Hydrologic Modeling in a Service-Oriented Architecture

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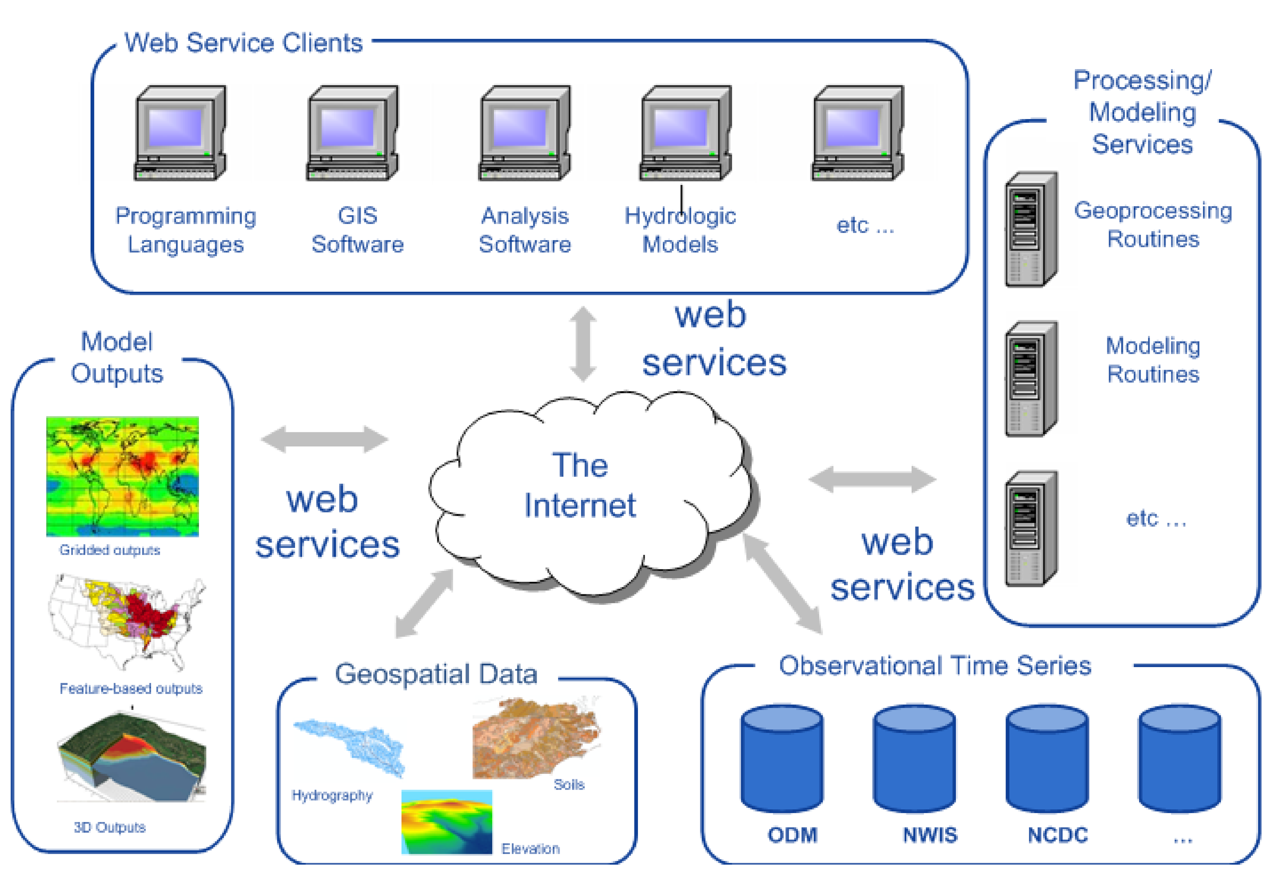
Abstract

Service Oriented Architectures (SOA) offer an approach for creating hydrologic models whereby a model is decomposed into independent computational services that are geographically distributed yet accessible through the Internet. The advantage of this modeling approach is that diverse groups can contribute computational routines that are usable by a wide community, and these routines can be used across operating systems and languages with minimal requirements on the client computer. While the approach has clear benefits in building next generation hydrologic models, a number of challenges must be addressed in order for the approach to reach its full potential. One such challenge in achieving service-oriented hydrologic modeling is establishing standards for web service interfaces and for service-to-service data exchanges. This study presents a prototype service-oriented modeling system that leverages existing protocols and standards to perform service-oriented hydrologic modeling. The goal of the research is to access the completeness of these existing protocols and standards in achieving this goal, and to highlight shortcomings that should be addressed through future research and development efforts.

Background

The Consortium of Universities for the Advancement of Hydrologic Science, Inc. (CUAHSI) Hydrologic Information System (HIS) provides access to hydrologic observations using a service-oriented architecture paradigm. Data services are one component of an overall service-oriented architecture for hydrologic science. Another important part of the architecture is analysis and modeling routines. These services can perform simple operations ranging from simple data processing to sophisticated hydrologic modeling.



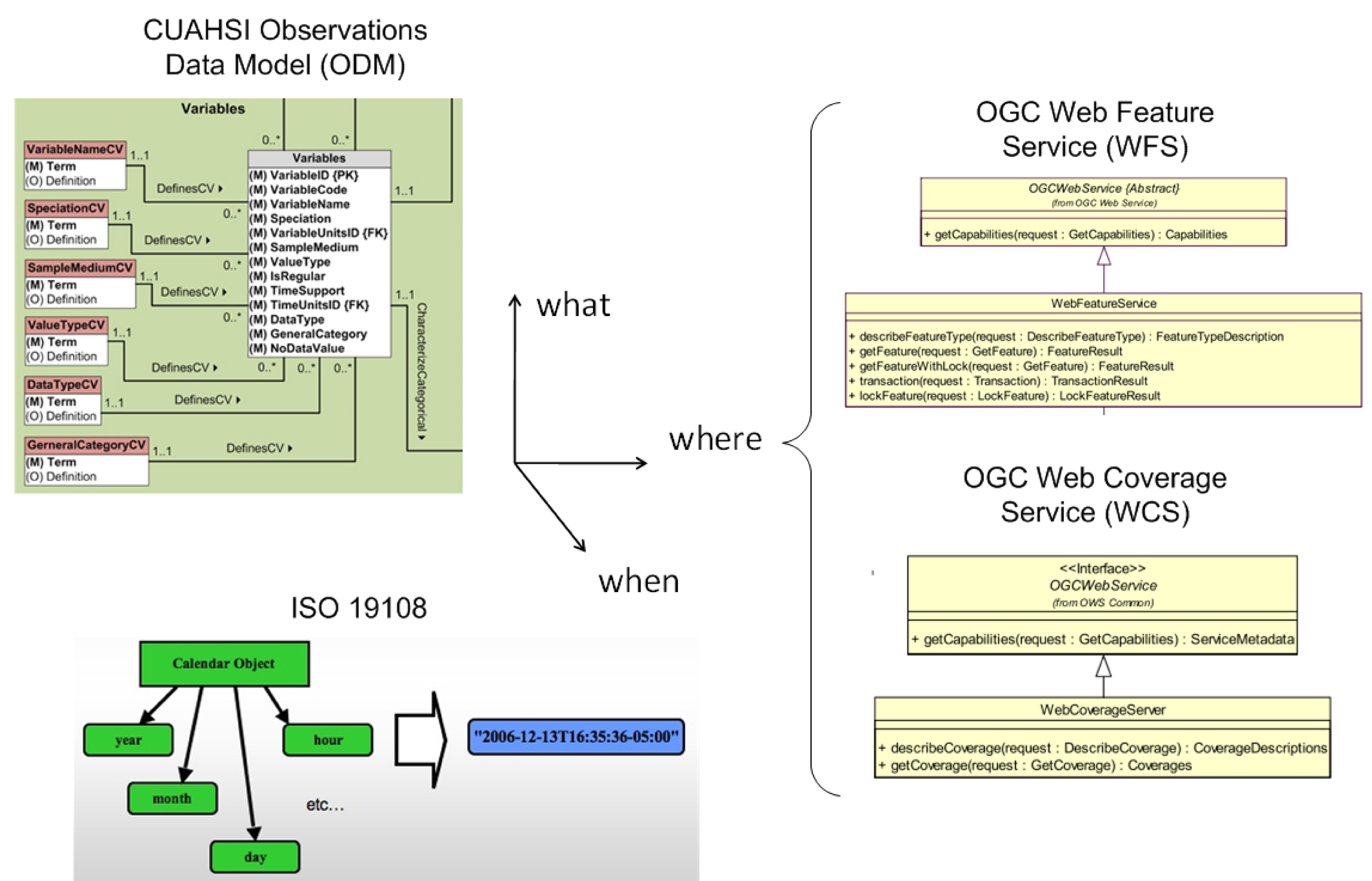
Service-oriented architectures allow for the integration of a variety of remote data and processing resources.

Research Questions

1. How should models play a role in a service-oriented architecture paradigm?
2. What standards exist for exposing models as services and are these existing standards adequate for hydrologic modeling?
3. How should a model's system state be maintained in a service-oriented architecture paradigm?

Representing Hydrologic Data

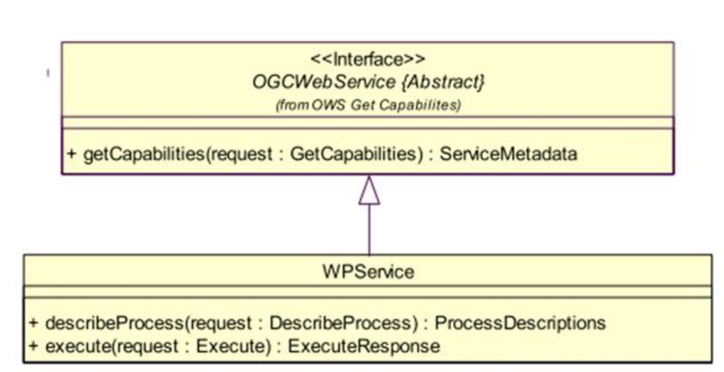
Hydrologic data is often indexed by what, where, and when dimensions. The "what" dimension can be described using hydrology specific standards (i.e. CUAHSI ODM), while the "where" and "when" dimensions can be described using Open Geospatial Consortium (OGC) and International Standards Organization (IS0) standards.



Web Services for Data Analysis and Processing

The Open Geospatial Consortium (OGC) Web Processing Service (WPS) standard provides an interface for exposing processing routines as web services.

A Web Processing Service is useful for implementing functions as web services. These functions can have parameters, inputs, and produce outputs. They are "stateless", however, so they are not intended for modeling applications that step through time or space.

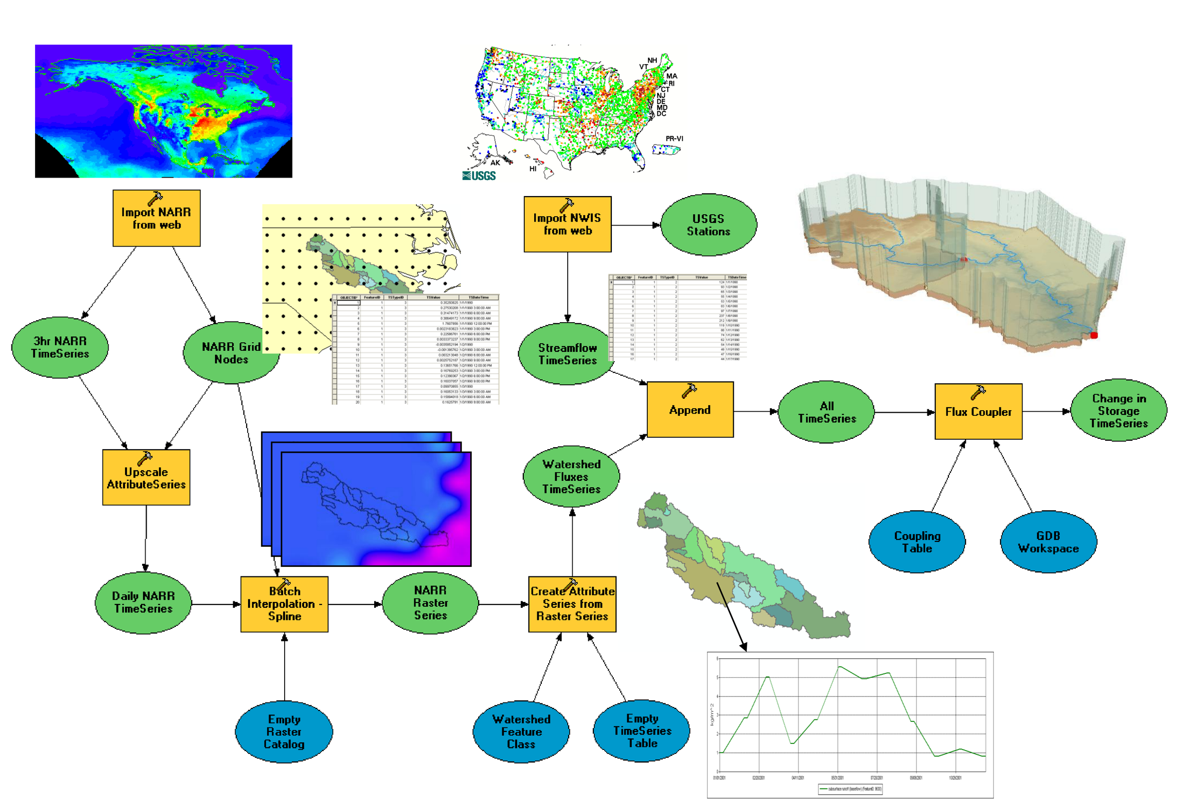


GetCapabilities returns a description of the names and general descriptions of each of the processes offered the service

DescribeProcess returns the required inputs, allowable formats, and outputs produced by the service

Execute runs the service, given the input parameters, and returns the outputs produced by the service.

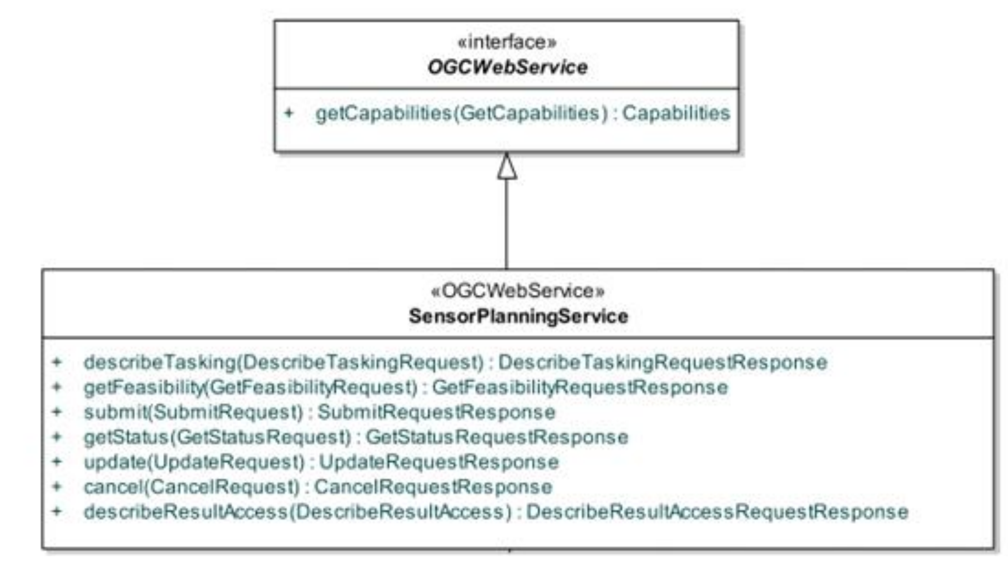
This is an example of a workflow that uses remote data to perform simple data processing needed to run a water balance model. The processing, while done locally in this example, could be implemented using WPS to create a service-oriented hydrologic analysis system.



Web Services for Modeling

There are no Open Geospatial Consortium (OGC) services specifically designed for modeling. However, the OGC Sensor Planning Service (SPS), while designed for remote control of sensors, could be used for modeling that requires state be maintained with a server.

OGC's Sensor Planning Service (SPS)



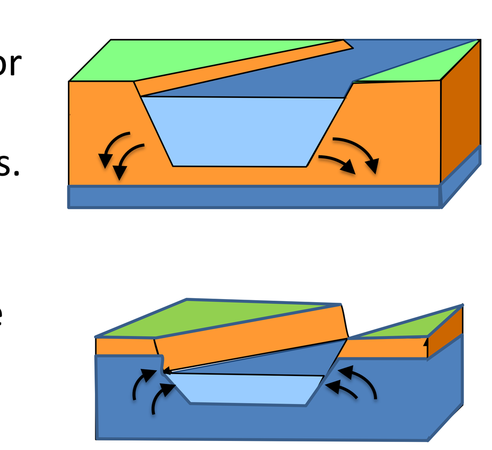
GetCapabilities – same as for WPS
DescribeTasking – returns information describing the tasks which the service can complete
GetFeasibility – can be used to check if parameters are valid or if process can be completed given current server demands
Submit – starts a task
GetStatus – checks task status (waiting, completed, failed, etc.)
Update – change attributes of a task
Cancel – end task
DescribeResultAccess – describes how to retrieve data resulting from the task

Furthermore, the Open Modeling Interface, while not following a strict service oriented architecture, does provide an interface standard that could be extended for a service-oriented paradigm.

Proposed OpenMI inspired web service interface

GetMetadata()	Called to "learn" about model
Initialize ()	Called to setup the model for a run by user X; returns a "token" to the user to maintain state.
SetValues(token, values)	Sets values for an input exchange item for the model's current time step
PerformTimeStep(token)	Forwards the model in time
GetValues (token, exchangeItems)	Returns requested values for model's current time step
GetCurrentTime(token)	Returns the current time for the model
Finalize(token)	Called to clear the memory of the model run by user X.

Maintaining model state is important for tightly coupled systems like groundwater/surface water interactions. Web services are typically stateless, however the proposed OpenMI service introduces the idea of sessions to make the services stateful.



Summary

Many general standards for service-oriented hydrologic data and analysis exist, however these general services and must be supplemented with concepts specific for describing hydrologic data and models. For this, the CUAHSI Observation Data Model schema provides a means for describing hydrologic information, and the OpenMI provides a means for communicating between hydrologic models. Models can be leveraged both as service consumers or as services themselves, however tightly coupled systems present challenges because services are typically stateless.

Acknowledgements

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References

Open Geospatial Consortium (www.opengeospatial.org)
CUAHSI (www.cuahsi.org)
CUAHSI Hydrologic Information System (his.cuahsi.org)
Open Modeling Interface (www.openmi.org)