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Development of a web-platform for mining applications

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ABSTRACT

"Web ground control" (webGC) provides users with instantaneous access to mine design applications anywhere, at any time, through a web browser. Utilizing a web-based multiple-tier architecture, users are able to easily access ground control designs, perform on-demand calculations in the field, as well as facilitate project collaborations across multiple users, devices, and operating systems. Currently, the webGC platform contains five ground control related design applications previously developed and distributed by the US National Institute of Occupational Safety and Health (NIOSH), that is, analysis of roof bolt stability (ARBS), analysis of longwall pillar stability (ALPS), analysis of retreat mining stability (ARMPS), analysis of retreat mining stability–highwall mining (ARMPS-HWM), and analysis of horizontal stress in mining (AHSM). With respect to design decisions made by the webGC development team, the webGC platform will be able to further integrate future mine design applications providing the mining industry with one of a kind umbrella suite of ground control related software available at ones fingertips. The following paper provides a detailed overview on the current state of the webGC platform with discussions ranging from back-end database development and design to the front-end user-platform interface. Based on current progress in platform development as well as beta testing results, the webGC platform is scheduled for release in the fall of 2018.

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1. Introduction

Due to the increase in design intricacies as mining operations continuing to develop reserves at deeper depths and in more complex geologic and geometric conditions, there has been an industry and regulatory demand for mine designs to better replicate site-specific conditions for the evaluation of support performance, pillar stability, stress conditions, etc., with respect to ground control. Mining personnel are provided with a suite of ground control design programs for the evaluation of underground coal mines which has been developed, validated, and are distributed (free of charge) by the National Institute of Occupational Safety and Health (NIOSH). The NIOSH programs, for example, analysis of roof bolt stability (ARBS), analysis of longwall pillar stability (ALPS), analysis of retreat mining stability (ARMPS), analysis of retreat mining stability–highwall mining (ARMPS-HWM), analysis of horizontal stress in mining (AHSM), etc., have become instrumental in obtaining mine plan approvals from United States (US) federal and state authorities for underground longwall, room-and-pillar, multiple-seam, and surface highwall mining operations [1,2]. ARBS provides users with a means of evaluating the performance of a given roof bolt system with respect to the depth of cover (stress), intersection span, roof condition and quality, bolt/cable location, geometries and strength, etc. In utilizing this program, one is able to quickly compare the effectiveness of the given roof bolt system against an extensive and verified database of 100 case histories [3]. ALPS estimates the applied loading conditions and evaluates the stability of the longwall pillar system with respect to the development and extraction of longwall panels. ALPS analyses the longwall pillar system with respect to mining depth and geometries as well as the condition of the roof and further compares calculations results against a database containing 90 case histories [4]. ARMPS aids mine operators and planning personnel in the sizing of pillars for room-and-pillar development and retreat mining operations. ARMPS has become the most widely used pillar design methodology in the United States coalfields and has resulted in a dramatic reduction in the number of pillar squeezes, collapse, and bumps during the development and retreat phases of single seam underground coal mining operations [5]. The ARMPS program estimates pillar loading and stability with respect to mining depth and geometries and compares stability calculation results against a large (>600) case history database [6]. ARMPS-HWM evaluates the stability of both web and barrier pillars with respect to highwall geometries in a similar manner to the ARMPS program previously discussed. AHSM estimates horizontal stress magnitudes and

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evaluates mine panel layout and mining direction with respect to underground stress orientations [7].

While the NIOSH suite of ground control design programs provides the mining industry with a reliable means of evaluating underground stability, their "stand alone" or "single-tier" architecture often becomes a hindrance when updating design parameters with respect to new site-specific conditions observed or measured in the field. Similarly, the inherent limitations of the single-tier architecture, as described in Newman et al., are further compounded when collaborating with multiple mine design personnel as files are emailed back-and-forth without a reliable mechanism of documenting user changes and versions [8]. Currently, these programs require an individual or workgroup computer equipped with a Microsoft Windows operating system on which all program data resides. Recently, taking advantage of web-based computing technologies, a new online platform is being developed for mine design applications called "web ground control" (webGC). Through the adoption of a multiple-tier architecture, webGC provides multiple users on-demand access to ground control mine design applications across multiple devices and operating systems (OS) by means of an internet connection (Fig. 1).

With the expansion of internet connectivity on the surface and underground, webGC will provide users with the means of performing on-demand design calculations in the field with respect to varying site-specific underground mining conditions, observations, and measurements as well as facilitating online collaboration between mine operations and planning personnel. This paper discusses the framework of the webGC web-platform and demonstrates its ability to provide the mining industry with an umbrella suit of mine design applications and ground control analyses at the stroke of a key or swipe of a finger. It is expected that the mining industry will rapidly embrace this new product and webGC will be a new paradigm for mining engineering computer applications.

2. Platform architecture

WebGC provides a web-based platform which can be accessed through either a local area network (LAN) or a wide area network (WAN) environment. The system can be configured to run inside a corporate network on a dedicated server or through a server located in the cloud. Furthermore, webGC has been developed utilizing a multiple-tier architecture comprising of a presentation, logic, and data tier (Fig. 1) [9]. These tiers can be serviced by multiple independent servers or by a single dedicated server. In both cases, platform maintenance and scalability are easier as modifications and improvements can be made to a single tier without having to redesign the entire software package.

The presentation tier, i.e., where information is processed and displayed to the user through a web-browser, serves as the human-platform interface and is responsible for the flow of user requests and the display of results. The data tier is responsible for managing the data, i.e., the coordination of data flow to and from the database server. Finally, the logic tier is situated between the presentation and data tiers and is responsible for processing information received from both tiers. User requests submitted through web forms are handled by the logic tier. After the logic tier tasks are completed, the results or feedback is displayed on the user's device through the presentation tier. The logic tier has been developed using the Python coding language allowing for seamless interactions between both the presentation (developed in HTML and JavaScript) and data (SQL) tiers.

The asynchronous communication between tiers allows multiple users to concurrently access the webGC platform and the available design application. Since multiple users are able to handle the same code within the platform at the same time, data integrity as well as platform and application stability is very important. To ensure that webGC effectively addresses these challenges, a significant amount of effort was devoted to the development of the logic tier with respect to a robust central controlling mechanism: the logic controller. A simplified schematic diagram of the logic controller is shown in Fig. 2.

As illustrated by Fig. 2, once the platform is launched and a design application has been selected, the logic controller assumes control in order to effectively manage user requests and data as well as perform necessary calculations, and generate output results to be viewed by the user through the web browser (presentation tier). While a detailed description of the logic tier and logic controller is provided in Newman et al., simply put, requests are made by the user through the presentation tier that are then passed to the logic tier which completes the request by placing queries to the data tier [10].

The webGG platform has been designed as a central repository of mining projects and scenarios for a single corporate structure. It supports multiple projects within a given corporate entity and multiple scenarios per project as detailed below. WebCG has been designed so that it can take advantage of a corporate network infrastructure and can provide access to a user based on local authentication credentials.

3. Platform navigation and scenario analysis

While a significant amount of time has been dedicated to the back-end database and logic controller to ensure data integrity and security, a substantial amount of effort has similarly been committed to the development of the front-end user-platform interface allowing for fluid navigation through and operation of webGC and its many mine design applications. Navigating through the webGC platform has been broken down into three main components, that is, project administration, scenario administration,

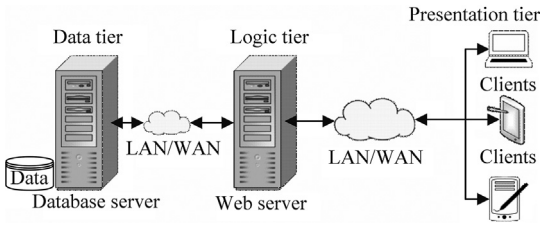

Fig. 1. Multiple-tier architecture as implemented by the webGC platform.

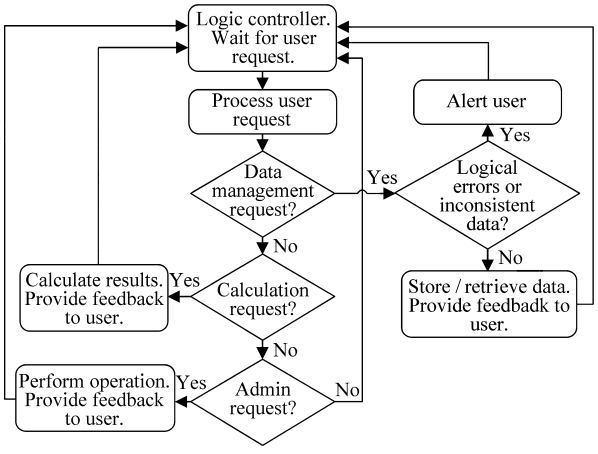

Fig. 2. Logic controller schematic.

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