Nationaal Lucht- en Ruimtevaartlaboratorium

National Aerospace Laboratory NLR

Executive summary

Designing a WebGIS architecture for aviation impact assessment

Problem area
In aviation a lot of research is focused on the assessment of environmental and anthropogenic impact, by modelling and monitoring sound and emission levels. To do so, advanced models are developed that use different input datasets, such as aircraft and engine characteristics and geographic information of the point of interest. Currently, the results of this research are assessed by aviation experts using a locally installed full scale Geographic Information System (GIS) software package, while mainly viewing and basic analytic tools are required.

To be able to use a GIS as a truly supportive tool for these users thereby excluding non-essential functionality and offering easy web access, the National Aerospace Laboratory (NLR) in The Netherlands has developed a service-oriented WebGIS infrastructure based on Adobe Flex, ArcGIS Server components and generic SOAP/WSDL services.

The ArcGIS Server Flex API based RICH client offers users access to data processing and analysis functions implemented as SOAP services. These services are partly built on ArcGIS components providing a large set of data visualization and geo-processing functions. Components related to user management (including security aspects like authentication and authorization), data management and data conversion are developed and implemented by NLR.

The benefits of this web-based client and a service-oriented architecture relate to the quick development of dedicated applications (in this case for environmental and anthropogenic impact studies), which can be centrally managed and maintained. For users it offers easy access to many GIS functions without the need of expert knowledge

Description of work
Development of the GDSC viewer architecture.

Results and conclusions
A GIS can be a valuable asset to specialists working in many fields, including aviation. However, a GIS provides a large amount of functionality, more than usually required by the specialist. With cloud computing, a GIS specialist can offer geographic information and dedicated functionality to specialists in other fields without

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Author(s)
R.J.J. Dost
R.W. van Swol
R.H. Hogenhuis

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This report is based on a presentation held at the ESRU User Conference, San Diego, 12-16 July 2010.

the need of a GIS background. This can reduce operational costs significantly by making the workflow more efficient en by reducing software and hardware needs.

Applicability

The architecture developed by the NLR combines the industry standard ArcGIS server software and innovative in-house developed routines to achieve this within its field of expertise, aviation. However, other fields of expertise can also benefit greatly from this development.

Nationaal Lucht- en Ruimtevaartlaboratorium, National Aerospace Laboratory NLR

Anthony Fokkerweg 2, 1059 CM Amsterdam,
P.O. Box 90502, 1006 BM Amsterdam, The Netherlands
Telephone +31 20 511 31 13, Fax +31 20 511 32 10, Web site: www.nlr.nl

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Designing a WebGIS architecture for aviation impact assessment

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DESIGNING A WEBGIS ARCHITECTURE FOR AVIATION IMPACT ASSESSMENT

R.J.J Dost[1], R.W. van Swol[1], R.H. Hogenhuis[1]

[1] *National Aerospace Laboratory (NLR), PO Box 153, 8300 AD Emmeloord, The Netherlands, E-mail: remco.dost@nlr.nl*

ABSTRACT

In aviation a lot of research is focused on the assessment of environmental and anthropogenic impact, by modeling and monitoring sound and emission levels. To do so, advanced models are developed that use different input datasets, such as aircraft and engine characteristics and geographic information of the point of interest. Currently, the results of this research are assessed by aviation experts using a locally installed full scale Geographic Information System (GIS) software package, while mainly viewing and basic analytic tools are required.

To be able to use a GIS as a truly supportive tool for these users thereby excluding non-essential functionality and offering easy web access, the National Aerospace Laboratory (NLR) in The Netherlands has developed a service-oriented WebGIS infrastructure based on Adobe Flex, ArcGIS Server components and generic SOAP/WSDL services.

The ArcGIS Server Flex API based RICH client offers users access to data processing and analysis functions implemented as SOAP services. These services are partly built on ArcGIS components providing a large set of data visualization and geo-processing functions. Components related to user management (including security aspects like authentication and authorization), data management and data conversion are developed and implemented by NLR.

The benefits of this web-based client and a service-oriented architecture relate to the quick development of dedicated applications (in this case for environmental and anthropogenic impact studies), which can be centrally managed and maintained. For users it offers easy access to many GIS functions without the need of expert knowledge

1. INTRODUCTION

Over the past decades the number of aircraft movements around the world has grown, increasing its impact on the local and global environment. Today, the air transport industry is paying a lot of attention to growing public concerns about the environmental issues of air pollution, noise and climate change (Clean SKY, 2010). Research is carried out in a large number of (inter)national projects aiming at the understanding and reduction of this impact. Two examples of such projects where to which the NLR contributes are the Clean Sky and CROS pilot projects.

The Clean Sky project is commissioned by the European Commission and aims at the development of breakthrough technologies to reduce the environmental impact of air transport. The CROS project is a national project commissioned by the Dutch ministry of transport, public works and water management. The goal of this project was to reduce the public annoyance caused by sound from the air traffic to and from Schiphol airport. This reduction can be obtained by modifying flight routes to reduce public exposure to aircraft noise. In order to demonstrate the effects that new technologies or new flight routes can have on the environment, it is important that the effects can be clearly explained and visualised.

For example, flight routes can be designed such that they avoid overflying densely populated areas. This has little effect on actual noise or emission levels produced by the aircraft, but the location of the impact changes. By visualising this impact on a map using a GIS, the effects become instantly clear providing valuable insight in the effects required for the assessment of newly proposed routes.

A GIS is thus a valuable asset to aviation experts. However, a GIS provides a large amount of functionality, more than required by the aviation specialist. Therefore either a GIS expert is required to operate it, or the aviation expert has to be trained to use only a small part of the system. Both ways are not efficient. In the first case the GIS expert is required to do even the smallest of jobs which is not practical in a normal workflow, in the latter case a large amount of resources are required such as training, licenses and hardware which is not cost efficient. Designing a dedicated stand alone application using a GIS API can provide a solution, but requires constant maintenance and updating. The constant evolving internet can now provide a more efficient solution, cloud computing.

Cloud computing is internet-("cloud") based development and use of computer technology where software is offered as a service and data is accessed and processed at a server using these services (wikipedia, 2010). With cloud computing a GIS specialist can offer not only geographic information to his clients, but also developed functionality to process data as a service.

This has a number of advantages. The client no longer has to invest in GIS software to view results or use the functionality developed by the GIS expert to analyse data. The GIS specialist can develop any routine required, convert it to an automated process and then to a service. The client can access the service and use its process either in a desktop GIS, or as a service within a viewer. The latter has the advantage that no other GIS software licenses have to be obtained than a GIS server license if the cloud is developed within the company. If the cloud is accessed from a third party no license is needed at all. This reduces the costs of hiring a GIS specialist and training of staff to be able to operate the complex software. Another advantage is that processes and applications developed by third parties that are offered as services can now be integrated in your own cloud computing solution.

This mode of operation ensures that the expertise remains with the right people and that the geographic data and software can be centralised, further lowering costs by reducing data duplication. To be able to take full advantage of cloud computing, a NLR User Interface (UI) has been designed so clients are able to work in the cloud with dedicated software without the need of locally installed GIS software.

2. ARCHITECTURE

The ArcGIS API for Flex allows the creation of Rich Internet applications on top of an ArcGIS Server. It offers programmers a comprehensive set of functions to make dynamic and interactive applications using ArcGIS resources such as maps. However, despite of the broad functionality the API does not support modification of the resources on the server. For instance, it is not possible to modify the rendering properties of the layers or to add new layers to a map and to make these modifications persistent. Also the printing capabilities offered by the API are modest and do no meet the requirements laid down by geo-professionals.

To make these functions and more available the ArcGIS Server ArcObjects API is required. Using the ArcObjects API, it is possible for a client to make changes to ArcObjects on a remote GIS server. Thereby, the communication among the different computers is supported by the Microsoft Distributed Component Object Model (DCOM).
Based on the above considerations, a service-oriented architecture (SOA) was designed using the SOAP/WSDL framework comprising a map management service acting as client communicating with the ArcGIS server using DCOM and additional services for user management, file handling, data conversion, printing and geo-processing (Figure 1). This setup has several advantages. Because of the flexible and extendable nature of the system, it meets future needs and new functionality can be easily added as services. Moreover, these services can be developed independently in any language, and on any platform. The architecture also includes a security layer which implements WS-Security with respect to authorisation and authentication. In the future this layer will also support policy enforcement and policy decision points to regulate the access to individual resources in the infrastructure.

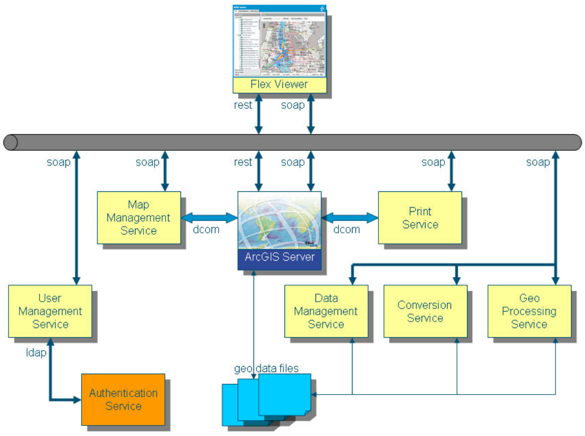

Figure 1 Architecture

Both the map management service and the print service communicate to the Flex client using SOAP and to the ArcGIS server using DCOM. The ArcGIS services are deployed as pooled map services. Modifications made by the SOAP services to the map server objects are made persistent by calling the refreshServerObjects method. Since the Flex client communicates via the REST interface with the map server, the cache of the REST service needs to be cleared after each modification to the map server objects in order to serve the new state to the client.

The current implementations of the map management and print service support amongst others, adding and removing layers to a map, loading and saving .MXD documents, creation and modification of color ramps, renderers and symbol properties and page layout properties such as legends and grids. All servers are developed in Java and run in an Apache/Tomcat and Axis2 environment.

3. CLIENT INTERFACE

The geocloud application client interface consists at the moment of three main parts (Figure 2):

- The viewer, where the data is visualized and can be printed or saved to disk;
- Data management, where projects can be opened and saved and data layers can be added and removed;
- Geo-processing; where geoprocessing services can be accessed.

3.1 Viewer

The 2D client viewer is designed as a rich internet application using the Adobe Flex programming environment.

The viewer has access to both in-house developed and ArcGIS server functionality, the latter being accessed via the ArcGIS Application Programming Interface (API) for Adobe Flex. The viewer consists of a Table of Content (TOC) and a geospatial data visualisation section.

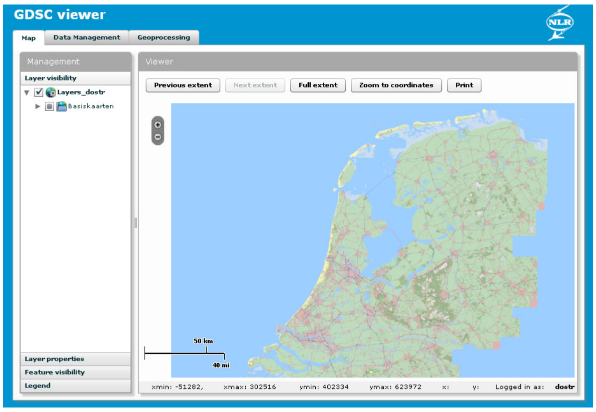

Figure 2 Viewer

The TOC is divided into four sections.

1). The Layer visibility section displays what (sub)Layers are available for display in the Viewer section and these can be toggled on and of with a check mark.

2). The Layer properties section allows editing of the (sub)Layer display properties. Rendering properties like transparency, fill and outline color, visibility and style can be set as well.

3). The Feature visibility section allows a user to toggle Feature of a Layer on and off.

4). The Legend section displays the legend of the selected Layer features.

The Viewer section displays the Layer and Features and offers functionality such as zooming, extent, zoom to coordinates and Print. Printing is done using a selection of custom made predefined ArcGIS templates. This ensures maximum user flexibility because any custom made ArcGIS template can be included, so a user can make use of its companies style. The generic annotations such as Legend, Grid and North Arrow can also be toggled off.

The resulting map can be printed to .pdf, .png, .jpeg and .bmp files allowing the map to be viewed or incorporated into documents. Because the printing is done using a print server, the map is printed with a high resolution ensuring high quality maps. This in contrary to the common practice of using the print functionality of an internet browser, resulting in a print at screen resolution.

3.2 Data management

The data management section is used to convert data from one format to another, to add Layers to the viewer and to Load and Save project files. The data is stored in user specific folder that can contain project folders on a GIS server. The start situation, the "base map" is stored here also and is basically an ArcMap .mxd file that contains links to data on the GIS server or services on external servers. This .mxd file is made in advance on a desktop ArcGIS installation which has as a main advantage that for every user a custom start environment can be made.

File conversion services have been added in this section instead of the Geoprocessing section, because users intuitively expect this kind of functionality in the Data management section. At the moment the application can convert vector files from a native model format to .shp files, but preparations are made to include the ArcGIS Data interoperability extension allowing access to a large number of common data format conversions.

Vector shape files can be added as a Layer to the viewer as well as removed from the viewer, ensuring flexibility for the user. The combination of added or removed layers and the background layers can be saved in this section as .mxd files. Consequently .mxd files can also be loaded, including .mxd files created earlier in desktop ArcGIS as long as the files and services directed to are present in the directory or servers, equal to the “base map”.

3.3 Geoprocessing services

Next to storing, managing and visualising geographic data, one of the main purposes of GIS is to process raw data into end products for users and geoprocessing is an essential part of this. The purpose of geoprocessing is to automate GIS tasks to reduce repetition of work by automating workflows. The kinds of tasks in a workflow can be mundane to quite creative, using a sequence of operations to model and analyze complex spatial relationships (ESRI Developer Network, 2010) Typical GIS operations are geographic overlays, feature selection and extraction, topology processing, raster processing and data conversions. Geoprocessing is a job typically done by a GIS specialist, using the functionality of a GIS and database. First a workflow is designed that processes the data into a product. Next this workflow is automated using modelling or application programming resulting in an automated process, a geoprocessing model. This model can be used as a tool in a geoprocessing environment such as a desktop GIS or database, but can also be used for cloud computing, so called geoprocessing in the cloud. This is useful for large organizations who wish to centralize both their data and their geoprocessing operations (ESRI webhelp, 2010). To do so, the geoprocessing models need to be published to a server to become geoprocessing services. Once published, geoprocessing services can be used by a number of different client applications, including Web Mapping Applications, such as a viewer, and ArcGIS Desktop.

In this manner a GIS specialist can develop a geoprocessing service that executes on the server, using resources of the server and can be used by the developer, but can also be offered to a client. A client can than analyse data using the developed geoprocessing service using GIS software or by using an internet based viewer that incorporates these services as long as an internet connection is established. The latter has as an advantage that no expert GIS software or expertise is required for the client because any complex workflow can be turned into a geoprocessing service by a specialist for use by the client who only needs to define the input for the process and analyse the result. Geoprocessing services have been incorporated in the viewer in a specific tab where a service and input parameters can be selected. The output is visualised in the viewer and stored in the user’s directory.

3.4 Future development considerations

Future work can include the visualisation of 3D data, adding a temporal component, and integrating models (such as required for noise calculations) as a service. Extending the functionality to pocket devices using mobile server software is also under study.

4. USE

At the moment, the described architecture is used within the NLR to visualize the impact of air transport on the environment within the vicinity of an airport. More particular, the results of environmental assessments that study aircraft noise and third party risk. These assessments are used to show the effect of air transport during the current operation of an airport, and also the effect of for instance noise abatement measures by comparing the noise impact of scenarios with and without the noise abatement measures. Figure 3 shows an example figure that is created using the viewer. It is an example of a noise contour in the vicinity of Schiphol Amsterdam airport. More functionality is constantly added.

The architecture has great potential for use within many different fields. The modular structure ensures great flexibility and the web based solution offers excellent accessibility. The architecture can be customised to suit different users needs using different modules available within the architecture. Geoprocessing services can be developed in-house or obtained from 3rd parties via the internet and data can be accessed from various distributed databases using international standards.

A lot of interest has been received from clients that work in fields varying from defence to engineering in governmental and commercial sectors. Their main interest is the use of the architecture as a portal to their required GIS information and services.

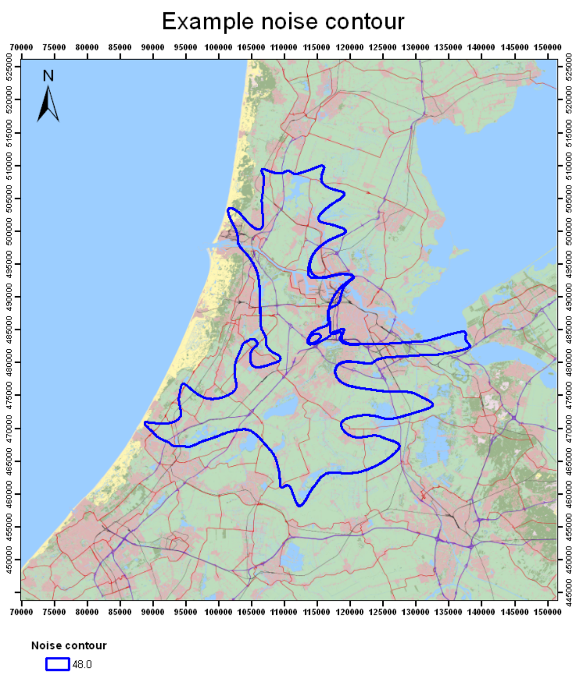

Figure 3 Example of a figure with a noise contour

5. CONCLUSION

A GIS can be a valuable asset to specialists working in many fields, including aviation. However, a GIS provides a large amount of functionality, more than usually required by the specialist. With cloud computing, a GIS specialist can offer geographic information and dedicated functionality to specialists in other fields without the need of a GIS background. This can reduce operational costs significantly by making the workflow more efficient en by reducing software and hardware needs. The architecture developed by the NLR combines the industry standard ArcGIS server software and innovative in-house developed routines to achieve this within its field of expertise, aviation. However, other fields of expertise can also benefit greatly from this development.

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