Moving Forward: Refinement of the INTELLIGENT RIVER®, A Basin-Scale Monitoring Instrument

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ABSTRACT. *Water is the planet's most precious natural resource, the sine qua non of human health and economic prosperity.* This manifest fact has startling consequences in light of the growing incongruity between water supplies and water demand. Population growth, industrialization, and climate change are putting the nation's watersheds at risk. The impact can be catastrophic, disrupting local ecosystems, decimating native species, stifling energy production, damaging food crops, and compromising human health. The nation's watersheds are at risk.

Safeguarding water resources in the face of shifting sands requires a national investment in basin-scale environmental research programs. The extent of these programs is dictated by the plexus of relationships that link land use, energy production, climate change, and water. To discern meaningful connections, the span of a given program must encompass all of the major elements of the constituent watersheds — from stormwater systems to riparian forests to hydroelectric impoundments, and all of the elements in-between. The challenge stems from the enormity of the systems under study. The task calls for an observation instrument with a broad lens, one which enables basin-scale visibility from a single point of observation — *an environmental macroscope.* In late 2011, the Clemson University INTELLIGENT RIVER® team received a $3M award from the National Science Foundation to build it (CNS-1126344).

The INTELLIGENT RIVER® is a basin-scale observation instrument comprising a heterogeneous fabric of in situ sensors that cover an expansive geographic area. The core of the design is built on cyberinfrastructure that enables end-users —researchers, educators, and policymakers— to collect, share, and utilize a broad spectrum of hydrological and environmental data at ultra-dense temporal and spatial scales. The instrument architecture is illustrated in Figure 1; it consists of four tiers, each defining a technology research thrust at Clemson. The first tier implements a wireless *sensing fabric* comprising multi-parameter river sondes (both stationary and profiling) and terrestrial platforms, the latter deployed at ultra-dense scales. The second tier provides a *transit and uplink system* for relaying observation data from the sensing fabric to Clemson's high performance computing backbone. On the backbone, the third tier provides *observation management middleware* for automating the validation and dissemination of observation data from multiple data publishers to multiple data subscribers. Finally, the fourth tier provides *repository and presentation services* for translating (and storing) observation data to a range of formats and presenting that data to a diverse set of end-users.

The instrument will be deployed along the 300-mile reach of the Savannah River, running from the headwaters in the Blue Ridge mountains to the estuary of the Atlantic Ocean. The Savannah River provides drinking water to municipalities in two states, sustains 130,000 acres of irrigated land, and supports 350 industrial and municipal facilities via 69 intakes and 600 points of discharge. Three major impoundments and a system of dams support flood control and hydroelectric power generation. The Savannah is of tremendous value to the region and exhibits all of the key management and instrumentation challenges associated with major U.S. rivers. It is an ideal demonstration site for the instrument.
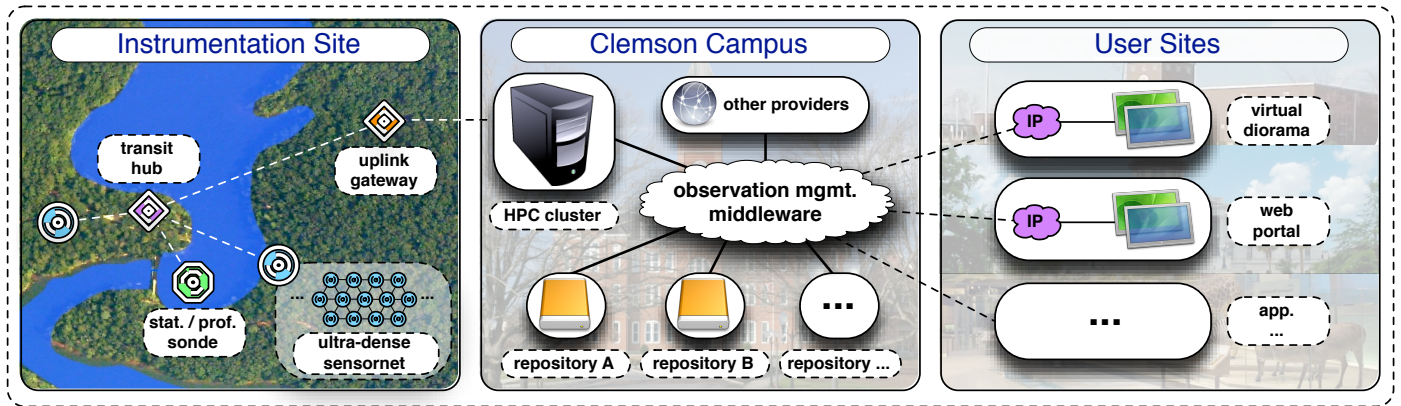
Figure 1: INTELLIGENT RIVER®Architectural Overview

Presenter Biography. Jason O. Hallstrom is an Associate Professor in the School of Computing at Clemson University and serves as Associate Director of the Institute of Applied Ecology. He holds the B.S. and M.A. degrees from Miami University in Systems Analysis and Economics, respectively. He also holds the M.S. and Ph.D. degrees from Ohio State University in Computer and Information Science and has approximately 10 years of industry development experience. His research is at the intersection of embedded network design and software engineering. Specifically, he works to enable the reliable design, deployment, and maintenance of long-lived embedded network applications at scale. He has published numerous journal, conference, and workshop papers across these areas. He is currently supported by grants from the NSF (CNS-1126344, CNS-0745846, CNS-1116976, DUE-1022941) and was previously supported by the NASA Space Grant Consortium and Microsoft Research.