Geo Spatial Service Oriented Architecture of the Indiana Flood GRID

A People/Sensor/Machine Workflow Orchestration

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The Polis Center
We bring things into perspective.
Background the Pilot Research Project

- Our pilot study area is Ravenswood
- Ravenswood floods very frequently

- Indianapolis Museum of Arts “Nature Park” get flooded too and had an interest in modeling this area

- USGS water scientist had modeled this area with high resolution DEM’s

- The Polis Center had experience in Hazus-MH pre disaster mitigation planning tools (Prepared plans for IN/IL/WI for more than 100 counties)

- Partnership between USGS Water Sciences Division and The Polis Center
Objective

- Generate current and forecast flood inundation maps: USGS and NWS data, 2D Hydraulic model (FastMECH)
- Generate flood maps for HAZUS-MH Analysis
- Serve flood maps (near-real-time) through Web
Innovation

- USGS Cap 2 Geospatial SOA Best Practices grant
- The Polis Center at Indiana University Purdue University Indianapolis and Community GRID Lab at Indiana University
- Opportunity + Research > Innovation
Distributed Processes and Asynchronous I/O

- CGNS Data
- Parcel Assessment & Hazus FIA D-Curves Service (Polis)
- Property Assessment Data
- Loss Estimate
- Reports
- Flood Map
- Demographics
- Essential Facilities
- Parcel Map
- Maps
- Hazus Data (Polis)
- Parcel Boundaries (Marion County)
- FastMech Process (IU Big Red)
- Flood Depth Grid Data
- Water Flow Data
- CGNS Data
- Model Design & Calibration (USGS Water Scientists)
- Real-Time Water Flow Gauge Data (USGS-AHPS)
- SAVI (Polis)
- Parcel Map
- Marion County
- Indiana

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Pervasive Technology Institute
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We bring things into perspective.
Heterogeneous (not homogeneous)

- Operating Systems
- Compilers
- Communication Protocols
- Development Frameworks
- Databases and File Systems
- Standards

Software logos and names:
- Fortran
- Java
- NetBeans
- C#
- Python
- Oracle
- Microsoft
- Google
- OGC
- IIS7
- Microsoft Visual Studio
- Fx
- SQL Server 2008
- REST/SOAP
- Windows
- Linux

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## Service stack

<table>
<thead>
<tr>
<th>Service name</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Real time data import service</td>
<td>This service downloads flow gauge forecast data from USGS National Water Information system.</td>
</tr>
<tr>
<td>Input process service</td>
<td>This service fuse the flow gauge data into the input CGNS file.</td>
</tr>
<tr>
<td>Flood simulation service</td>
<td>This service runs FastMECH simulation model on a given input CGNS file by submitting the computation job to a condor queuing system on an IU Gateway hosting VM.</td>
</tr>
<tr>
<td>Output process service</td>
<td>This service post process the FastMECH output files and generates curvilinear grids. Generated grid geographic projection is in UTM 16</td>
</tr>
</tbody>
</table>
## Service stack

<table>
<thead>
<tr>
<th>Service Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Grid generation service</strong></td>
<td>This service consumes the curvilinear grid files generated from FastMECH and generate rectilinear flood depth ASCII grid file. This service also transform the data from UTM 16 coordinate to geographic coordinates. Grid cells are generated by using nearest neighbor clustering techniques.</td>
</tr>
<tr>
<td><strong>Loss calculation service for building damage</strong></td>
<td>This service consumes parcel assessment data and the overlay on top of the grid and intersect the flooded parcels. After that it uses building assessment information and flood depth information from the grid and calculate the losses per Federal Insurance Agency (FIA) flood loss curves.</td>
</tr>
<tr>
<td><strong>Map tile cache service</strong></td>
<td>This service consume the grid file and generate flood map for visualization. In this process the grid coordinates are transformed to World Mercator coordinate system</td>
</tr>
</tbody>
</table>
Work/Process Flow and Controls

Flood Studies

<table>
<thead>
<tr>
<th>ClusterId</th>
<th>Date</th>
<th>Simulation</th>
<th>Estimation</th>
<th>MapCache</th>
<th>Runner</th>
</tr>
</thead>
<tbody>
<tr>
<td>5954</td>
<td>4/29/200</td>
<td>Running</td>
<td>Pending</td>
<td>ndevadas</td>
<td>ndevadas</td>
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<tr>
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<td></td>
</tr>
</tbody>
</table>

Selected study properties

Cluster Id: 1

CIGNS file: http://community.uic.edu/cgi-bin/fm/fm.rural.cgn
Bounding box: 39.868, -86.146, 39.9, -86.12
Affected parcels:

Estimated Total loss

The damage curve source is FIA
Total building damage loss = $10,159,634.93
Number of affected parcels = 389
Average building damage loss = $26,117.31

Map layers

- Flood Grid
- River flow gauges
- Dry
- Normal
- Wet
- Flood study areas
- Flooded parcel centroids
- Parcel boundaries

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Special Thanks to USGS Water Scientists

- Scott Morlock (smorlock@usgs.gov)
- Moon Kim (mkim@usgs.gov)
- Leslie Arihood (larihood@usgs.gov)
- James Kiesler (jkiesler@usgs.gov)
Demo

- [http://in-polis-app09.ads.iu.edu/FloodLossEstimatorWS/FILA/FILAUI.html](http://in-polis-app09.ads.iu.edu/FloodLossEstimatorWS/FILA/FILAUI.html)
Identify best practices that resulted from this work that are relevant in the federal/intergovernmental environment

This work resulted in an application that has integrated existing flood data streams from the National Weather Service and U.S. Geological Survey to create a real-time and forecast flood inundation tool. The tool allows Federal, State, and local emergency managers to make flood planning, response, and mitigation decisions to safeguard life and property. The tool displays both real-time and forecast flood depths and extents on a street-level map. The tool can be used to identify flooded parcels and create real-time flood damage loss estimates. The SOA architecture used by the tool allows flood data from independent agencies and operating systems to be seamlessly combined to create flood maps and reports for the user. The best practice of most relevance is that existing data streams and sources have been combined to create a visual flood response and mitigation tool for the 21st century.
What is the level of maturity and viability of the referenced SOA/Cloud solutions or infrastructure within a governmental computing environment?

This solution has the highest level of viability as it builds existing multi-agency services into a single application for flood planning, response, and mitigation. This tool is highly expandable on State, Regional, and even National Basis. This is because the base data streams NWS flood forecasts and USGS streamgage data are widespread and uniform in data distribution, and because the need for real-time and flood forecast maps is universal for flood prone communities. The level of maturity of the real-time flood application is new this is a cutting edge and new application; however, the maturities of the services that are integrated by the tool are very high.
What are perceived impediments to adoption of your highlighted SOA/cloud practices in the government environment?

Funding resources may be limited, as there is currently not an identified long-term source of operations and maintenance funds. For the foreseeable future there are resources to keep the pilot river reach application running, but expansion of the effort will require sources of funding for further development, refinement, and maintenance.
Questions?

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  – Marlon Pierce (mpierce@cs.indiana.edu)