A Distributed Data Sharing System for Interdisciplinary Ecosystem Services Modeling

Min Feng[1,2], Chengquan Huang[2], Zhiliang Zhu[3]
1. Institute of Geographic Sciences and Natural Resources Research, Chinese Academy of Sciences, Beijing 100101, China;
2. University of Maryland, College Park, MD, 20742, USA;
3. U.S. Geological Survey (USGS), Reston, VA, 20192, USA

Currently, there is much interest in developing ecosystem models to forecast how ecosystem services may change under alternate land use and climate futures. Ecosystem services are diverse, including supporting services or functions (e.g., primary production, nutrient cycling), provisioning services (e.g., wildlife, groundwater), regulating services (water purification, floodwater retention), and cultural services (e.g., ecotourism, cultural heritage) [1]. Hence, the knowledge base for ecosystem services is broad, and is often derived from diverse scientific disciplines. Building the required interdisciplinary models is especially challenging, because the data needed for ecosystem simulations are from different disciplines. These data must be interoperable in order for them to be used together, and be accessible from remote locations for distributed models [2]. Additional difficulties include inconsistent data structures, formats and metadata, and limitations on computing, storage, and connectivity [3]. Although Geospatial databases, data sharing systems, metadata systems, and modeling systems have been introduced or developed, they could not meet the needs of interdisciplinary ecosystem service simulations for several reasons. First, the shared data, metadata, and models within such systems are generally designed for use on standalone computers or within closed networks, not for extensive sharing and integration of resources for interdisciplinary ecosystem simulations (Liu, Peng, Apps, Dang, & Jiang, 2002). Further, the systems designed to share the resources are typically built using inconsistent data formats and model coupling methods. Hence, the resources are often not interoperable and are not directly accessible to support the collaborations needed to address interdisciplinary ecosystem studies [4,5].

To address the above issues, we will develop an approach for open sharing and integration of geospatial resources, including data, metadata, and models, using distributed Geographic Information System (GIS) techniques and open geospatial standards. Geospatial theories and technologies have improved over the last thirty years, and GIS has evolved from Single-Tier, Three-Tier, to Service Oriented Architecture (SOA)

(David, 2005). The Open Geospatial Consortium (OGC) published standards for geospatial data services, including Web Map Service (WMS), Web Feature Service (WFS), and Web Coverage Service (WCS). OGC also published the first version of Web Processing Service (WPS) standards, which defines a standardized interface to facilitate publication, discovery, and consumption of those geospatial processes by users through network [6-12]

In this paper, we propose an architecture for sharing and integrating resources for interdisciplinary ecosystem services studies (Figure 1). Data from various sources, including satellite images, field observation, and other data types, are collected and stored in databases. Although different databases may be used to house different datasets, geospatial data services and metadata services are established to provide a consistent data access interface. The data services are compliant with OGC standards, such as WFS, WCS, and WMS. Metadata generated through metadata services will be compliant with ISO 19115/ISO 19139 geospatial metadata standards. For data sets that do not follow ISO 19115/19139 standards, metadata conversion rules will be established to convert them following ISO 19115/19139 standards [13,14].

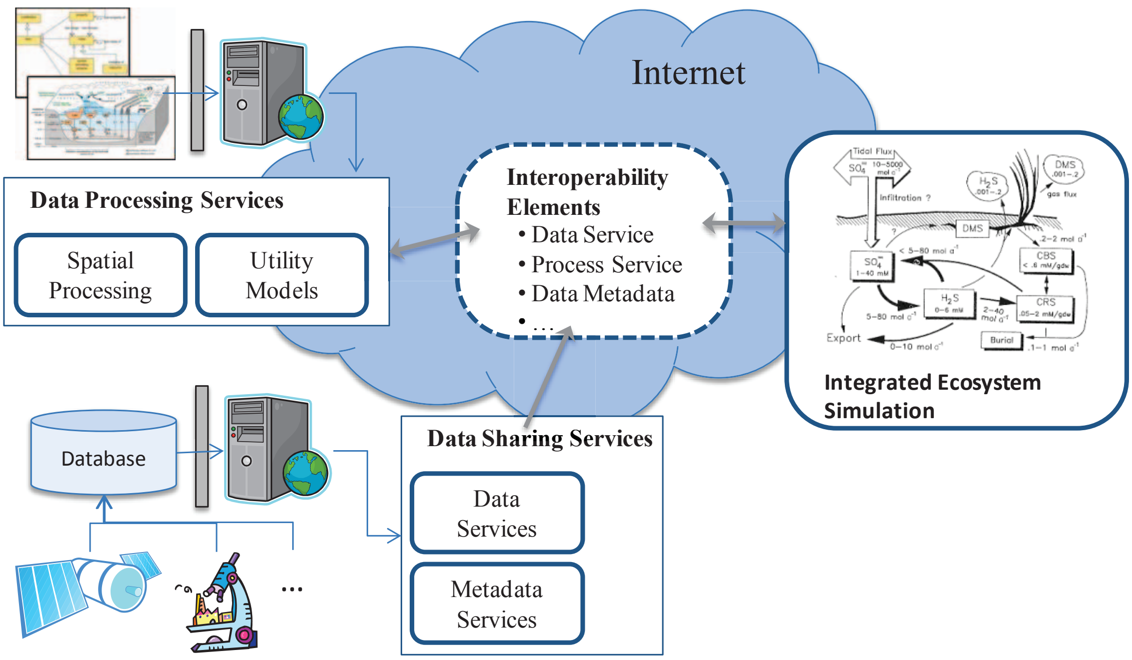

Figure 1 Architecture of the data sharing system

In addition to data values, each data entry has three main features for describing its scope, including theme, spatial coverage/resolution, and time range/resolution [2]. The spatial, temporal, or thematic characteristics of a particular data set may not match the requirements of different models. The Data Processing Services will provide the functionalities necessary for converting such a data set such that it meets the requirement of a particular model. Example functionalities include spatial/temporal interpolation and aggregation. These utilities are shared though services complaint with OGC WPS standards to facilitate interoperability.

Data sharing system will be developed to support data sharing and data processing model sharing. This system will help users reduce redundancy and make data and model sharing more efficient. It will provide tools for users to manage and share their data and data processing models as OGC services. It will be developed using Java Platform Enterprise Edition (J2EE). As one of the Object Oriented Programming (OOP) languages, Java has enhanced network capabilities and numerous libraries that are available to support the platform we will develop. Additionally, open source libraries (e.g., GeoTools [http://www.geotools.org], GeoServer [http://geoserver.org], and OpenLayers [http://openlayers.org]) can be used to empower the geospatial related features (e.g., geospatial data reading and writing, spatial data checking). The platform will be OS independent and can be deployed on any OS that supports Java Virtual Machine (e.g., Windows desktops, Linux servers).

The approach and the system described here have been implemented to support ecosystem services simulation for the Prairie Pothole Region (PPR), an area where mid-continental climate variations interact with glacial geology to produce one of the most productive ecosystems in North America [15].

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