DEVELOPMENT OF DISTRIBUTED WEB SERVICE FOR GEOPROCESSING AND 3D VISUALIZATION IN WEB-GIS CLIENTS

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ABSTRACT

Nowadays, the availability of simple accessed geospatial data through the Spatial Data Infrastructure (SDI) has been rapidly growing. This is a benefit from Open Geospatial Consortium (OGC) interoperability that allows different vendor software exchange data using compliant standard ways. Therefore, the idea of distributed geoprocessing has been broadly addressed in the recent years. The need of such an infrastructure is increasing. The Web Processing Service (WPS), which is also a OGC specification, is developed to allow web-based geoprocessing for simple sharing of spatial analytical functionalities. Various spatial analysis or simulation scenarios can be carried on the web-based application using this distributed geoprocessing infrastructure for spatial decision support systems such as flood modeling, landslide and debris flow. Further, in order to promote easy understanding of analytical results, 3D geospatial data visualization in widely used web browser is being implemented. In this study, the prototype application is developed to give an idea about the benefits of distributed web service for geoprocessing and its 3D visualization.

1. INTRODUCTION

Geographic Information Systems (GIS) play a rapidly increasing role in the field of environmental control and disaster prediction application. Recently, widespread availability of Internet and related services (e.g. World Wide Web) has been widely applied in providing the general public channels to access GIS service almost anywhere and at anytime. Many simulation scenarios have been carried on the web-based application for spatial decision support systems such as flood modeling, landslide and debris flow. The Web Processing Service (WPS) defined by the Open Geospatial Consortium (OGC) is intended as a solution for sharing geoprocessing through internet's open and service-based application. It makes use of geospatial data and turns it into knowledgeable information which is much easier to understand and less expensive for better decision making. In our earlier study, the environmental monitoring application for water quality was developed (Ninsawat *et al.*, 2008). The Water Quality Index (WQI) map generated using WPS could serve as useful information to monitor, evaluate and quantify on the water quality and allow for making better-informed decisions. Moreover, the same technology and structure can be applied to develop different useful disaster prediction applications.

Although very few applications provide the capability of realistic visualization of the modeling result. Most system only provides potential dangerous area as two-dimensional maps. 3D visualization of geospatial data in Web-GIS clients has attracted wide interest recently. Huang *et al.*, (1999) developed client/server architecture system (called GeoVR) which enable interactive creation of 3D scene as Virtual Reality Modeling Language (VRML) model from 2D geospatial data. Most available solutions for 3D geospatial data visualization offer little flexibility in accessing of dynamic data from WPS as a "browser only" client solution.

In this study, a new solution is implemented using various open standards that enable 3D visualization of geospatial data as VRML or X3D model. The system offers a "browser-only" solution, wherein not only the existing data from distributed Web Feature Service (WFS) and Web Coverage Service (WCS) can be visualized but also dynamic results offered through WPS can be accessed. The system is implemented under the multi-layer distributed web service architecture which is based on a clearly demarcated Service Oriented Architecture (SOA) workflow. The application of simulating rainfall-surface run off model has been developed. The system has been implemented entirely using Free and Open Source Software (FOSS).

2. SYSTEM ARCHITECTURE

The basic structure for this system is multi-layer distributed web service architecture consisting of client application, Data Processing Service, 3D Rendering Service and Data Provider Service as shown in Figure 1.

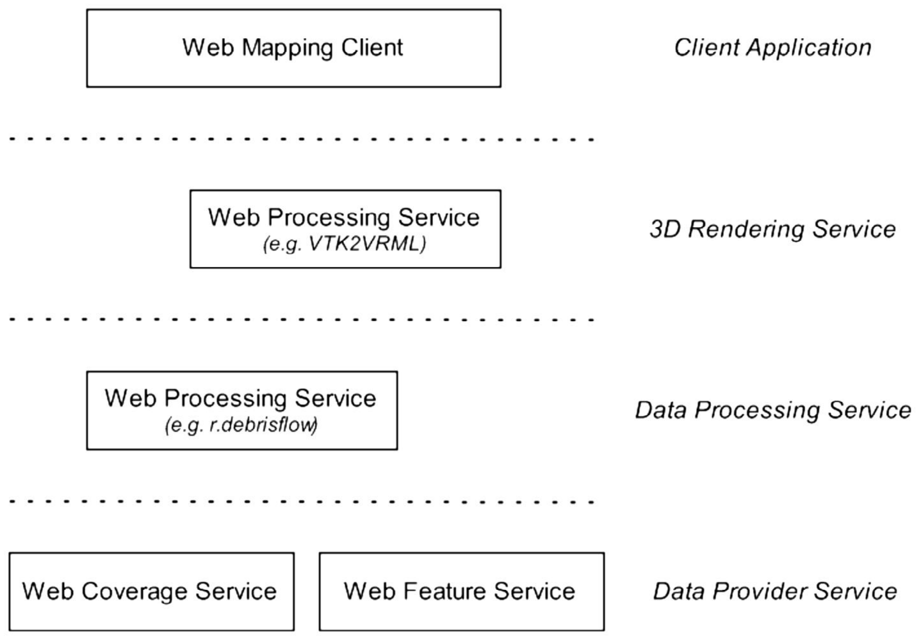

Figure 1. Overview of multi-layer distributed architecture for 3D GIS visualization.

In this system, the Data Provider Service creates a web service that publishes various geospatial data source. These services add a level of abstraction to the data that is extremely important in distributed computing environments (Kiehle, 2006). The desirable online geospatial data source are accessed across the network connection using the standard OGC here WFS and WCS.

In this system, the Data Processing Service is capable of integrating several data from difference origin and turns them into desirable information. After entire series of geoprocessing is completed, the heterogonous results are integrated and manipulated in a 3D scene as exchangeable web-based standards VRML or X3D model by the 3D Rendering Service. Subsequently, the results are forwarded to client application. The WPS which is used to allow web-based geoprocessing for simple sharing of spatial analytical functionalities describes and controls all task of both services. The WPS specification defines a mechanism and procedures by which predefined series of geoprocessing task will be carried out on a remote server and processed product can be obtained

The client application indicated in the front-end interfaces include map browsing tools, simulation parameters initializing tools, result map display, preview 3D scene of modeling result and network accessible address of manipulated results. The sufficient input parameter values from user inputs are collected and submitted as a request in the form of Uniform Resource Locators (URLs) via HTTP GET replied on WPS specification to the Data Processing Service. Then, the produced output of process will be visualized as part of web-application and downloadable for further analysis at local user machine.

3. PROTOTYPE SYSTEM

In this study, the prototype system of simulating rainfall-surface run off model was developed. The r.debrisflow which is a GIS-supported model framework for simulating the potential spatial patterns of debris flow initiation, movement and deposition (Mergili and Fellin, 2007) has been used. The model constitutes of a framework of a number of sub-modules.

Sub-modules of r.debrisflow framework:

- Hydraulic module
- Slope stability module
- Sediment transport module
- Debris flow run out module

However, only the hydraulic module is examined in this system. The deterministic hydraulic module distributes water from input rainfall among interception of vegetation, infiltration of soil and runoff on surface of catchments area. Then it approximates the soil water status and surface runoff parameters.

The web-application (as client application) was created to facilitate user interaction and visualize output results. The OpenLayers Javascript API was used to construct web-enabled GIS functionalities in this application. The rainfall or precipitation data are collected from user input at front-end interface then submitted to Data Processing Service. AJAX, (Asynchronous JavaScript and XML) technology has been adopted to construct asynchronous connection using the XMLHttpRequest object therefore it could efficiently manage requests and results from distributed geoprocessing service. After all necessary supplied parameters are gathered, the desired data will be requested across network connection from the Data Provider Service. The physical data of study areas which is composed of elevation, soil class, soil depth, land cover, hydrological surface, flow channel and etc. are prepared in Data Provider Service as open standards and service of WCS and WFS.

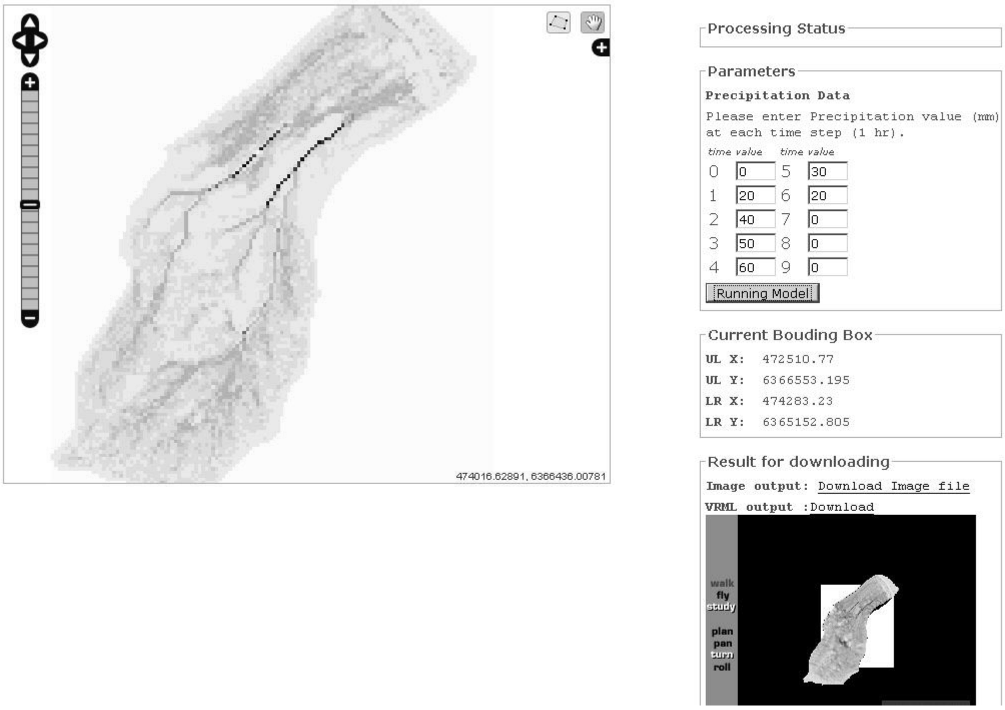

Figure 2. The prototype application of distributed web service for 3D GIS visualization.

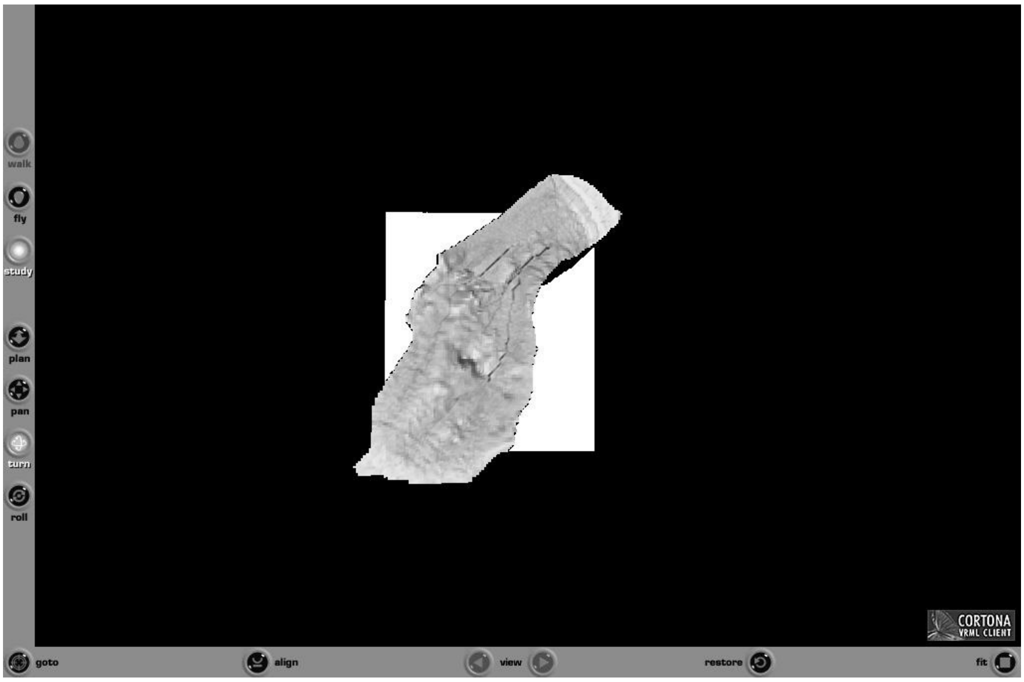

Figure 3. VRML model of geoprocessing result.

The Data Processing Service describes the r.debrisflow framework process. The Data Processing Service provides the two output results. First, the raster image of Maximum depth of surface runoff is displayed as 2D map in client application. Another output is the 3D scene of maximum depth of surface runoff in VTK (Visualization Tool Kit) file format. However, VTK file is not a 3D-enabled Web browser for display and navigation. The conversion process of analytical results into a VRML mode was done by 3D Rendering Service. The offscreen VTK script is capable of conversion functionalities has been developed. Not only is it capable of converting single feature as 3D scene, but also the integration of heterogeneous features is possible. Then, both the output products will be stored in a place corresponding with a return URL location. Thus, the presentation can be visualized on its application and URL address of actual downloadable file is provided.

4. CONCLUSIONS

This paper presents our developed multi-layer distributed architecture system to utilize distributed, heterogeneous open standards web service for 3D visualization of analytical data from geospatial modeling. This SOA for 3D visualization, not only allows the presentation of real world of existing data from distributed Spatial Data Infrastructure (SDI) service, but also the 3D representation of simulation scenario using calculation modeling. Since the back-end of Data Processing Service is carried on GRASS GIS software which provides many powerful GIS functionalities. Therefore all modeling calculation can be processed on difference data set before returning as a 3D scene Web browser enabled for simulation scenario. Since the Service-based architecture was implemented and it required a simpler level of coordination that supports a more flexible reconfiguration for an integration of the services. Therefore the web-GIS application was extended for enabling visualization of dynamic geospatial data as 3D scene, which can be explored interactively by a user, from both distributed Processing Service and Data Provider Service.

5. REFERENCES

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