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A System Architecture Based on Gateway for Monitoring Underground Facility

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Abstract. In the modern era of urbanization, we have underground facilities in the form of water supply and the sewer management, the underground railway lines and the parking lots. Their facilities play important roles to facilitate the residents and save ground surface area for other uses. However, we present a crucial challenge as critical problems for the management and maintenance of their facilities in such facilities can directly affect lives. Advanced monitoring systems based on state of the art technologies with effective data acquisition and processing models can help predict such critical problems and assist the management to efficiently maintain the underground facilities. In this paper, we present a system architecture for monitoring underground facility and provides a model for data acquisition from heterogeneous sensing sources and the analysis of such data.

Keywords: Underground facilities, Monitoring, Data acquisition, Data analysis.

1 Introduction

Underground facilities has several meanings depends on the term of context used utility and facility functional operations, the infrastructure represents the underground cables and pipes networks supported with all related assets. Mayers presents a data acquisition and data management system model [1]. Such a system is the base of an underground monitoring and provides an insight into the technologies required for the implementation of an underground monitoring system. Such a system is used by contractors and tunneling crew which manages the Tunnel Boring Machines (TBM) [2] guidance system and the other machine sensors, owners/clients and the authorized guests who evaluate the works as the client representative at the jobsite. These data management systems focus on the Key Process Indicators (KPI) for the quantitative and qualitative evaluation of underground tunnel driving and also for the entire sensor network as part of the surface instrumentation.

The construction of a the middle section of Warsaw metro line 2 presented many challenges according to this aspect and may studies were performed i.e. 650 drillings were ordered to a total length of 14800 meters to collect data on the land and water conditions within the construction site [3]. A monitoring infrastructure was deployed for risk assessment and construction process control using data from 7993 measuring

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sites and collected by 11 devices. The devices would send the data to a monitoring center where construction process would be controlled based or generated alerts by the risk analysis system.

Systems architecture is the conceptual model that defines the structure, behavior, and more views of a system [4]. An architecture describes a formal representation of a system, organized in a way that supports reasoning about the structures and behaviors of the system.

This paper presents the system architecture based on the monitoring of underground facilities such as water supply lines, sewerage system, subway structures, oil and gas distribution etc. The underground monitoring system consists of a data acquisition infrastructure regarding various factors concerning the health of the underground facilities, data input system and a data processing infrastructure. An efficient data acquisition and processing system is an important factor in the efficiency of underground monitoring systems.

A collective utilization of data from these desperate sources can provide an efficient way for monitoring and forecasting critical issues in the underground facilities and may assist in the maintenance efficiency as well. This paper presents an architecture and data acquisition model for such a system. Section 2 describes the conceptual architecture of the proposed system. Section 3 presents the data acquisition and analysis model. Section 4 describes the unique identification scheme for such a large network of sensing equipment. Section 6 presents the conclusions and future work.

2 System architecture for monitoring underground facilities

Figure 1 illustrates the conceptual system architecture for monitoring underground facilities. The main components for a facility monitoring, as shown in the figure, includes a sensor network for acquiring the data from the infrastructure of the underground facility. The type of sensors and the data acquired from through them is dependent on the facility being monitored and the requirement specifications of the monitoring system. For example, for water supply lines, the monitoring system should have data related to underground leakages, water contamination, and water pressure levels from source to the consumer points etc.

The second component of a system architecture for monitoring underground facilities, as shown in the figure 1, is a point or sink for the data generated by all the sensors in a specific area. In the figure, this data sink is labeled as the gateway for the underground sensor network. Gateways provide a communication bridge between the sensing infrastructure and the brains of the system where all the data processing takes place. The gateways act as an abstraction layer for the heterogeneous hardware platforms of the sensing nodes and provide an easy approach to scalability of the system.

The third component of a system architecture for monitoring underground facilities is the data processing system labeled as server in the figure. The server is a system or a cluster of systems to provide storage and processing services for the data acquired from the sensing network by the gateways and sent to the servers in real-time. The

server implements various data analysis and data processing algorithms to filter, clean, analyze and correlate data in order to detect various events (leakages, blockages, contamination etc.) in the underlying facilities being monitored. It also uses the same data to perform risk analysis of the system and predict or forecast events. The server provides notification service in order to convey, notify or alert the concerned entities once a real time event is detected or forecasted as a result of the data analysis and processing. The risk analysis data is also used in conjunction with the maintenance and safety control services. Specifically, the maintenance and safety service is of immense importance with regards to the underground facilities.

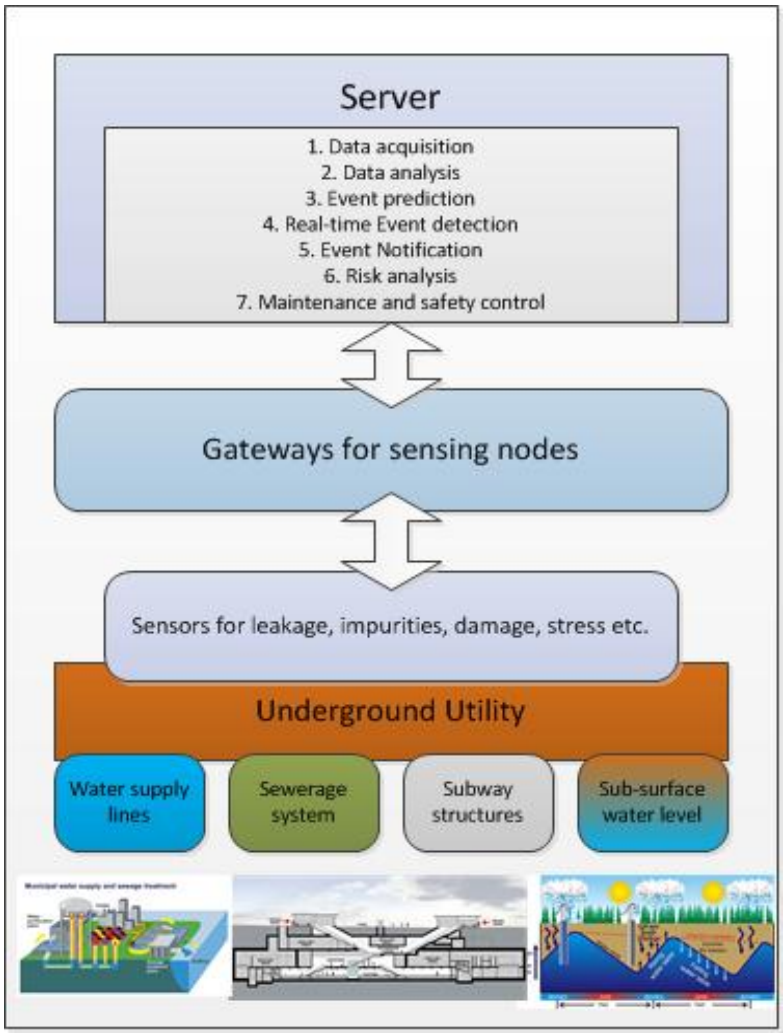

Figure 1. System architecture for the underground facility monitoring

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