An Enterprise GIS Solution for Bond Forfeiture Program in West Virginia[1]

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Abstract. In support of its mission to protect and improve environment, the Bond Forfeiture program at West Virginia Department of Environmental Protection (WVDEP) is implementing an enterprise Geographic Information System (EGIS) approach to maximize efficiency and effectiveness. This approach includes building or improving server side geospatial data warehouse, and client side user-friendly geospatial applications.

This paper first describes what EGIS is, then elaborates the approach to BFP EGIS development, and later explains BFP EGIS key components in details.

This paper also summarizes experiences and lessons learned from planning, designing, developing, testing, and deploying the approach.

Additional Key Words: approach, database, application

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Introduction

For a long time the Bond Forfeiture program (BFP) at West Virginia Department of Environmental Protection (WVDEP) has been looking for a solution to integrate geospatial functions into its decision making. There are two fundamental requirements for the solution. First of all, an essential part of the solution should be a central geospatial data warehouse that fits into the agency's data management structure. BFP currently maintains a few individual GIS databases and a non-spatial Oracle database, which is fortunately closely tied to the rest of mining related non-spatial databases in the agency. These GIS databases are disconnected from one another and lack connections to the non-spatial databases. No data concurrency is available between the two types of data. Also at issue is data accuracy. For instance, many of the coordinates for water sampling sites lack datum or enough precision to be relocated successfully in the field. One more concern at BFP is that historical data, including spatial data, are stored in various formats which can be paper or digital media files. The fact that several satellite offices exist statewide also exacerbates the chaos of data management. The historical data are maintained in various formats by different hands in separate offices. Without data centralization, data concurrency, and data accuracy, work efficiency and effectiveness are relatively low. For instance, a BFP employee may have to carefully examine these separate data sources before a decision is made, which is time consuming and error-prone.

Secondly, the solution must provide easy-to-use business intelligent geospatial application tools. Lack of user-friendly and easy-to-use GIS applications is another factor restricting BFP staff's ability to take advantage of GIS. Proprietary GIS packages like ArcGIS desktop are designed for GIS professionals or at least designed in a way that caters to experienced GIS power users. However, few BFP staff fall into these categories of users. These packages are also "designed for high-end GIS analysis" (Thomas, 2007), which are not needed in most circumstances by BFP staff. The majority of BFP employees or average GIS users also lack time to keep their knowledge in using the packages updated since they spend most of their time in the field. Therefore, it is not surprising that many of the rich functions of GIS available in the packages are not fully utilized at BFP. Even with the generous support from Office of Surface Mining (OSM) of Department of the Interior (DOI), ESRI products such as ArcGIS desktop and

ArcPad are not in most BFP employee's toolboxes. These employees still manually perform spatial operations and draw maps by hand.

As a result, the Technical Application and GIS (TAGIS) unit of Information Technology Office at WVDEP is collaborating with BFP to develop an Enterprise GIS (EGIS) solution to address the above issues.

The remaining part of this article will first describe what EGIS is, then elaborate on the approach used for BFP EGIS development, and later explain BFP EGIS key components in details. Experiences and lessons learned from the work will be summarized too.

What is EGIS?

EGIS "is an architecture that integrates geospatial data and services and shares them across the organization. In more general IT terms, it can also be viewed as an infrastructure that extends and enables existing enterprise systems using geospatial data and services." (ESRI, 2008a)

Implementing an EGIS infrastructure can bring many potential benefits, including:

- Broad access to geospatial data
- "Considerably reduced data redundancy
- Improved accuracy and integrity of geographic information
- Efficient and timely data sharing
- Improved enterprise-wide knowledge management and decision support capabilities
- High level of interoperability between GIS and non-GIS applications
- More effective use of departmental GIS skills and resources
- Reduced overall GIS maintenance and support costs" (ESRI, 2008a)
- Improved performance

In addition, many GIS tasks can be accomplished by using internally developed applications. With an EGIS environment, it is highly possible to deploy a customized geospatial application for individual departments with various business models inside an organization.

Apart from these benefits, past success of EGIS implementation in other programs at WVDEP and free rides on ESRI products from OSM also support the choice. The adoption of EGIS has been successful in Title V and Title IV mining programs at WVDEP (Wu, 2004). Currently each program is served by an ArcSDE multiple user geodatabase and a few customized GIS

applications, which have become an integral part of the agency's enterprise information system (EIS) infrastructure. The provision of free copies of ESRI products by OSM removes the software procurement cost for the project and training opportunities offered by OSM pave the way for BFP employees to quickly acquire GIS knowledge or update their skills in using ESRI products. In addition, the existing hardware and software infrastructure at WVDEP is mature and scalable enough to support the implementation of an EGIS solution for BFP.

Approach to BFP EGIS Development

A multiple phase project was initiated for the BFP EGIS development in January 2007. Although Tomlinson (2003) advocates a practical ten stage method for planning a GIS that has been proven successful in real public and private sector organizations, this project follows a simplified version of the method proposed by ESRI (Fig.1) that includes five steps:

- Project strategy and planning
- Project analysis and design
- EGIS development
- EGIS deployment
- EGIS production and operations

During the first step: project strategy and planning, a team comprised of members from both BFP and TAGIS was selected. After several field trips and in house meetings, TAGIS staff was able to familiarize themselves with the business logic at BFP and BFP staff took the chance to express their concerns and desired results. Business cases were drafted. A work plan (scope, schedule, and budget) was developed. The plan was also continually monitored and adjustments are made as needed throughout the project.

During the second step: project analysis and design, business processes were analyzed and use cases were identified. Specific requirements and outcomes were laid out for each individual use case. User requirements were built into a comprehensive design blueprint, covering database design, application design, and system architecture design, guiding the subsequent development work.

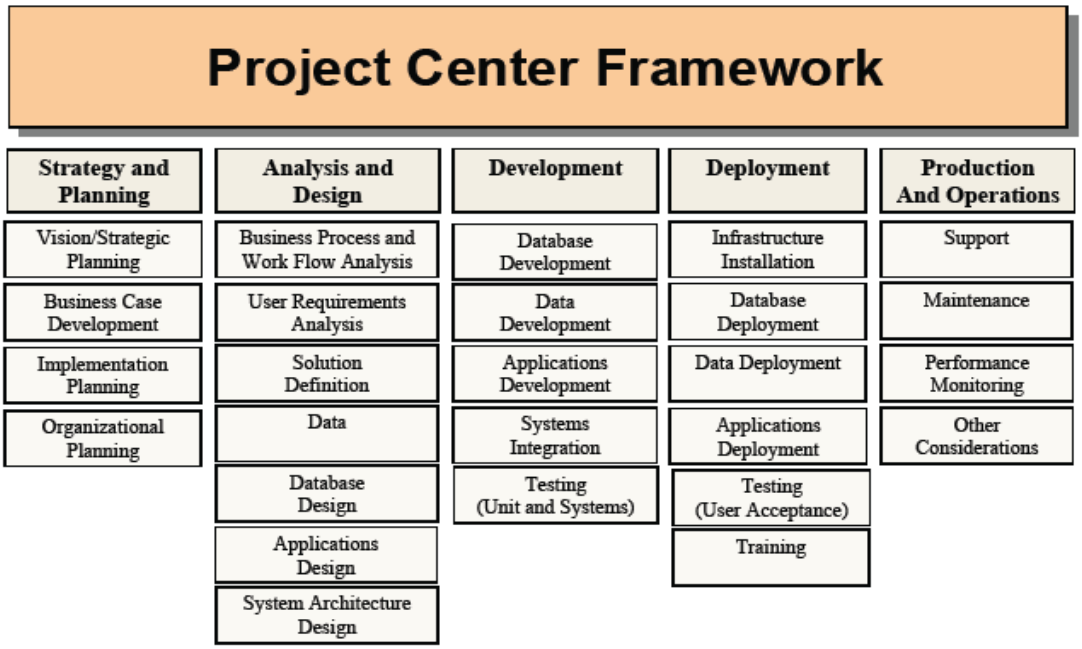

Figure1. Project framework (ESRI, 2008b).

During the third step: EGIS development, applications and databases were built following appropriate standards. Feedback was routinely acquired through review sessions between TAGIS GIS application developers and BFP employees in the team and beta copies of BFP EGIS were released for BFP employees to test.

The next step is EGIS deployment, including installation, client acceptance, and training. Given the available IT infrastructure, databases and applications were installed and integrated into the agency's operational environment and tested to ensure that they would perform as desired. Multiple tests occurred again to remove defects and make sure that the defined requirements are met. Soft and/or hard-copy technical documentation and operation instructions for using the system were prepared and technical training was conducted.

The final stage is EGIS production and operations. This stage involves supporting the installed BFP EGIS in the BFP production environment. During this stage, TAGIS maintains the system and responds to changing technology and user needs; BFP employees are educated on the skills needed to use the system and their expertise is developed.

The project is in the final stage of phase I at this moment. As stated before, the project has multiple phases. As enhancements or new functionality needed to better support business

functions at BFP are identified, a phase II sub-project will be initiated. In other words, a new requirements analysis would be developed and the GIS project life cycle described above would repeat.

BFP EGIS

BFP EGIS is a client-sever based system that is seamlessly integrated into the WVDEP EIS setting (Fig. 2). As shown in Fig. 2, in addition to existing software and hardware, the BFP EGIS development team added five more key components:

- An ArcSDE multiple user geo-database
- A digital multi-media database
- An ArcGIS desktop ArcMap BF toolbar
- An ArcPad mobile GIS application
- A multi-media uploading tool

The first two, plus the BFP land and water database, form a server side geo-spatial data warehouse while the last three are client side geo-spatial applications.

ArcSDE multiple user geo-database

The ArcSDE multiple user geo-database was built on top of the existing BFP land and water database, a component of WVDEP EIS. The land and water database stores geographic coordinate data for water sampling site and forfeited sites. Five feature classes were derived from the coordinate data by applying certain selection criteria. They are:

- Water_Assessment_Sites: a feature class showing those forfeited sites under water quality assessment
- Treatment_Sites: a feature class showing those forfeited sites under treatment
- AMD_Inventory_Sites: a feature class showing those forfeited sites listed in the acid mine drainage (AMD) inventory at WVDEP
- Forfeited_Sites: a feature class showing the centers of forfeited sites
- Water_Sampling_Sites: a feature class showing where water samples are taken

Since the first three are special kinds of forfeited sites, the three feature classes: Water_Assessment_Sites, Treatment_Sites, and AMD_Inventory_Sites are a subset of the feature class: Forfeited_Sites.

In addition, TAGIS is building a polygon feature class that depicts spatial boundaries of forfeited sites. Temporary staff are hired to digitize and geo-reference paper project maps.

The geodatabase is managed by ArcSDE, which relies on Oracle, the sole enterprise database management system that supports all non-spatial databases at WVDEP, so a two directional link was established between the geo-database and the BFP land and water database to ensure data concurrency and integrity. BFP employees are able to update spatial data in one database while the other one is updated simultaneously.

Digital multi-media database

The digital multi-media database was created to store digital pictures and digital video files. Over the years, BFP has accumulated thousands of such digital multi-media files. However, these files are kept in separate places by different staff, resulting in less accessibility. Loss of data is also possible due to turnover of staff. Therefore, the database was set up to centralize the data. Worth mentioning is that the database can store two types of digital pictures: the ones taken by regular digital cameras and the ones by GPS enabled digital cameras, a couple of which have been recently used in the field by BFP. The second type of digital pictures stores spatial information that can be extracted and processed to show where the pictures were shot.

The database stays in the WVDEP data center and is managed by using a file based system structure. An authorized BFP employee can upload digital media files into the database using the digital multi-media uploading tool, which will be described later.

ArcGIS desktop ArcMap BF toolbar

The ArcGIS desktop ArcMap BF toolbar is also called WVDEP BF Information Navigator. It was developed for BFP employees to retrieve information from the BFP geo-database, the BFP land and water database, and the BFP digital multi-media database.

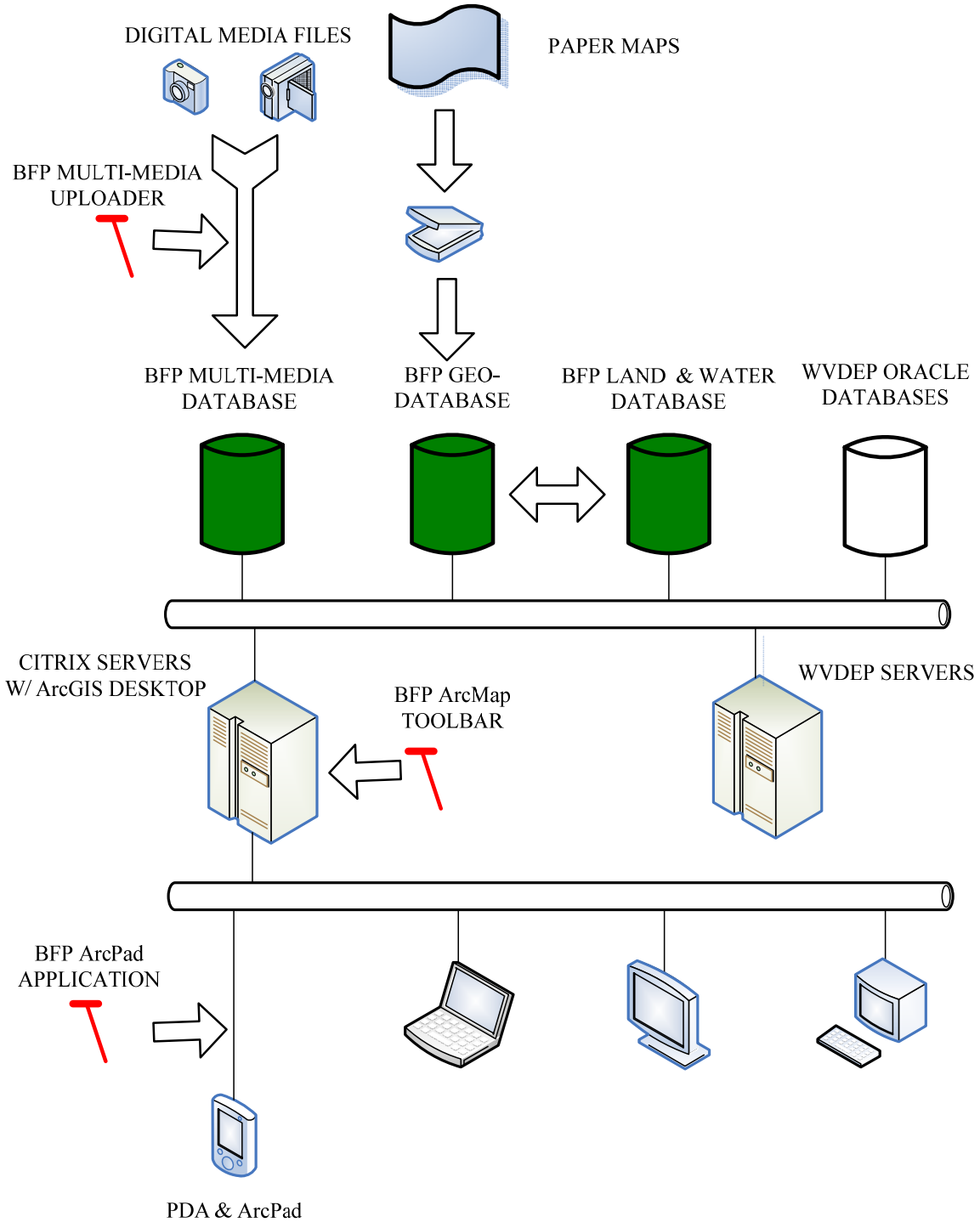

Figure 2. Simplified diagram of BFP EGIS.

The development of the toolbar followed two principles: easy-of-use and economy. Easy-of-use means that the toolbar offers end users an easy way to perform complex GIS operations that can be done in ArcGIS desktop without demanding for advanced skill sets of GIS, ArcGIS

desktop, and database principles. Economy means that the toolbar was developed with constraints of a tight IT budget and limited resources, without resorting to expensive proprietary GIS software packages that may cover only part of the toolbar's functions.

As shown in Fig. 3, the toolbar contains twenty two buttons or tools. These buttons are divided into four groups by their functions, which generally allow BFP employees to assess GIS data, search spatial feature, query databases, and apply GIS to their work.

Figure 3. ArcGIS desktop ArcMap BF toolbar.

The toolbar is integrated into the ArcGIS desktop ArcMap framework. ArcGIS desktop, including ArcMap and ArcCatalog, is deployed using a Citrix terminal service technology and a license server provided by OSM. The set-up ensures that the average GIS users or majority of BFP employees are able to perform simplified GIS operations via the toolbar while power users take advantage of the rich functions embedded in ArcGIS desktop.

ArcPad mobile GIS application

As discussed earlier, many of the coordinates for water sampling sites lack datum or enough precision to be relocated. The ArcPad mobile GIS application is a solution to the problem. Specifically, the application was developed for BFP employees to improve spatial data quality. In phase I of the project, the application focuses on verifying locations of water sampling sites or collecting new water sampling site locations. In the subsequent phases of the project, the application will be extended to check the quality of the rest spatial data in the BFP land and water database and will probably be used as a template for field mobile GIS work in other programs at WVDEP.

Fig. 4 is a screenshot of the application. It shows that the application is a toolbar staged inside ArcPad interface. By turning on the ArcPad for ArcMap toolbar in ArcGIS a BFP employee can check out data into ArcPad from the Water_Sampling_Sites feature class in the BFP geo-database. The employee can then edit the data in the field using the ArcPad mobile GIS

application, ArcPad, a Windows Mobile device that runs ArcPad, and a GPS unit. And by using the ArcPad for ArcMap toolbar upon returning from the field, the employee can check in edits from ArcPad into the feature class. Once the edits are approved, the BFP geodatabase is updated. Spatial data related to water sampling sites in the BFP land and water database are updated as well via the live connection between the two databases.

Figure 4. Screenshot of the ArcPad mobile GIS application.

Multi-media uploading tool

The multi-media uploading tool was designed for BFP employees to upload digital media files that they have saved or collected into the centralized digital multi-media database. The tool has been modified to work for Title VI and Title V mining programs at WVDEP as well.

Fig. 5 is a snapshot of the tool interface. A typical routine for using the tool is as follows. After logging in, a BFP user can browse or preview digital media files or screen their attribute data or add comments. If a file is a digital picture with geographic coordinates in its head file, the user can check the picture's spatial location or where the object of interest in the picture was taken. After verifying data, the user can create a selection list and upload the list of chosen files to the database. In the meantime, relevant information such as permit identification number and project stage is saved too. If the user wants to check the uploaded media files later, the SP tool on the ArcGIS desktop ArcMap BF toolbar provides that function. Fig. 6 depicts how a user

feeds multi-media data into and retrieves the data from the database by using the digital multi-media uploading tool and the ArcGIS desktop ArcMap BF toolbar.

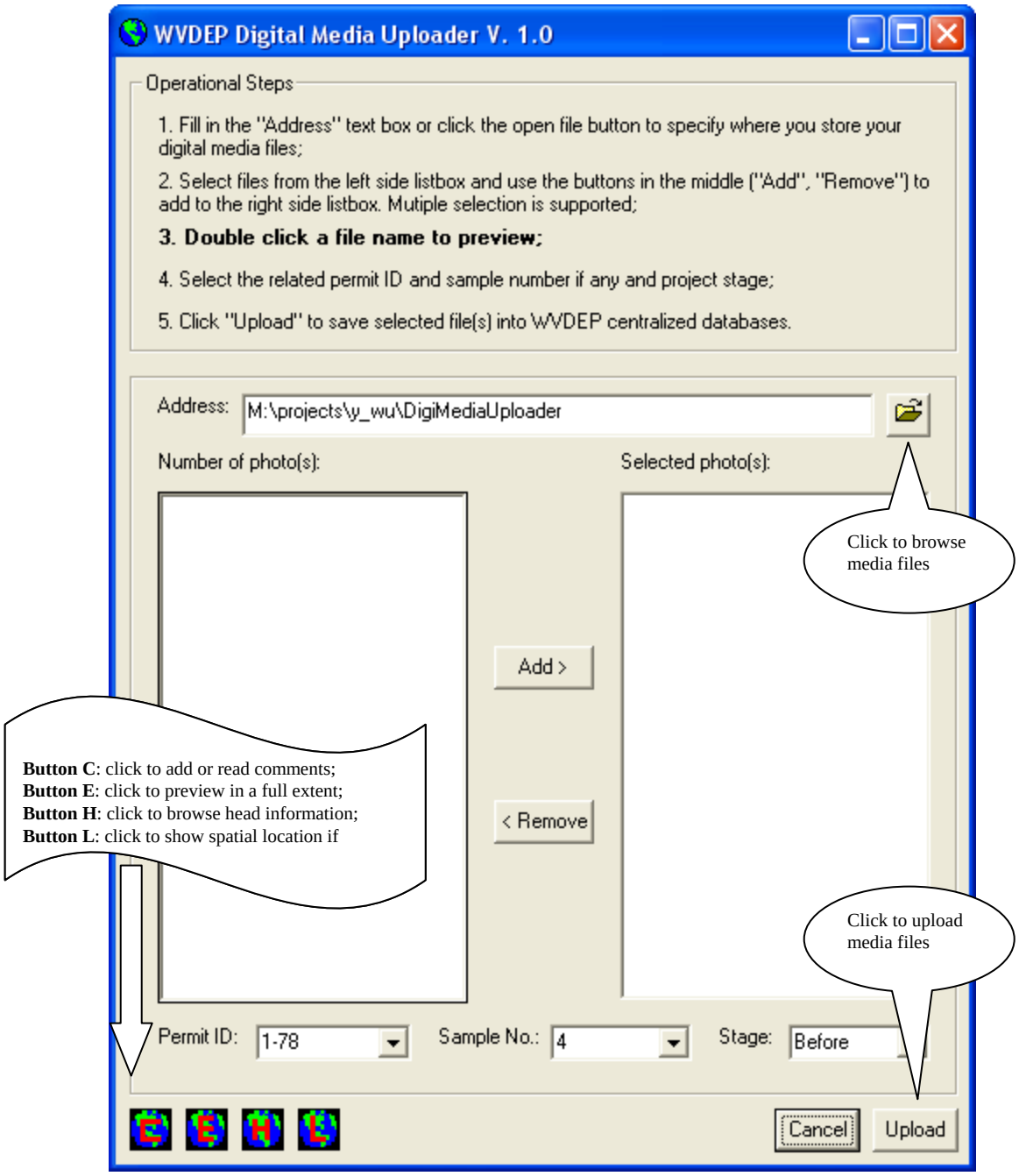

Figure 5. A WVDEP multi-media uploading tool for BFP.

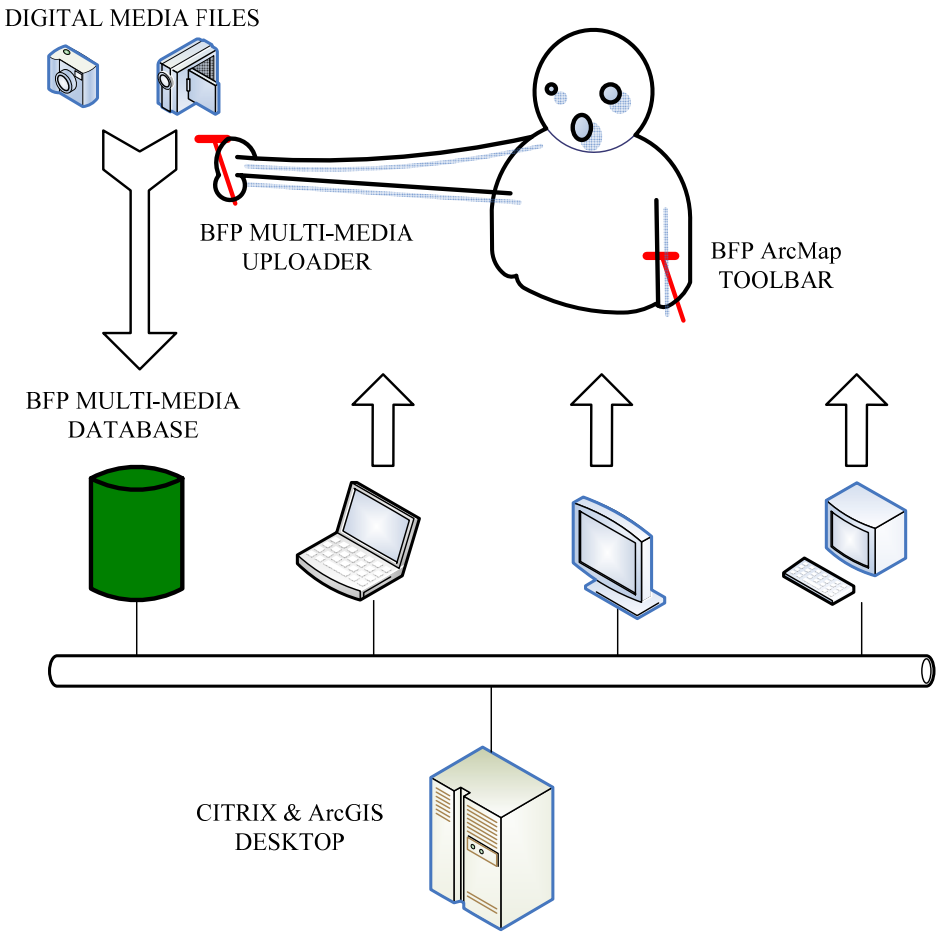

Figure 6. Interaction between users and the multi-media database.

Experiences and Lessons

In addition to past GIS application development work (Wu, 2006), two types of lessons have been learned from BFP EGIS development and implementation, both administratively and technically.

Administrative lessons

First of all, continuous interaction with end users is the key to the success of EGIS development and implementation. A development team, including staff from both BFP and TAGIS, was established at the beginning of project. Through the whole phase I project TAGIS

GIS application developers and BFP users were actively involved. Therefore developers gained an understanding of end users' needs and work routine well enough for inclusion in their design and the BFP users were happy to see that the geospatial applications were customized in a way they are familiar with thereby addressing their concerns. The effort resulted in meaningful and easy-to-use applications that would lead to great understanding and support.

Secondly, a tight budget may limit EGIS development and implementation in many organizations. However, keeping economy as one principle for the project in mind makes a great difference. By leveraging existing resources such as available IT infrastructure, in house experienced GIS application developers, and free software from OSM, the development team was able to get management's support and have the job done in a timely fashion. Past success in EGIS development implementation at WVDEP also saved the team's time and effort considerably.

Third, collaboration plays an important role. Soon after the project started, IT functions in West Virginia state agencies were centralized. However, with a close collaboration with the state Office of Technology (OOT), the project was not unacceptably delayed. The development team also collaborated well with other units at WVDEP. For example, the BFP land and water database is administered by a different unit which shared some duties of server side work with the team.

Technical lessons

During BFP EGIS development, especially client application development, the development team made full use of free snippets available online, sample code from ESRI, and code inherited from past application development projects. By modifying or improving existing code rather than starting from scratch, the development team was able to speed up the project. The team also encouraged end users to get involved since the earliest stage. By sitting with an end user and explaining what he or she was seeing, a developer could get prompt feedback and update his or her code responsively. This strategy ensured time saving in coding, and, undoubtedly, user-friendly and easy-to-use applications.

During the process of testing BFP EGIS, both client side testing and server side testing were conducted. The development team divided the whole application development project into smaller piecemeal ones, each of which would perform a specific task but was written, tested,

compiled, and deployed independently. This method simplified the testing work and would also in the future benefit the one taking over the code left by his or her predecessor developer.

During BFP EGIS deployment, the development team counted on existing scalable infrastructure without requiring additional procurement cost. The team also focused on performance. Prior to the project, WVDEP had implemented a Citrix client sever system to deploy ArcGIS desktop and other applications for end users in its satellite offices. With performance as the priority, the team dropped its original design of using the ArcMap BF toolbar to upload digital multi-media files. Instead, the team developed the multi-media uploading tool to perform the task. This change removed the possible delay caused by the Citrix system middleware during file uploading.

During the stage of BFP EGIS production and operations, the development team paid close attention to customer service. The team also responded promptly to the changes in technologies (i.e., service packs released by ESRI) and provided timely updates.

Future Work

At the end of the phase I, the development team has started thinking about moving into phase II for future updates and improvement. On the one hand, the team would like to take advantage of new geospatial technologies. For instance, TAGIS was given a free copy of enterprise version ArcGIS Server by OSM. TAGIS also acquired two ESRI developer network (EDN) licensed ArcGIS Server copies. An ArcGIS Server production server has been set up and a geo-database data service has been published, which is part of a collaboration project sponsored by OSM. During the coming project phases TAGIS geospatial application developers will probably publish some GIS functions on the BFP ArcMap toolbar using ArcGIS Server functionality. So BFP end users would be able to perform BFP related spatial analysis in a friendly browser environment.

On the other hand, the team would like to improve functions of the client geospatial applications. For example, the ArcPad mobile GIS application can be extended to delineate a forfeited site boundary in the field or verify location data for forfeited sites. In addition, ESRI released ArcPad 7.1 in late 2007, which adopts a new data model to speed up data transfer and

storage using XML schema. Therefore, the ArcPad mobile GIS application can be modified to collect more attribute data through field work using the new model.

Conclusions and Discussion

In support of its mission to protect and improve environment, WVDEP BFP has been seeking a solution to maximize efficiency and effectiveness using geospatial technologies. The solution demands for two key components: a central geospatial data warehouse and client side user-friendly geo-spatial applications.

A multi-phase project was initiated in January 2007. And a team of BFP employees and TAGIS geospatial application developers has come up with an EGIS which is built on top of the existing WVDEP EIS infrastructure with five additional elements: a digital multi-media database, an ArcSDE multiple user geo-database, an ArcMap toolbar, an ArcPad mobile GIS application, and a multi-media uploading tool. Future updates and improvement are expected in future phases of the project.

The uniqueness of the project is two fold. First, it always keeps easy-of-use as priority. Since most BFP employees are average GIS users, BFP employees and TAGIS developers worked together to build user-friendly business intelligent client side geospatial tools. Second, it follows a cost-effective principle. Given a tight budget, the team leveraged existing resources and delivered its products in a timely fashion.

The significance of the project is that the EGIS solution helps BFP incorporate geospatial technologies into its decision making. The success of the project also sets up a template for other programs or organizations with a limited budget to follow.

Acknowledgements

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