Final Report

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Project title:	**Assessing the Potential Benefits of Hosting Maryland's Basemap in the Cloud**
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Executive Summary

This partnership with the Maryland State GIO, the Center for GIS (CGIS) at Towson University (TU) led a project to assess the value of making Maryland's latest basemap data available in Amazon's Cloud-based web services. MD iMap is Maryland's public-facing enterprise GIS infrastructure. We compared the load handling capability of the current MD iMap hosting environment with an Amazon EC2 hosting environment built around a recommended Large server instance. This test intended to quantitatively compare, the Amazon Virtual core EC2 compute units with CPU capacity on MD iMap servers to clarify this important architecting parameter and provide a recommendation for a server instance size suitable as a basis for hosting MD iMap services in EC2. Additionally, we tested the server scaling capabilities for cost of ownership analysis. We determined that a Large EC2 instance was not robust enough to meet the peak demand that MD iMap occasionally responds to. For a variety of methodological reasons we were not able to quantify the differences between current MD iMap server CPU capacity verses EC2 compute units of the Large instance. While an estimated cost of ownership was completed showing MD iMap's traditionally hosted infrastructure having a lower cost over a 6 year period, there are many ways in which

Amazons cost could be brought down by fine tuning testing that was beyond the scope of this project. The most savings in Amazons costs would be wrought by rebuilding GIS services, applications and architecture completely around Amazons hosting services. The project is completed.

Project Narrative

Background
The Center for GIS at Towson University (CGIS) led a project to assess the value of making Maryland's latest basemap data (6-inch imagery and Gazetteer) available in Amazon's Cloud-based web services. MD iMap is Maryland's public facing enterprise GIS infrastructure for providing mapping applications, products, and services online that assist citizens and government employees with managing and presenting data linked to a location. The state's 6-inch imagery is maintained by MD DNR and is hosted on the MD iMap infrastructure at Towson University. Per the proposed scope of work, CGIS anticipated completing the following technical activities.

1. Prepare and cache the data in an ArcGIS Server 10.1 compact cache.
    a. Reproject the data from Maryland State Plane, meters, to Web Mercator coordinates. Data uploaded and published in ArcGIS.com is automatically available to mobile browsers in a JavaScript viewer designed to work well in small-screen devices. Making Maryland's imagery and basemap available in Web Mercator, hosted in the Cloud environment, will enable the browser-based GPS location function to work properly and will speed up map draws on mobile devices.
    b. Cache the reprojected data.

2. Deploy an Amazon EC2 ArcGIS server infrastructure that has the same level of availability as MD iMap, while taking advantage of Cloud-based scalability to only pay for what is needed at the time, based on system load.

3. Deploy Maryland's basemap and 6-inch imagery data and services on the EC2 environment.

4. Test the published CPU equivalencies by Amazon (Virtual core and EC2 compute units) and compare them from a performance perspective with the current MD iMap infrastructure hardware.

5. Develop and conduct a workshop to enable participants to create a mobile application.
    a. Teach participants to use the data cached in the Cloud in conjunction with Esri's free ArcGIS.com application development tools to enable mobile mapping.

6. Collaborate with partners and participating organizations to test the real-world use of the system in the Amazon Cloud environment.
    a. Assist MEMA with using the data as an alternate source for the OSPREY public information mapping application.

7. Work with MEMA and Maryland DNR to test the data and compare performance.
    a. Based on performance characteristics and real-world utilization of the basemap and imagery services, optimize the cloud-based deployment design.

8. Publish a white paper that fully documents technical tasks and outcomes, deployment costs, performance characteristics, and the estimated cost of ownership for both environments at the current level of utilization.

Project Outcomes

In the interim between writing the proposed scope of work and launching the project, several unanticipated impediments to progress occurred, namely, changes in project partners' plans, a change in the upgrade schedule for the MD iMap infrastructure, and delays in testing due to non-availability of the MD iMap system prior to and during Hurricane Sandy. The changes not only delayed progress, but also became significant impediments to the original project vision.

The original scope of work proposed testing of ArcGIS Server (AGS) 10.1 (versus 10.0.x) based on the state's plan to migrate MD iMap to AGS 10.1 and because the server performance in AGS 10.1 was significantly improved over 10.0.x. The final decision by the state's GIO to *not* migrate to AGS 10.1 was made on November 2, 2012. Independently of this grant project, the GIO also requested that CGIS work with Amazon to architect and cost out the requirements for deploying an equivalent hosting environment for MD iMap with AGS 10.1 in Amazon's cloud environment. After thorough due diligence, the decision was made to keep the physical infrastructure host at Towson University at AGS 10.0.x and to not deploy hosting within Amazon at this time. The State made the decision to host the MD iMap infrastructure at a new State owned enterprise hosting facility.

The decision process yielded the architecture and related costs for the Amazon hosting environment as developed by an Amazon Systems Architect. The GIO also decided to redevelop MD iMap-hosted applications to make them mobile compatible, and to deploy OSPREY "lite" (as referenced in Task 6a above) on Maryland's ArcGIS Online (AGOL) Premium license.

As an alternative to the original Task 5, a Cloud-based load testing service was used that enabled simulation of real-world user application interaction as part of the environment comparison load testing. CGIS also invited students in the Towson University Computer Science program to become involved as part of their senior year Capstone project. The students brought a fresh, dynamic approach to the research, and their professor assisted with ensuring the quality of their work.

Despite the changed circumstances, CGIS achieved core project goals by assessing the cost and performance equivalencies of the Amazon environment with the current MD iMap hosting infrastructure. The final outcomes of the project tasks are listed below.

Project Tasks
1. Prepare and cache the data in an ArcGIS Server 10.1 compact cache.
    a. Reprojecting the MD iMap Basemap from Maryland State Plane, meters, to Web Mercator coordinates is complete.
        i. Note with the real-world application testing no longer feasible, only one cached service was needed. The basemap service was chosen over the imagery, primarily because of the shorter timeframe needed to create the cache relative to the compressed schedule.
        ii. Vector datasets were required for simulated real-world application load testing. Five current MD iMap data sets were chosen and projected for use in testing in this manner.
    b. The reprojected data has been cached.

2. Deployment of Amazon EC2 ArcGIS server instances at a similar level of server capacity to MD iMap is complete. Cloud-based scalability to only pay for what was needed at the time based on system load was tested.
    a. To emulate the server capacity and architecture as closely as possible, an additional Amazon instance was required. With the change in testing methods, the instances do not need to be on

all the time. Therefore, this line item cost was reduced yet still provided the additional server instance needed.

3. Deployment of Maryland's basemap data and services on the EC2 environment is complete.

4. Test the published CPU equivalencies by Amazon (Virtual core and EC2 compute units) and compare them from a performance perspective with the current MD iMap infrastructure hardware.
   a. Testing is complete on both the MD iMap infrastructure and on the Amazon infrastructure. The testing results were inconclusive due to architectural differences that interfered with quantitative analysis. Testing determined that an m1.Large instance was not going to be able to handle peak loading in MD iMAP and that a larger instance was needed to scale properly.

5. The project did not develop or conduct a mobile application workshop due to the change in partner participation and the turn of events described in the project narrative above.

6. *Real-world* use of the system in the Amazon Cloud environment was not tested due to the change in partner participation described in the project narrative above.
   a. OSPREY Lite was developed at the Maryland Emergency Management Agency (MEMA) in AGOL.

7. The project did not work with MEMA and Maryland DNR to test the data and compare performance due to the change in partner participation and turn of events described in the project narrative above.

8. The completed white paper fully documents technical tasks and outcomes, deployment costs, performance characteristics, and the estimated cost of ownership for both environments at the current level of utilization.
   a. The cost of ownership analysis and documentation is completed and included as part of the white paper. While an estimated cost of ownership was completed, showing MD iMap's traditionally hosted infrastructure having a lower cost over a 6 year period, there are many ways in which Amazons cost could be brought down by fine tuning testing that was beyond the scope of this project. The most savings in Amazons costs would be wrought by rebuilding GIS services, applications and architecture completely around Amazons hosting services.

Next Steps

- The project's activities will not continue after the performance period.
- What formal or informal organizational relationships have been established to sustain activities beyond performance period?
- The State made the decision to host the MD iMap infrastructure at a new State owned enterprise hosting facility. Hosting MD iMAP framework datasets in Amazon is not in their plan at this time.
- Requirements (more technical assistance, software, other?)
  - The project is used some of the savings in the cost of the Amazon hosting environment to pay for load testing services from LoadStorm.com.

  - No other requirements were identified in the final stage of this project.

Expenditures

The project has expended $22,136.67 of the award funding (plus $12,481.25 non-cash recipient share). Leaving the remaining award balance is $2,825.45.

Feedback on Cooperative Agreements Program

What are the CAP Program strengths and weaknesses?
The CAP Program funds statewide projects that might not otherwise be supported. CGIS did not encounter any CAP program weaknesses.

Where did it make a difference?
The CAP program allowed the State of Maryland the benefit of a developed cost estimate to help evaluate hosting in Amazons EC2 environment as part of their analysis on hosting MD iMap next generation.

Was the assistance you received sufficient or effective?
CGIS requested technical assistance from Esri and Amazon for support to ensure that best practices were followed while building out the test environments and procedures.

What would you recommend that the FGDC do differently?
No recommendations were developed from the grant activities.

Are there factors that are missing or are there additional needs that should be considered?
There are no additional considerations.

Are there program management concerns that need to be addressed, such as the time frame?
CGIS had adequate time to complete the project as we were granted an extension.

If you were to do the project again, what would you do differently?
MD iMap had a limited timeframe for testing, if CGIS was to do this project again, CGIS would have tested in Amazon first to confirm the details of the methodology before running the tests in MD iMAP. Reversing the hosting environment order would have provided additional time for more quantitative performance results. This would have likely led to in a more precise cost of ownership comparison.

Closing Statement

At the time of writing this grant CGIS did not find standards are best practices on how to access hosting of basemap services in Amazon–cloud. While there were challenges in implementing this grant the results obtained provided important lessons learned and consideration for others considering moving a GIS infrastructure to Amazon-Cloud. The outcomes of this grant initiative provided decision support for Maryland and future plans for infrastructure.

The Center for GIS, the Maryland Geographic Information Committee, and the Maryland State Geographic Information office appreciate the funding that makes the opportunity to work on this important endeavor for the State of Maryland possible.