On-Demand Cloud Computing for Multi-Model WRESTORE – A web-based planning software for participatory optimization of conservation practices in watersheds

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Overview: WRESTORE (Watershed Restoration Using Spatio-Temporal Optimization of Resources) (www.wrestore.iupui.edu), supported by an NSF grant and an NOAA grant to the authors, is a web-based, participatory planning system that can be used to connect with watershed stakeholder communities, involve them in using science-based methods for the design of potential conservation practices on their landscape, and reduce undesirable impacts of extreme hydroclimatic events[1][2]. The underlying optimization algorithms and interfaces allow users to not only spatially optimize the locations and types of conservation practices based on quantifiable goals estimated by the dynamic simulation models, but also allow users to include their personal subjective, and/or unquantifiable criteria in the spatial optimization of these practices.

System Architecture: Figure 1 is a schematic configuration of the various components used to support the web-based WRESTORE software. The architecture model in WRESTORE is based on services provided by multiple servers. The remote client users run their browser interfaces to access the various services provided by the WRESTORE project website (http://wrestore.iupui.edu) that resides on the web server. The web server interacts with the data base servers and the main WRESTORE program server to access additional services on storing, communicating, and processing user data and instructions.

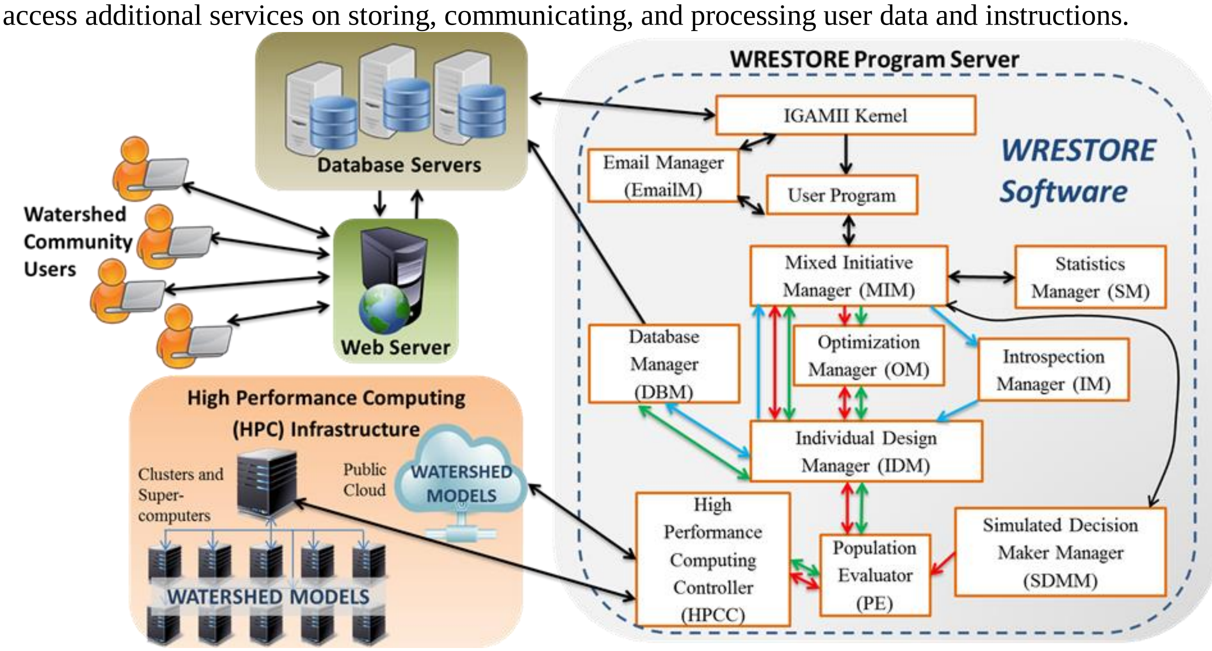

Figure 1. WRESTORE Architecture (Arrows indicate data flow. **Blue** arrows are executed specifically during *introspection* session, **green** arrows are executed specifically during *human-guided search* sessions, **red** arrows are executed specifically during *automated search* sessions)

The Watershed Models in current WRESTORE system is based on the well-known, complex, Soil and Water Assessment Tool (SWAT) model and the optimization algorithms are based on Interactive Genetic Algorithm with Mixed Interaction (IGAMI) algorithm. Both the simulation models and interactive optimization algorithms are computationally intensive, particularly in a multi-user, collaborative scenario. For a recent stakeholder WRESTORE workshop that we conducted in August, 2014, involving 35 watershed stakeholders, we had to use the high-end Amazon Cloud resources to complete the user experiments with WRESTORE in the allotted time of 2 hours. These computations grow even more intensive if multiple models (instead of single ones) are used, as described below.

Multi-Model WRESTORE: One overarching goal of our current research is to develop a novel, computational and mathematical framework for characterizing uncertainty in one of the participatory design methods – Human-Centered Interactive Optimization – for watershed planning and design, using a *multiple models* based systems approach. The *multiple models* approach, in different formulations, has proven to be extremely successful in many scientific and engineering domains for adaptive learning and design but has never been used to rigorously characterize and analyze uncertainty arising from multiple stakeholder-driven design processes. Such multiple models arise in WRESTORE in different forms: multiple hydrological models (multi-physics models or even multiple instances of a SWAT model), multiple climate models, or multiple user models (for a single user or multiple users).

On-Demand Cloud Computing for Multiple Models: It is clear that the multiple model computations in our project are inherently parallelizable with no interdependence among the models. For the purpose of experimentation and development of the methodologies, we plan to use an on-demand HPC Cloud Computing infrastructure such as the *NSFCloud*. We will utilize this on-demand HPC infrastructure, in conjunction with local distributed, cluster infrastructures. To facilitate easy coordination between the local cluster and on-demand HPC resources, we will use a Microsoft Windows HPC job scheduler [3]. When multiple models need to be executed, a number of jobs equal to the number of models are submitted to the Windows HPC job scheduler, which will dispatch the jobs accordingly, preferring the local resources over remote ones (including NSFCloud). A similar architecture was successfully used in [4] for parallel calibration of multiple SWAT models (the same hydrological model used in our current WRESTORE project), where more than a 100 fold speed up was reported as compared to a lap-top computer, making such a platform well-suited for interactive optimization using multiple models.

REFRENCES:

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