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THE DEVELOPMENT OF A WEB-BASED PLATFORM FOR GROUND CONTROL APPLICATIONS

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ABSTRACT

As underground mining continues to operate at deeper depths and in more complex multiple seam mining geometries there has been an increased demand for higher design standards in ground control safety and stability within the mining industry. For the past 20 years, NIOSH has developed and validated a number of software tools to aid in the development of safer mining environments with respect to improved roof support performance, pillar stability in longwall and room and pillar mines, formation characterization, the prediction of roof conditions, etc. These tools are available, free of charge, to the mining industry as stand-alone software packages.

As cloud computing gains momentum, there is a definite need to develop internet based applications for mine design that would be easily accessible to any user at any time, including underground where permitted. This paper introduces a new web-based product which will allow for faster and easier access to existing ground control designs, on-the-fly calculations in the field as needed, and instant online collaboration between operations personnel and planning engineers. It is expected that the industry will rapidly embrace this product and, as it is common with all new innovative technologies, it will be a new paradigm for mining engineering computer applications.

INTRODUCTION

Since its release to the public in the late 1980's, the World Wide Web has drastically changed from a collection of static HTML web pages to a dynamic vehicle driving e-commerce, collaborative working relationships, and the mass distribution of information and media (Offutt, 2002). Recent developments in Internet capabilities, such as Cloud Computing and Software as a Service, have begun a migration away from desktop-based software in adoption of the web application (Hayes, 2008). Web applications, or web apps, are designed on the client-server architecture paradigm in which the client, or user, can interact with an application through web browsers without disrupting or installing software on potentially thousands of client computers (Nations, 2015).

Currently, web-based software applications are being utilized in all business sectors and markets from commerce, finance, media, and even engineering. In fact, the Alabama Department of Transportation has developed a web-based geotechnical geographical information system (GeoGIS) for the management of and access to geotechnical and subsurface data for transportation projects across the state (Graettinger, et al., 2001). Similarly, Dyno Noble has developed a service application for explosive engineers. The Explosives Engineers' Guide application equips users with a full range of product information as well as on-demand blasting calculations for powder factor, airblast prediction, ground vibration, etc. Through the incorporation of a web server, one is able to utilize the functionality of the desktop-based software through a web browser located on any personal computer, tablet, or Smartphone (Vaughan-Nichols, 2002).

For the past 20 years, the National Institute of Occupational Safety and Health (NIOSH) has developed, validated, and distributed a number of free software packages (ALPS, ARMPS, AMSS, AHSM, ARBS, etc.) for the safe design of underground coal mines with respect to ground control. Currently, these software applications are still required to be run on a desktop computer equipped with a Microsoft Windows™ operating system.

This paper will present the concept and initial steps behind the development of a new web-based software package which will build upon existing NIOSH ground control design software. This new package, called “webGroundControl” will take advantage of current web technologies utilizing a multiple-tier architecture which will allow users to easily access existing ground control designs, perform on-demand infield calculations, and provide the ability for online collaborations between operational personnel and mining engineers through a web browser.

This shared platform will ensure more transparent calculation in cases of variable conditions as well as the instant recognition of problematic areas under specific design parameters. Due to an increase in availability, even while underground, as well as increased data security, application maintainability, and cross-platform compatibility, it is expected that the mining industry will embrace this product as it has with other innovative web technologies.

EVOLUTION OF SOFTWARE APPLICATIONS

Most legacy engineering or other more general purpose computer applications rely on a, “stand alone model,” where the application either includes all necessary data in its code, or the data resides in a disk file on the same or a workgroup computer (Figure 1 and Figure 2).

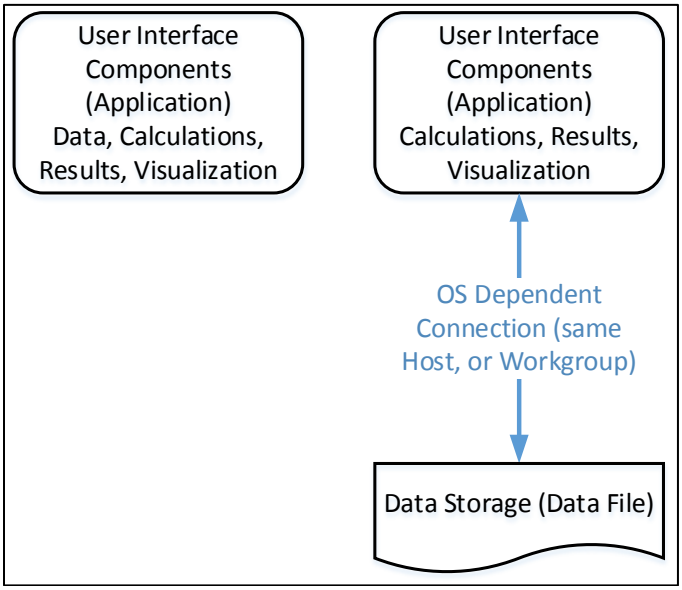

Figure 1. Desktop Application Architecture.

Modern day applications tend to move away from this paradigm and include application and user data in databases as shown in the logical framework depicted in Figure 3. Thus multiple users in an operation can query and manage such data with respect to their individual data access privileges (Agioutantis, et al., 2015). These database-driven applications are becoming very common, especially in small or large office environments (Figure 4).

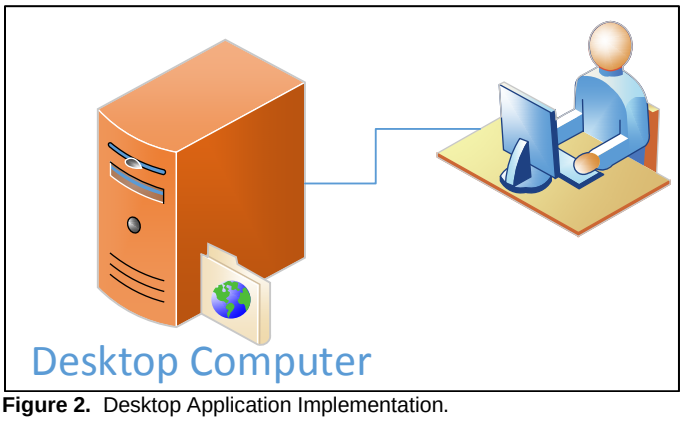

Figure 2. Desktop Application Implementation.

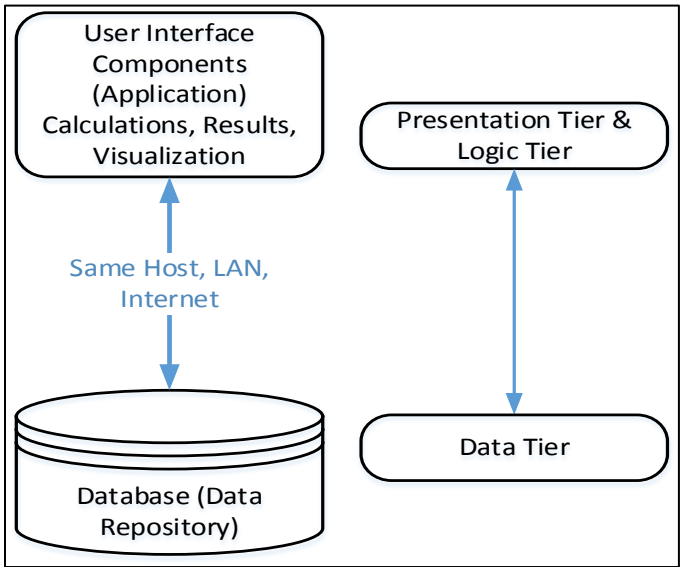

Figure 3. Desktop Application in a Stand-alone or Networked Environment - This is a Typical Two Tier Application.

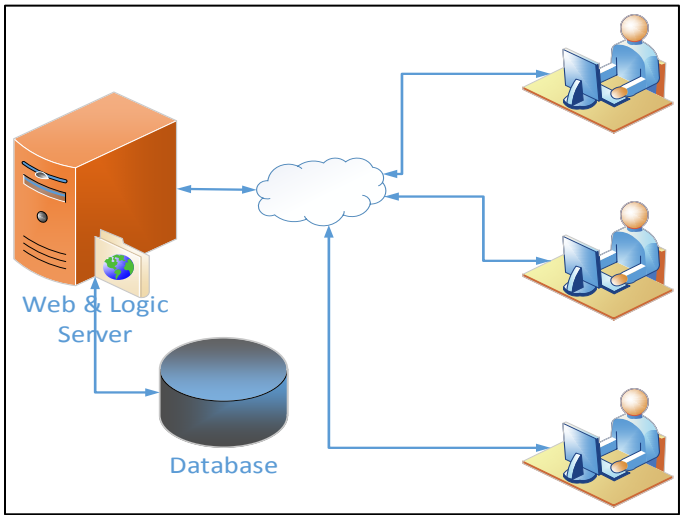

Figure 4. Implementation of Desktop Application in Networked Environment.

There are numerous advantages for using a database to manage, analyze and present data. Data is preserved in a central system instead of being stored at individual computer systems; users can easily share data; project continuation is ensured even if projects were handled by users which are no longer active, etc. Using a database saves time and also reduces possible user errors and thus increases the confidence level of the presented results. Once a dataset is cleaned up and all errors and bad entries have been eliminated, that dataset set can be shared by all members of the project group.

Databases related to mining and/or geotechnical applications may include core data from multiple projects and sites, blasting data, fuel consumption and equipment utilization data, fleet management, operational data, etc. Typically the design of the database should allow data from a single or multiple projects to be easily accessible to the user through a defined network or internet connection following typical client/server protocols. User and role management subsystems can also be implemented within the database requiring users to obtain a username and password for access to the database. Users will then be provided access to specific data subsets with respect to the assigned role (admin, supervisor, guest, etc.) ensuring the integrity of the data and providing data security.

Desktop-based software database applications (Figure 3) utilize an operating system dependent two-tiered approach in which a user, or multiple users given a networked environment, is able to interact directly with the database through a user interface.

With the advent of cloud computing, web applications have become more popular with their adoption of a multi-tier, or n-tier, architecture containing independently developed tiers; a typical three-tier application which includes Presentation, Logic, and Data Tiers is shown in Figure 5. At the top of the application framework is the Presentation Tier which maintains a user interface translating client requests and displaying results through a web browser.

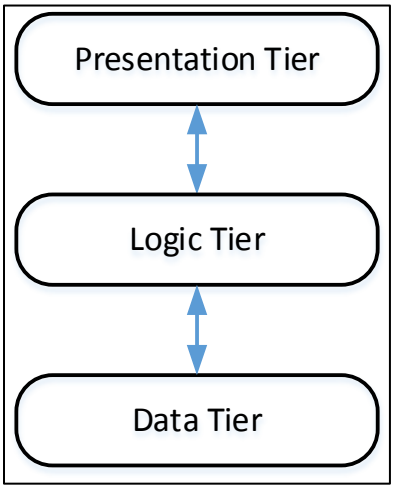

Figure 5. Architecture of a Multiple Tier Web Application.

Application management through the Presentation Tier allows for on-demand access from multiple users and compatibility with numerous personal computer, tablets, and Smartphone operating systems. The Logic Tier provides a means of communication between the Presentation and Data Tiers. Requests are sent from the web browser to the Logic Tier which completes the request by making queries to the Data Tier. The Data Tier is where the database is accessed and maintained. Information from the Data Tier is reported back to the Logic Tier with respect to the previous user request. This information is further processed in the Logic Tier and packaged for display in the Presentation Tier (Oluwatosin, (2014).

Separation of the application into a series of tiers greatly increases the maintainability and scalability allowing for the adoption of new technologies which can be applied to a single tier without redesigning the software.

Figure 6 illustrates the concept of a multiple tier web application where the different “clients” may use different devices to access the web browser. Since the application logic is separated from the web server logic, the web server will return the same results to any device requesting information.

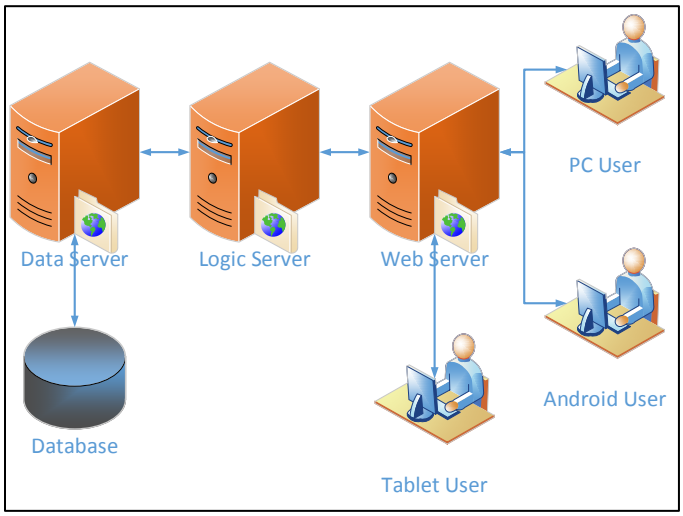

Figure 6. Implementation of a Multiple Tier Web Application.

IMPLEMENTATION CONSIDERATIONS

The webGroundControl application will be developed implementing a three-tier architecture. Similar to the multi-tier architecture shown in Figure 5, the three-tier application utilizes a Presentation Tier (Web Server), a Logic Tier (Logic Server), and a Data Tier (Data Server). The database part of the data server will actually reside inside the data server itself for this application. As shown in Figure 7, multiple users are able to access the Web Server through personal computer, tablet, and Smartphone web browsers. The Web Server takes client requests and transfers them to the Logic Server which completes the request by making queries to the Data Server. The Data Server authenticates the client request and, if the client has the appropriate authentication rights, retrieves the queried information from the database. This data is then transferred from the Data Sever to the Logic Server where calculations are performed. The results of these calculations are packaged by the Logic Server and forwarded to the Web Server which *displays the received results in the client interface or* web browser.

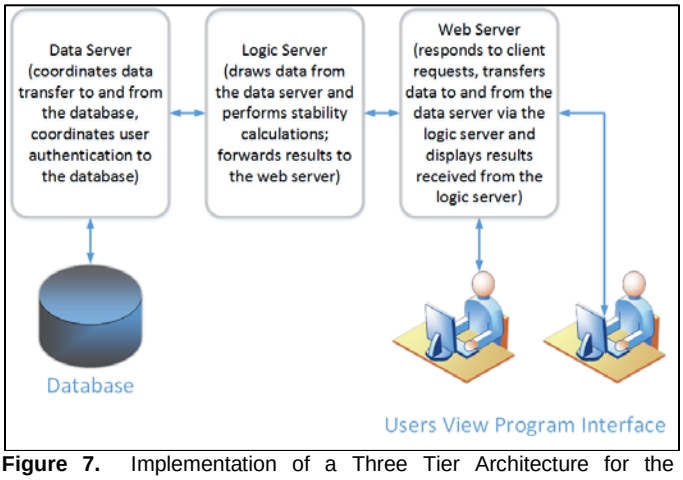

Figure 7. Implementation of a Three Tier Architecture for the webGroundControl Application.

Utilizing this three-tier architecture for the webGroundControl application, NIOSH ground control software can be repackaged for distribution as a web application. For example, the schematic in Figure 8 depicts the implementation of a three-tier architecture of a web application for ARBS (Analysis of Roof Bolt Stability).

Through the use of data entry form displayed in the Web Server, users will be able to define a series of input parameters such as CMRR, Depth of Cover, Intersection Span, Number of Support Systems, and the roof support parameters for each defined support system. This information will be checked for consistency at the Logic Server and will be transferred and stored on the database through the Data Server. When the user requests evaluation of a specific roof bolting design, under a defined project, the input parameters will be retrieved from the database to the Logic Server through the Data Server. The Logic Server will perform a series of calculations with respect to the user defined input parameters. The results of these calculations (Suggested Intersection Span, Suggested Bolt Length, ARBS factor, etc.) will then be transferred to the Web Server and displayed to the user.

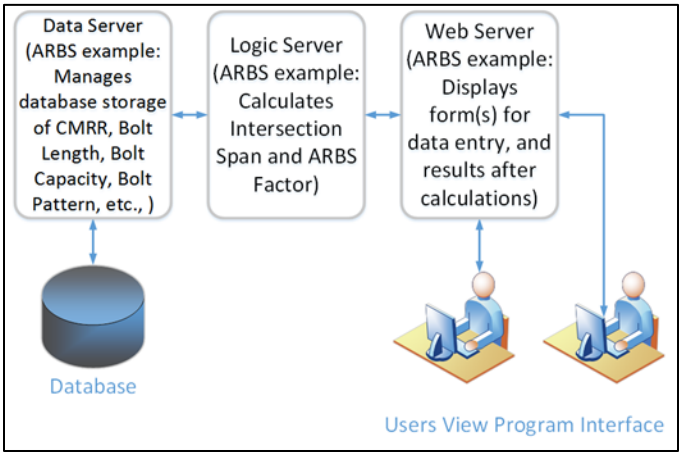

Figure 8. Implementation of the ARBS software package.

SUMMARY AND FUTURE WORK

The ground control design software developed and distributed by NIOSH has provided engineers with a series of software tools aiding in the design of underground roof support, formation characterization, pillar optimization for longwall and room and pillar mines, etc. This paper outlines the proposed implementation of a three-tier architecture for redistribution of the ALPS (Analysis of Longwall Pillar Stability), ARMPS (Analysis of Retreat Mining Pillar Stability), and ARBS (Analysis of Roof Bolt Stability) NIOSH ground control software in the webGroundControl web application. In developing this web application, users will be provided with faster and easier access to existing ground control designs, on-demand calculations in the field, and instant online collaboration between operations personnel and planning engineers.

Currently, only the theoretical three-tier architecture for the web application has been completed. In the coming months, work will be focused on developing code for the application framework in the form of the Web Server, Logic Server, and Data Server. Once the framework has been developed, work will commence on database security through user authentication and roles. The final step in this project will be the integration of selected NIOSH ground control software into the Logic Server and open distribution online.

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