Thesis for the Degree of Master of Engineering

Design and Implementation of an Evacuation Path Generating System using KML and Web Map Services

by

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Interdisciplinary Programs of Information Systems

The Graduate School

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February 2012

Design and Implementation of an Evacuation Path Generating System using KML and Web Map Services (KML 및 웹 맵 서비스를 이용한 대피경로 생성 시스템 설계 및 구현)

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by

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KML 및 웹 맵 서비스를 이용한 대피경로 생성 시스템 설계 및 구현

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요 약

대피소로 신속히 대피하는 것은 긴급상황에서 재해에 대처하는 방법중에 하나이며, 최적의 대피로는 중요한 요소이다. 위험지역에 있는 사람의 현재 위치를 기반으로 가장 가까운 대피소 혹은 최단경로와 같은 정보들을 통해 대피수단을 최적화 할 수 있다. 이러한 정보들은 사람들이 편리하게 사용할 수 있는 스마트폰, 웹, 데스크탑 기반의 응용프로그램과 같은 플랫폼으로 쉽게 접근될 수 있어야 한다. 그러나 이러한 정보를 위한 실시간 재해 데이터와 사용자 위치를 기반으로 수행 가능한 'on-the-fly routing'의 계산은 막대한 양의 공간데이터와 이를 처리할 수 있는 고성능의 컴퓨터가 하다는 제한성을 가진다. 그렇기 때문에 이러한 수행과정은 서버에서 완료 되어야하며, 사용자는 최적의 정보만 확인할 수 있도록 해야 한다.

사용자에게 믿을만한 정보를 생성하기 위해서는 서버의 공간 데이터 프로세싱에 대한 도로망, 대피소, 병원, 긴급 의료기관, 재해지역 등을 포함하는 가장 최근의 데이터가 필요하다. 이러한 데이터셋은 서로 다른 데이터공유 정책으로 제한되기 때문에 그들에게 적합한 다른 구조로 생성이 이루어진다. 다행히 Spatial Data Infrastructure(SDI)라 불리는 프레임워크는 재난관리를 위해 이러한 데이터들의 생성과 공유를 가능하기 때문에 데이터셋에 접근하여 검색 및 처리할 수 있는 환경을 생성한다.

본 논문은 Open Geospatial Consortium (OGC)표준을 사용하여 데이터 처리에 있어서 하나의 웹 기반에서 다양한 온라인 공간데이터 네트워크에서 데이터 셋의 통합을 초점으로 하고 있다. 본 논문에서 개발한 시스템은 OGC 표준에 따르는 분산된 데이터 소스를 통합 할수 있을 것이다. 이러한 데이터 소스를 사용한 지오프로세싱은 가장 적합한 대피소 또한 사용자의 현재 위치에서 대피소까지의 경로는 네트워크 분석을 사용하여 만들어 낼 수 있다.REST기반의 웹 서비스를 사용하는 표준 데이터 출력 형식은 대피소와 경로 정보를 제공 할 수 있을 것이며, 이러한 정보는 스마트 폰과 웹 브라우저에서 Rich Internet Application(RIA) 그리고 데스크탑 기반 매핑 애플리케이션을 이용하여 사용자에게 제공 할 수 있다.

Design and Implementation of an Evacuation Path Generating System using KML and Web Map Services

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Abstract

The rapid evacuation to disaster shelters are one of the actions involved in the disaster response phase of emergency management. Evacuation to the shelters can be optimized by giving instructions to the evacuees such as suitable shelters and shortest routes from their current location. This information should be readily accessed to evacuees using the platforms of their convenience such as on smartphones, web based applications or desktop applications. However, performing on-the-fly routing calculation based on real time disaster data and user position requires large amount of spatial data and computing power. Therefore, the processing must be done in servers and only its results are shown to users.

In order to produce reliable information to users, the spatial data processing in servers requires most updated data including road networks, potential shelter, hospitals, medical emergency stations, disaster areas, etc. These dataset are produced by different organizations and therefore are also constrained to their data sharing policy. Fortunately a framework called Spatial Data Infrastructure (SDI) can facilitate these data production and sharing for disaster management. It creates an environment in which dataset can be accessed, retrieved, and processed.

This thesis focuses on integrating dataset from various online spatial data networks into one web based data processing using Open Geospatial Consortium (OGC) standards. The system developed in this thesis allows the integration of any remote data sources which are published according to OGC standards and present them to the users. By using these data sources, geoprocessing to select the most suitable shelters can be done. Furthermore, routes from user current location to the shelters can be produced using network analysis. Standard data output format which are transferred using REST based web services provides the shelters and routes information to users which can be presented using smartphone and Rich Internet Application (RIA) on web browser and also desktop based mapping application.

1. Introduction

1.1. Background

The goal of evacuation plan is to guide all evacuees into the safety area. To achieve this goal, an effective evacuation plan necessary. Busan Metropolitan City has designated several dedicated site for emergency shelter. Moreover, it also defined several facilities regarded appropriate as temporary shelters including schools, churches and other public facilities due to its traditional usage as venues for community gatherings. Evacuation to these shelters needs to be performed in timely manner to minimize casualties in disaster. Moreover, information on shelters and routing should be easily available to users using smartphone, web based or desktop application. However, shelters selection and routing generation requires a lot of processing and manipulation of several data sources. Therefore it needs to be done in the server with spatial data processing capability and only the results are sent to clients.

With the advancement of technology in spatial data creation, spatial data is created and owned by many different agencies that utilize spatial data to satisfy their own needs. The fragmentation of spatial data owners causes diversity in policies related to spatial data, and standards and tools to manage and coordinate spatial data. The diversity of approaches in data coordination leads to inconsistency and heterogeneity among multi-source spatial datasets.

The diversity of spatial data requires a sharing platform to facilitate access and integration of data. Spatial Data Infrastructure can be used for this purpose. With a framework that maintains standards, access and interaction of spatial data, processing of these distributed data can be done. Moreover, this framework also enables output to be presented in multiple platforms for easy access to appropriate shelter and route generation.

1.2. Problem Statement

Reliable and up-to-date spatial data are required for proper response by citizen. These spatial data are often produced by different agency involved in disaster management. Users need a platform where these data can be viewed in single application. The system developed in this thesis will allow integration of any remote data sources that publish data consistent with OGC standards and present it to the users.

Moreover, in emergency situation, evacuation to a safe shelter is needed. Evacuation plan consists of shelter selection and routing to the selected shelter. These require geoprocessing and routing analysis using multiple data source. The process should be done in a server which will return a standard format output which is accessible in multiple formats.

1.3. Thesis Objective

This research project aims to develop a system which enables viewing of different spatial data sources from multiple agencies. Moreover, it will provide a feature for shelter selection and route generation in case of emergency based on disaster and user location.

The research project has three main objectives:

1. Identify the possibility of multiple data source integration on the medium of web service using OGC standards
2. Using the data source to generate appropriate shelter selection and routing based on user position
3. Design and develop system that enable viewing multiple data source and result of shelter selection and route generation in multiple platform using a standard output data format.

1.4. Scope

Busan Metropolitan City has designated several dedicated site for emergency shelter. Moreover, it also defined several facilities regarded appropriate as temporary shelters including schools, churches and other public facilities due to its traditional usage as venues for community gatherings. Therefore, this thesis will focused on generating shelter selection and route generation in Busan area, specifically Nam-Gu.

The shelter selection uses a disaster damage area data source. This data source is one of the inputs of the whole geoprocessing. However, this thesis will not specify how to determine the area of disaster.

1.5. Thesis Outline

The thesis has been divided into five chapters which are:

Chapter I, Introduction

Introduction consists of thesis background, problem statement, thesis objective, scope, and thesis outlines.

Chapter II, Literature Review

Literature Review explains the theoretical supports and methods. It includes explanation about disaster management systems, Spatial Data Infrastructure, OGC Standards and Evacuation plan using Geoprocessing model and Network Analysis.

Chapter III, System Requirements and Design

This chapter contains the functional requirements and actors involved in the system. It includes geoprocessing model and network analysis model. Furthermore, it also includes UML design of the system such as Use Case Diagram

Chapter IV, System Implementation for Shelter Selection and Evacuation Path

System Implementation contains the process of development using RIA tools such as Silverlight, Web service programming and smartphone application programming. It is also consists of the overal architecture of the system and the database schema.

Chapter V, Comparison

This chapter contains the review of related works and how the proposed system compared with the reviewed works.

Chapter VI, Conclusion and Future Work

This chapter contains conclusions and additional features that is required but not yet developed in the thesis.

2. Literature Reviews

2.1. Disaster Management

Disaster management is defined as a cycle of activities including mitigation, preparedness, response and recovery as defined in figure 2.1[1].

(a). Mitigation includes any activities that prevent an emergency, reduce the chance of an emergency happening,

(b). preparedness includes plans or preparations made to save lives and to help response and rescue operations,

(c). response includes actions taken to save lives, such as seeking shelters or any activities take place during an disaster, and

(d). recovery includes action taken to return to a normal situation after disaster

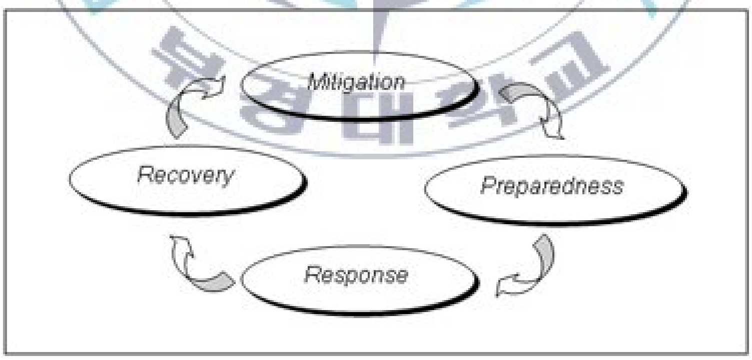

Figure 2.1. Disaster management phase

The hazard and vulnerability assessment and mapping of disaster response agents are the first and foremost step in starting the cycle. All data is critical for whole phases of disaster. These data can be defined in two categories which are:

- Pre-disaster baseline data about the history and risks of disaster
- Post-disaster real-time data about the impact of a disaster and the resources available to manage it

The ability to make a right decision on disaster management can be greatly enhanced by completeness of the information. However, information management and processing in disaster management are challenging due to the unique combination of characteristics of the data in this domain, which include [3]:

1. A large number of producers and consumers of information
2. Time sensitivity of the exchanged information
3. Various levels of trustworthiness of the information sources
4. Lack of common terminology
5. Combination of static (e.g., maps) and dynamic (e.g., damage history) datasets
6. Heterogeneous formats, ranging from free text, XML and multimedia data

Pre-disaster baseline data, such as damage history, are important in performing comprehensive spatial analysis for disaster management. It is noted that disaster or damage history needs a considerable amount of resources to produce and disseminate (1), to keep updated (2), to validate (3) and to integrate (4,5,6).

Those data can be gathered from the key parties involved in disaster management process which are[2]

- Communities, the most vulnerable and vital people-centered early warning system. The proposed system will use the communities as one of the provider of disaster data.
- Local governments, as provider of considerable amount of knowledge of the hazard in their governed area
- National governments, which responsible for policies and frameworks to gather all the resources in their respective country.
- Regional institutions and organizations that provides specialized knowledge to advice national efforts on managing disaster.
- International bodies to foster the exchange of data and knowledge between individual contries.
- Non-government organizations and its role to advocate government.
- Private sector who is better equipped to implement information system based solution in their disaster plan.
- Media for dissemination of disaster information
- Scientific community for providing scientific and technical input to assists governments and communities.

There should be a system in which all of the parties can produce and share data in one platform.

2.2. Evacuation Plan

The rapid evacuation to disaster shelters are one of the actions involved in disaster response phase of disaster management. The goal of evacuation plan is to guide all evacuees into the safety area. To achieve this goal, an effective evacuation plan necessary. Evacuation plan should covers four critical decisions, such as[5]

(i) decide where to evacuate people (shelter destination)

(ii) decide the best route to shelter

(iii) regulate flow of traffic to destination

(iv) determine rate of evacuees admitted to shelter from different areas or region.

Shelters are important in order to provide safe space for the displaced victims. However, maintaining several sites solely for the shelters is costly because it is only used in case of disaster. Therefore, a cost effective solution is to identify existing facilities (e.g. community centers, churches, schools) that are physically and socially (population-wise) suitable for temporary evacuation shelters.

There are several researches conducted to determine variables to support shelter destination selection. The variables included in the shelter suitability model based on other studies including:

- Flood zone: shelters should not be located inside a flooded zone[1]
- Proximity to highways and evacuation routes[2]
- Shelter coverage of danger area [3]
- Proximity to health care facilities.[4]

Determining danger area is one of the variables required in shelter site selection. Danger area can be determined according to disaster type. The Federal Emergency Management Agency (FEMA) provides taxonomy of disaster and hazard events and categorizes them into three types: man-made, natural and technological (FEMA 2006). The different categories of events are shown in Figure 2.2. It can be divided into two categories which are expected or unexpected disaster. Unexpected emergency events are those events that give emergency responders short or no advanced notice to react. In other words, the responders have no time or only have a small amount of time to prevent or prepare for the impact of the impending event. Examples of these types of events are tornadoes, earthquakes and even human-caused events such terrorist attacks[9].

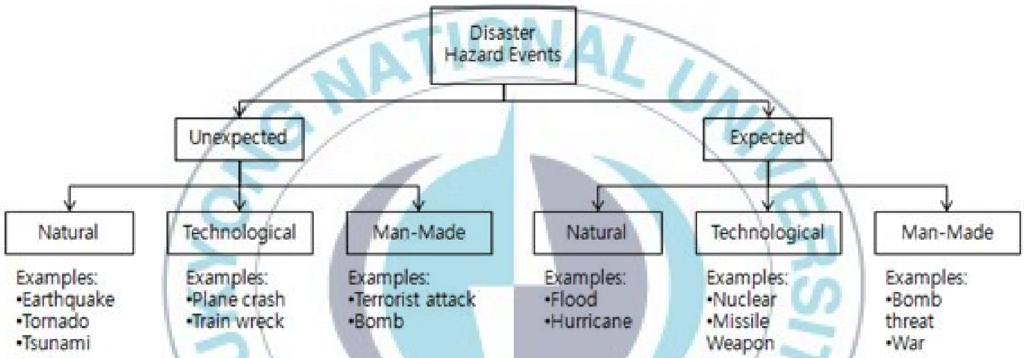

Figure 2.2. Disaster categories

This thesis covers evacuation route planning for expected disaster, such as hurricanes, wildfires, flooding which allow more time to prepare for protection of property and evacuations of citizens in the targeted area. In this case, emergency management officials have some a priori knowledge about the type of event, the trajectory of the event, scale of the event, and the location of the targeted areas. Therefore it can determine the size of danger area to be used for shelter selection.

This thesis assumes that damage data is updated by emergency management agency and readily available before the incident occurs and obtained through the expert opinion or policies. If the damage area is changed that means shelter selection is changed and another geoprocessing need to be performed. This is easily done using distributed datasets and geoprocessing using web services.

2.3. Spatial Data Infrastructure

Lemmens described five unique features that distinguish spatial data from other types of scientific data [3]. Those features include:

1. Multiple versions - Versions of the same entities of the earth's surface may differ in terms of data models, scales that are mostly collected by different agencies
2. Implicit linking - In general data, explicit references must be presented to combine information from multiple sources in a meaningful manner. Spatial data enable linking without explicit references, i.e., via a coordinate reference system.
3. Massive datasets - Compared to general (administrative) information, spatial data would be massive. In case of satellite imagery, for instance, raster data volumes would be huge.
4. Maps as implicit interfaces - Everyone is familiar with reading maps, so they are a natural manmade interface for representing spatial data.
5. Spatial data is geometry based - It is possible to apply many mathematical tools in Geo-services (such as to compute the distance between two objects or compute the buffer around an object) whereas other data types use only limited operations such as string manipulation or statistical operation.

Before mass use of the Internet and its technologies, spatial data for a particular location had been stored in different physical locations and often used based on different standards or formats. This made it difficult for a potential user to access and utilizes the data. Potential users of this disordered data might be an organization that could not afford to acquire data on their own, or access needed data from outside their organization.

An SDI is a coordinate series of agreements on technology standards, institutional arrangements, and policies that enable the discovery and use of geospatial information by users and for purposes other than those it was created for, Steigner[4] deduct the following key characteristics of SDI:

1. Spatial Data (or Spatial Information),
2. Technologies, i.e: hardware and software,
3. Laws and Policies
4. People, i.e: data providers, users and
5. Standards for data acquisition, representation and transfer.

Due to the need for collaboration in spatial data production and sharing for disaster management, an SDI can be used as an appropriate framework to facilitate disaster management. This is because it creates an environment in which agents can access, retrieve and disseminate disaster data. Moreover, it can provide a framework for spatial data integration process which is depicted in figure 2.3.

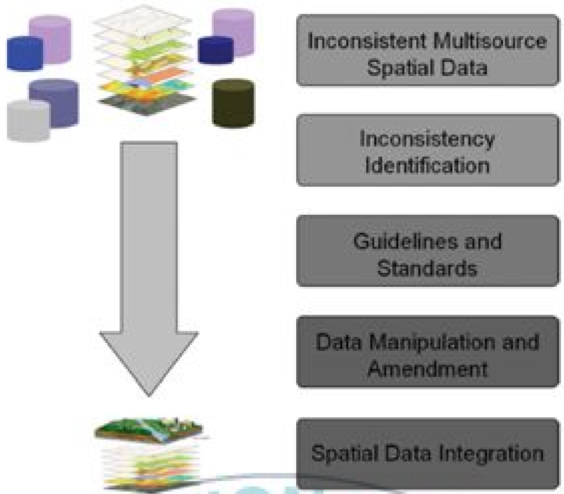

Figure 2.3. Spatial data integration

In this paper, we use and define the technological key characteristics to build SDI for disaster management. We will answer questions such as: What are the standards required to collect spatial data from several sources, manipulate, transfer and finally present it to users on different platforms? What is the technology required for developing the system? Lastly, how can people contribute to complete the disaster information?

2.3.1. Open Geospatial Consortium (OGC) Standards

OGC is an international industry consortium formed by numbers of companies, government agencies and universities participating in a consensus process to develop publicly available interface standards. These standards play an important role in the dissemination and processing of spatial data. In general, they describe communication protocols between data servers, servers that provide spatial services, and client software, which request and display spatial data. In addition, they define a format for the transmission of spatial data. This paper identifies the following OGC standards that are required to build an SDI required for our system:

- WMS (Web Mapping Service) provides a simple HTTP interface for querying and accessing map layers from mapping server
- WFS (Web Feature Service) which operations support INSERT, UPDATE, DELETE, LOCK, QUERY and DISCOVERY operations on geographic features from the feature server using HTTP
- KML is an XML language focused on geographic visualization, including annotation of map and images. It is primarily used by Google Map family

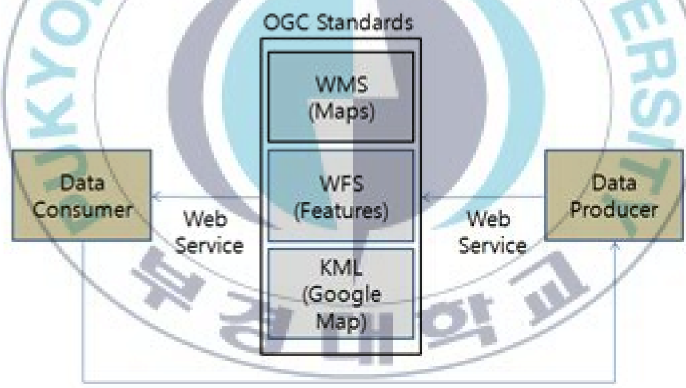

Figure 2.4. OGC standards used in the system

Figure 2.4 shows the implementation of those standards in the proposed system. Data producer includes the agents involved in providing disaster data. All of this data will be collected and manipulated so it will conform as the input for the standards. Data consumers are administrator and users.

Users primarily interact with KML formatted data because disaster data will be presented to the platform which is most comfortable for them to use which is Google Map. For administrator, additional capability for editing data is needed. Therefore, the system enable administrator to use WMS for interaction with the map layer and WFS for manipulating feature inside the map layer. These data delivery standards will use ordinary XML format for data transfer. Administrator will use another browser-based or desktop-based application in order to manipulate these spatial data. All of the data transfer will be done using web service on top of HTTP protocol.

Muehlen, et al. compared two types of Web Service protocol platforms, REST and SOAP [6]. REST is an architectural style described by Fielding [7]. In REST architecture, objects are identified by a URI and specific message protocols such as PUT, POST, GET, and DELETE are used to process the data objects. A request message sent to an object results in the processing for accessing or manipulating the objects, typically in the form of an XML document. This document provides the client with the ability to change the state of the data objects.

While SOAP based architecture is applicable in certain frameworks, it is inferior to REST based Web Service architecture in terms of both network bandwidth utilized when transmitting service requests over the Internet and the round trip latency incurred [8]. Therefore, to maximize bandwidth usage for data exchange, the system is developed based on the REST architecture.

2.3.2. Web Based Geoprocessing Service

Geoprocessing services turn simple input data into useful geographic information. It contains geoprocessing tasks accessible by clients[8]. Tasks are created by publishing geoprocessing toolboxes or map documents containing tool layers. When a geoprocessing task called, it executes on the server computer, using resources of the server computer. Geoprocessing services and their tasks are accessed across the public Internet and private intranets and will be used in this system to generate the shelter selection. Web clients are lightweight applications which only know how to send packets of simple data to a server, such as text, numbers, and uncomplicated geographic features. A geoprocessing service takes this simple data; processes it; and returns some meaningful and useful output, such as the probable evacuation area for a hazardous chemical spill, the predicted track and strength of a gathering hurricane, a map of land cover within a user-defined watershed or a parcel map with historical details of ownership[3].

In this thesis, geoprocessing involves multiple tasks connected together in a geoprocessing model. Geoprocessing model is a series of tasks which are combined together to achieve a common purpose.

2.3.3. Network Analysis

A network is a system of interconnected elements, such as edges (lines) and connecting junctions (points), that represents possible routes from one location to another. Network analysis is a procedure that navigates through the connectivity of the transportation network to yield meaningful results, such as finding all elements upstream of a point or the shortest path between two points[9]. The analysis has several functionalities including: route, closest facility, service area, and origin-destination cost matrix. This paper will use closest facility service which determine the closest shelter from user location and generate the routing from user to the shelter. The closest facility service uses variant of Djikstra algorithm on shortest path calculation. It modifies the algorithm to include several constraints on the calculation which are included in a network dataset property in figure 3.

Network datasets is the core geodatabase network model for representing undirected networks, particularly transportation networks. When creating a network datasets, special attributes can be added such as hierarchy (road classification, such as highway, major road, minor road levels), elevations (setting the physical level of roadways), one way or vehicular restrictions, and cost of travel time or distance traveled. Usually, commercial data vendors include these attributes when creating their datasets on street networks.

In calculating route, result of network analysis solver performance depends on impedance chosen by the user. If the impedance is time, then the best route is the quickest route. If it is distance, then the best route is the route that has the shortest distance between origin and destination. This impedance is chosen from network attributes in network datasets.

3. System Requirements and Design

3.1. System Architecture

In order to accomplish the objectives of the thesis which relies on using web services to integrate multiple datasets, there are several requirements that need to be fulfilled such as (i) Decentralization for offering autonomy and independence for data producer to use and manage their own data, (ii) Accessibility for offering access to the system using web service enabled device, (iii) Up to date which means data displayed in the application must be the latest data produced by disaster related organization.

According to these requirements, the logical architecture of the proposed system are defined in figure 3.1 which includes the interaction among three layers: Data Layer, Service Layer, and Application Layer.

1. Data Layer consists of datasets used by the system. It classified into three sections:

- Busan UIS Data : It contains data from Busan Urban Information Systems and used for Disaster Prevention Systems
- Shelter selection & evacuation path analysis datasets : It contains datasets which are used in performing shelter selection and evacuation path analysis.
- Useful datasets : This dataset is dynamically linked by organization managers or users which post their dataset to the system. It contains

data which is related and is useful for disaster management process but not necessarily used for shelter selection and route analysis. It can be trusted data from trusted organizations or contains unrelated data. Therefore, site administrators must verify the data before it can be shown to citizens.

- User management : This dataset deals with user management, especially with organizational managers because they can add their datasets to the system.

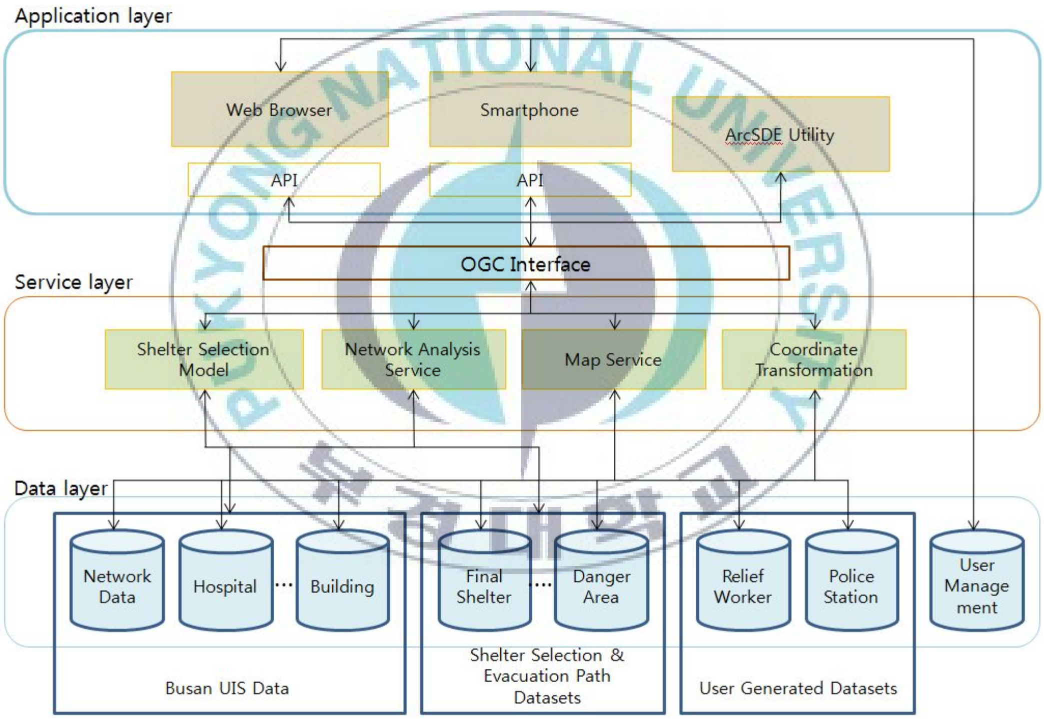

Figure 3.1 Logical architecture

2. Service Layer consists of services published by the system

- Spatial analysis for shelter selection : It processes the dataset in order to generate appropriate shelters.

● Network analyst service generates routes based on input given by user and the result from spatial analysis for shelter selection. Figure 3.2 shows the detail of the service and its parameters in web browser. The service is asynchronous so the application can perform other tasks without having to wait for the calculation to complete.

Figure 3.2. Network analysis service

● Map service hosts KML files and WMS data representational standard: KML is a Google based XML schema to perform geographic tasks and finally adopted as a standard by OGC. Figure 3.3 describes the typical sample of a KML which is used for damage report while figure 3.4 describes the detail of the web service for WMS standard.

```
▼<kml xmlns="http://www.opengis.net/kml/2.2">
  ▼<Document>
    ▶<Style id="FD">...</Style>
    ▶<Style id="WV">...</Style>
    ▶<Style id="LS">...</Style>
    ▶<Style id="WD">...</Style>
    ▶<Style id="SN">...</Style>
    ▶<Style id="FR">...</Style>
    ▶<Style id="WF">...</Style>
    ▶<Style id="TS">...</Style>
    ▼<Folder>
      ▼<Placemark>
         <name>CD201111160003</name>
         <description>Reported flood in Nam-Gu area</description>
         <styleUrl>#FD</styleUrl>
        ▼<Point>
           <coordinates>129.090514,35.193032</coordinates>
         </Point>
       </Placemark>
      ▼<Placemark>
         <name>CD201111160002</name>
         <description>An accident happens near Gwangan bridge</description>
         <styleUrl>#FD</styleUrl>
        ▼<Point>
           <coordinates>129.106749,35.190291</coordinates>
         </Point>
       </Placemark>
```


Figure 3.3. KML for damage report

Figure 3.4. WMS MapServer for Hospital data

- Coordinate transformation transforms the projection used by the map server to the default projection used by the system. In this thesis, there are two supported coordinate projections which are Web Mercator and WGS84

3. Application layer deals with the user interface, user interaction and data visualization. It consists of two different GUI for each web browser and smartphone. It has a direct connection with User Management database.

- API (Application Programming Interface) is a collection of classes and procedures that connects the application with OGC interface.
- ArcSDE Utility is Spatial DBMS used in the system

3.2. Functional Requirements

The functional requirements describe the possible effect of the system or what the system must accomplish. Based on the studies in the literature review, we determine the functionalities that are needed for the application are as follows:

- Able to represent spatial information from several data sources using layers and integrate them in one map using supported spatial projection and OGC standards
- Able to determine suitable shelters based on spatial analysis on disaster location and data source layers
- Able to generate shortest route from user current location to the shelters

These capabilities should be presented to three types of users involved within the system, which are depicted as actors in figure 3.5:

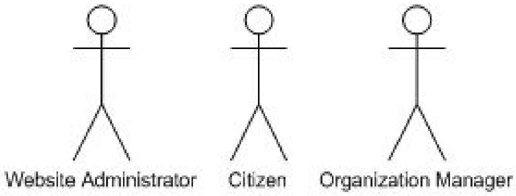

Figure 3.5. Usecase diagram actors

Website administrator is a super user or an administrator of the system. He/she is responsible in managing the server, user, and database. Therefore, this actor can perform all tasks defined in the system. Organization manager is the person who posts their own data source to be used by the system as map layers or used in performing shelter site selection. Citizen is general public who uses the system to view the available shelter and to generate route from his/her own location to that shelter.

The actors are capable of performing these following tasks using the proposed system:

1. Layer Management

- Add, edit or remove spatial data sources URL address and information to the database for both website administrator and organization manager. Website administrator is responsible for screening all the data sources posted in the system.
- Add, or remove spatial data sources as layers to map for all actors

2. Shelter Selection and Evacuation Path Analysis

- Users can view the latest disaster happening from the map and generate the suitable shelters

- User can generate the shortest routes to the shelter.

3. User Management

- Website administrator can add manage users or organizational managers

Table 3.1 list summary of the relationship between features, users and use case which are depicted in Figure 3.6

Features	User	Use case
Layer management	Website Administrator	Manage published datasets
	Citizen	Manage layers on map
	Organization Manager	Publish Datasets
Shelter selection and evacuation route analysis	Citizen	Generate shelters Generate paths Add current location
User management	Website Administrator	Manage users
	Organization Manager	Register user

Table 3.1. List of use cases

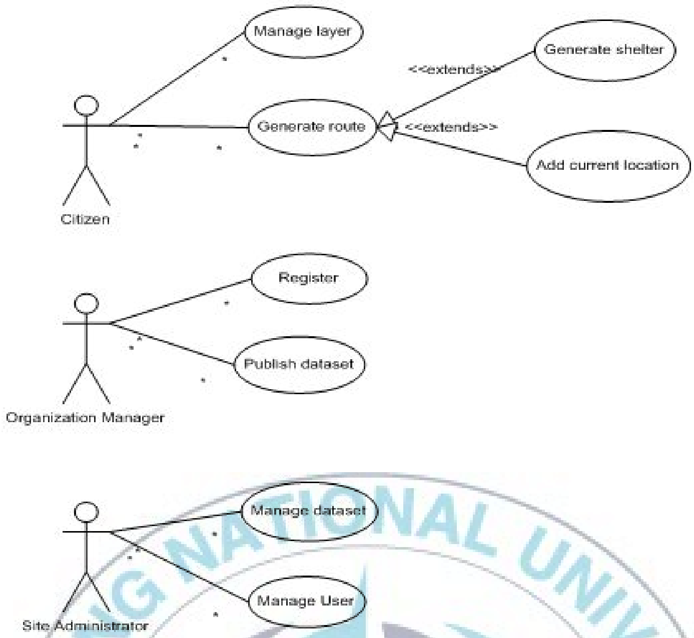

Figure 3.6. Usecase diagram

3.3. Spatial Analysis Model

3.3.1. Web Service Chaining

A service chain is a sequence of service where, for each adjacent pair of services, an occurrence of the first action is necessary for the occurrence of the next action. By using web service chaining, all of the data sources which located in separate places can be shown in layers on map as well as manipulated to add additional information to users. Figure 3.7 shows how the chaining is done in order to provide a complete layer of data on the map.

By using a distributed data sources approach, data is not exclusively used by this application, but it can also be reused by another application such as Building datasets for building inspection or Road datasets for traffic application. All of these applications will access the same version of datasets.

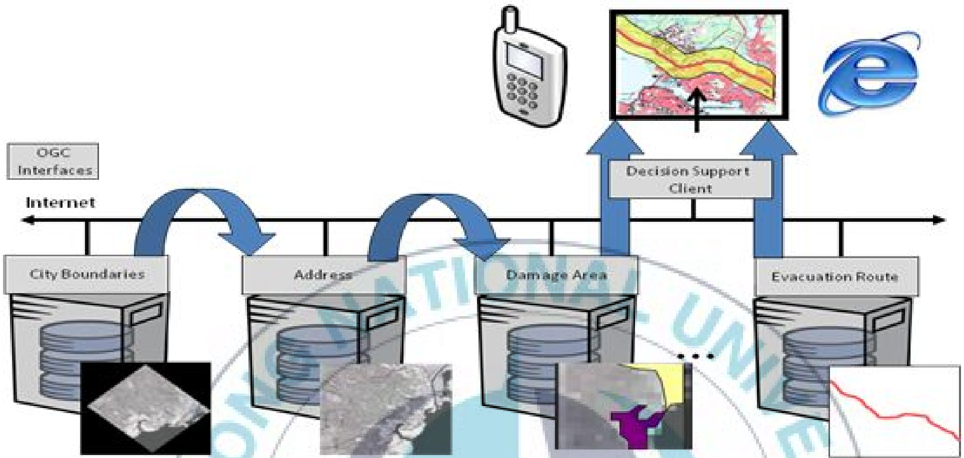

Figure 3.7. Web service chaining

3.3.2. Shelter Selection Model

Based on review on related works, four factors are defined to determine shelter selection for evacuation plan. These factors are:

1. Shelter coverage of danger area : the more coverage of the shelter on the danger area, the more suitable the shelter is
2. Proximity with major road network : shelter which are located near a major transportation route is considered to be more suitable candidate
3. Proximity with medical facilities : this is important in order to treat evacuees who need medical attention
4. Location outer than flood history and hazardous place : shelter must be

located in a safe building far from flood or dangerous facilities.

Shelter selection process uses these factors in determining the most appropriate facility for evacuation destination. Each of the four factors was reclassified into five intervals, and a factor rating was assigned to each interval. Existing facilities are given score for each of the factors. Facilities with the highest accumulative scores are selected as evacuation destination. However, the selection of factors scores is one of the most controversial parts in selection suitable shelter[4]. Assigning score to each of the factors requires detailed study about the factors and its impact to site suitability. Therefore this thesis will assume that each of the factors has the same weight.

In order to select the interval for each factor, natural breaks (Jenks) will be used. Natural breaks is done by identifying break points by picking the class breaks that best group similar values and maximize the differences between classes. The data are divided into classes or intervals whose boundaries are set where there are relatively big jumps in the data value. Geoprocessing model is performed to select and give interval and scores to each facilities. When the result is generated, scores will be assigned to each variable and sum them to generate the most appropriate shelters. The number of the shelters needed is provided by the administrator.

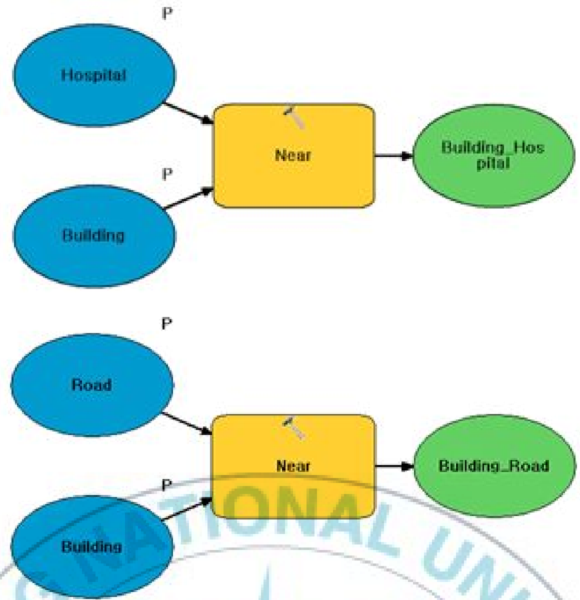

Figure 3.8. Building "Near" operation with Hospital and Road

In figure 3.8, the spatial analysis process is displayed. The oval symbol represents Input and output data while rectangle symbols represent operation on those data. Moreover, for the input, there are additional P symbols which represent a Parameter. Therefore, oval symbols are input variables.

During the geoprocessing, these data are manipulated and its fields are calculated. By performing “Near” operation as depicted in the figure with Hospital data and Road data, system will generate additional fields in Building layer which is NEAR_ID and NEAR_DIST which contains ID of the Hospital or Road which is closest to the Building. Therefore, there are two additional datasets generated by the system which are Building_Hospital and Building_Road.

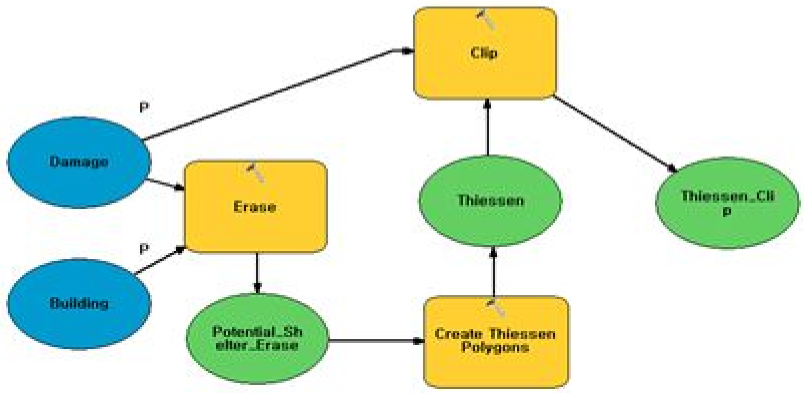

Figure 3.9. Thiessen operation

Next, "Thiessen polygon" operation described in figure 3.9 Thiessen polygon is used to describe the area of influence of a point and determine which building that has the most coverage of dangerous area. Result of this data is saved in Thiessen_clip dataset.

These generated datasets are saved in the database and it is refreshed when there are new processing inputs submitted by users. The application assigns score to each of the building by using the NEAR_DIST value from Building_Hospital and Building_Road and AREA field from Thiessen_clip and save the score in Final_Shelter table.

3.3.3. Network Analysis

After the final shelters are selected, next step is to create routing to those shelters by using network analysis. There are several parameters included in the model such as: Current Location which describes user current location, Final Shelter which is the output of the shelter selection process and Routes which is the evacuation route output from the model.

This model uses “Closest Facility” method which takes two variables, “Stops” and “Facilities” and calculates the shortest route from each stop to each facility.

There are several operations in this model such as: Make Closest Facility Layer which is the process to make “Closest Facility Layer”, “Add Location” to add Final Shelter as Facilities and “Add Location (2)” to add CurrentLocation as Stop. Next is “Solve” which calculate the entire shortest route between each stop and each facility. Last operation is “Select Data” to select the Route as output to be displayed.

Figure 3.10. Route generation using network analysis

4. System Implementation for Shelter Selection and Evacuation Path

4.1. Data Collection

There are three data groups in used by the system as described in data layer in Figure 3.

1. Busan UIS : In order to perform the shelter site selection and route analysis, there are five data sources that are needed from Busan Urban Information System, such as:

- NamGu : Contains administrative data and city boundaries
- Building : This data records all of the building in NamGu area. This data later on will be filtered to only display schools or churches as candidate for shelter selection process. It is also included hospital data. In total, there are 774 shelters candidate to accommodate evacuee in NamGu district of Busan
- Damage History : Contains disaster history in NamGu area which focused on flooding data. The shelter selection process will filter building which has a flooding history
- Damage : Includes the damage area of a happening disaster. This datasets should be collected as soon as possible by disaster agency in order to determine the scale of disaster and coverage of dangerous area.
- Road centerline : This data includes the network datasets and road

which is used in route analysis process.

2. Shelter selection & evacuation path analysis datasets : Datasets from Busan UIS are processed according to spatial analysis model and several new datasets are generated, including

- Final shelter: contains information and location of the appropriate shelter and its score (SCORE) generated based on the damage area and its proximity with hospital and road.
- Building_Hospital: contains information on building proximity with hospital (NEAR_ID, NEAR_DIST)
- Building_Road: contains information on building proximity with main road (NEAR_ID, NEAR_DIST)
- Thiessen_Clip: contains thiessen area (INPUT_ID, AREA) of the building which is inside of damage area

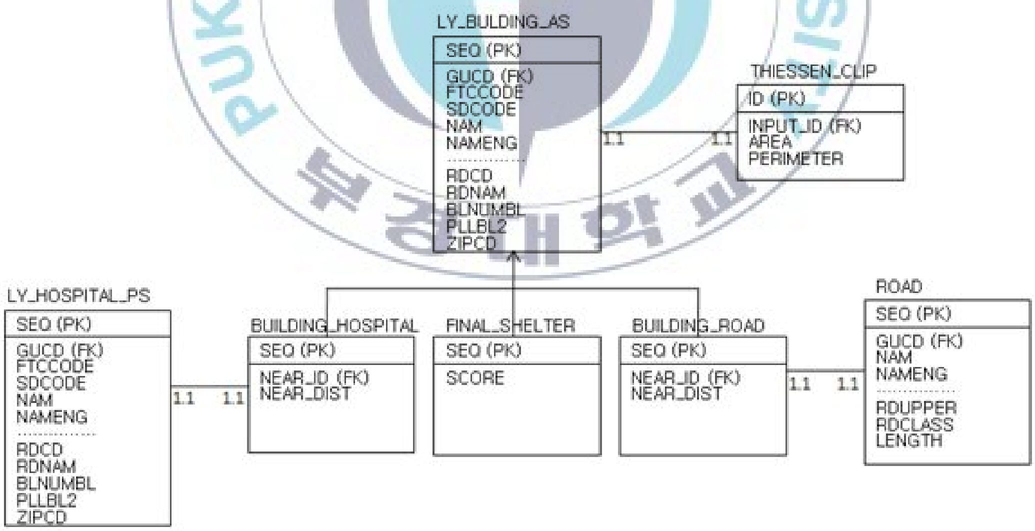

Figure 4.1. Database schema for the system

3. User management : Database to save users and its role as well as the data source information that users post to the system.

Field name	Data type	Purpose
ID	NUMBER	Primary Key
Name	VARCHAR(20)	Name of the map service
URL	VARCHAR(200)	Map service URL or location of KML file
Standard	VARCHAR(3)	OGC Standard used for representing the data
Publisher	VARCHAR(20)	Organization who owns the data
Official	VARCHAR(1)	Whether or used for shelter selection process
UserID	VARCHAR(20)	User who published the data

Table 4.1 Layer table

Field name	Data type	Purpose
UserID	VARCHAR(20)	Username
Password	VARCHAR(20)	Password
Organization	VARCHAR(40)	Organization represented by user
Email	VARCHAR(30)	Email
Userdivi	VARCHAR(10)	User Role
Createddate	TIMESTAMP(6)	Created date

Table 4.2 User table

4.2. Physical Architecture

This section describes Busan Disaster Shelter and Evacuation System architecture. The system consists of software which deployed in several machines including client, Busan Disaster Information Web Server and each of the organization's GIS servers. Deployment of the software or the physical architecture is described in figure 4.2.

The following are software needed to develop the system:

- Desktop GIS and Map Engine: used for data creation, editing, analysis and map generation. This thesis use ArcGIS suite from ESRI because the software suite arguably offers the most complete solution on GIS application development. ArcMap is used to create the model for shelter site selection and network analysis.

- Database Management Systems (DBMS): used for storing user and layer data. Oracle DBMS is used in this system.
- GIS Server (Map Server, Spatial and Network Analysis): used to remotely process and analyze spatial data. It is also used to perform geoprocessing as well as network analysis. This system uses ArcGIS Server
- Web clients: to display and query spatial data stored at remote locations that are only accessible via Internet or intranet. The GIS clients is developed using Microsoft Silverlight Version 4.0
- Web Server (IIS): to serve requests from the Web client. IIS is chosen because it is a platform in developing Web application on an ArcGIS server domain.
- Smartphone Application: This application is used by the citizen to view the map and route to safe shelter. In this thesis, the application is developed using Android OS Version 2.2.

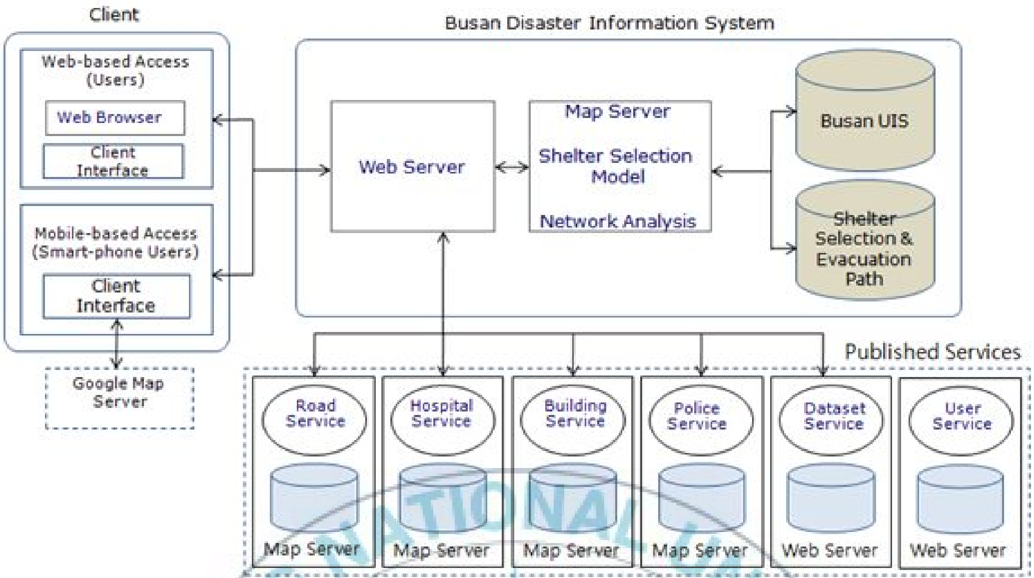

Figure 4.2. Physical architecture

4.3. Search Scenario

4.3.1. Menu Diagram and Scenario

The system features are divided into three categories for each of the actors involved which are administrator, manager and citizens. The menu diagram and security access of each menu is described in figure 4.3. Administrator is the super user which can access every menu in the system and capable of altering the database including user table and layer table while manager only capable of altering layer table. Therefore, a login system is needed to be implemented for those two roles to enable a secure system. Only authorized users can change the state of the system. Citizen is not able to alter the system and only performing an on-the-fly calculation which is cleared every time the application restarted or web browser refreshed.

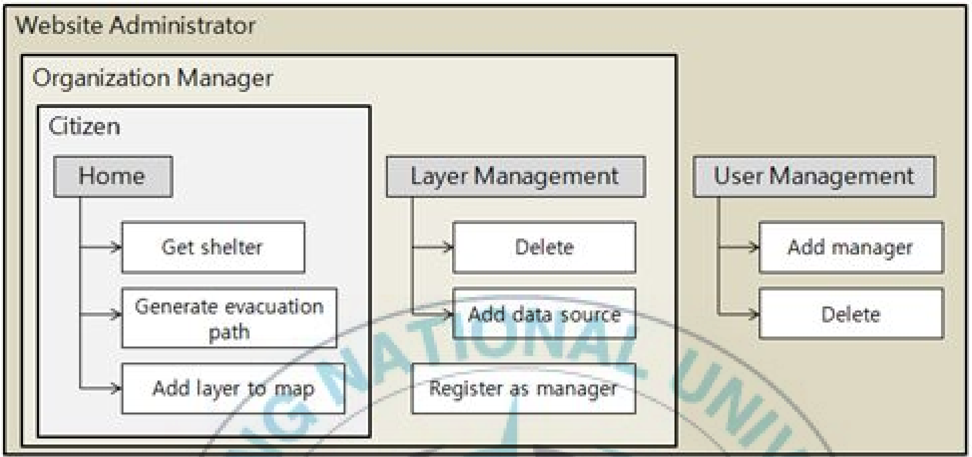

Figure 4.3. Menu diagram and security access

In order to fully describe the capabilities of the proposed system, two scenarios will be presented using on how it can benefit users.

1. Add new datasets or URL of map service to the system and add them to the map to be viewed as citizen.

IT Manager for Ministry of Health needs to put their data which describes the location of every hospital in NamGu area. Therefore he/she needs to put Map service URL of their hospital data to the proposed system.

Manager need to register and verified by administrator to publish their datasets as described in activity diagram in figure 4.4. This new hospital layer can be added to the map as layer by users as shown by activity diagram in figure 4.5. This activity diagram presents the communication process between data source server and Busan Disaster Web Server in adding new layer to the map activity. The server also performs a re-projection in case the data source uses different geographic projection. Moreover, it gets the OGC standard used by data source server to represent the data to be drawn appropriately in the map.

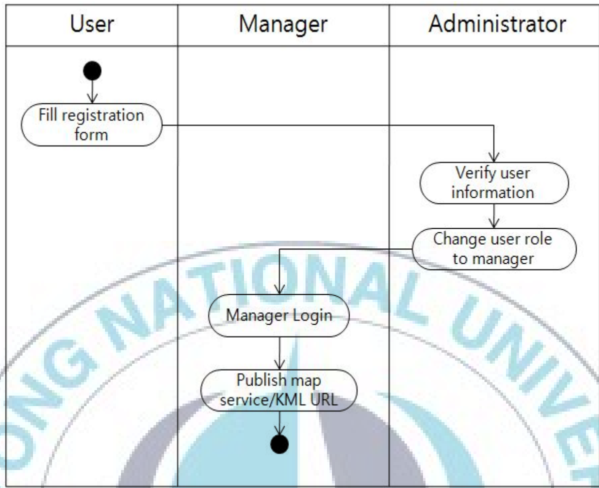

Figure 4.4. Registering and publishing dataset process

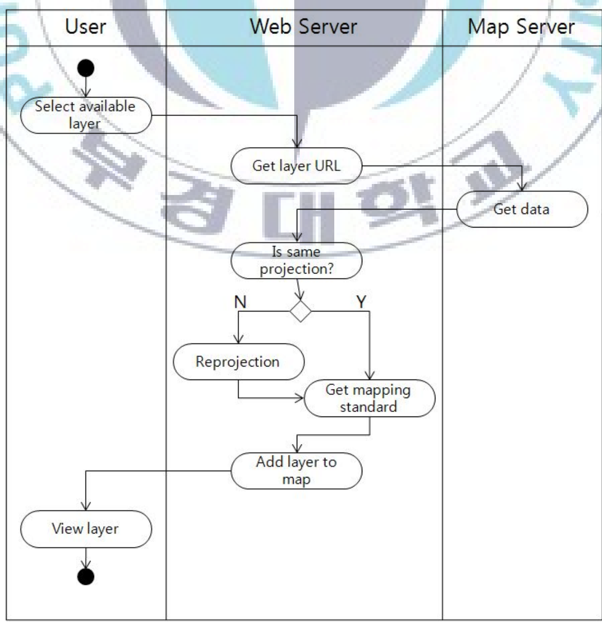

Figure 4.5. Adding layer to the map

2. Generating new shelter selection and evacuation route

Suppose there is a disaster happening in an area, users needs to view the most appropriate shelter based on damage location and path to get there. This process consists of three actions. First action is selecting current location which is done by clicking the location on the map of by searching current address on the user interface provided. Second action is to generate the shelter selection as described in figure 4.6. Location of the citizen is submitted to the shelter selection process and it is used in the spatial analysis process. The server responsible in performing shelter selection returns point geometry to web server by using WMS standard and finally the web application can draw those points on the map. The process is similar with network analysis process described in figure 4.7.

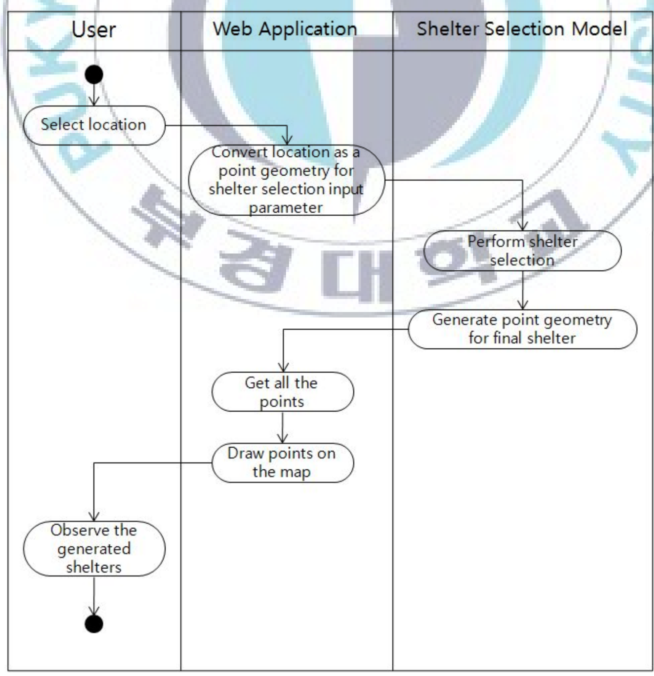

Figure 4.6. Shelter selection process

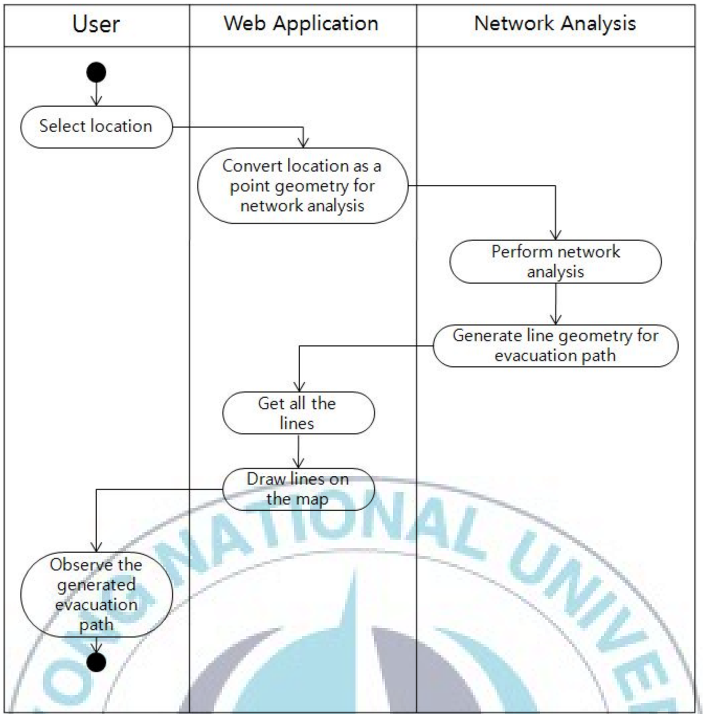

Figure 4.7. Evacuation path generation process

4.3.2. Adding New Layer

The application initial display is shown in figure 4.8. In order for manager to add new hospital data to the system in order for users to view it, these following steps must be done on the system.

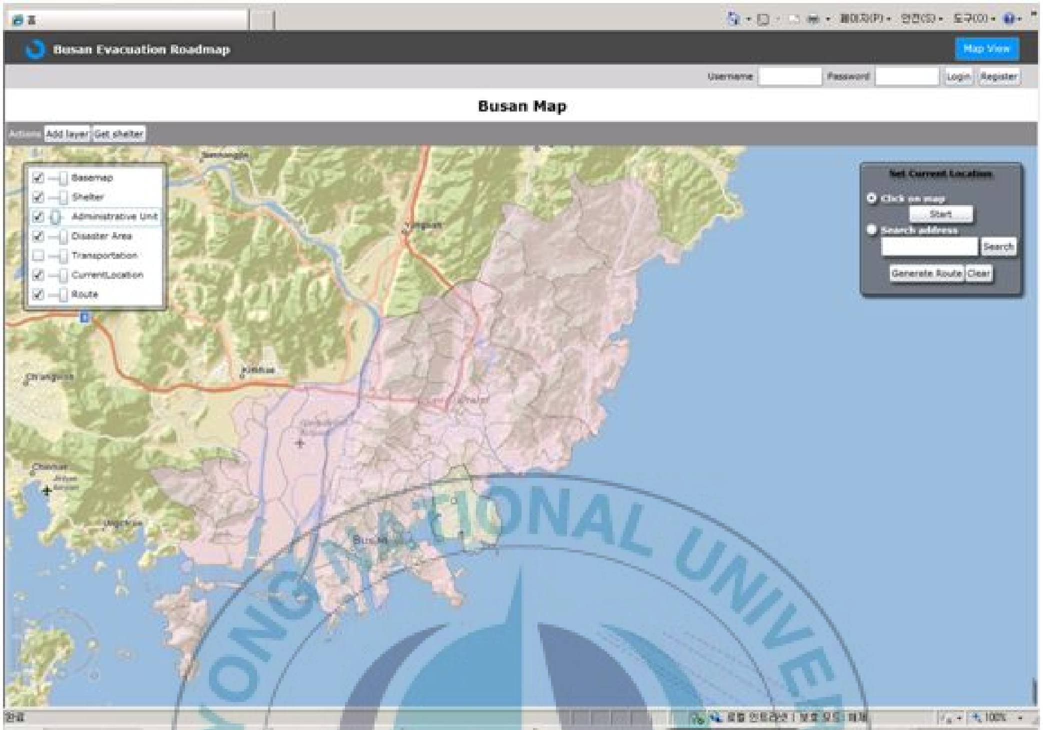

Figure 4.8 Home page

1. Register as a manager for the system using the register button
2. Manager fills the registration form. Every user who registers to use the system is stored and awaiting for administrator approval for manager role
3. An administrator checks the registered users and changes the role to manager based on verification by an email. He/she needs to login to the system.
4. Successful login will display the menu for user management.
5. Change the role for Hospital IT manager
6. Manager can login to the system and successful login will present the menu in figure 4.9

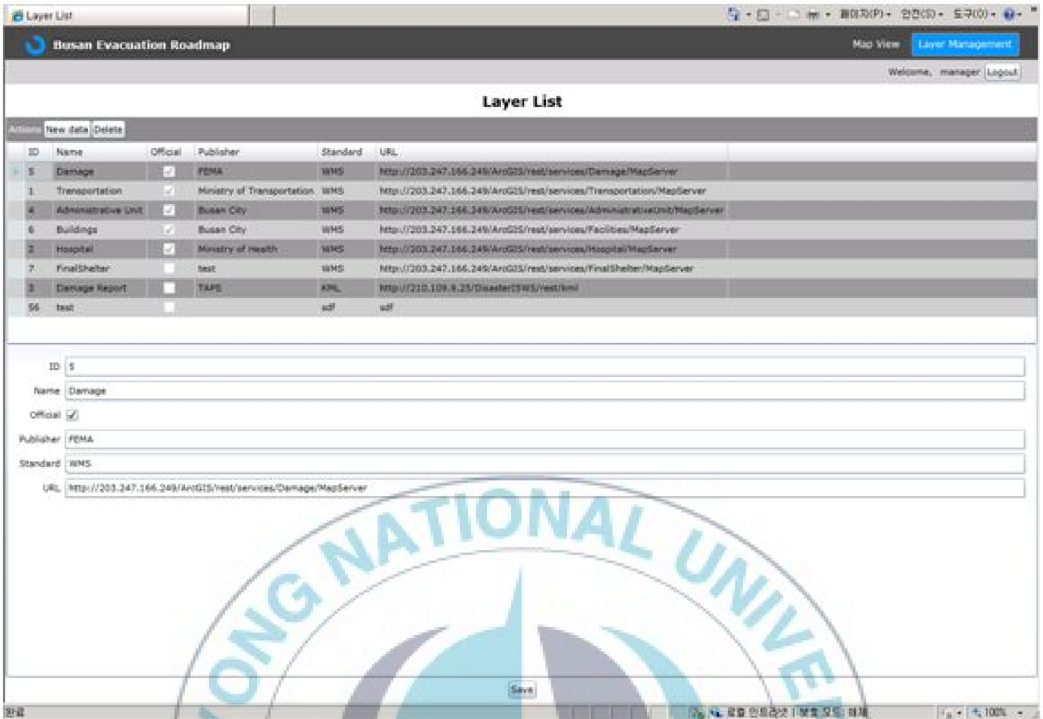

Figure 4.9. Layer management page

7. Finally, manager adds the URL of their map service to the system.
8. When User clicks the Add layer button, the LayerList dialog will appear. He/she can choose the desired layer to be added to the map.

Figure 4.10 Layer list on the map

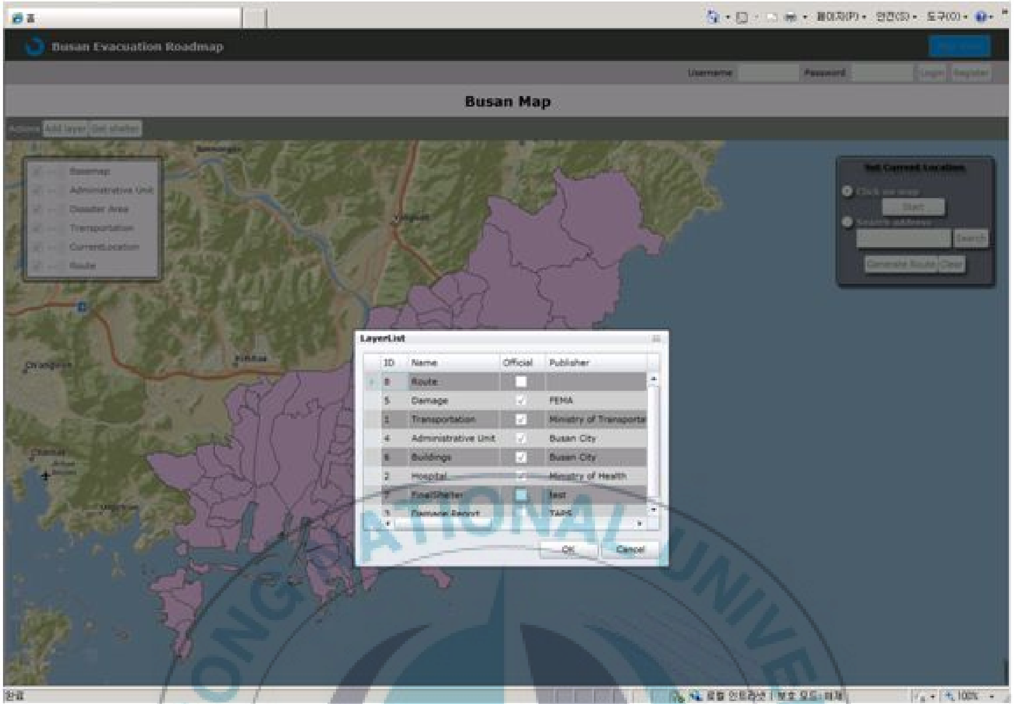

Figure 4.11. Available layers to be added to the map

Figure 4.12. Smartphone application

9. Since the system uses web service, it is also possible to display it in smartphone application. The interfaces for smartphone application for add layer function is described in figure 4.13.

4.3.3. Shelter Selection and Evacuation Path

Suppose there is a disaster happening in an area as described in figure 4.13, user needs to view the most appropriate shelter based on damage location and path to get there. This process is described in the following stepswas used, and for disaster search in the administrative areas, spatial operation SQL were used.

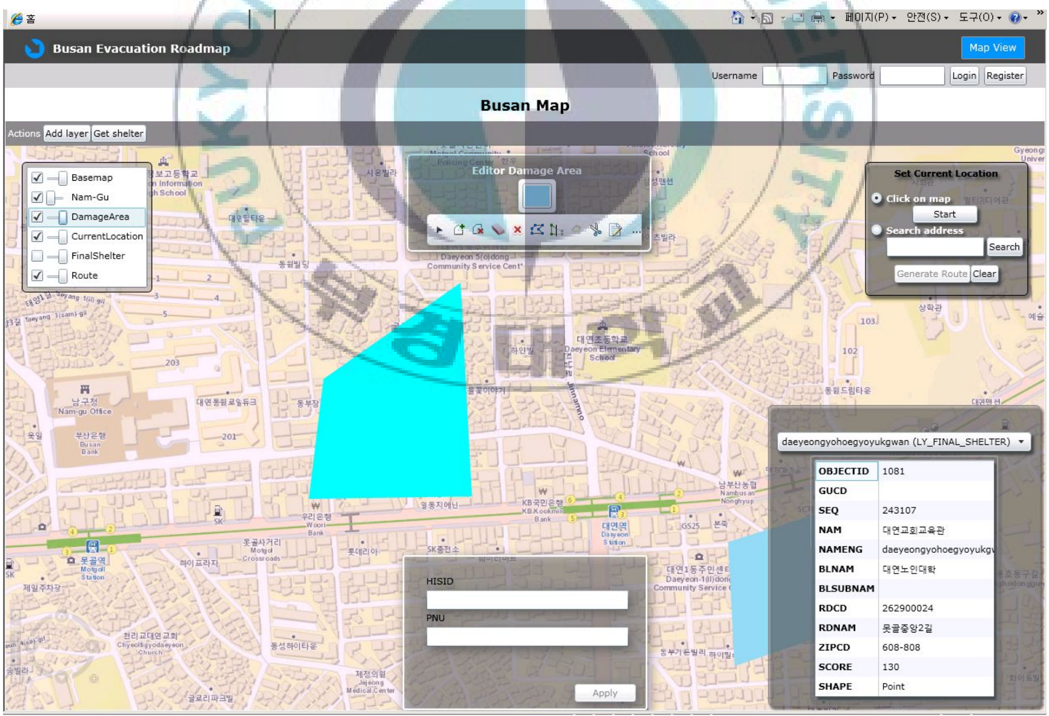

Figure 4.13. Rectangle representing disaster damage area

1. Users can input their current location in order to get the shelters and shortest route to the shelters. System provides two ways for them to input their location which is either by selecting on the map or searching the address which they are located as shown in Figure 4.14.

Figure 4.14. Set current location panel

2. Use the Get shelter button. Once users click the button, system will generate appropriate shelter and perform the shelter selection model
3. Final shelters have been generated; user can view the detail information of the shelters by clicking its symbol.

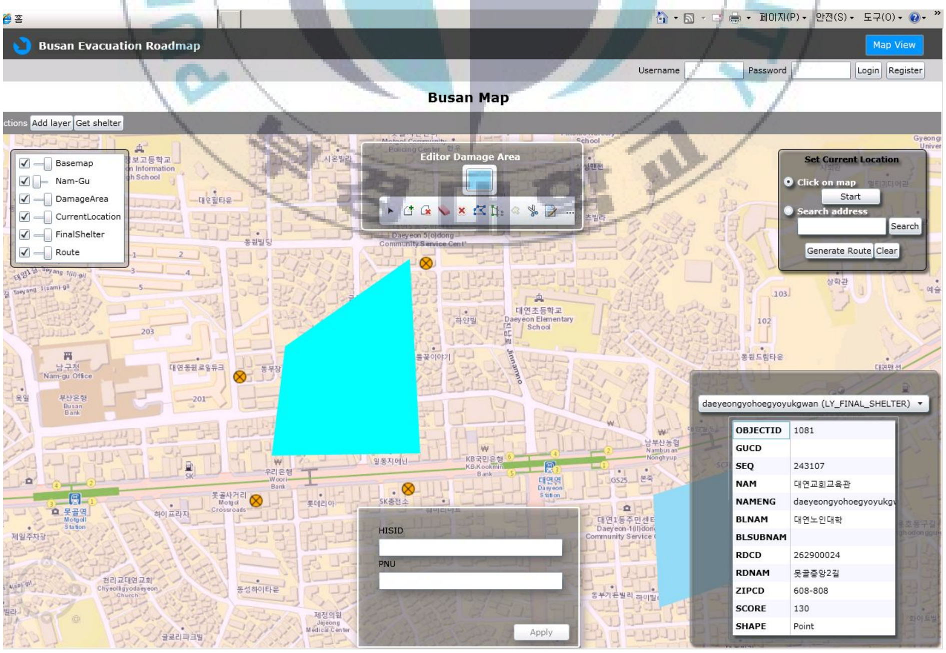

Figure 4.15. Generated final shelters

4. Once the shelters are generated, Next step for route generation is to click the Generate Route button. Once the button is clicked, system will perform series of action to get the evacuation route
5. Once the process are done, the route will be displayed along with additional information such as distance of the route and road

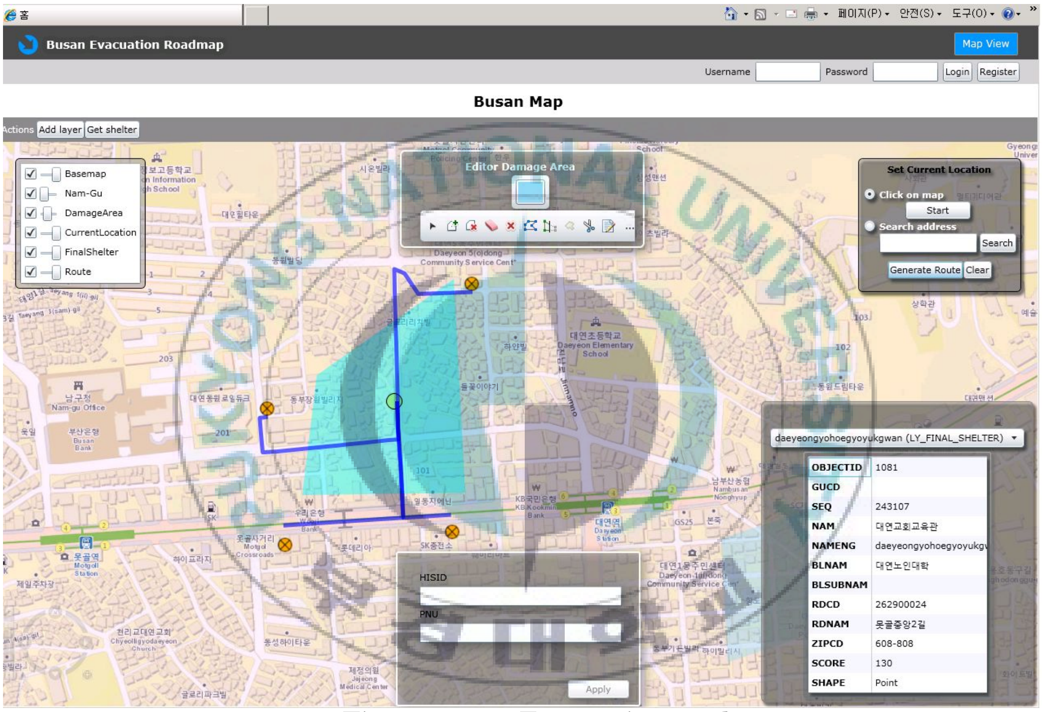

Figure 4.16. Evacuation path

5. Comparison

There are several studies and works which related to the thesis. Most of this works uses OGC standards for performing data integration between spatial data source using web services.

The Andean Information System for Disaster Prevention and Relief (SIAPAD) is an initiative promoted by the Andean Committee which provides tools for discovery, visualization and access to data related to disaster risk, available in different organizations within the countries of the Community of Andean Nations (Bolivia, Columbia, Ecuador and Peru). However, unlike the proposed system in this thesis, it does not possess geoprocessing capability inside the system itself. It only provides catalogue of data source and overlay them on top of provided basemap

Another example is PREVIEW global data risk platform also facilitate in sharing and disseminating data using OGC standards. It is used for accessing the risk of a disaster happening in an area on a global scale. It has several capability including 1) portal service which enables discovery of data, 2) catalogue which enables viewing detail information of the data and 3) processing which enables data to be used in a spatial analysis. However, this platform is used by expert and professional who know how to perform geoprocessing tasks. It does not include a predefined task such as shelter selection or route generation.

Another system that focused on generating appropriate shelter based on web service based map service uses WPS (Web Processing Service) for performing geoprocessing on the data. In addition, it uses Route Service

(RS) which is one of OGC standards. One of the examples of the system is done by Wengling at al. This system, however, uses a predefined shelter selection and does not dynamically assign available building as shelter based on location of damage area unlike the proposed system in this thesis. All of this comparison is summarized in table 4

System name	OGC Standards Used	Multiple Data Source Integration	Spatial Analysis	Evacuation route analysis
The proposed system	WMS, WFS, KML	V	V	V
SIAPAD	WMS, WFS, KML, GeoRSS	V		
PREVIEW	WMS, WFS, KML, GeoRSS, WPS	V	V	
Meng, X	WPS, RS			V

Table 5.1. Comparison with related works

6. Conclusion and Future Works

With the advancement of technology in spatial data creation, spatial data is created and owned by many different agencies that utilize spatial data to satisfy their own needs. The fragmentation of spatial data owners causes diversity in policies related to spatial data, and standards and tools to manage and coordinate spatial data. The diversity of approaches in data coordination leads to inconsistency and heterogeneity among multi-source spatial datasets.

Therefore, the thesis aims to identify the possibility of multiple data source integration on the medium of web service using OGC standards. Using the data source to generate appropriate shelter selection and routing based on user position. Design and develop system which enables viewing data source and result of shelter selection and route generation in multiple platforms.

To perform these objectives, several data sources are needed including: NamGu : Contains administrative data and city boundaries, Building : This data records all of the building in NamGu area. Damage History : Contains disaster history in NamGu area which focused on flooding data. Damage : Includes the damage area of a happening disaster. Road centerline : This data includes the network datasets and road which is used in route analysis process.

There are three actors involved in the system, each of which has different roles and capable of doing three kinds of management including layer management, route management and user management.

For future works, more detailed variables are needed to support the shelter selection process. Moreover, current program only support OGC standards such as WMS and KML. In addition, it can only support two projection systems which are WGS84 and Web Mercator. Future works should include other projection systems as well.

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황현숙 박사님, 한국에서 2년 동안 공부할 때 저를 지도해주고 좋은 강의 해 주셔서 감사합니다. 졸업논문을 쓰는 동안 언제나 저를 도와주었지만 부족한 점이 많아서 죄송합니다. 그리고 언제나 선물, 과자, 과일과 행복을 연구실에 가져와줘서 고맙습니다.

저의 학위논문 발표에서 좋은 조언을 해주신 박만곤 교수님과 송하주 교수님께도 감사드립니다. 제 논문을 읽으시고 만족해하시면 좋겠습니다.

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- 원석 행님, 제 논문을 완성할 수 있게 도와줘서 고맙습니다. 핀란드에서 행운이 있길 바랍니다.
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- 영학, 나를 이길 수 있도록 '위닝' 연습을 많이 하길 바랍니다.ㅋㅋ 밀양을 같이 갔던 친구들에게도 안부전해주길 바랍니다. 그리고 영학의 가족들에

게도 감사드립니다.

- 성제 행님, 언제나 유쾌한 사람이여서 감사합니다.
- 장명 행님, 기숙사에서 좋은 룸메이트를 해줘서 감사합니다.

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