system.

The Global wildlife Diseases News Map system is also another example of disease map system. The Google map has been used to implement the disease outbreak for wild life system. The disease mapping system gather information about diseases from wild life disease digests and embedded them with the mapping system. The information is gathering by both locally and globally. The end user can get information from both locally and globally. The mapping system is filtering and embed diseases outbreak article from 45 days in different geographical locations and are updated frequently. The disease outbreak information are collected from different sources like Pubmed, Google Alert and Emails.

## **2.9 Open source mapping solution**

Open source software provides source code to its end user so that users are allowed to change and distribute the source code. The major benefits of open source solutions are, user need not to be depend of vendor, free to use, free to distribute and change. The open source solutions are mostly used by non-profit research based organization and for educational purpose. Open source solution are maintained and defined by the community (OpenSource 2009).

During this master project, I researched available open source solution for mapping applications. Some of the open source mapping solutions are *Map Server, Oracle Map viewer, NASA World Wind, MapGuide Open source, LizardTech, GeoServer, GeoMedia, ArcIMS, ARCGIS, Open Layers, GRASS GIS, gvSIG, UDig, Qgis, OpenJump, Google Earth, DeepEarth* (OpenSource 2009; WMS 2009).

## **2.10 Map Server**

The University of Minnesota has developed an open source mapping application during 1990's in co-operation with NASA, named map server *for land management's* (MapServer 2008). Map sever was written in programming language called C. The map server is widely accepted and used for developing interactive mapping applications and publish *spatial data* over Internet. The map sever is platform independent open source application so that the user can benefit from

developed application in different platforms, Windows, *Linux* and *MacOSX* (MapServer 2008).

Some important features of map server are:

- a. *Support widely used and popular scripting and development Environment like Python, JavaScript, Perl, Ruby, and .net*
- b. *Support multiple working platform, Microsoft, Linux and MacOSx*
- c. *Support different file formats ESRI shape files, PostGIS, ESRI ArcSDE, and Oracle Spatial. (MapServer 2008)*

### 2.10.1 System Overview

The map files (*shape file, postGIS, oracle Spatial*) are the input for the system. The map file has much information within its different layers and projection and such information are saved in either *vector data or raster data*. The map layers are combining *data and styles so that* layering is very important while developing applications. The vector format data structure and raster format data structure are the main source of input.

The different web services web map services (WMS), web feature services (WFS), and Tiles are also inputs for map server.

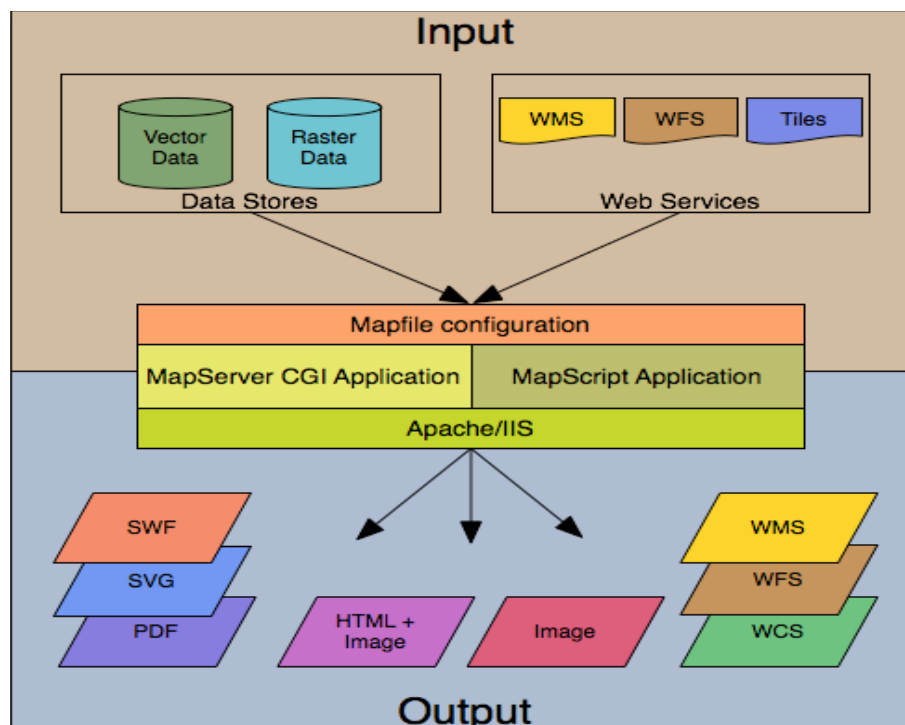


Figure 9: System architecture of map server

The web map services has two key roles in map server application ,

- a. Firstly, The WMS standards is used to produced .JPG,.PNG and .TIF and sometimes Scalable vector graphics (SVG) by using map files. The map file has different information within it but image does not include all information reside in map files.
- b. Secondly, The WMS play key role in communication; If the system is required to communicate among geospatial databases then WMS is acting as http interfaces for servers and databases.

The figure 9 described the architecture of the map server and how the input of system can generate the map file in different format.

## **2.11 Summary**

The chapter has described on overview of different approaches and technologies used to create interactive disease map.

## CHAPTER 3

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### REQUIREMENT SPECIFICATIONS

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This chapter will present the requirement specifications of interactive diseases map files. We used Volere Requirement Specifications Templates (Volere 2008) to define the system requirements and analysis in this chapter. The main aim of the thesis work is create an interactive map file production system. The system produce the interactive disease maps, population information(Volere 2008).

The main requirements specifications of this master thesis is based on previous work done at NST project Snow Agent system .The project is working on detecting infectious diseases before outbreak. The system will generate diseases map file according to the input given by the user. The system inputs are digital maps, epidemiological and demographic data. These factors are the basic input of the system.

We assumed that all output data will be displayed on the map after clicking by the physicians, for instance, based on the user input the system will display report of epidemiological data and demographic data on the maps.

Another assumption, Zip code area and all map information will be available in Microsoft virtual earth.

#### 3.1 Sources of Requirements

The main source of requirements was based on the project Snow Agent Systems previous work. The project has been working on detecting diseases outbreak in an early phase and using disease outbreak information in a clinical setting. Previously, The Snow Agent System used laboratory data of University hospital for this research.

Other sources of requirements were collected by discussing with specialist in this research area, project manager of Symptom Based Diseases surveillance system and consultant. Some of the requirements were taken from Norwegian institute of Public Health and Statistics Norway mainly epidemiological and demographical studies. We

collected some requirements from the World Health Organization epidemiological studies, diseases outbreak alert and prevention methods.

The iterative requirements of the system can be updated for better quality. The validation of collected information was of the challenging work during requirement specifications, the discussion with the project manager of Symptom Based Diseases Surveillance system helped us to review our extracted requirements of the system. We were taking references of some previous research data on epidemiological and population data statistics of WHO and Snow Agent System.

The Snow Agent System is developed based on data from GP offices in Tromsø Norway. We are using sample data for our prototype demonstration. All GP offices in Northern Norway are using electronic health record system so that they are using EHR to store patient information. Unfortunately we cannot use the real patient data for our prototyping because of Norwegian Data act.

The previous studies on Snow Agent system about specific patient epidemiological data gives an overview of the volume of data required to build real functional working system. We are covering some sample patient data and age group population in Tromsø for data modelling, in future same structure and algorithm can be used in larger scale of data modelling.

The main goal of system is how to develop interactive disease maps, to achieve this goal we were required to define what kind of information is displayed in the map, how the data is presenting in the maps. The healthcare professional are the user of system, System are required to be friendly with its user. The prototype may be used for co-ordinating diseases outbreak situation and use this information within the clinical setting. The prototype required to be evaluate after implementation.

The statistics of a population is dynamic; the population is changing with time. There are different factors which can effect statistics of population, we are not interested about those factors but changing population needs to be addressed by the prototype.

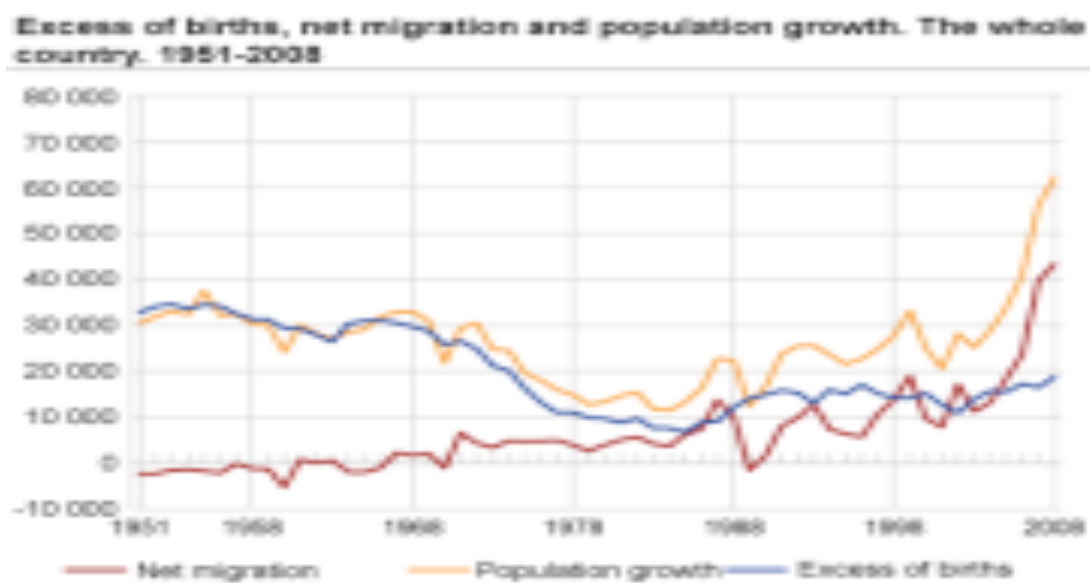


Figure 10: Population statistics in Norway from 1951 to 2008

Figure Source: <http://www.ssb.no/folkendrkv/en/>

From the above figure, the population statistics shows the variation of the population in Norway. The statistics is dynamic different colour lines are migration, population growth and excess birth.

We are targeting a different age group population from both male and females. Targeted population statistics are distributed as follows.

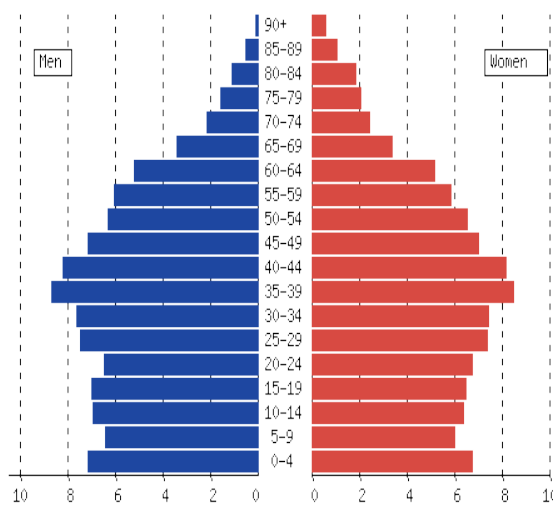


Figure 11: Population Distribution in Tromsø

Figure Source: <http://www.ssb.no/folkendrkv/en/>

Above figure is the population age distribution in the Tromsø municipality, the continuous series is used to distribute between both male and female population.

**Continuous series of male population distribution**

- 0-4 5-9 10-14 15-19 20-24 25-29 30-34 35-49 40-49 50-54 55-59 60-64
- 65-69 70-74 75-79 80-84 85-89 90+

&

**Continuous series of female population distribution**

- 0-4 5-9 10-14 15-19 20-24 25-29 30-34 35-49 40-49 50-54 55-59 60-64
- 65-69 70-74 75-79 80-84 85-89 90+

From the figure above we can see the population statistics, we are evaluating and using targeted population for data collection.

### 3.2 Challenges and Rejected Requirements

The population statistics and Epidemiological information are dynamic. Above we mentioned the issue of age group distribution, selecting age group for the research was one of the major challenges.

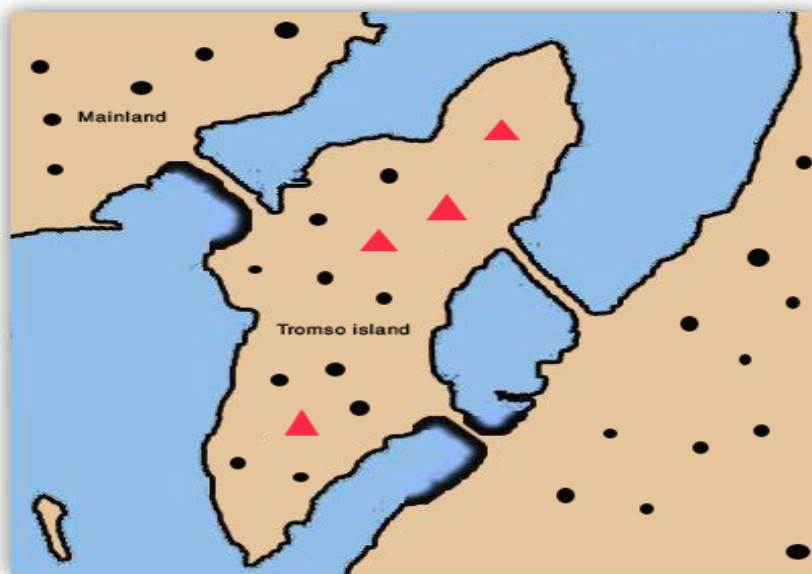


Figure 12 : Tromsø Population Distribution.

The figure above is Tromsø Island, we were making following assumptions

- ❖ Red triangle doctors office
- ❖ Black yellow population distribution

In Norway, all population have their own personal doctors, people who are living in same area might have different personal doctors. It is not necessarily so that people living near the doctor's office belongs to that doctor. People who are living Tromsø Island might be associated with doctor at mainland. The doctor can have his patient records only, people who living same area and not associated with that area doctor with infectious diseases can spread diseases, the doctor will not have those people record with him. The epidemiology data can be affected by following factors

- ❖ Geography
- ❖ Time
- ❖ Demographic



The quality of data is another important challenges associated with system

### **3.3 Functional Requirements**

The functional requirements covers the detailed of functional behaviour of the interactive disease map. This section gives a detailed description of functional requirements for the interactive disease map files production system. We are going to describe a list of functional requirement for the system.

#### **3.3.1 Interactive Map**

The interactive map allows end user to interact with the map system during run time. The system provides results according to the end user input at runtime or changes on maps in accordance with query or checking layers. Interactive map is widely applied in different areas like health care, tourism, communication, business and many fields for different purposes. In a health care scenario, interactive map can be part of diseases surveillence system for finding areas of disease outbreaks on a map. The outbreak news can be important for tour operator to make tour plans. Interactive map is very useful for hikers and travellers to find information about different routes, rivers, lakes, mountains e.t.c.

The thesis work is based on the health care issues. Our focused area is interactive map for the disease surveillence scenario. The primary goal of thesis is how to create interactive map system applied in diseases surveillence projects. We chose one Norwegian city Tromsø for our interactive map system.

The interactive map could be applied in different areas by different perspectives. The public health authority may be interested on suspected diseases outbreaks in geographical areas. Population research authority may be interested on population distribution on municipality and different age group distribution on that area. We assumed that health care professionals are end user of applications. The system required to be developed in accordance to health care professional demand.

The interactive map system required to implemented browser based application for Silverlight presentation and in the future if the system needs to be integrated with other Internet based applications. The map file system is required to be compatible with Internet browsers. The interactive map system is required to build system based on. The prototype required to make interaction facility on a same screen, by checking option in left side of screen change in map screen.

### **3.3.2 Searching**

The searching feature is one of the functionality of the interactive map files. The end user needs this function able to search in a geographical area. In general, if public health officers are user of interactive map, officer might be required to search geographical area in national, county, municipal and Zip code area. In business perspective company required to find out geographical area with demographical statistics with different age groups. Interactive maps are widely used in environmental research; researchers are required to search rivers, lakes, national parks, and wild life population statistics.

In the scenario of interactive map in diseases surveillance the health care professional is required to find out geographical areas with epidemiological statistics and the demographic statistics. The interactive map file is required to facilitate search functionality on the map. The user interface required to be user friendly for searching. The health care professional might be required to search geographical location, the system is required to have strong search functionality, if the health care professional searching a zip code area then system must locate that zip on the map. Map navigation is another functional requirement of the prototype, the end user must get the ability to navigate the map. The end user must be able to move the map from one co-ordinate to another co-ordinate.

### **3.3.3 Map Layers**

The prototype is based on the city Tromsø and the system is using a map of Tromsø. The system must use Microsoft Virtual Earth for mapping. The prototype required to map layering facility, after searching zip code area Tromsø the system is required to match county, municipality and zip code layer.

### **3.3.4 Diseases and population information**

We already discussed in previous section, this thesis work based on the diseases surveillance scenario. The demographic information and epidemiological information are the heart of the system. The system is required to assist health care professionals visualize the diseases and demographic information on the map. That visual information is for use in clinical settings for identifying demography in particular geography and epidemiology on that geography.

The system required to generate the diseases information and population information on the screen of map. The epidemiology data and population statistics

are main inputs to the system, after processing it, the system is required to display on the screen of maps.

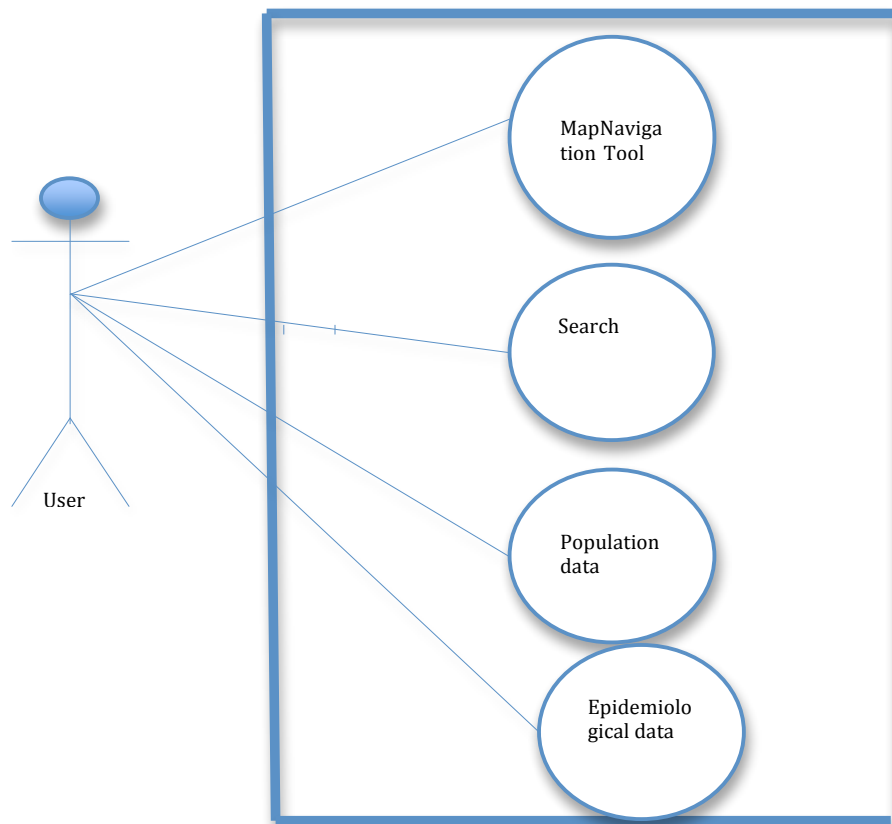


Figure 13: Use case diagram of interactive map

Figure 13 above describes the functionality of the interactive map system. The user is searching a geographical area on the map, after searching the system is required to locate that area on the map. Once zip code locates on the map, the system is required to visualize population and epidemiology data on the map screen.

## **3.4 Non Functional Requirements**

This section covered the non-functional requirements of the system. The health care professional are end user of the prototype, some of the non functional requirements captured were describing as follows.

### **3.4.1 Look and Feel**

The interactive map system is human computer interaction based application; look and feel is very important factors for the system. The end user of system is not assumed to be technical person so that system interfaces is required to be attractive and not complex in using.

The prototype is displaying demographic and epidemiological statistics on the maps so that UI required be informative. The end user should feel, the system is informative and attractive.

### **3.4.2 Performance**

The performance of system is based on the end user input epidemiology and demographic data and searching geographical area. The system is required to be highly performable while searching geographical area.

The acceptance of prototype is based on performance of the system. The performance of system is required to be higher scale. The health care professionals are depending on system for finding suspected diseases outbreak area and required to report for public authority.

### **3.4.3 Security**

The system is required to be highly secure. The interactive map file is developed on health care scenario so that the confidential data are used while developing application. The system is required to be highly secure to use and protect system from unauthorized access.

In Norway health care data must be sent through the health net need to assure the system security.

### **3.4.4 Robustness**

The output of the interactive map system is depending on the different kind of data sources. The quality of data is always important for reliable system. The demographics data and the epidemiological data are the main data inputs for the mapping system. The system generate the output based on that input, we are using population data from the Norwegian statistics, but epidemiological study itself is a huge area of research. To assure quality of epidemiological data is one challenge of system.

### **3.5 Summary**

This chapter described both the functional and non functional requirements of the prototype. The requirements were collected based on previous work done at NST within the project Snow Agent System and literature reviews.

We used unified modelling language for listing functional requirements of the system

## CHAPTER 4

---

### DESIGN

---

This chapter will describe the design of interactive disease map system which includes developing environments and modelling approaches. The main research work of the master thesis is how to developing map file production system which generating interactive diseases map based on the different input files such as digital maps, population data and epidemiological data. The project is formulating framework for map files based on diseases outbreak scenario based development human computer interaction so that map files can be reused in other different scenarios and modules can be extendible for further developments.

The thesis design is based on previous work done by the Snow Agent System team at NST. The focus in this master thesis is based on disease outbreak scenario to help health care professionals including primary care physician, public health officers and diseases surveillance researchers, epidemiological researchers and population research people to visualize the probable disease outbreak area on map and display information about population and epidemiology of that area. The population and epidemiological data research itself is a huge research area but the systems focus of interest is to visualize such data on a map. The epidemiological data analysis can be complex research the selection criteria of diseases information, epidemiological data can be a complex task.

The thesis framework is design based on generic modular approaches so that framework can be used for further enhanced for web based interactive mapping solutions. The modular approaches are used to design the interactive map files. The system modules are integrated with the framework to perform as an interactive disease maps which allow to extend the system in larger scale in the future. The modules can be reused or removed from application during validation procedure which increase the efficiency of the system and the developers. The modular approach helps the system to be extensible and is a reusable framework.

We are using Snow Agent System data, demographic data, virtual earth and ArcGIS which generate interactive diseases map as Silverlight presentation. This is very new and recent technological framework developed by ESRI and Microsoft, the developing version are changing rapidly which is the one of major challenges in the design and implementation phase. The thesis design work is divided into following sub domains.

- ❖ Data extraction

- ❖ Data modelling
- ❖ Map model design
- ❖ Integration of data model and map model with system framework.

## 4.1 Snow Agent System Architecture

The Snow Agent System at National Centre for Telemedicine (NST) implements a distributed agent scenario. In Norway, Health care data must be transmitted through Norwegian Health net.

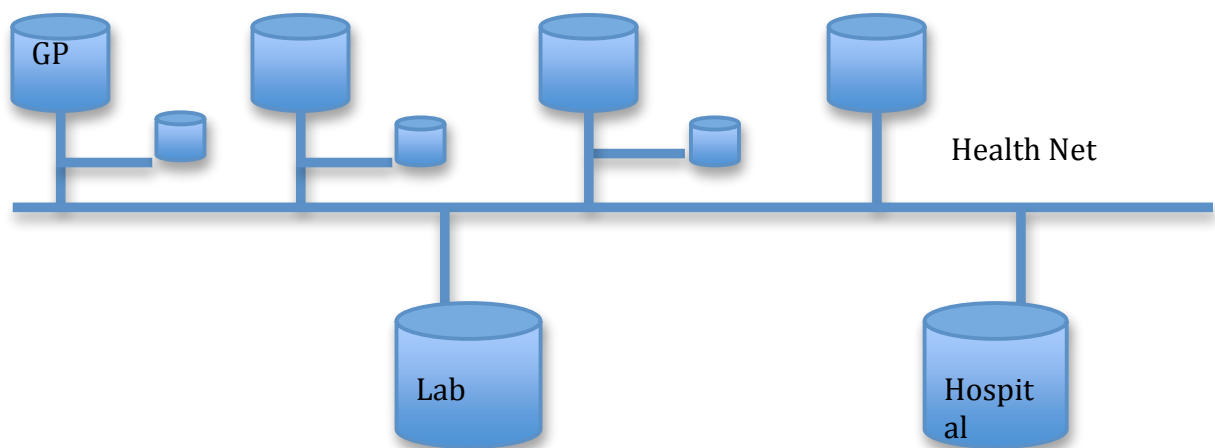


Figure14 : snow agent system

The figure above is about the description of distributed general parctioner's offices, hospital and laboratory over Health Net. Population database is stated separately from patient data. The system fetches population data by moving agents.

## 4.2 Data Extraction

We are going to describe different type of data variable extraction for the system and going to use data collected by the Snow Agent system which is described in requirement specification chapter. Extract required data from the patent data storage is one complex task and some assumptions are considered during data modelling part. Some of the data might not be required to visualize on the map so that we are excluding those data and including some primary data on the map.

The Snow Agent System collected data are the primary data of the interactive map system. The patient is directly related to geography municipality and zip code area, in other hand the primary care doctor office is also directly related to the patient. We are visualizing the extracted data from patient on the map. I am going to describe data model used Snow Agent system and some of the model is used in my design procedure as well.

- ❖ Patient Data
- ❖ GP Data
- ❖ Zip Code
- ❖ Epidemiology Data
- ❖ Population Data

#### 4.2.1 Patient Data

The data of patient is primary important data factor for interactive disease map system. The specific patients are part of the primary care doctor office system, part among population of particular geography area and also part of epidemiology studies so that we can agree that patient data is a primary data source for the system. I am going to describe the example of how patient data looks like.

Patient	
	PatientID
	Patient Gender Patient D.O.B Zip Code GP Patient FirstName Patient SurName

Table 2 : Patient Data fields

From the table above, the patient data is the primary data source for interactive disease map database. Specific patients are the part of population statics used for epidemiological studies so that patient data are primary data source for the system.

*Patient data –Limitation:* Norway has a strict personal data act for health care data, getting real patient data is therefore a challenging issues but Snow Agent System previously collected data have been used to designing the prototype.



The another limitation is that patient has huge volume of data and indentifying the required and helpful for decision making procedure is one limitations of the patient data.

#### 4.2.2 GP Data

The Snow Agent System is designed for the General Practitioner. The primary care doctors are the primary end use of the system. The GP offices is the place where they face patient at first stage, they have access of patient data. The patient data are using to analyze disease scenario and probable outbreak. The GP office is involved for consultation, laboratory results and prescription in general but the system is interesting only for communicable diseases. The system does not require all data of consultation and prescription. The GP data is presented in the following way.

GP	
	GPID
	Zip Code GP Name

**Table 3: GP data field**

From the table above, General practitioner office has unique GPID, which has two different data field Zip Code and GP Name. User can search General practitioner office on the map.

#### 4.2.3 ZipCode

In generic view, a country map has different level or layers, they are like

- ❖ Country
- ❖ County
- ❖ Municipality
- ❖ Zip Code

Zip Code area is also postal code as well; this code area is used for post office purpose as well. We are using zip code area to locate address. Zip code area is one of the inputs of interactive diseases map system. Norway has unique zip code area distribution, so that when user gives input by zip code area on the system, they will locate on that zip code area.

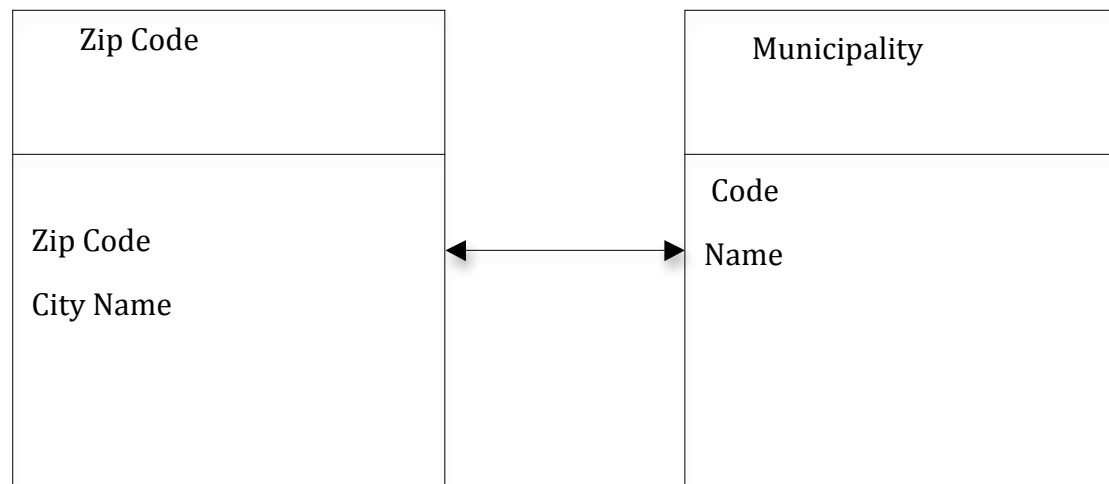


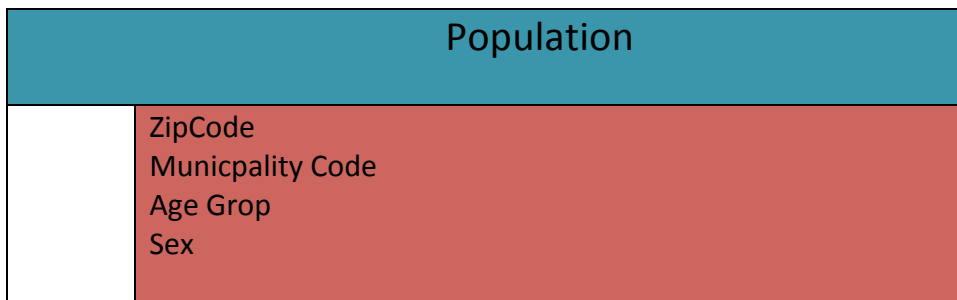
Figure 15: Entity diagram of Zip Code and Municipality

Zip code layer is one layer of map , the input zip code co-ordinate is matching with the map county co-ordinate and country layer.

#### 4.2.4 Population Data

The population data is input of interactive map system, this data is dynamic within a time interval. There are several reasons for population change which is not major focus of our design but increasing and decreasing population data are required to be updated regularly. The updated population data on the map play crucial role in decision making procedure. In disease outbreak scenario, the public health authority might be interested in total number population on the suspected outbreak area for prevention and protection of those populations. We already mentioned this is dynamic on the system, if population change then the system output is also changing according to change in input.

We are going to present entity diagram of population data structure.



**Table 4: Population data field**

From above entity diagram of population module, zip code and municipality codes are data for finding geographical location on the map. There are different age group population in a community so that we required divide population in different age group in both male and female population.

Municipal	Zip Code	Age Group	Sex	Total
1920	9012	0-4	M	345
1920	9012	5-9	M	678
1920	9012	10-14	M	123
1920	9012	15-19	M	456
1920	9012	20-24	M	122
1920	9012	25-29	M	121
1920	9012	30-34	M	123
1920	9012	35-39	M	411
1920	9012	40-44	M	234
1920	9012	45-59	M	456
1920	9012	50-54	M	234
1920	9012	55-59	M	456
1920	9012	60-64	M	234
1920	9012	65-69	M	256
1920	9012	70-74	M	965
1920	9012	75-79	M	567
1920	9012	80-84	M	678
1920	9012	85-89	M	345
1920	9012	90+	M	234

Table 5 : Example of sample Population data for male population at zip 9012

Above table is the data example of population on zip code 9012 and municipal code 1920 area for male population. The values of zip code and municipal code are the constant; Age Group and total number of population on that age group are variables.

The total number and Age group of populations are not constant, it will changes according to time. Population may increase or my decrease, the system is updating according to the population variation. We used Tromsø population statistics sampled by the Norwegian Statics Authorities for population models. We created the relation between age group and population statistics by following way.

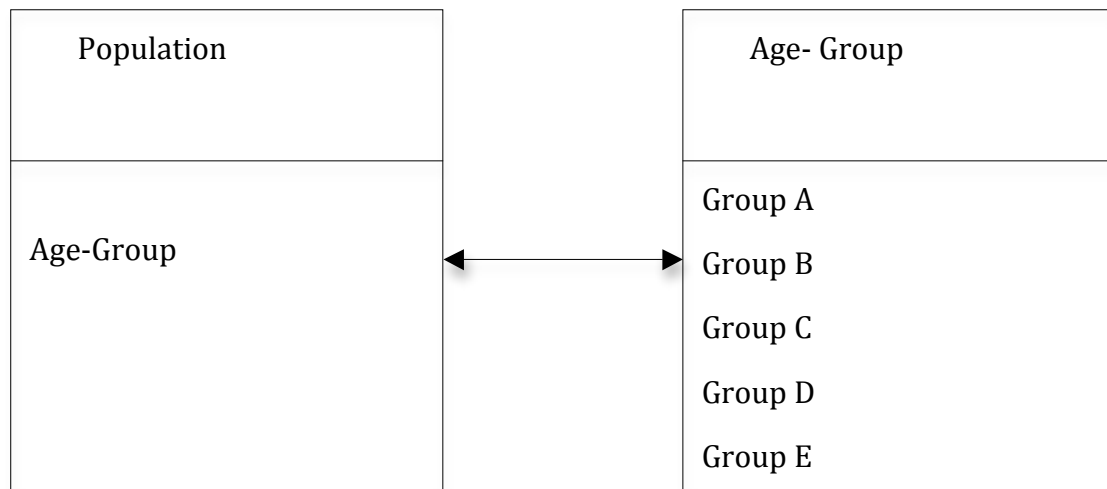


Figure : 16 Entity relation diagram of population age group

According to Norwegian statistics, they distribute five different age groups

Group A includes from Age 0-20

Group B includes from Age 20-40

Group C includes from Age 40-60

Group D includes from Age 60-80

Group E includes from Age 80-100

Above-mentioned group are the Norwegian standard population age group distribution.

#### 4.2.5 Epidemiological Data

The system required epidemiological data as system input. Epidemiology is study of diseases distribution among population; this is one of complex studies. The validity of epidemiological data is one of key issues in diseases surveillance system. The geographic dimension and time factors effected on this studies, in the real time diseases surveillance system should updated regularly epidemiological studies on the system.

The hospital could have records of incoming patients, but they did not keep track of outgoing patient and diseases spreading by the patient. These are really challenging issues of epidemiological data collection and analysis.

Epidemiological Data	
	ZipCode AgeGroup Diseases Total

**Table 6: Epidemiological data field**

The entity diagram data set above used interactive disease map as epidemiology data set. The prototype demonstrates the epidemiology on the map screen.

Our epidemiological data are based on specific geographic code area location. We are calculating prevalence and incidence for identifying the diseases outbreak with in a particular area and presenting on the maps.

The calculation of prevalence and incidence generate the diseases outbreak situation on that area. Prevalence is defined as total number of cases of the diseases in population at a particular time. The prevalence can be illustrated mathematically as well.

### 4.3 Map Models

The map models are key model for the interactive map system. The epidemiological and population data are stored in a database. The end users are interacting with the maps, so that map models has key role in interactive mapping application. The end of user of system could be the public health care officers, population research professional and researchers are using these models for interacting with the system.

Previous section described the data models using for the system. This section described the map components.

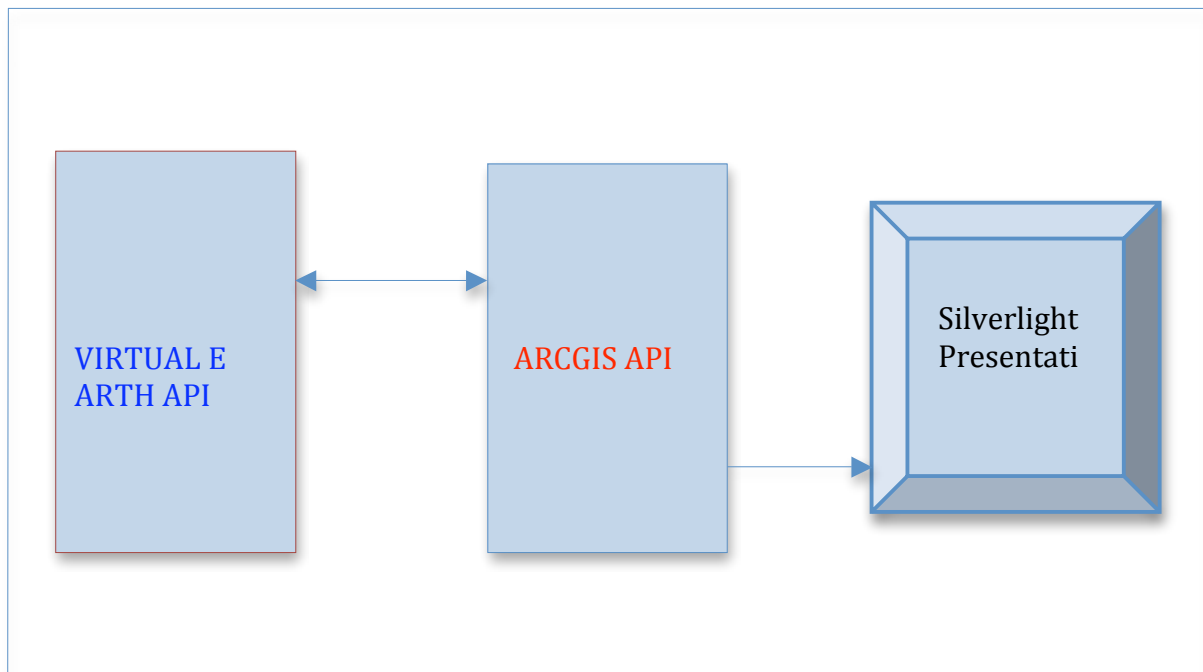


Figure 17: Map Component APIS of Interactive map system

Above figure are map API components. We used virtual earth API to use a map layers on virtual earth and ArcGIS API library for facilitating ArcGIS services including layers, graphics geometry and symbols. *This is also support geospatial and geo-processing operations on the map as result presented as Silverlight presentation.* The ArcGIS API combine the ArcGIS server and Microsoft Virtual Earth with applications. It allows for creating browser based interactive map applications.

## 4.4 Generic System Architecture

The preceding section described about map component and used library for the system development. In this section we are describing the generic overview of interactive map system.

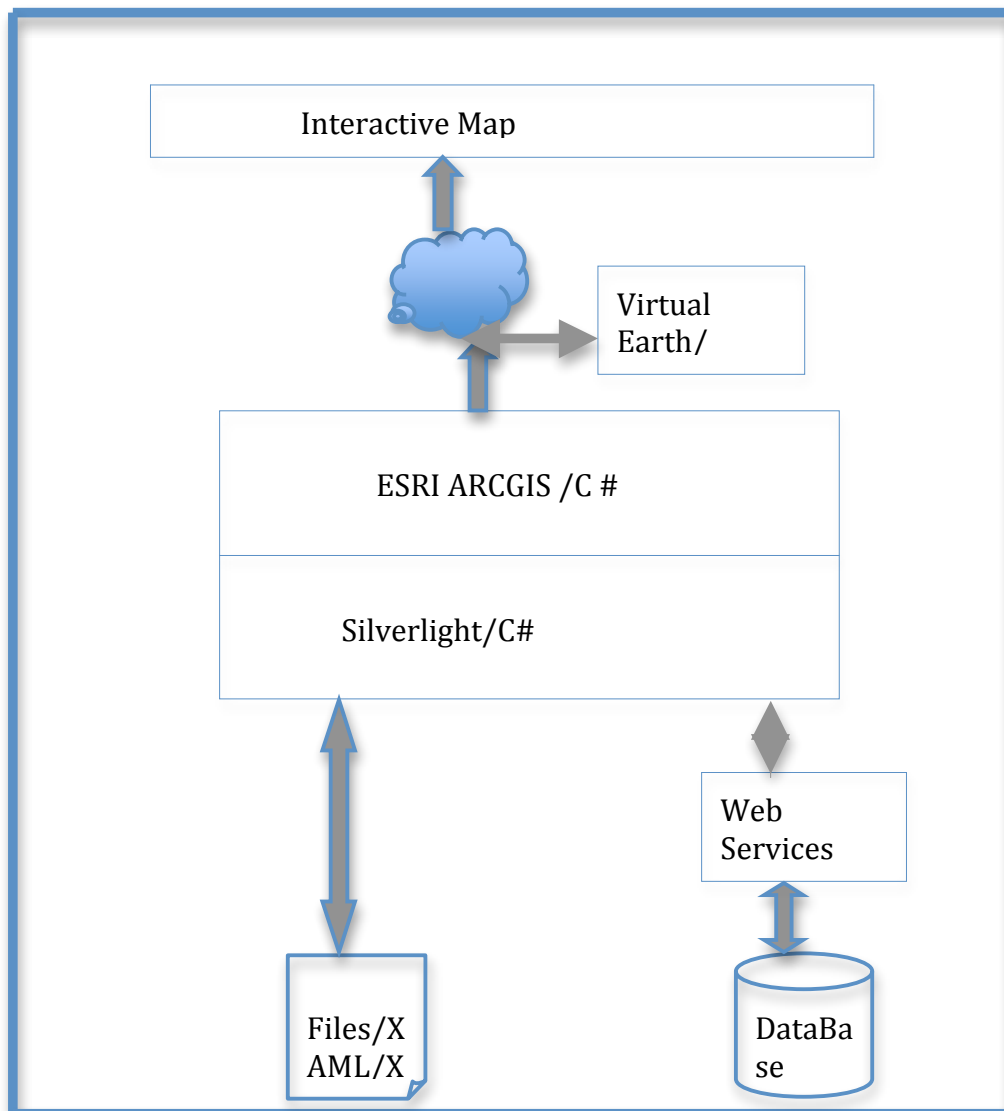


Figure 18 :Generic Architecture of Interactive map system

The diagram above shows the generic and conceptual framework for modelling and developing interactive map file production system. The framework illustrates how the map file system produces the interactive maps.

The system has heterogeneous data sources, the data are stored either in database or just in cvs and xml files. Data from the databases is accessed through the web services and C# is using to get access data from the database.

The data from database and geospatial information are integrated at middle layers ArcGIS layers with C#. Finally processed geospatial information is display on the Virtual Earth or Google Earth or Digital Maps. The end users are interacting with Virtual Earth and they are getting data out at Virtual Earth.

How- ever within this master thesis we are interested in disease information and population information on the map. The epidemiological and population data are stored in the databases and map layers and map information are stored at ESRI ArcGIS and Virtual Earth. The integration of disease data with geospatial data produces interactive disease map production system.

The following diagram described generic process of the interactive map system.

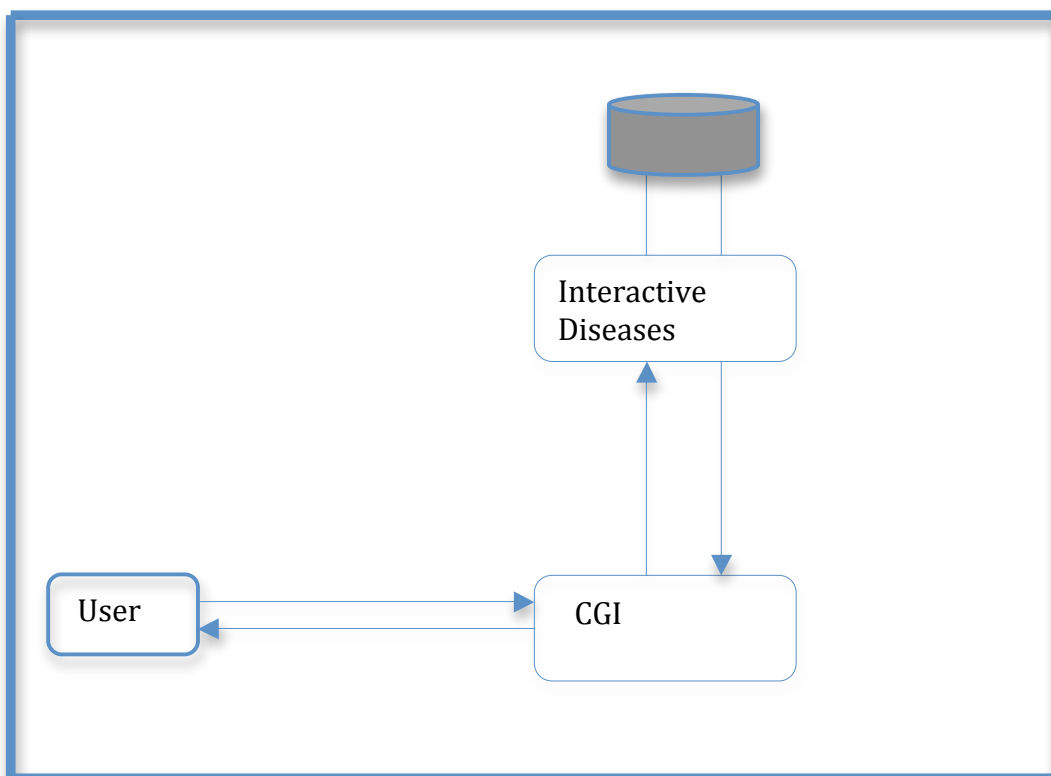


Figure 19: Process diagram of Interactive Diseases Map System



The user performs a query and CGI scripts is used to make connection to the database, it retrieves the result from the database and send response back to the user from an HTML pages.

#### 4 .5 Functional Diagram

This section introduces the function of the interactive map, where end user can access such functionality. The acceptance of system is depending on the accessible functionality of the system. The end user interacts with the map file at runtime. The system need to have flexibility in functional modules, so that after evaluation if system required more functions then system needed to allow adding more function. Similarly if system required to remove some function from system, system needed to allow for function removal without effecting other modules.

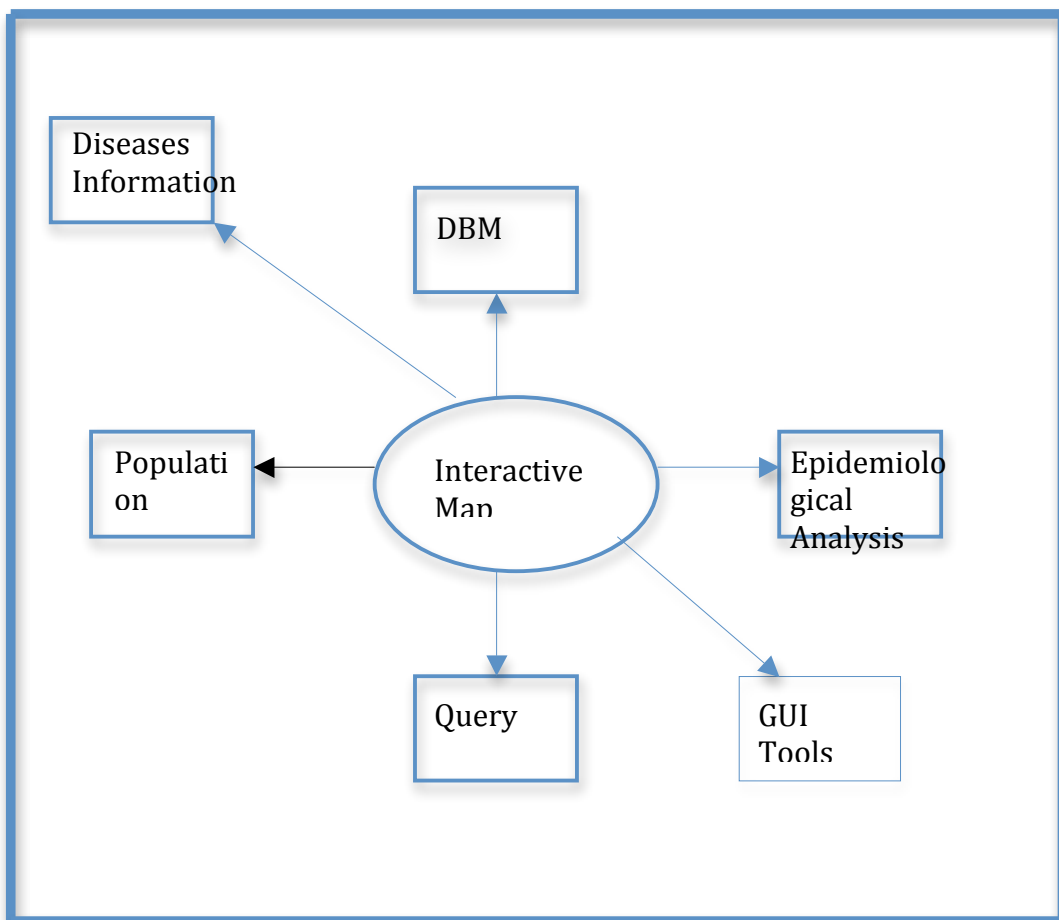


Figure 20: Functional Diagram of Interactive Map

The above diagram describes the functionalities of the interactive disease map system. The end user can access the above-mentioned functionalities from the system. The user can navigate the map on the screen, increase and decreases size of map user can load three different types of maps.

The system has search functionality so that user can give search query to system and system return results according to that query.

## **4.6 Summary**

This chapter described the detailed design of an interactive disease map system.

## CHAPTER 5

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### IMPLEMENTATION

---

This chapter describes the implementation of the previous chapter's design. The implementation was done by using Microsoft's .NET and visual studio Integrated Development Environment (IDE). This platform is widely accepted, used and supported by Microsoft for easy development. This working platform creates consistent, secure and reliable developing environments. We used custom component with system component by using web services.

#### 5.1 Microsoft .NET Environment

The interactive map file was developed by using .NET platform. The following advantages were noticed while developing the prototype.

- ❖ *Secure , Multi –Language Development Platform*
- ❖ *Rapid , Model-Driven Development paradigm*
- ❖ *Windows Presentation Foundation*
- ❖ *Web Application Development ASP.NET*
- ❖ *Secure , Reliable web services ( microsoft)*

Because of above mentioned features, .NET environment is widely used and accepted by Software development industry and research institution. The Microsoft .net framework including C#, XAML, ASP.NET.

The backend of system implemented in database SqlLite. Because of its unique features

- ❖ *Small*
- ❖ *Fast*
- ❖ *Reliable*

Opened door for implementing backend of large to small applications. This database can be used freely, source code this database is in *public domain (SQLite)*.

## 5.2 Data Flow Diagram

The data flow diagram in Figure 21 is for representation of dataflow in the system. The interactive map files uses virtual earth as map, the user of the map can search zip code of Norway on the map. Once system get zip input it will search on the map and if zip is matching then system will locate that zip on the map.

Technically, after zip code searching on the map it will make request to the web server. Once sever have got the request, the web server will create a request for that request and pass it to the SQLite DLL which will then fetch the data of that request.

After fetching data it will return to the web services, the web services return data as CVS text format. The CVS text format is converted into a list by Silverlight which will then bind it with the data grid and present it on the screen.

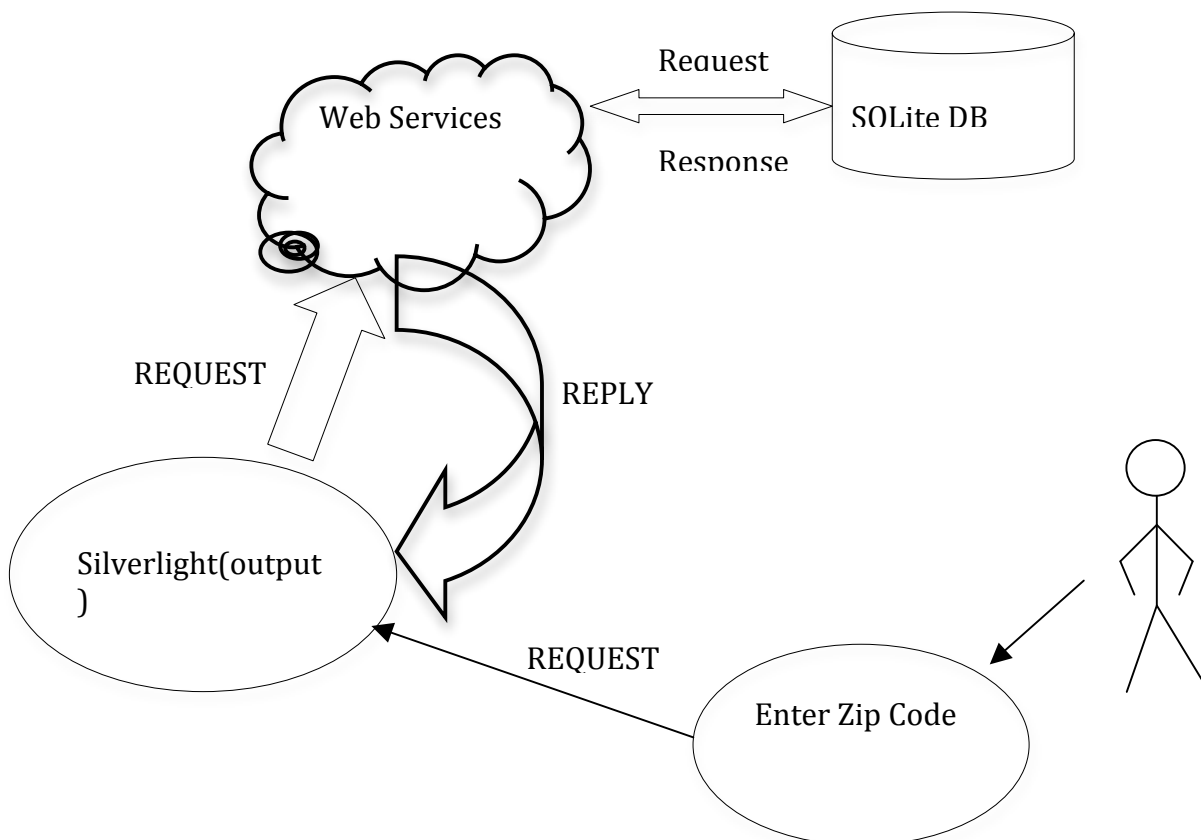


Figure21 : DFD of Interactive map

The figure 21 described the flow of data in the system, it shows how the data flow and how the result get visualised on the screen.

## 5.3 Architecture Implementation

The interactive map architecture is implemented by creating following Components

- ❖ Common Class
- ❖ SQLite DataBase
- ❖ VirtualEarthApp
- ❖ VirtualEarthApp.Web
- ❖ Webservice

When application is running, the component VirtualEarthApp.Web connect to the Virtual Earth Server after authentication it will get API verified through ASP.NET process XAML code and send to the browser. The following code is for creating virtual earth account and password. Once the application is running it will validate accounts and password at Virtual Earth server, after authenticating it will start staging the map. The map is staging from the following URL.

---

```
bool useStagingServer = true;
privatestring VEAaccountID = "141118";
privatestring VEAaccountPassword = "k&dk#2ldkdiKks";
protectedvoid Page_Load(object sender, EventArgs e)
{
    VirtualEarthService.TokenService.CommonService commonService =
    new VirtualEarthService.TokenService.CommonService();
    //Use staging server instead of production server
    if (useStagingServer)
    {
        commonService.Url = "http://staging.common.virtualearth.net/find-30/common.asmx";
    }
    else
    {
        commonService.Url = "http://common.virtualearth.net/find-30/common.asmx";
    }
}
```

---

The Following code is for html page for presenting the Silverlight presentation in browsers.

---

```
<!DOCTYPEhtmlPUBLIC"-//W3C//DTD XHTML 1.0
Transitional//EN""http://www.w3.org/TR/xhtml1/DTD/xhtml1-transitional.dtd">
<htmlxmlns="http://www.w3.org/1999/xhtml"style="height: 100%;">
<headrunat="server">
<title>VirtualEarthApp</title>
</head>
<bodystyle="height: 100%; margin: 0;">
<formid="form1"runat="server"style="height: 100%;">
<asp:ScriptManagerID="ScriptManager1"runat="server">
</asp:ScriptManager>
<divstyle="height: 100%;">
<asp:SilverlightID="MySilverlightControl"runat="server"Source="~/ClientBin/VirtualEarthApp.xap"
MinimumVersion="2.0.31005.0"Width="100%"Height="100%"/>
</div>
</form>
</body>
</html>
```

---

The code above illustrated the Common Gateway Interface (CGI). The validation procedure taken place at the virtual earth server.

The component VirtualEarthApp contains three different files. They are:

- ❖ Objects.cs
- ❖ App.xaml.cs
- ❖ Page.xaml.cs

The file objects.cs contains the two objects they are

- ❖ Population Object
- ❖ Epidemiology Object

Both of objects are used in program for data binding purpose in the data grid. The population data object contains the fields Municipal code, Zip code, Age group, gender and total number of population.

The Epidemiology objects contain the following fields Municipal code, Zip code, Diseases and total number of infected people.

The *page.xaml.cs* file is mainly handling event in the system, firstly this file loads the map on the application by following functions.

```
privatevoid MyMap_Loaded(object sender, RoutedEventArgs e)
{
// Associate Virtual Earth token provided as initialization parameter to application with
// the Virtual Earth tile layers defined in page xaml.
foreach (Layer layer in MyMap.Layers)
if (layer is TileLayer)
    (layer as TileLayer).Token = (Application.Current as
VirtualEarthApp.App).VirtualEarthToken;

// Wire up progress event with progress bar
    MyMap.Progress += (s, args) =>
    {
if (args.Progress < 100)
    {
        MyProgressBar.Visibility = Visibility.Visible;
        ProgressValueTextBlock.Visibility = Visibility.Visible;
        MyProgressBar.Value = args.Progress;
        ProgressValueTextBlock.Text = string.Format("{0}%", args.Progress);
    }
else
    {
        MyProgressBar.Visibility = Visibility.Collapsed;
        ProgressValueTextBlock.Visibility = Visibility.Collapsed;
    }
    };
}
}
```

The above code load map on the application and the following code is facilitating the zip code searching functionality. The Norwegian zip code are uniquely distributed. Once the user search zip code area on the map then it will locate that zip on the map screen.

```
privatevoid GeocodeButton_Click(object sender, RoutedEventArgs e)
{
//If nothing defiend serach, ask it to fill.
if (GeocodeInputTextBox.Text=="")
{
    MessageBox.Show("Please enter valid zip code");
}
else
{
//Disable Serach button for flooding or clicking twice.
    GeocodeButton.IsEnabled = false;

// Associate Virtual Earth token provided as initialization parameter to application with
// the Virtual Earth Geocoder constructor.
    Geocoder geocoder = newGeocoder((Application.Current as
VirtualEarthApp.App).VirtualEarthToken);
geocoder.ServerType = ServerType.Staging;
geocoder.Geocode(GeocodeInputTextBox.Text + ", Norway", Geocode_Complete);
}
```

```
}
```

After locating zip code on the map screen, the system will get data related to that zip code area and bind in data grid and present associated with zip code area. The epidemiological and population data are stored in database, it will call web services for data.

```
getDataFromWebService(GeocodeInputTextBox.Text);
```

This function gets data from the database through web services.

The SOAP client will be created and send asynchronous request for both population and epidemiological data. The following code is responsible for that task.

```
private void getDataFromWebService(string ZipCode)
{
    //Create soap client and send asyc request for population data
    //Create soap client
    ServiceReference1.Service1SoapClient proxy_population =
    new VirtualEarthApp.ServiceReference1.Service1SoapClient();
    //Soap client event, onComplete, fire event
    proxy_population.SerachDataCompleted +=
    new EventHandler<VirtualEarthApp.ServiceReference1.SerachDataCompletedEventArgs>(proxy_population.SerachDataCompleted);
    //Sent the Asynchronous request
    proxy_population.SerachDataAsync("population", ZipCode);

    //Create soap client and send asyc request for epidemiology data
    //Create soap client
    ServiceReference1.Service1SoapClient proxy_epidemiology =
    new VirtualEarthApp.ServiceReference1.Service1SoapClient();
    //Soap client event, onComplete, fire event
    proxy_epidemiology.SerachDataCompleted +=
    new EventHandler<VirtualEarthApp.ServiceReference1.SerachDataCompletedEventArgs>(proxy_epidemiology.SerachDataCompleted);
    //Sent the Asynchronous request
    proxy_epidemiology.SerachDataAsync("epidemiology", ZipCode);
}
```

SOAP is the specification for exchanging information in webservices; it is defined as Simple Object Access Protocol. Once the system got data from database through web services then the bind function will be active to bind data on the data grid.

```
bindEpidemiology(e.Result); bindPopulation(e.Result);
```

The above functions bind the result on the data grid. The following code is for binding the data.

```
private void bindPopulation(String popData)
{
    //Bind population data.
    //Data comes in comma separated value, in multiple line, so get each line of data.
    String[] row = popData.Split(new char[] { '\n' });
}
```



```

//For all rows
if (row.Length >= 1)
    {
    try
        {
            _Pop.Clear();
        foreach (String reader in row)
            {
            String[] cols;
            cols = reader.Split(',');
            if (cols.Length < 4)
                continue;
            //Add object in List
            _Pop.Add(new Pop() {
                Municipal=cols[0],
                Zip=cols[1],
                AgeGroup=cols[2],
                Gender=cols[3],
                Total=cols[4] });
            }

//Print the label
popLabel.Text = "Population Data";
//Bind the data wiht grid
gridPop.ItemsSource = _Pop;
        }
    catch (Exception ex)
        {
        MessageBox.Show("Error: " + ex.Message, "File Access Error", MessageBoxButton.OK);
        }

    else//cancel
        {
        MessageBox.Show("No Data Found");
        }

    }

privatevoid bindEpidemiology(String epiData)
    {
    //Bind epidemiology data.
    //Data comes in coma seperated value, in mutple line, so get each line of data.
    String[] row = epiData.Split(newchar[] { '\n' });

    if (row.Length >= 1)
        {
        try
            {
                _Epi.Clear();
            }
        foreach (String reader in row)
            {
            String[] cols;
            cols = reader.Split(',');
            if (cols.Length < 3)
                continue;
            //Add object in List

```

```

        _Epi.Add(new Epi() {
            Municipal=cols[0],
            Zip =cols[1],
            Gender =cols[2],
            Total =cols[3]
        });
    }

    //Print the label
    epiLabel.Text = "Epidemiology Data";
    //Bind the data wiht grid
    gridEpi.ItemsSource = _Epi;
    }
    catch (Exception ex)
    {
        MessageBox.Show("Error: " + ex.Message, "File Access Error", MessageBoxButton.OK);
    }
    }

    else//cancel
    {
        MessageBox.Show("No data found");
    }
    }
}
}
}

```

## 5.4 System Output

The following screen is for the testing page.

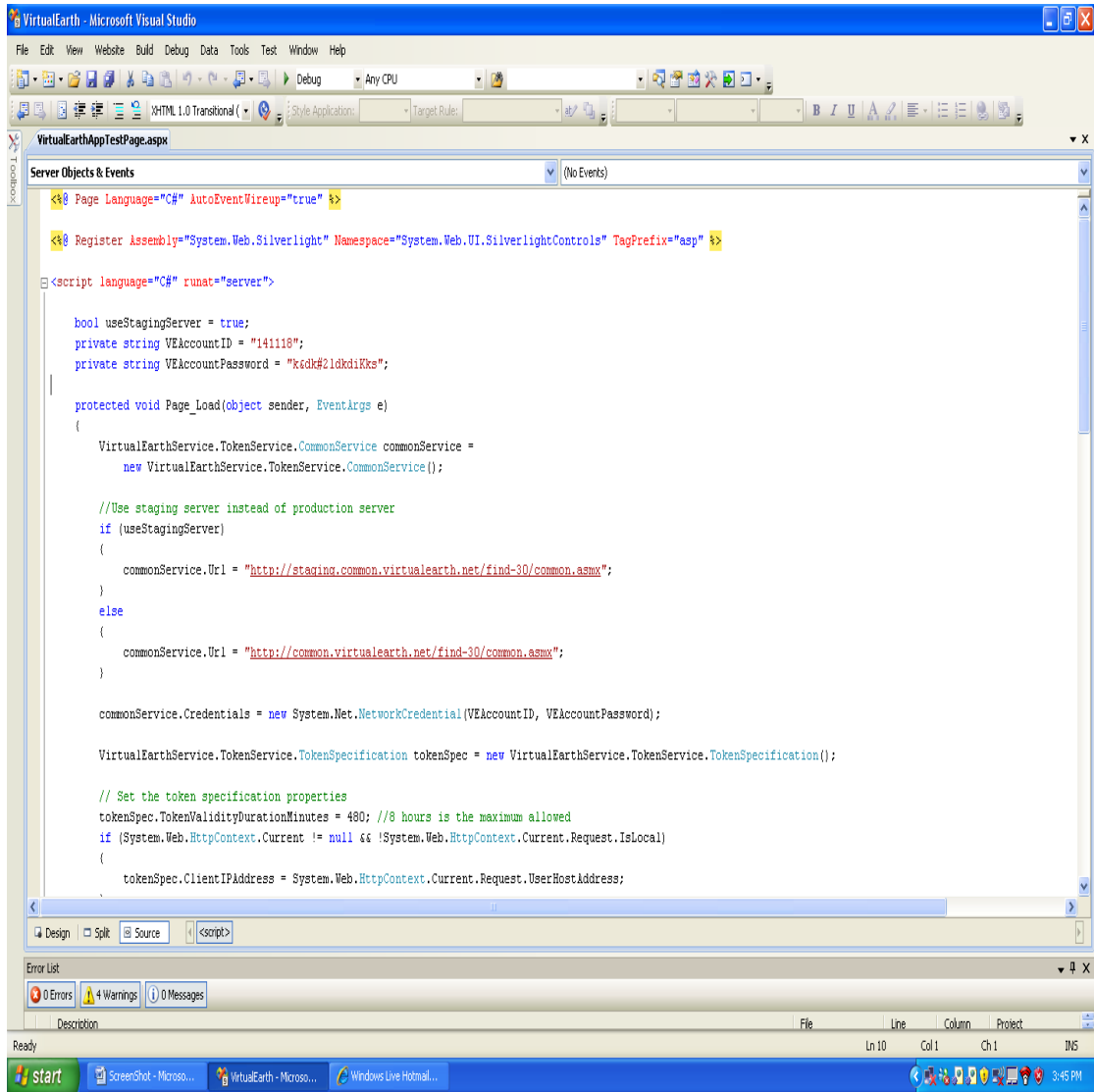


Figure 22: Screen shot of Test page

Figure 22 is screenshot of test page, then user require to press f5 to run the application. Once system start to run following screen will appear on screen.

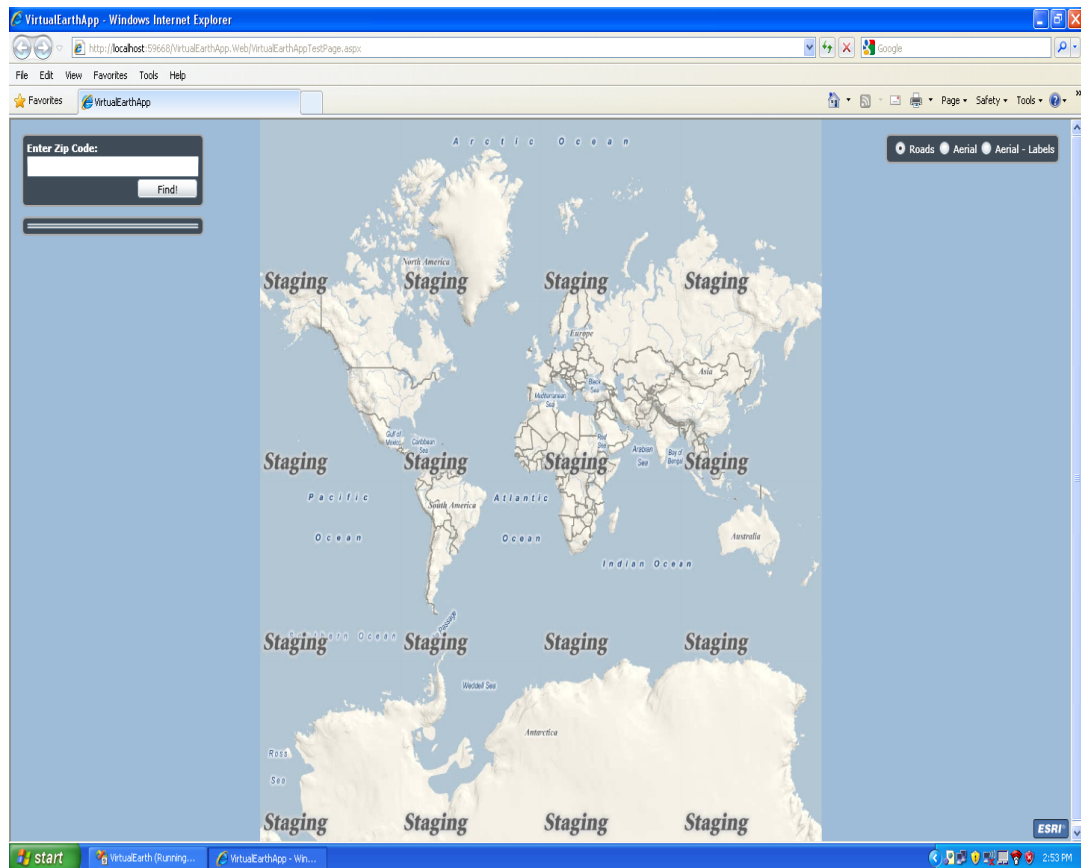


Figure 23: Screenshot of interactive map file

Figure 23 is the first screen shot of the application, this map is staging from Microsoft Virtual Earth to local host of end user computer. The virtual earth server validates the user and allowed to staging the map.

The user has three different choices for loading maps, they are

- ❖ Roads
- ❖ Aerial
- ❖ Aerial-Labels

By default is Roads type of map. We are going to present screen shot of Aerial and Aerial-Labels maps as follows

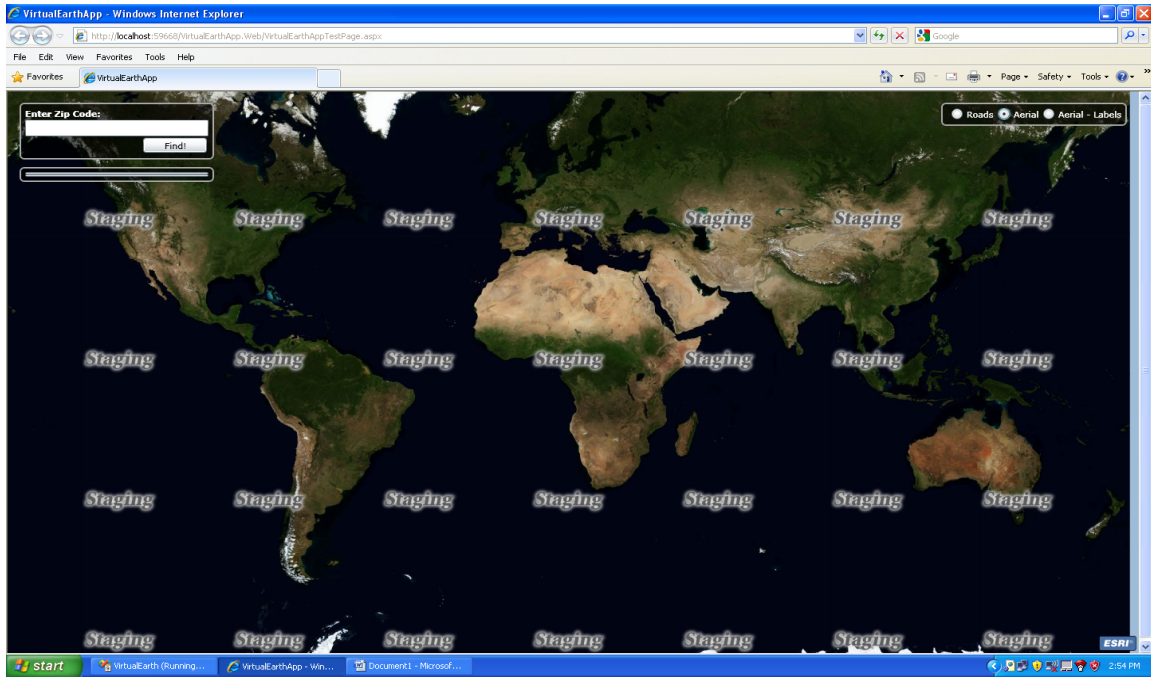


Figure 24: Screen shot of Aerial map on

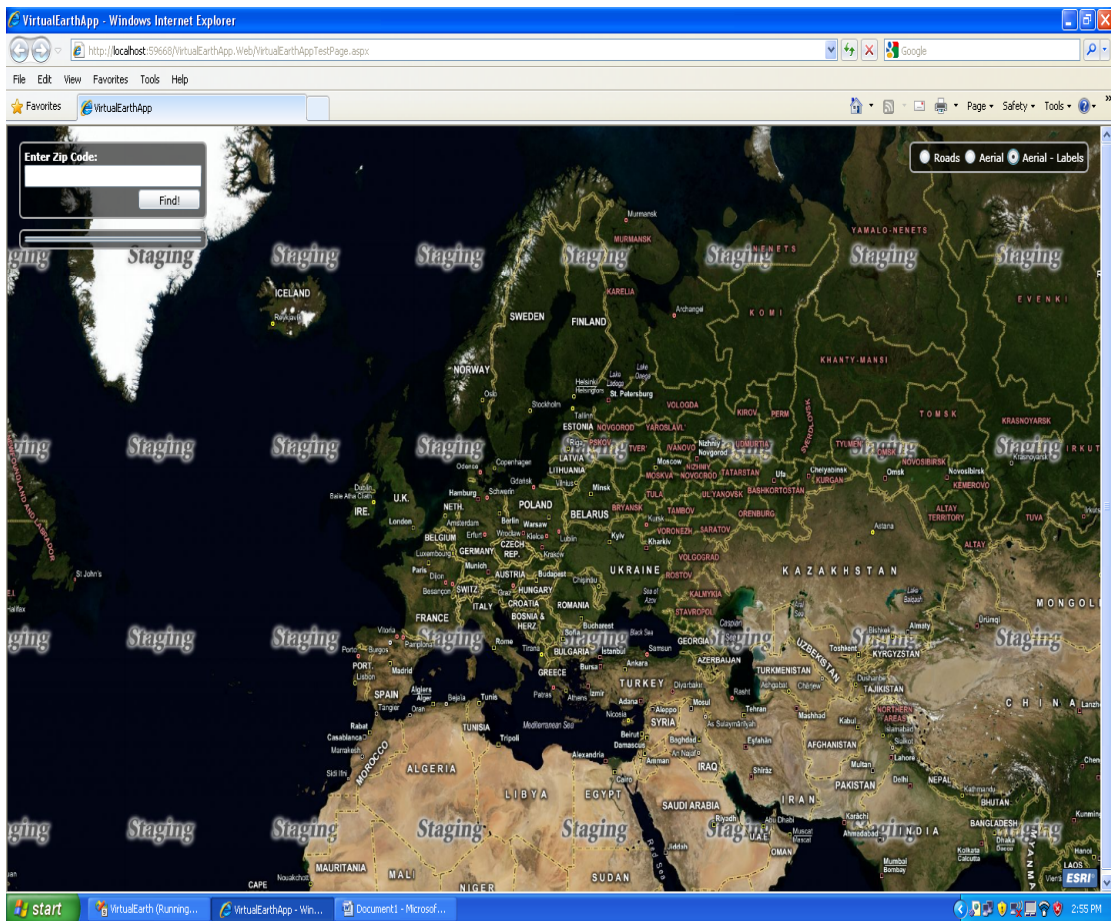


Figure 25:Screen shot of Aerial road map



The figure 24 and 25 are two different type of map on the screen. We can see the search menu left side of screen; the end user can search zip code area of Norway in the application.

Once the User search Zip code on the map, If zip is the correct zip of Norway then the system locate on the map by blue point. The following screen shot shows the matching zip code on the map.

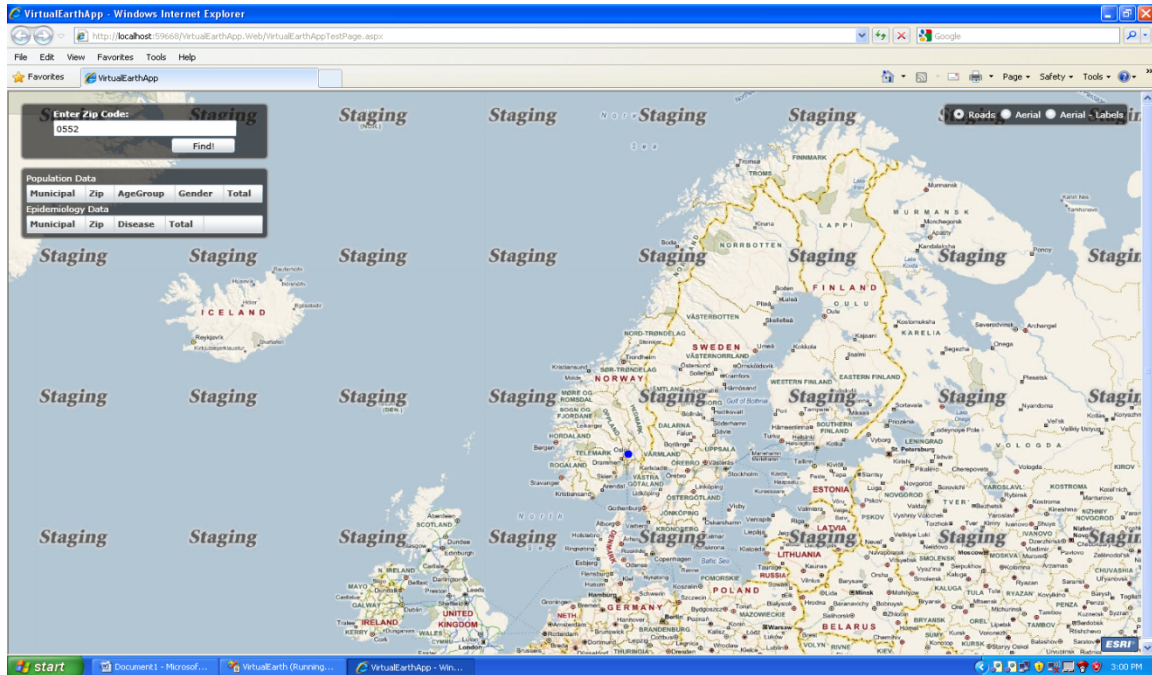


Fig 26: Zip code Search on the Map

Once the zip codes matches, then it will locate that area on the map. We can see blue point on figure 26, which is locating 0552 zip code of Norway. If user enter wrong zip code then system will show display message not found.

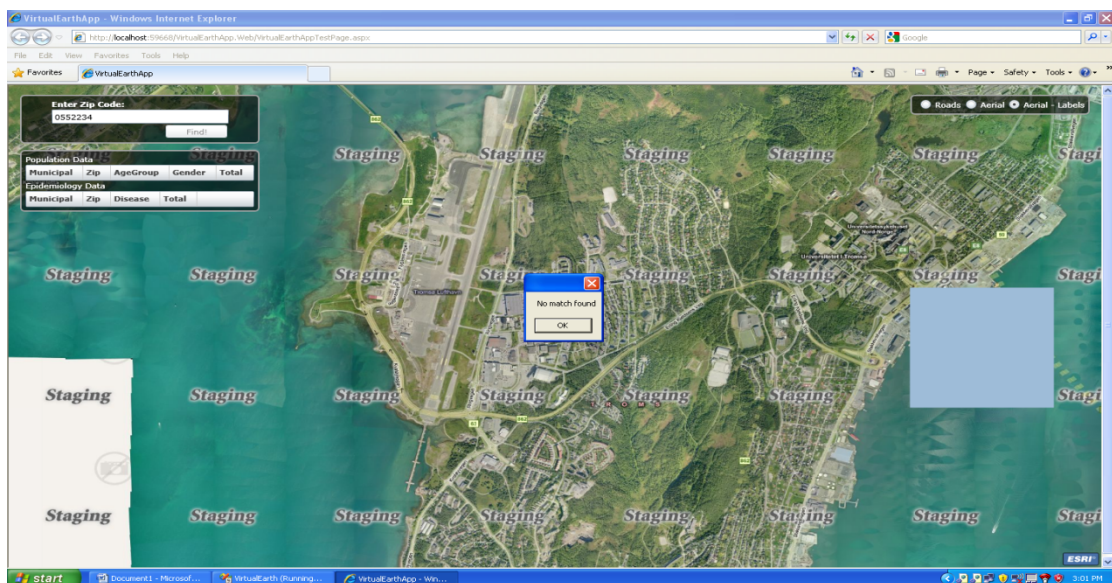


Figure 27: Wrong zip search on the Map

The figure 27 showed that if user enter wrong zip code then system will display message that “no match found”.

Once zip code matches, the system search data in the database. If system found data then it will be retrieved through web services and present on the map.

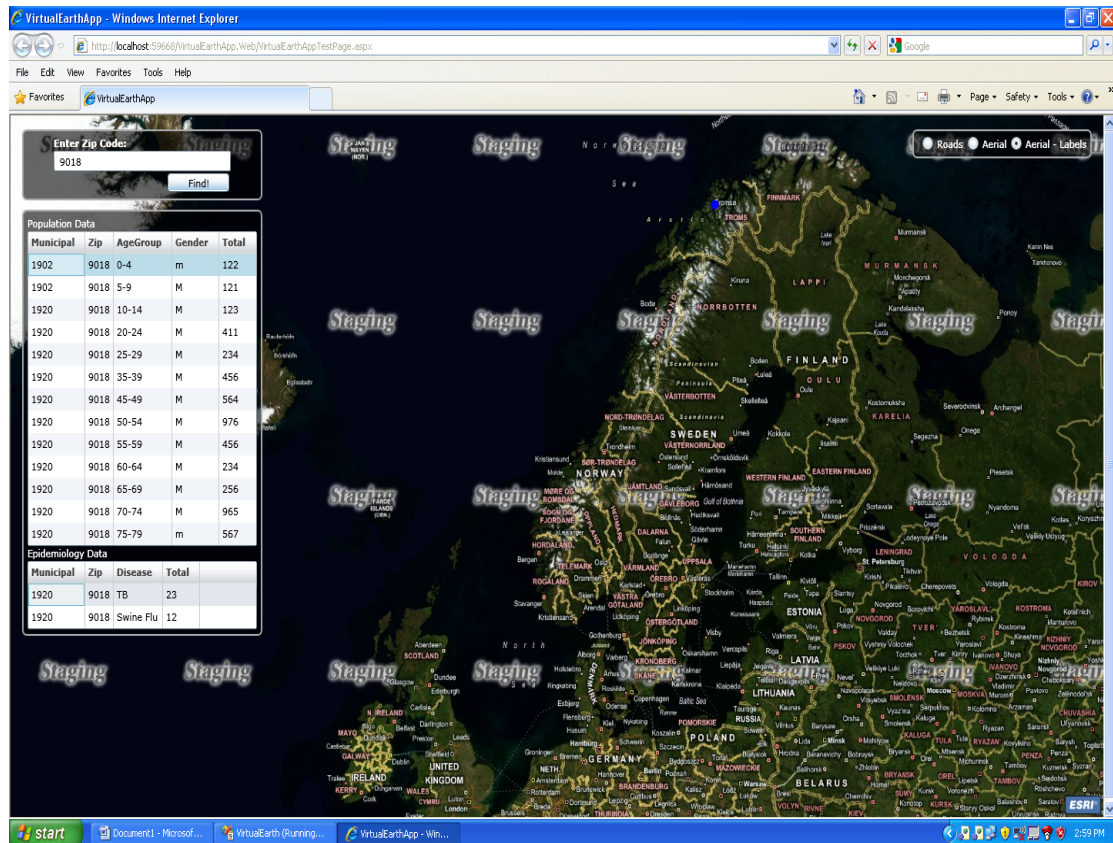


Figure 28: Interactive map with Epidemiology and Population data

Figure 28 demonstrates what the interactive map looks like, once the user gives valid zip codes of Norway then system locate that zip on the map. The user has three different choices to view the map, user can move left right and up down and user can increase the size of map by mouse clicking.

The system will search population and epidemiological data of that zip code area, if system found the data then it will present like in Figure 28.

## 5.5 Limitation of System

We choose the Silverlight as our interactive map presentation, a stable version of Silverlight has not been released yet according to Microsoft there will be stable version by end of June. We faced challenges with adopting new framework and new technology for formulating the solution according to our requirements. The system used remote sever for staging the map, which is also one limitation of the system.

The user must have Internet access to staging maps, the system relies on remote sever so that security can be one issue of system.

We could not get access of real patient data for epidemiological data model and could not able to access Norwegian Health Net for our research, which is also limitation of the system. Due to time limit of our research, we used sample data for a few zip code area of the city Tromsø for our prototype.

## **5.6 Summary**

This chapter described how the interactive diseases map is implemented by using Microsoft .Net framework as a Sliverlight presentation. In the output section, we described the output of the system in different approaches, the prototype demonstrate the possibility of visualizing healthcare data for use in a clinical setting. The prototype can be viewed as generic templates for creating interactive maps and visualize the different kinds data combined with geo-spatial information.



## CHAPTER 6

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### DISCUSSION

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This chapter describes results of the interactive map system and possible interpretations of the results with diseases surveillance system. The master project is based on the diseases surveillance scenario of the Snow Agent System project at NST.

The Snow Agent System was at the time of this thesis work still in the developing phase and had not been implemented at any health care organization. The interactive diseases map system is not implemented in real time so that during this research it is nearly impossible to foresee the real impact of system in a health care organization. The discussion is therefore based on the experiments that was carried out and an interpretation within the diseases surveillance scenario.

#### 6.1 Data Collection and Visualization information

We used Microsoft Virtual Earth as digital map input of the interactive map system. To create and formulate the population and the epidemiology data model, we are required to collect population and epidemiological data. We took the Snow Agent data model as reference data for the interactive disease map system and collected some sample data from Norwegian Institute of Public health, Norwegian statistics and World Health organization. (Bellika, Sue et al. 2007; WHO 2008; NIPH 2009).

We created the data model for the interactive map system and integrated it with Microsoft Virtual geo-spatial data and presented it as a Silverlight presentation. The Silverlight implementation satisfies the cross platform presentation with interactive browser based application.

The ArcGIS API provided and allowed the opportunity to implement geospatial information on the system. The system implements interactive capabilities on the map, some of the points are as follows.

- ❖ Zip Searching

- ❖ Locating Zip on the map
- ❖ Finding attributes of the Zip code Area
- ❖ Presenting Population and Epidemiological data on related to ZipCode

The system has satisfactory performance regarding the above-mentioned features.

The epidemiological and population data are changing with time. The system is implemented using sample population data from Tromsø and Norwegian population statistics. The population is a dynamic variable in the system. The system is required to be updated with changes in population.

The interactive disease map system was developed by consideration of a dynamic population variable. The system demonstrates the feature of integrating population data with the zip code area. When user search a specific zip code area of Norway on the map , then system locate that zip code area and present total number of population living on that area both male and female.

The epidemiological data research itself is a big area of research, collecting and analyzing exact and real epidemiological data during project work was nearly impossible. The epidemiological can be viewed in different dimension with geography, time and population. Different legal prospective and data inspecting regulation of Norwegian law created challenges to collect real patient data.

The system have demonstrated the feature of epidemiological data statistics with population. Assumption of probable disease information was presented on the specific geographic location on the map.

## 6.2 User Experience

The usability, reliability and performance of system can be evaluated after user experience. The system is developed on the basis of the diseases surveillance scenario. The system was developed under consideration of the healthcare professionals as end user of the system. The healthcare professional may be primary care doctors, public health officers, health care researcher or a population officers. We were not able to test the implemented system with real end users. Due to lack of time and immature system we did unfortunately not get real feedback from healthcare professionals.

The system demonstrates the feasibility of visualizing information on the map which can be beneficial from different perspectives.

### **6.3 Functional Requirements**

The interactive diseases map satisfies the functional requirements of the system. The system facilitates the zip code searching in whole Norway. Once the user searches a zip code on the system then the system locates that zip code on the map.

Similarly, the population and epidemiological data were visualized on the map in relation with zip code area.

### **6.4 Usability of System**

The prototype was developed under consideration of providing a solution for visualizing information on the map for the diseases surveillance system scenario. The prototype demonstrates visualizing demographic and epidemiological data by integrating geospatial data. The prototype demonstrated probable bridge among different public health organization to deal with disease outbreak situations.

The system can be viewed as a generic map development model as well. The system demonstrated strong feature of visualization of different data with geo-spatial information. The system framework contributes the technique, methodologies and source code for visualizing map application.

### **6.4 Critique of System**

The system used virtual earth as digital map input, once the system starts running authentication with remote server is required to and get API. The reliability question can be raised; the system cannot guarantee 100% reliability. A problem may occur with a remote server, which affects the reliability of the interactive disease map. The system relies on the Virtual Earth server practically. However, failure of virtual earth is rare. The system security can be also one of issue with system. The system used Internet for communication with virtual earth. The system and data security issue can be raised in real implementation of the system in health care organization. According to Norwegian regulation for sharing health care data, any system is required to use Health Net for sharing and transmitting health care data. Because of many circumstances of both legal and technical, the system does not used Health Net for sharing data.



## CHAPTER 7

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### Conclusion and Future work

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#### 7.1 Conclusion

This chapter provides the conclusion of this master thesis project construction of Interactive Disease Map files and possible future work the prototype. The thesis main problem was to construct an interactive disease map system for Snow Agent System, based on following inputs

- ❖ Digital maps
- ❖ Population Data
- ❖ Epidemiological Data

The major challenges were to create data model for population data and epidemiological data and combining them with digital maps. To make an interactive map system, It is required to allow the end user to interact with system during run time. The system must produce result according to end user interaction. Another challenge was zip code matching on the map of Norway in real time and locate that point on the map. The following questions described the research problem and the developed solutions.

**Question 1:** How can the variable information sources be integrated and represented with the constant input to the interactive diseases map file production system?

The digital map (Microsoft Virtual Earth) is the constant input of the system. The system first requires authentication at Virtual Earth Server for staging map on the screen. Once it is authenticated, system stages Microsoft Virtual Earth in the application, then the system process following two different inputs and integrated with the map.

- ❖ Population Data

- ❖ Epidemiological Data

The disease map file system produce interactive map files according to input variable the population and epidemiological data are stored in the database, data is accessed through web services. Once system fetch data from database then it binds population and epidemiological data in data grid, finally presented as interactive map system to the end user. The chapter 4, 5 and 6 describe how we create the model and implement it.

**Question 2:** How can epidemiological and population model integrated with digital map and presented in an interactive way?

The input variables in diseases map file production system are digital map. They have Zip – Code, Municipality, County and Nation layers, epidemiological and population data. The diseases map file production system is required to produce file that can visualize population and epidemiology data in interactive graphic presentation. We use Microsoft Virtual Earth as digital map of interactive map system and The ArcGIS Silverlight API provides inbuilt map layers in Virtual Earth. The map layers are matches from bottom layer to up approaches and tiles accordance that manner.

The population and Epidemiological data were integrated with geo-spatial information and presented in data grid on Microsoft Virtual Earth. We used Snow Agent System previous data model as reference of our interactive map data model. The population data varies accordance time and there are several reasons for it, either it can be increases or decrease as well. The age groups of population are also diverse so that we have created model for different age groups population and present on the map. We have sampled five zip code areas population data for visualize on the map from different age groups distribution.

The epidemiological data is also related with population data. We have created epidemiological data model for those population and present diseases information among population.

### **Question 3:** How can user interact with the system?

The end user of system is allowed to interact with system during run time. One system stag Microsoft Virtual Earth from server and load it in local host, then a user can search for a zip code area of Norway during run time.

## **7.2 Thesis Contribution**

The main contribution of this master research project was to provide an overview of how to produce interactive mapping solution by integrating different data input with geo-spatial data and present it in an interactive map solution. The research introduces the modelling technique, formulating logic to develop interactive map and deploying mapping solution in Microsoft .NET framework.

The system deployed in diseases surveillance scenario but the concept, logic and modelling approach could be exported or referenced for other area of research as well.

From our research, we showed how to integrate Population and Epidemiology data in interactive diseases map for Snow Agent System. The interactive map system can play an important role in co-ordinating different public health authorities during an outbreak situation.

## **7.3 Future Work**

### **1. Implementing interactive map system in real time.**

We developed an interactive diseases map by integrating population and epidemiological data with geo-spatial information. It demonstrates interaction with the system during run time. The performances of system are at a satisfactory level. In the future, it should be possible to implement interactive disease map system in a real environment with health care professional as end user. The user feedback may change and components of the system might require re-engineering according to user feedback.

### **2. Standardizing diseases code and population code.**

We used sample data from the Snow Agent system project; Norwegian population statics sample data, and Norwegian sample data of age distribution. The thesis demonstrates the possibility of integrating population and epidemiological sample data with geo-spatial information. In the future a standard can be developed for diseases information and population. The system may use international standard of

diseases code (ICD) for diseases information in larger scale of real time implementation.

Similarly, in future the system may use International or European standards for population representation and age-group distribution among population.

#### **7.4 Generic scenario**

The thesis mainly focused on the healthcare scenario and the disease outbreak situation. The system can be viewed as a generic solution as well. The concept of integrating data models with geo-spatial information can be applied in other area.

In future, the thesis concept can be used to develop interactive map in different field for different purposes.



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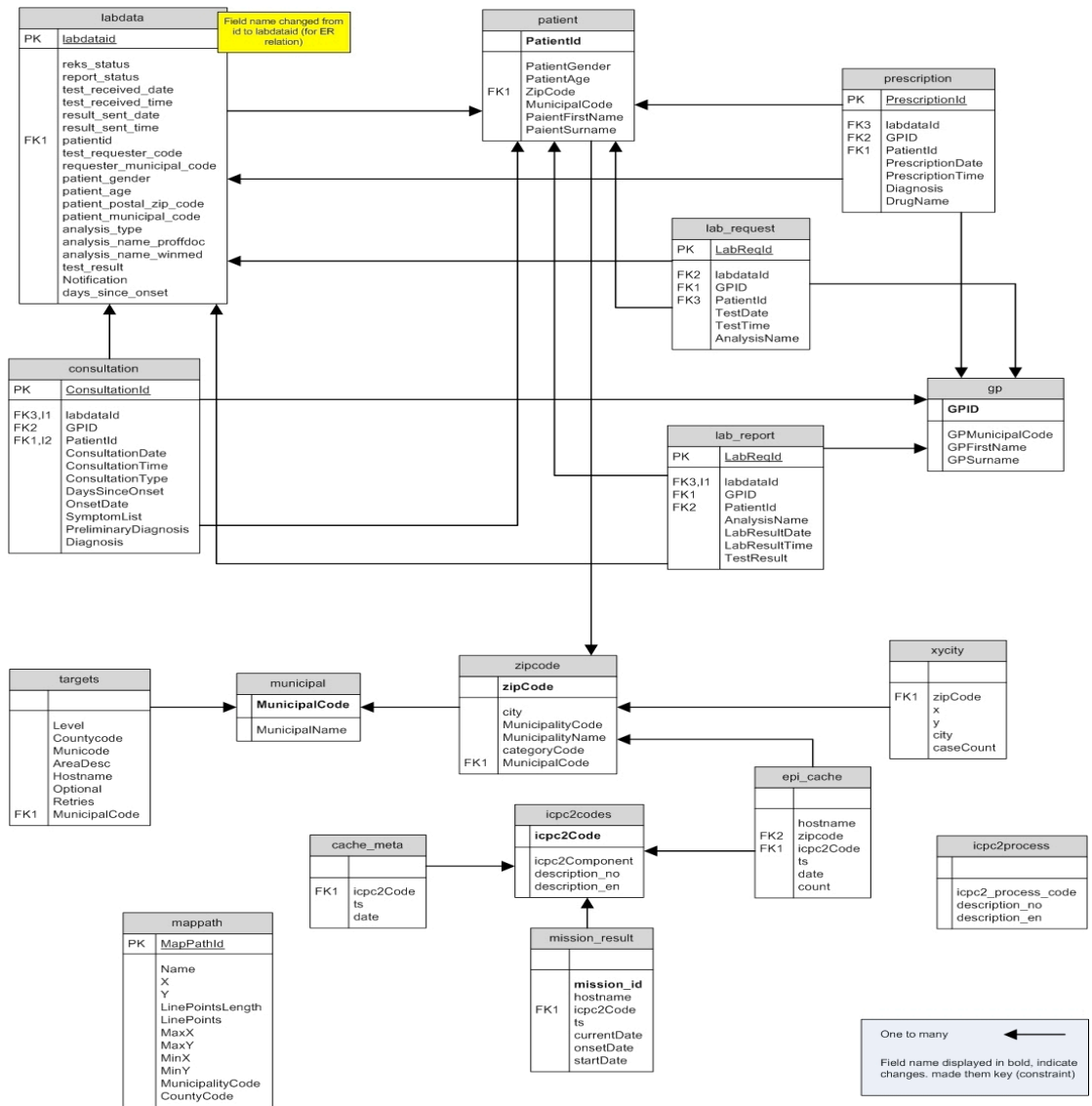
# APPENDICES

## Appendix -1 A: ArcGIS API for Microsoft

### ArcGIS API for Microsoft Silverlight/WPF - Core Library



# Appendix -1 B: Snow Agent System ER Diagram



## Appendix -1 C: Population and Epidemiological Data

SQLite Expert Professional 2.0.22.1840

File Database Import/Export Table View SQL Transaction Scripting Tools Help

Database: vearth(3) Table: population File: D:\Project\Version5\CS\Sharp\_snj\vearth.s3db SQLite Library: sqlite3.dll version 3.6.13

Database Schema SQL Builder SQL Data Design DDL Scripting

Refresh

RecNo	municipal	zip	age	disease	total
1	1902	9012	5-9	M	121
2	1920	9012	10-14	M	123
3	1920	9102	15-19	M	123
4	1920	9012	20-24	M	411
5	1920	9012	25-29	M	234
6	1920	9012	35-39	M	456
7	1920	9012	45-49	M	564
8	1920	9012	50-54	M	976
9	1920	9012	55-59	M	456
10	1920	9012	60-64	M	234
11	1920	9012	65-69	M	256
12	1920	9012	70-74	M	965
13	1920	9012	75-79	m	567
14	1902	9015	0-4	m	122
15	1902	9015	5-9	M	121
16	1920	9015	10-14	M	123
17	1920	9102	15-19	M	123
18	1920	9015	20-24	M	411
19	1920	9015	25-29	M	234
20	1920	9015	35-39	M	456
21	1920	9015	45-49	M	564
22	1920	9015	50-54	M	976
23	1920	9015	55-59	M	456
24	1920	9015	60-64	M	234
25	1920	9015	65-69	M	256
26	1920	9015	70-74	M	965
27	1920	9015	75-79	m	567
28	1902	9018	0-4	m	122

<Filter is Empty> Record 1 of 55

SQLite Expert Professional 2.0.22.1840

File Database Import/Export Table View SQL Transaction Scripting Tools Help

Database: vearth(3) Table: epidemlogy File: D:\Project\Version5\CS\Sharp\_snj\vearth.s3db SQLite Library: sqlite3.dll version 3.6.13

Database Schema SQL Builder SQL Data Design DDL Scripting

Refresh

RecNo	municipal	zip	disease	total
1	1902	9015	Malaria	2
2	1920	9017	TB	3
3	1920	9018	TB	23
4	1902	9012	SARS	22
5	1902	9015	Swine Flu	32
6	1920	9017	Bird Flu	11
7	1920	9018	Swine Flu	12

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