THE OBJECT MODELING SYSTEM (OMS): A COLLABORATIVE APPROACH TO COMPONENT-BASED COMMUNITY MODELS AND TOOLS

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Abstract The Object Modeling System (OMS) is a modeling framework that uses an open-source software approach to enable members of the scientific community to collaboratively address the many complex issues associated with the design, development, and application of distributed hydrological and environmental models. The modular modeling framework concept 1) facilitates using the resources of a larger science community to work collaboratively on development and application of a variety of modeling approaches to multi-disciplinary problems; 2) provides a framework in which to objectively compare alternative modeling approaches; and 3) provides a means of sharing the latest modeling advances. OMS is a framework for model development, testing, and deployment. The USDA Agricultural Research Service (ARS) has the lead in OMS design and development. However, strong collaborative support, in terms of financial resources and personnel involvement, is provided by the USDA Natural Resources Conservation Service (NRCS) and the US Geological Survey (USGS).

OMS version 3.0 represents a major milestone towards an easier to use, more transparent and scalable implementation of such an environmental modeling framework. Its development is the result of an in-depth analysis of successful (modeling) framework design and software engineering principles as provided by general-purpose frameworks. Like all modeling frameworks, OMS3 is *enabling* technology for modeling. The main goal of OMS3 development is an easier integration of model source code while being tolerant and flexible to adopt existing legacy models. In OMS3, the internal complexity of the framework itself was reduced while allowing models to implicitly scale from multi-core desktops to cluster to clouds, without burdening the model developer with complex technical details.

(i) OMS3 is using a *non-invasive* approach for model or component integration that is based on annotating existing language constructs rather than introducing yet another framework specific API. The need of a traditional API for model coupling was mostly eliminated; no framework specific data-types or protocols have to be learned and used. By allowing any data type to be exchangeable, the full potential of object-oriented modeling can be leveraged without imposing any framework required UML design. Descriptive annotations are used in favor of programmatic APIs in OMS3.0.

(ii) The framework fully embraces *multi-threading* as the default execution model of simulation components. Component execution is controlled by synchronization on objects passed from and to components. If possible and permitted by those dataflow constraints, components will run in parallel without explicit programming by the

component developer. The framework is able to optimize threading for multi-core/multiprocessor environments as well as for cluster/cloud environments.

(iii) OMS3 leverages recent advantages in *Domain Specific Languages (DLSs)* for modeling and simulation. This approach tremendously simplifies the complex setup of simulations for model calibration, optimization, uncertainty and sensitivity analysis or just for single model applications or component testing

OMS3 has successfully being used to implement the (i) USDA AgES model, a fully distributed watershed model for conservation effects assessment, a comprehensive NRCS – ARS modeling effort, and (ii) the PRMS model applied for NRCS water supply forecasting in the western US. (iii) a cloud based modeling web-service infrastructure within NRCS, and (iv) the JGRASS-GIS modeling engine for geo-processing. OMS3 provides methods for model calibration, uncertainty analysis and forecasting such as LUCA multi-step wise multi-objective calibration, Ensemble Streamflow Prediction, Dynamic Dimensioned Search auto calibration, or extended FAST sensitivity analysis for any model application. All OMS3 related resources, documentation, models, tutorials, etc. can be found at http://oms.javaforge.com.