VISUALIZATION AND COMMUNICATION PLATFORM FOR REMOTE MONITORING OF INFRASTRUCTURE PROJECTS

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Abstract
This paper proposes a conceptual framework for developing a communication platform to monitoring construction projects remotely. The need for remote monitoring is a requirement today in the construction industry as the number of project sites has increased significantly and the expertise available to resolve site related problems is not easily available. Individuals with expertise are required to visit projects physically and as a result they are travelling most of the time and this results in unproductive utilization of their expertise. The proposed system integrates Digital Maps, CAD/BIM, scheduling software and live video into a single platform which can be used for communicating and resolving the issues remotely. The software Google Maps, Primavera, and Navisworks were used for the current implementation. The paper describes the architecture of the proposed platform and illustrates the features of the prototype platform under development.

KEYWORDS: Remote Monitoring Dashboard, GIS,BIM & Schedule Integration,

INTRODUCTION

Over the past few years there has been a rapid rise in the number of infrastructure projects undertaken by large construction organizations. These projects are usually distributed over a wide range of geographical regions and in many cases the regions are remote and travel can take many days.

While the routine day to day work on these projects can be carried out by local engineers and workers, specialized engineering decisions as well as other higher-level management decisions requires inputs from experts who are shared between multiple projects. There is a significant shortage of expertise both in technical and management levels, as a result the qualified personnel are over-stretched in their efforts to travel to multiple sites to understand and resolve problems.

With the advancement in network and wireless services as well as web-based maps and other technologies, it is proposed to design and develop a system that an expert team from the home office can use to understand analyze and resolve problems from multiple sites without physically visiting the sites. A system which can deliver such a service is expected to enable a company effective share the expertise of key technical and managerial personnel efficiently.

To address the above issue a survey of problems which required expert intervention on cross-country pipeline projects was conducted. It was found that the technical problems ranged from varying soil types, obstructions to pipe line alignment, design incompatibility between pumps/valves and pipelines as well as resource and schedule uncertainties. Based on the nature of problems identified, it was decided that the platform should contain the following components (i) Map based interface highlighting the location and layout off various projects at required levels of detail (ii) Video based communication platform (iii) CAD/BIM based tools to allow the user to navigate visualize the building or component levels during discussions (iv) Monitoring tools to indicate schedule completion, cost and other conventional project parameters (v) a dashboard interface to access and control various components of the system.

The objective of this paper is to discuss the design of a prototype system which incorporates the above features to develop a platform for remote monitoring and communication. The preliminary design of the above system is based on integrating Google Maps with Primavera Enterprise, further extension on integrating CAD/BIM software has also been discussed.

The paper is organized into five sections. The next section reviews the past work done on remote monitoring of construction projects. The third section presents the architecture of the system and the fourth session illustrates the features of the system. Finally, the summary and conclusions are presented.

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Past Work

The area of remote monitoring has been an active area of investigation for a number of years. The features of the world wide web has been at the core of these developments and it has been used extensively to transfer data, share common databases, enable live video feeds and schedule virtual discussions. However, very few platforms have attempted to integrate these features into a single platform.

Use of web-cams to monitor projects has become popular. This technology enables viewers to access the live video feed of the project and monitor the visible physical state of construction. Enhancements to this technology include integration of the planned project schedule with the video to enable the viewers to compare the planned vs. actual state of the project. Commercial technologies PHOTO-NET II (Abeid et.al, 2003) and NetVision (NetVision, 2010) have emerged from research in this area. The limitations of these technologies are that they only integrate the broad building scale visual elements, the geographic scale components and the element scale components are not integrated. Further, tools for face-to-face discussions are independent of the platform.

Another area of research which is critical for remote monitoring is the development of visual analytics and dashboards for data analysis and integrated access to construction monitoring information. Visual analytics enables decision makers to ascertain the state of a project by viewing relevant slices of data generated from the planning and control system (Chen et.al. 2009). The dimensions in which the data should be sliced and the graphical presentation of the information for facile interpretation forms the core issues in visual analytics research (Russel et.al. 2009).

The integration of hierarchal dashboards to navigate through the project data is also another aspect of investigation. It offers the users a structured method to view the project from different facets and entry for discussion points and resolution of issues. The visual analytics frameworks forms an interface with the existing databases and using the framework remote teams can interact. The potential to interface complementary tools such as digital maps, project drawings, video feeds and schedule through a common dashboard framework has not been utilised in any of the published research. Hence the focus of this work will contribute to the development and testing of a unique framework.

System Architecture

The interactions between the core components of the proposed system are shown in Figure 1. As the system is designed primarily to monitor projects which have geographically distributed work areas, the scheduling software Primavera and the mapping software Google Maps form the core of the system. The platform integrating this software is developed by Gaea Global and called Terra 6 (Tera6, 2010) additions to this platform are an interface to a video-streaming window where live feed from a site can be viewed, as well as a CAD environment where details of components can be displayed.

An overview of the architecture of Terra 6 is shown in Figure 2. The links between the different software are enabled through a Java interface which is developed using the Primavera interface.

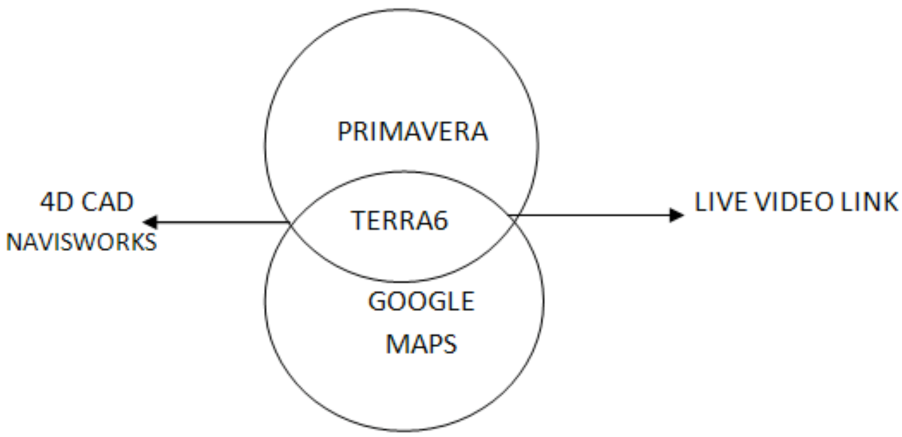

Figure 1: Core System Design

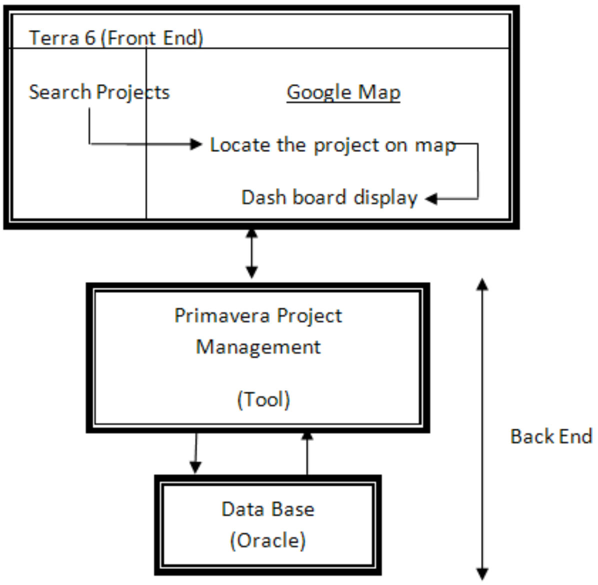

Figure 2: Terra 6 Component Interactions

One of the key concepts required for representing the system is a hierarchical breakdown of the system associating the components and the activities. Figure 3 shows the hierarchical breakdown where the components occupying geographical scale space are represented in the Map, while the smaller sub-components are represented in CAD/BIM and the activities required to construct a component are represented in the scheduling software.

This representation is critical to integrated use of the platform. Typically monitoring queries can be directed towards a component, sub-component or an activity. The representation allows the system to categorize the query being raised and aids the discussion by allowing the team to utilize the appropriate tool required to visualize and clarify the query.

System Features

The features of the communication platform was finalised based on analysis of cases requiring resolution and feedback from site and visiting experts of a group specialising in construction of water supply projects. Components of water supply projects are distributed geographically. Typical components include, pipelines bringing water from the source, pumping stations, treatment plants and distribution networks. As a result of the geographical distribution of components and detailed engineering required within some of the components, issues are faced at various levels of detail.

Figure 4 shows the interface to the platform highlighting the geographical location of component. Using the WBS window on the left an user can select any component of the project and the geographic footprint of the component will be displayed on the map. The satellite image shows the location and proximity of the site where the selected component is to be constructed. Based on the image a team can identify attributes such as accessibility, location of lay down and storage yards as well as proximity to other features such as water bodies or transmission lines.

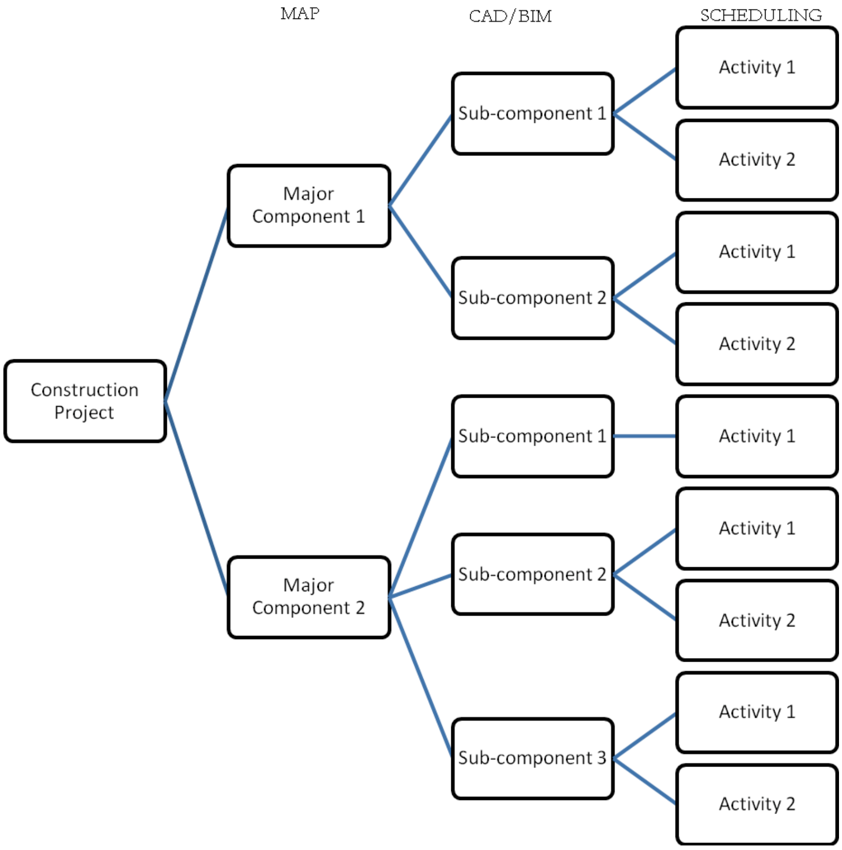

Figure 3. Component Breakdown

Figure 5 shows the interface to the video link which can be used for live discussion during the review meetings. The link window also has options to display graphs and other visual analytics to enable the teams to illustrate the non-spatial aspects of the project data. Using appropriate tabs the user can toggle between various windows to view and comprehend the

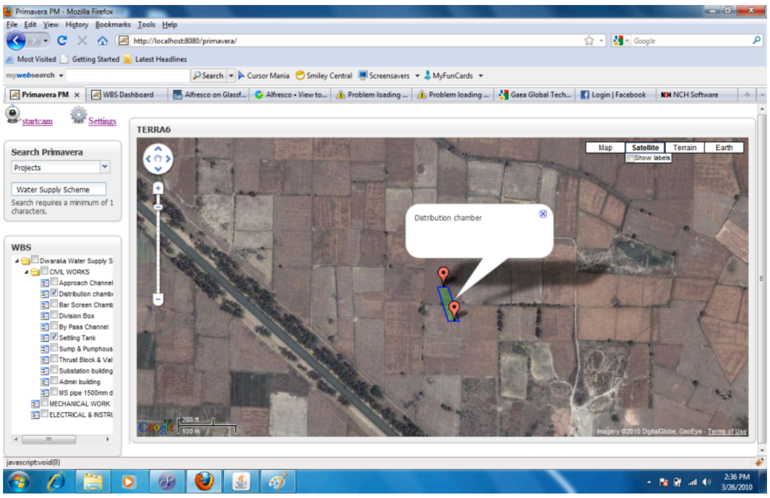

Figure 4: Interface Between Map Location and Project Component

issues being discussed. Having the integrated video link and analytics was expected to have more utility that using an external platform.

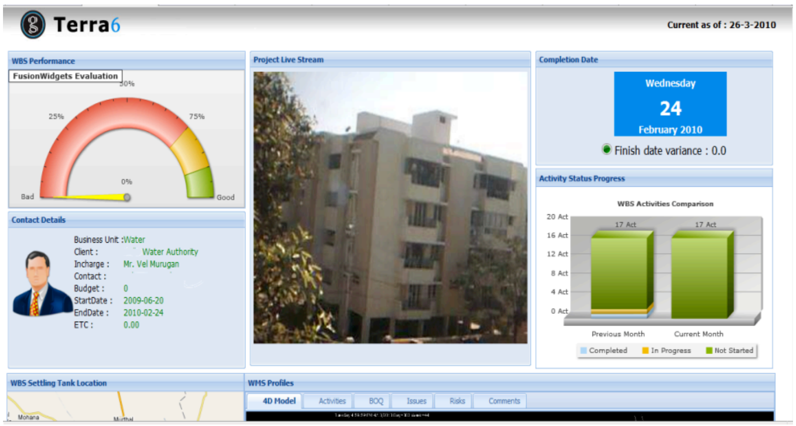

Figure 5: Interface to Video Link and Project Analytics

If issues to be discussed involve clashes or other details which require visualising the sub-components of the project components then the team has option to display the CAD/BIM details of the subcomponents as shown in Figure 6. The geometric details of components and the geographic location can be shown in the same window as shown in the figure. The specific interface shown is to the software Navisworks and through the interface a 4D schedule of the project can be visualised. However, any CAD or BIM package can be linked to the interface to enable visualization in the native environment for the project model.

Figure 7 shows a window linking the various activities and the geographic location at which they will be performed. This interface can be used to estimate the quantity of materials required at a particular location and the resource demand by activities at different locations. This input can be used to jointly plan the logistics of various activities requiring similar resources such as cranes etc.

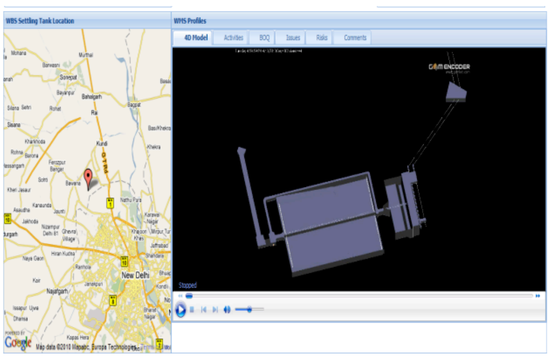

Figure 6: Interface showing CAD Model and Map

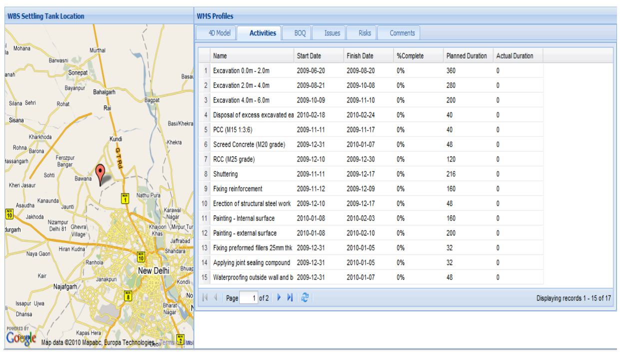

Figure 7: Window Showing Activities and Associated Location

Summary & Conclusions

This paper discussed the need for a integrated platform for remote monitoring of construction projects. The platform integrates Digital Maps, CAD/BIM and scheduling software into a single platform which can be used for communicating and resolving the issues remotely. A prototype was developed using Google Maps, and Primavera Enterprise, this system is called Terra6. An interface to Navisworks and live video feed with construction analytics was added to Terra6 to form the integrated platform.

The platform is currently being tested on a water supply project. The testing involves utilizing the system for day to day interactions and evaluating if the features function as designed and assessing the effectiveness of the features in resolving the issues to be addressed.

Further work in this area should focus on designing appropriate analytical dashboards for different types of construction projects, enabling knowledge capture and sharing engines and ensuring that the system is portable and can be used on mobile devices.

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