A New Framework for Multi-Reservoir Operations and Management

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The Internet of Things
What are Decision Support Systems/Tools
Introduction to the OptiRTC Framework
Current Smaller Systems Applications
Possible Framework for Multi-Reservoir Systems
Q&A
Who is Geosyntec?

- We are 28 year old consulting firm focusing on challenging problems in select engineering and environmental disciplines.
- We have been in Portland for 12 years and have 42 offices in the U.S.
- We have a wide variety of practices in geo-environmental sciences and engineering which include:
  - Watershed, Environmental, Stormwater and Waste Management
  - Geotechnical/Geological Engineering
  - Water and Natural Resources
  - Decision Support Systems, Real Time Control and Data Management

What do I do

- Hydrodynamic and water quality modeling of rivers, reservoirs and estuaries
- River and reservoir multi-objective management (hydropower, flood control, FERC relicensing, TMDLs and ESA listings etc.)
- Sediment and fate and transport modeling
- Numerical model and data integration
Definition of “Internet-of-Things”

• “things having identities and virtual personalities operating in smart spaces using intelligent interfaces to connect and communicate within social, environmental, and user contexts” (EPoSS 2008).

  European Technology Platform on Smart Systems Integration

• Geosyntec is seeing rapid and ubiquitous adoption occurring in civil environments
What are Decision Support Systems and Tools?

Tools that makes sense of disparate data and information in a decision space by presenting it in a compelling format.
OptiRTC Solution

Internet Based Weather Forecast or other data sources (Web service API)

Azure Tables/Blobs

Data Logging and Telemetry Solutions

Microsoft Silverlight

OptiRTC User Interface Web Services and User Dashboards

OptiRTC Data Aggregator and Decision Space

Field Monitoring, Modeling, and Control (Sensors, Gauges, and Actuators)

Email
Tweet
SMS
Voice Autodial
Interactive Dashboard Browser (Map/Pod View) Interface and Alerts

Note Live GARR Imagery Overlays on Map View Dashboard Browser
Example Real Time Dashboards with “Pod” Components

- Time Series - Stage, Flow, Precip.
- Scatter Plots
- External Data Sources (e.g., Real Time Radar, QPF)
- Data Viewers/Explorers
- QA/QC tools
- Basin and Summary Stats and Charts
OptiRTC is different than your standard DSS.

It’s not a piece of software, it’s a framework to generate many different solutions based on needs.

Overarching considerations
- Integration of data collection, analysis, and control
- Fully scalable
- Fully customizable
- No special software requirements
- Competent developer base
Environmental data is like any other enterprise data stream, utilizes enterprise data management solutions.

Used by many industries so there is a large and competent developer base (i.e., Microsoft Azure, Silverlight, HTML 5, etc...) which means forward compatibility.

ANY internet-accessible structured dataset (IoT) can be integrated.

Cloud-based (internal or external) data processing and storage allows 99.95% application uptime.

Mobile Applications

ioBridge Pro Controller
Major Component Technologies

Server Stack/Cloud Platform and Storage Solution

Federated Authentication Service

Physical-world interface

Primary User Interface for Dashboards

Future Mobile Applications
Run Complex Models in Real Time

- Run HEC-RAS, CE-QUAL-W2, HEC-ResSim, HYDSIM and other models as part of decision space calculation.
- Incorporate spatial processing libraries.

CE-QUAL-W2 Model

MapWindow GIS .NET spatial processing library
Decision Support Tools Project Examples

- **Advanced Rainwater Harvesting**
  - 1 System Online since July 2011, New Bern, NC
  - 7 Systems Online since September 2011 - St. Louis, MO
  - 2 Systems, Installed, Online in March - Washington, DC

- **Active Green Roof**
  - SAP America’s Headquarters Building, Newtown Square, PA

- **Controlled Underdrain Bioretention**
  - Gwinnett County, GA – Online in Q1 2012
Data Acquisition and Management (Real Time)

- Geotechnical and instrumentation data, Herbert Hoover Dike, FL; Wolf Creek Dam, KY; and Center Hill Dam, TN
- Grouting Instrumentation and Water Quality Data, Wolf Creek Dam, KY; and Chickamauga Lock and Dam, TN
- Instrumentation Data, TVA Kingston Facility, Kingston, TN
- Nestle Spring Water Monitoring: Water Quality Monitoring, Various Sites, FL
Simplest Definition: Drain storage in advance of predicted rainfall or other trigger
NC State, System Behavior Week of 9/20/2011, Forecast Data Stream

70% Threshold
QPF and POP Forecast Data stream (Threshold of 70%)
Forecast Predicts
Inverted Siphon Downspout Design

(Note: location of cistern is shown close to building for illustrative purposes only)
Initial Modeling for the Site

- DDOE Modeling Summary
- Baseline runoff volume:
  - 12,680 cf/yr
- Passive detention wet-weather runoff volume:
  - 11,326 cf/yr
  - 11% reduction
- Real-time controlled wet-weather runoff volume:
  - 3,899 cf/yr
  - 69% reduction in wet-weather flow volume
  - Note no harvesting factored in, assumes accurate forecasts
Flow Comparison – DDOE Modeling

Timing of release relative to forecast (blue line) allows for dramatic reduction in wet-weather discharge without giving up harvesting performance. Note no discharge during baseline event.

Water remains in system for potential onsite use while providing improved CSO flow control. Drains only right before events.

Detention tank empty except during rainfall.
Kingston Fossil Plant, Kingston, TN: On December 22, 2008, 5.4 million cubic yards of material released into the Emory River and other areas.

Client needed an area for temporary processing, dewatering, and storage of fly ash excavated and collected from the Emory River and other areas.

Due to presence of soft foundation materials, similar to those found underneath the Cells that failed instrumentation were needed to monitor pore pressures and settlement imposed by filling within the Site.
Instrumentation Plan

Legend
- Green circle: Piezometer (5)
- Blue triangle: Clay Piezometer (5)
- Red diamond: Settlement Plate (5)
- Yellow circle: Slope Inclinometer (7)
- Green line: Protective Casing
Instrumentation Network

- **15 Vibrating Wire Transducers**
  - AM16/32B Relay Multiplexer
  - AVW200 Vibrating-Wire Spectrum Analyzer
  - CR800 Data logger

**Monitoring Enclosure (Field)**

- RF401 Radio
- NL100 Network Interface

**On-Site Office**

- Internet TCP/IP
- Geosyntec Server

**Internet TCP/IP**

- On-Site Office
- Client’s PC

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- NOAA stream flow forecasts
- Quantitative Precipitation Forecasts (QPFs), spatial data sets
- Quantitative Precipitation Estimates (QPEs), real time gauge adjusted rainfall radar, spatial data sets
- Real time data acquisition
- Integration with hydrologic and hydraulic models
- Multi-reservoir system operations
- Warning or alert systems and notifications
Individual reservoir operational objectives

Multi-reservoir system operational objectives

ESA, BiOp, TMDLs

- Temperature
- Total Dissolved Gas (TDG)
- Total Suspended Sediments (TSS)

- Fish passage
- Ramping rates
- Minimum flow requirements

Operational scenario testing

Model scenario manager
Hydropower Optimization

- Individual reservoir optimization
- Multi-reservoir optimization
- Bracketing operational constraints
  - Environmental compliance
  - Flood control
  - Margin of safety for operations
- Operational scenario testing (for operators)
- Real time data acquisition and status reports
  - e.g. flow, meteorological conditions, forecasts, power usage and rates
- Integration with hydraulic and hydrologic models
Additional Applications for Reservoir Systems

- Efficient use of resources
- Hazard monitoring
- Watershed management
- Predictive control
- Adaptive management solutions
- Alert notification
- Handles any data stream, seismic, rainfall, gauge adjusted radar rainfall, QPF, meteorological, flow, discharge, temperature, water quality (any external data).
- Integration of environmental data with existing IT
Field Monitoring for Modeling and Downstream Compliance

NOAA Streamflow Predictions

Azure Tables

Blobs

Time Series Database

ResSim, HYDSIM, or Other

NN/Genetic Algorithm or Other

Model Execution and Optimization

User Input data

OptiRTC Data Aggregator and Decision Space

Multi-user Interface and Dashboards

Possible Hydropower Decision Support Tool
Multi-Reservoir Operations

Demo
Lower Columbia River Dashboard

OptiRTC

Gage Height
- Past 24 Hours - Latest record at 9:02 AM
- Export: 1d, 3d, 7d

Water Levels
- Current Status
- Export: 1d, 3d, 7d

Beaver Army
- 76.05 feet

Below Boneville
- 2.74 ft feet

The Dalles
- 12.29 feet
Lower Columbia River Dashboard
Questions?

Thank you