AN AGENT BASED SYSTEM FOR CUSTOMIZING DISTRIBUTED GIS SERVICES

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ABSTRACT

The development of Geographic Information Systems (GIS) has been promoted by the development of information technology (IT) networking, and software engineering.
Due to the popular use of the Internet and the progress of telecommunications, GIS is shifting into a new direction, distributed GIS (DGIS). In distributed GIS environments, users may need to interact with heterogeneous data models and different command syntax in different GIS softwares that deal with geo-information as one of the most complicated information types stored in computer systems. In this paper, the mobile agent technology is used to reduce user work and information overloads. In this context, intelligent mobile agents provide services in searching, filtering geo-data and geo-processing services, converting GIS data into different processing formats. Potential advantages of the proposed system include reduced network traffic, decentralization, increased robustness and fault-tolerance. The .net framework is use for building a mobile agent system for distributed GIServices hosted in ARC GIS server. To demonstrate how the proposed system greatly enhances the offered GISservices, a real case example is presented on forecasting the areas of the fast growing damage that may be caused by the cotton leafworm, *Spodoptera littoralis* (Boisd.).

KEY WORDS:

GIServices, GIS Meta Data, Mobile Agent, Information Technology

1. INTRODUCTION

Initiated in 1960's [1], GIS software experienced several development phases and gradually evolved into the mainstream of Information Technology (IT). With the rapid development of computer network technology and the fact that more and more individuals and organizations adopted GIS as their solution, the demands for an open, network-centric distributed GIS became the common concern of GIS software vendors, geographic information providers and GIS users.
As more and more people tend to use geographically referenced information and GIS software, GIS services that provide geographical information to broader users became a hot issue in the recent years, especially GIS services over the Internet.
GIS software has changed its paradigm several times: From the initial GIS functional packages to the integrated huge system and from modular GIS to component GIS, from desktop GIS to network-centric GIS, and now from traditional client/server GIS to Distributed GIS (DGIS) that may be called Internet GIS. Each of these changes marked a big progress in the history of GIS development.
Rapidly evolving network and computer technology, coupled with the exponential growth of the services and information available on the Internet, will soon bring us to the point where hundreds of millions of people will have fast, pervasive access to a phenomenal amount of information, through desktop machines at work, phones, pagers, and car dashboards, from anywhere and everywhere. Mobile code, and in particular mobile agents, will be an essential tool for allowing such access[2].

The term agent originates in artificial intelligence and describes the logical entity that has some level of autonomy within its environment or host. A mobile agent has the added capability to move between hosts. In a computing context, mobile agent is a combined unit of data and code that can move between different execution nodes.
There are three main design patterns for a mobile agent, which can be combined for any implementation. These patterns are named after the agent's primary purpose: travelling, task and interaction used for processing. A travelling agent is mainly concerned with location; a task agent is used for processing, and the interaction agent for management and collaboration with other agents.
Mobile agent is a recently developed computing paradigm that offers a full featured infrastructure for the development and management of network efficient applications for accessing information at any time, any where, with both wire-based and wireless devices. Mobile agents are programs that can migrate autonomously from one host to another during their execution on behalf of their owners or creators. Mobile agent based computing can benefit internet (especially mobile internet) applications on providing asynchronous task execution and more dynamics, supporting flexible and extensible cooperation, reducing communication bandwidth, enhancing real time abilities and higher degree of robustness, enabling off-line processing and disconnected operation.
A web service has many characteristics such as; easy to maintain, discoverable, self–describing, conceal complexity, independent. Mobile agents [3, 4] are an excellent technology for implementing Web services.
This paper is organized into several sections. In section 2, we review related research on developing GIS services and different methods to improve the performance of GIS services. Section 3, discusses the proposed system and the use of mobile agent for GIServices. In section 4, outlines the proposed system architectural hierarchy and implementation. In section 5, A real case example, using the developed system is discussed, finally, Section 6, includes the conclusion with the challenges solved using the mobile agent.

2. RELATED WORK

The rapid development of the Internet provides GIS communities with a new technology for disseminating geographical information to the general public. Web GIS or Internet GIS is a new phenomenon in the recent years [5]. A lot of approaches were introduced into GIS mainly to provide geographical information (geo-data) in the Internet.
The Common Getaway Interface (CGI) was the first generation technique applied to the Internet GIS. CGI actually acts as the middleware between the web server and the GIS server [5]. Using CGI makes a lot of limitation, as every processing must call for server even simple ones such as zooming and panning.

CGI, Plug-ins [5] was used to overcome these limitations by installing GIS software extensions to the web browser, which identify the concept of thick client that caused no independent browsers. As a result for this limitation, intelligent document [6] was designed to be efficient for network transportation and self contained. Intelligent document enhances geodata publishing, not the GIS functionality. Internet Programming Languages [5] were a good solution to solve the problem of thick client, where the work was to be done on the server. One of the important advantages of the Internet Programming Language method is that the whole structure of the program can be very flexible and scalable; developing distributed GIS models. Although there is a lot of advantages for the internet programming languages using GIS Web Services [7] have the potential to revolutionize the way in which GIS is developed, accessed, and used. They make it easier to share geographic data and functionally for GIS to be deeply integrated into other technologies. A web service is a software component that can be accessed through the World Wide Web and used by other applications. GIS web services provide spatial data or functionality on the World Wide Web. They make it possible to users to access GIS data and functionality through the web and to integrate them with their own systems and applications without the need to develop or host specific GIS tools. GIS web services has a lot of examples: Open Geospatial Consortium (OGC) Web Services 1.1 Initiatives OGC Web Services (OWS-1.1) [8], ESRI ArcWeb Service [9] and Microsoft MapPoint .NET Web Service [10].
Software agent technologies have been explored since the 1960s when scientists began to develop a type of self managed tools that are capable of dealing with heterogeneous data and computational components within distributed computing environments. As modern computer science and technology evolved, software agents have gradually become more and more intelligent and can interact with the user's inputs and other agents without human interference [11]. Intelligent software agents may possess capabilities to execute tasks based on their learning experiences. This process takes advantage of prior domain knowledge they have obtained [11].
Intelligent software agents have already been applied to help solve practical problems such as network traffic monitoring, web–based data mining and information retrieval. Li [12], There are a few cases where the intelligent genet have been used to address and solve GIS problems, among these efforts, Nolan et al. [13] proposed an agent based architecture for imageries and geospatial computing. Hossein Mohammadi [14] constructs a wireless GIS, using Java and XML technologies. Using some spatial data layers in XML format and applying in a Java program, an interface with a search module to select requested region has been developed, which uses Java code, and XML parsers to act on XML and results are displayed using java graphical procedures.
However, all the previous systems mainly depend on the traditional web services which have some drawbacks that affect their performance such as: 1) all webpage contents must be downloaded in the local area, processed, and then the processed and irrelevant information will be abandoned. This will greatly increase network traffic and even cause local obstruction; (2) during the search period, a connection with network should be maintained, otherwise a search interruption will take place; (3) The result of a search engine is incomplete due to the limited index size; (4) Moreover the search engine server needs a large capacity of memory and the high performance processor.

3. PROPOSED SYSTEM

The proposed system is 4 tiers to support advanced search, filtering, queering functions, and interpreting GIS data for distributed GIServices. The .Net framework, Mobile Agent and GIS web Services are used to implement the system that involves; client sites, sever sites and mobile agents roaming on the Internet/Intranet for retrieving information on behalf of the users. Fig. 1 shows the main 4 tiers infrastructure of the system as follows:

- Tier 1: *Web Portal Interface* It is a user interface for allowed user capabilities and specifications.
- Tier 2 : *Mobile agent*, that contains components for searching / filtering, interpreting geo-information, and controlling,
- Tier 3: *Meta-data*, for GIS data services and/or geo processing services. Such as: actual location, descriptions, data parameters and specifications
- Tier 4: *Geospatial Web Services*, which present the actual location of the data services and / or geo processing services.

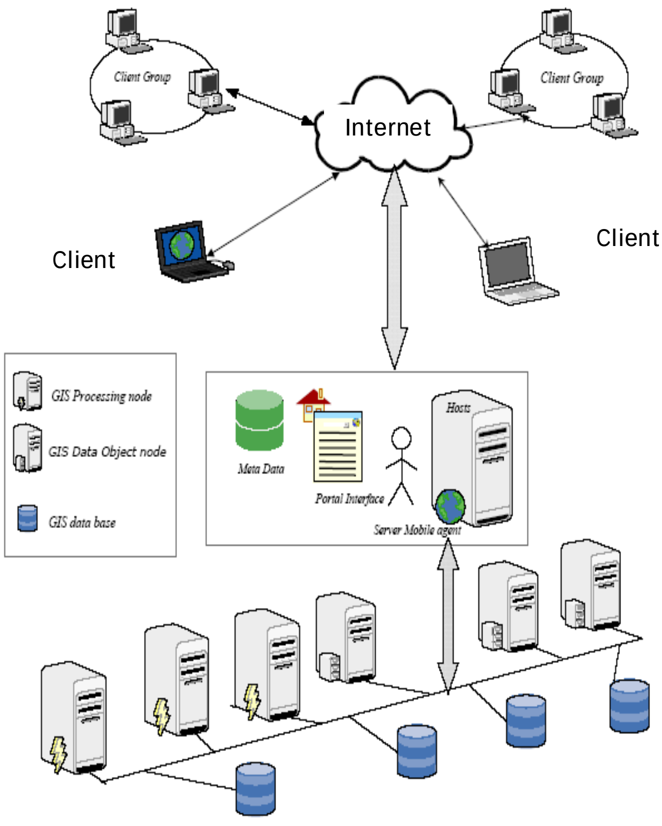

Figure 1: Proposed system architecture

3.1 Web Portal Interface (Client Site)

The web based user interface helps user to search, view, execute both geo-services; geo-data or geo-processing. The portal is also used as a visualization tool for searching, spatial analysis, and display GIS data and results.
With user requests, via a plain text box, the location of the query and the geoprocessing needs are specified then the mobile agent, automatically downloaded from server side to the user machine, takes over requests to act on user behalf for the following the following tasks:

- Collect information from the user.
- Monitor the progress of GIS tasks.

3.2 Tier 2: Mobile agent

A mobile agent instance is created and uploaded to the client machine for finding/ filtring, interpreting, and controlling of information.

Information finder/filter role: helps users find the requested information after filtering out unnecessary elements, see Fig. 2.

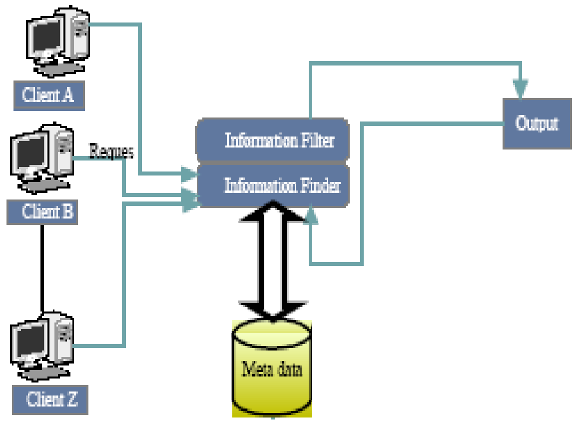

Figure 2: Information finder/filter agent.

Information interpreter role: accesses and conveys information between different sides in heterogeneous environments. as illustrated in Fig. 3.

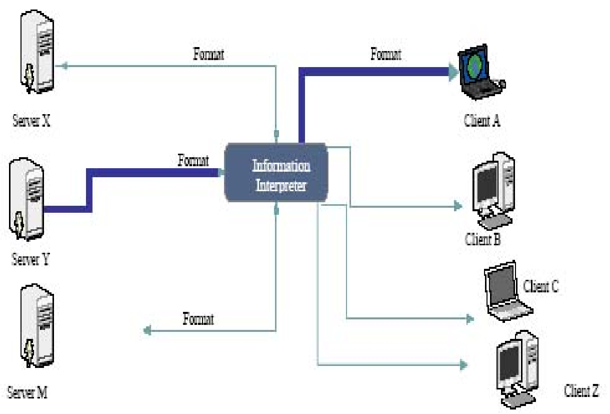

Figure 3: Information interpreter agent.

Controller Agent role: making decisions autonomously based on rational rules defined by its own knowledge-base, user-defined rules, or the collaboration with other agents as shown in Fig. 4.

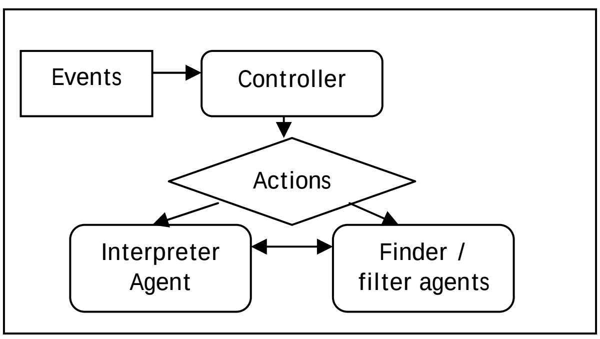

Figure 4: Controller Agent

3.3 Tier 3: Meta Data

This tier is a data base about the geo-data and geo-processing services such as services name, actual location, specification, parameters and required data. These Meta data enables searching for the required geo data and/or geo processing services that is adequate for user requests.

3.4 Tier 4: Geo- Spatial Web Services

This tier hosts the geo-data and geo-processing services in the accepted web services standards. Internet GIServices utilize both wired and wireless internet networks to access geospatial data and /or geo processing analysis services. The mobile agent searches across the network for a suitable node for processing and returns the results to the client.

4. PROTOTYPE IMPLEMENTATION

4.1 Mobile Agent

The .Net framework is used in the implementation of the mobile agent. The .Net Framework is a platform that simplifies application development in the highly distributed environment of the Internet. As opposed to the virtual machine in Java, the .Net version of a virtual machine is the Common Language Runtime (CLR).

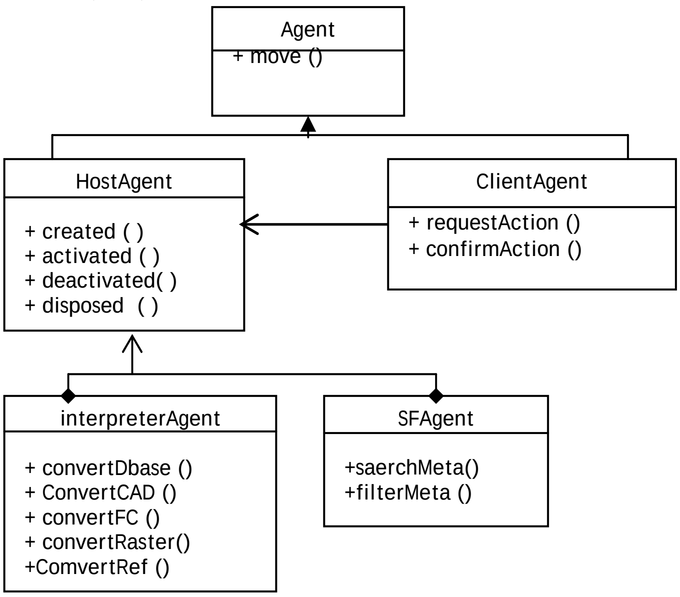

Figure 5: A class diagram of the mobile agent

Fig. 5 illustrates the class diagram of the mobile agent and the specification of the structure of each agent. This diagram identifies the methods of each class, tasks that each agent is able to perform. Each agent can play his role in the system using his own methods. Fig. 6 illustrates the activity diagram model of the mobile agent.

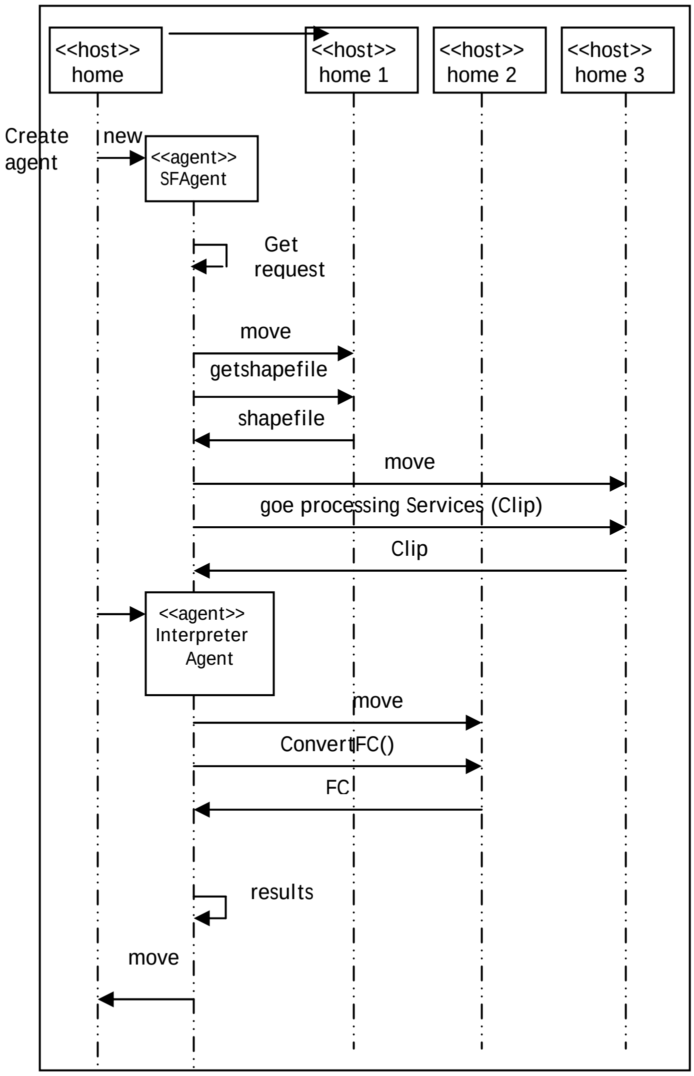

Figure 6: Mobile agent activity diagram.

4.2 Geospatial Services

Table 1 illustrates the 6 geospatial services implemented in this prototype.

Table 1: List of the geo-data/geo-processing services implemented and hosted by ARCGIS Server

Service name	Service type	Service description
Kaliobia Map	data	*Kaliobia topological map*
*Kaliobia*Land	data	*Kaliobia land use / land cover map*
Waterres	data	Water resource map for Egypt
Zipdown	processing	download the result to the client sit.
Zipup	processing	Upload the user data to be manipulated by the system.
Clip	processing	clip the raster data .

4.3 Meta date

In this tier, developed a data base to host the Meta-data information, Fig.7 describes its structure

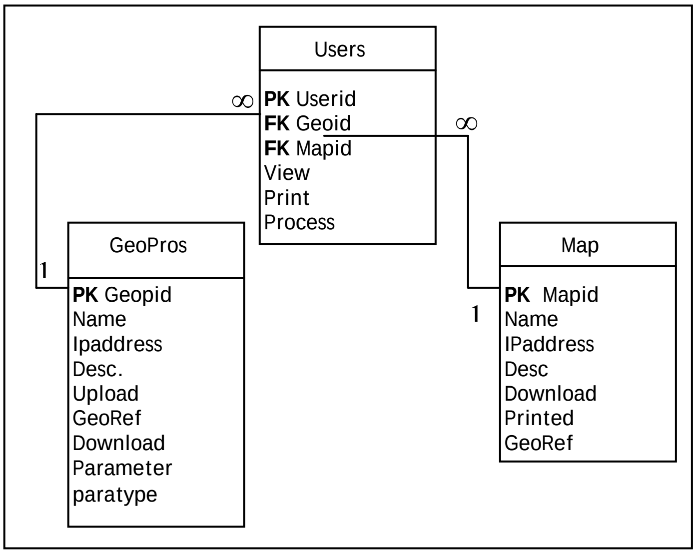

Figure 7: ER Diagram for Meta-database

4.4 Portal Interface

The portal interface shown in Fig. 8, allow client users to deal with the system, searching for the data and services that satisfy their needs.

This portal interface is divided into several sections:

- User display area, where the geo data and/ or result could be displayed.
- Geo task area, where we can find GIServices which satisfy the client user's needs.
- User's tools, which can be used by the client user to get interactive with the geo-data.
- Result section, where the results could be displayed as data grid record.

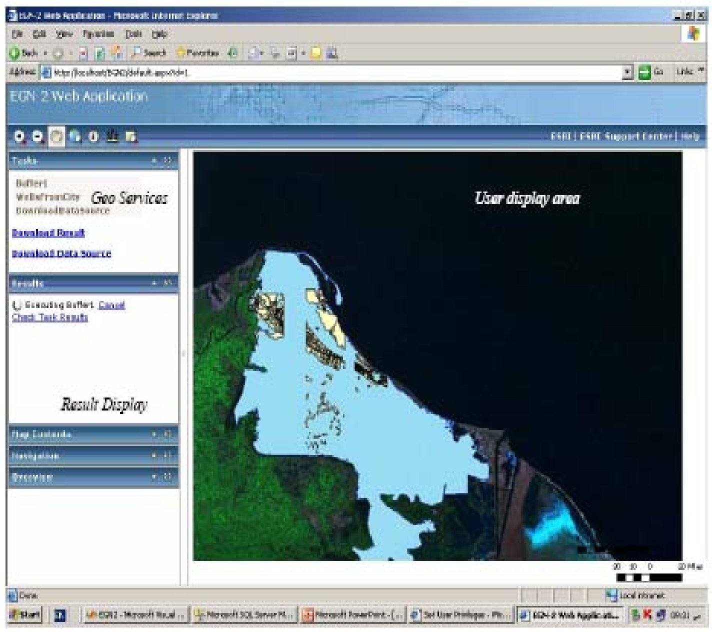

Figure 8: Portal interface

5. A REAL CASE EXAMPLE

SPODOPTERA LITTORALIS PREDICTION AND MANAGEMENT PROTOTYPE

One of the major obstacles facing the production of more crop and food for Egypt's fast-growing population is the damage effects caused by pests, specially the cotton leafworm, *Spodoptera littoralis* (Boisd.). Daily Maximum and minimum air temperature that derived from satellite images appeared to be the best way for predicting and calculation of the average of thermal units in degree-days (DD's) required for the completion of development of *S. littoralis* generation. Therefore, it is important to develop a GIS Model for calculating the degree days units by Remote Sensing (RS) and Geographic Information System (GIS) as a base for cotton pest outbreak prediction. The results obtained from this model are important for quick prediction and managemtnt for *S. littoralis* in Egypt. The developed model as a prototype is shown in Fig. 9. In such a problem the local government will need to respond immediately in order to save lost and prevent further damage. This model will hep in this serious problem. The model major task is to simulate and detect the *Spodoptera littoralis* development stages, decide the location of emergency for residence.

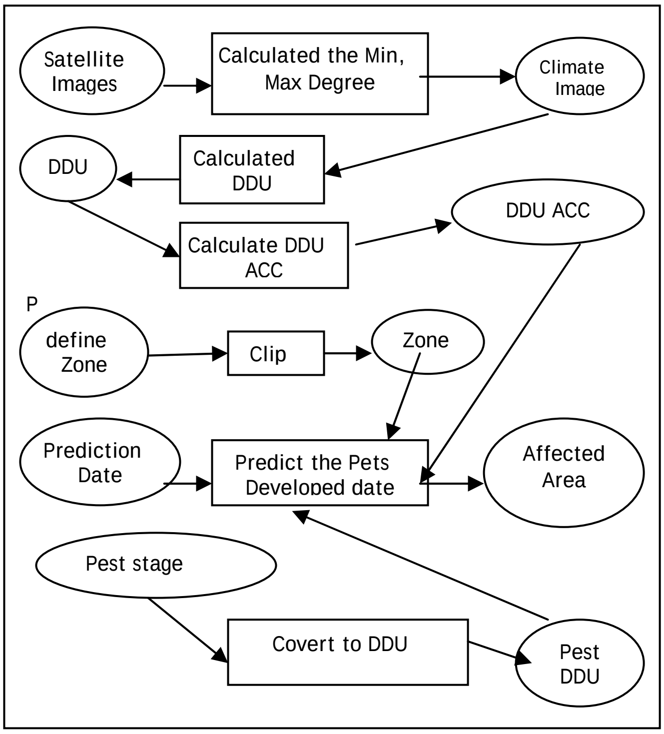

Figure 9: *S. littoralis* Prediction and management Model

5.1 *S Littoralis* Model Scenario

The client request the zone to apply the model, the agent is upload from the host to the client machine, the agent is moved to search meta data for service that match the defined zone, return with the file, agent check for the Geo-reference and convert it if necessary, agent again search meta data for DDU service and start calculate the DDU then DDU ACC, return with this information, obtain from the client the pests stage and convert it to DDU units in client machine, the agent start execute the prediction model., sending back the client the affected area highlight by red color. Figure 10 illustrates the M
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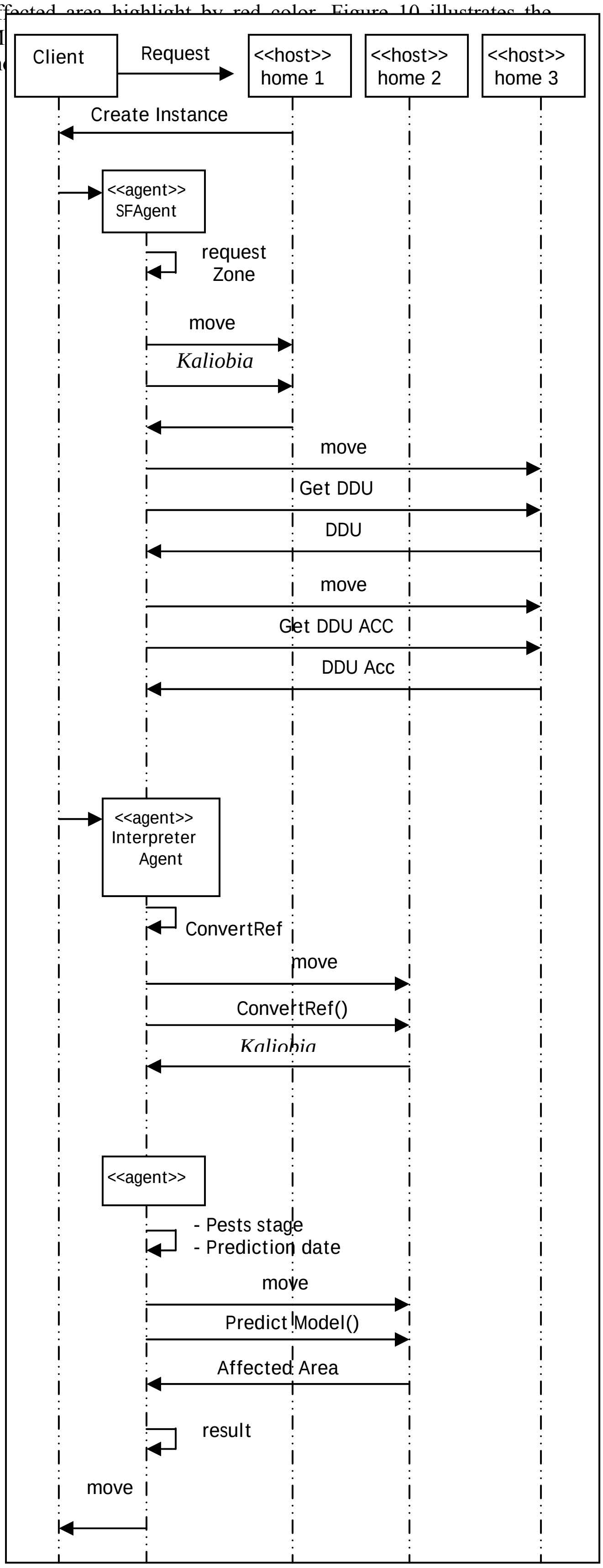

Figure 10: Model scenario

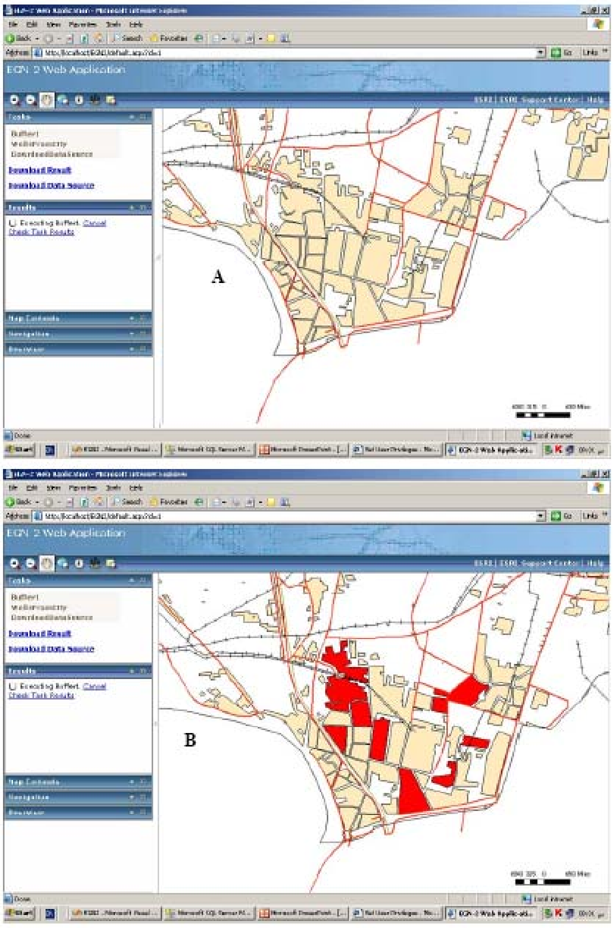

Figure 10: Affected region a) before and b) after running the model.

6. CONCLUSIONS

The paper presented a prototype for a system that integrates the GIServices with a mobile agent. The proposed system helped GIS users overcome two important challenges. Firstly, the problem of finding a suitable GIServices and data that meet their needs, where numerous Internet GIServices and data warehouses have been deployed. Since a geospatial application requires geospatial data and GIS analytical tools, the proposed system facilitated the geo services registration, Meta-data management and telecommunication across heterogeneous network computing environment. Secondly, how the web portals can be intelligent enough to understand user's inputs, requests and respond accordingly. The portal was designed with a user friendly interface that helped the client users to launch the appropriate GIS procedure. The portal interface have enough built in intelligence to understand the user's requests and automatically search for appreciated data or services to meet their needs. Moreover, the proposed architecture is based on the .Net Framework, mobile agent and XML, which helps in simplifying the structure of the client, reduce network traffic, decentralization, increase robustness, fault tolerance, and easy deployment. A real case example was solved to illustrate the usefulness of the presented system.

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