Architecture for Web-based Water Supply & Sewerage Asset Management System – A Case Study

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Abstract:

One of the major challenges that municipal and local government bodies face in India is the maintenance of existing urban infrastructure. Against the present approach to asset management and maintenance and operations of the water supply and sewerage systems, web GIS offers a platform where the decision makers can consolidate all the information giving a wholesome picture. This paper discusses the structure of web based GIS architecture planned for implementation of asset management module and creation of customer database for water supply and sewerage systems in the municipalities of one of the Indian states. ArcGIS server technology with a backend Oracle® database server is the platform chosen for this application. The system is designed to address the regular operations and maintenance issues of the public health engineering department and to collect the data relating the pipelines, valves, manholes of water supply and sewerage systems. Moreover the system will also bring the data to a common web platform and carry out the proper zoning of the pipeline network by providing necessary pipeline network hydraulic design and analysis for equitable distribution of water. This GIS based asset management system shall exploit the ability of web GIS to search asset records /information database and performing user-friendly queries which will be significant for adopting modern system of financial planning for asset management.

Easy access and retrieval of information through simple query generation feature, in web GIS server, would prove to be useful to make informed and well-engineered decisions on locating new water supply and sewerage projects with maximized environmental and social benefits.

About the Author:

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Amarsh is a B.Tech. in civil engineering from IIT Kanpur and is certified by Consultancy Development Center (DSIR, Govt. of India) as a technical consultant with expertise in surveying, remote sensing and GIS.

He is currently leading a project for a government organization for developing a GIS based asset based management system using server based GIS applications.

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Introduction

Municipal bodies in India, particularly those responsible for managing water supply and sewerage systems, are slowly adapting computerized management and information systems to handle their regular operations and maintenance tasks, asset inventory management and customer grievance redressal systems. Factors like funding problems, organizational issues and administrative constraints have had an impact on adopting best practices in the past, but with the given pace of development and embracing technology to empower the current systems, these bodies are trying to improve operational and commercial performance through increased focus on institutional strengthening and capacity building elements. GIS is an important tool that can help in transforming the current stance from reactive to a more pro-active approach. With the availability and easy access of layouts and maps, several labour intensive manual practices involving a large number of employees performing clerical, administrative or menial tasks can be avoided and they can be involved in performing tasks which are more technical in nature. GIS will add value in decision making for managing the information which is currently maintained manually. Best practices adopted in any particular localities can also be shared and knowledge transfer can be easily affected when GIS-based management systems come into place. This study aims at designing solution architecture for enabling GIS-based asset management and customer management system for one of states in India.

Approach and Methodology

In order to design the proposed GIS based management system, various components of the project were listed. Workflow diagram shown in Fig 1 demonstrates the various parameters and stages that are involved in designing this system. Water supply pipelines (supply mains and distribution), controlling valves, sewerage lines and manholes/chambers are most of the assets of water supply and sewerage departments which need regular operations and maintenance. Since these assets are widely spread geographically, it is difficult to manage and keep a record of them unless the asset layouts/maps are available.

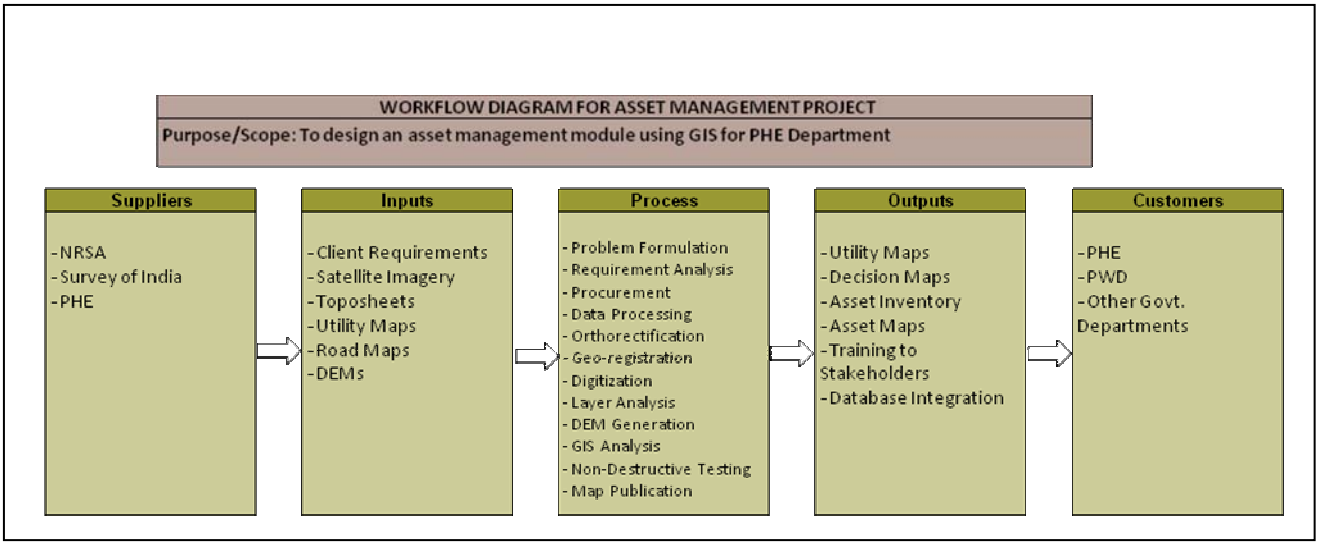

Fig:1 – Workflow Diagram for Asset Management System using GIS

Apart from asset maps and layouts, a base map is extremely essential for the system to generate meaningful information in the form of maps for the end-user. In this particular system, the base map of 1:2000 scale is prepared using high resolution satellite imagery (preferably, Quickbird/Worldview/Cartosat-2/GeoEye) complimented by limited ground verification. Asset maps and base map will essentially form the entire dataset of the proposed system. Mapping of the assets like water supply lines, sewerage lines, valves, manholes and other fixed assets is being done in GIS/Mapping mode of GPS receivers in post-processing operation, wherein the data from field mapping is post-processed and differentially corrected using the network of base stations established at secondary control points to ensure maximum accuracy. A feature library for all the asset types is created in the GPS devices and the same would be used to map the assets. Asset ID is then attributed to the data received from these devices after correcting the data and placing on the base map parcels. The attributes which shall be captured while carrying out this survey are shown in Figure 2.

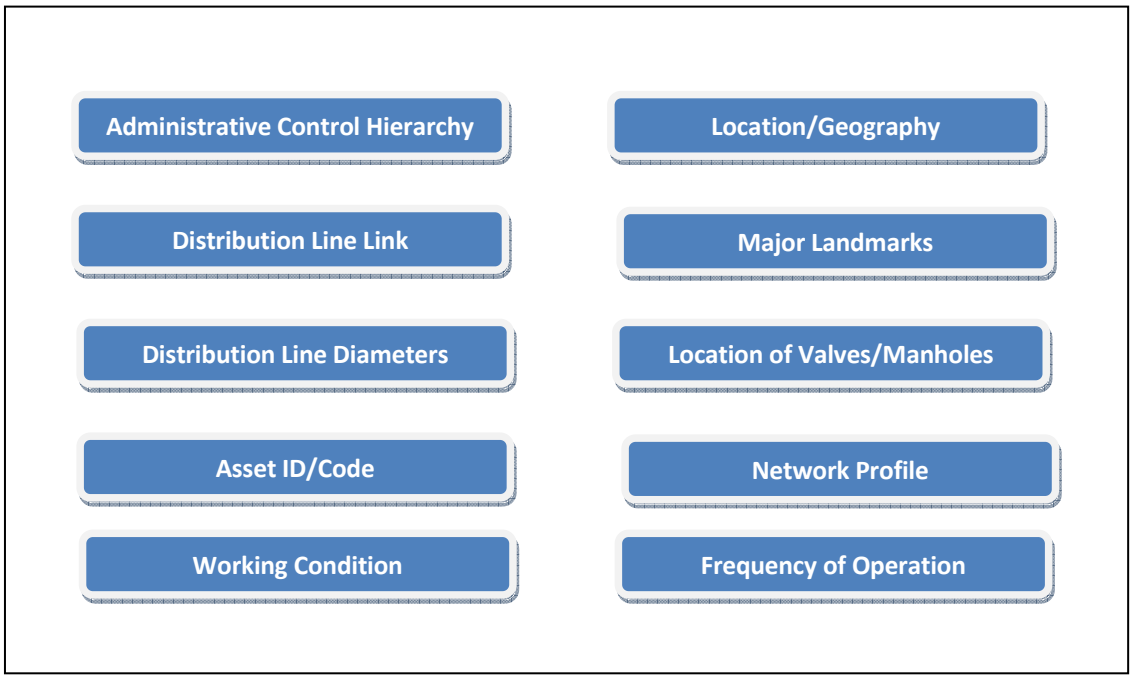

Fig:2 – Attributes captured for Assets

Using the inputs from available data, maps and asset survey, databases are created and unique IDs generated for all the entities. These databases are also filled with other non-spatial attributes which may not have been captured in the field during survey. Upon completion of this work, the databases are streamlined and used for further GIS implementation. In this particular application, Oracle 11g was chosen for creating the database server. This choice was made keeping in mind the load that the database server would handle and its compatibility with ArcSDE and ArcGIS server platforms which will be used for actual implementation of web GIS in the project. This database server will then be used with a GIS server, namely ArcGIS® Server based on ESRI technology to generate the enterprise level, easy-to-use web-based GIS system. The architecture suggested for this application relies on a client/server model. ArcGIS Server will be used to create a WebGIS portal which will act as a client that enables access to the geodatabase. This portal will be used by the end-user for day-to-day GIS operations.

System Design and Architecture

Designing the GIS based asset management system will entail the design of its sub-components: database server, web services and user level categorization. Database server design is based on the requirements from the asset management system plus data attributes that will be used to generate the desired queries. A possible data model is shown in Figure 3.

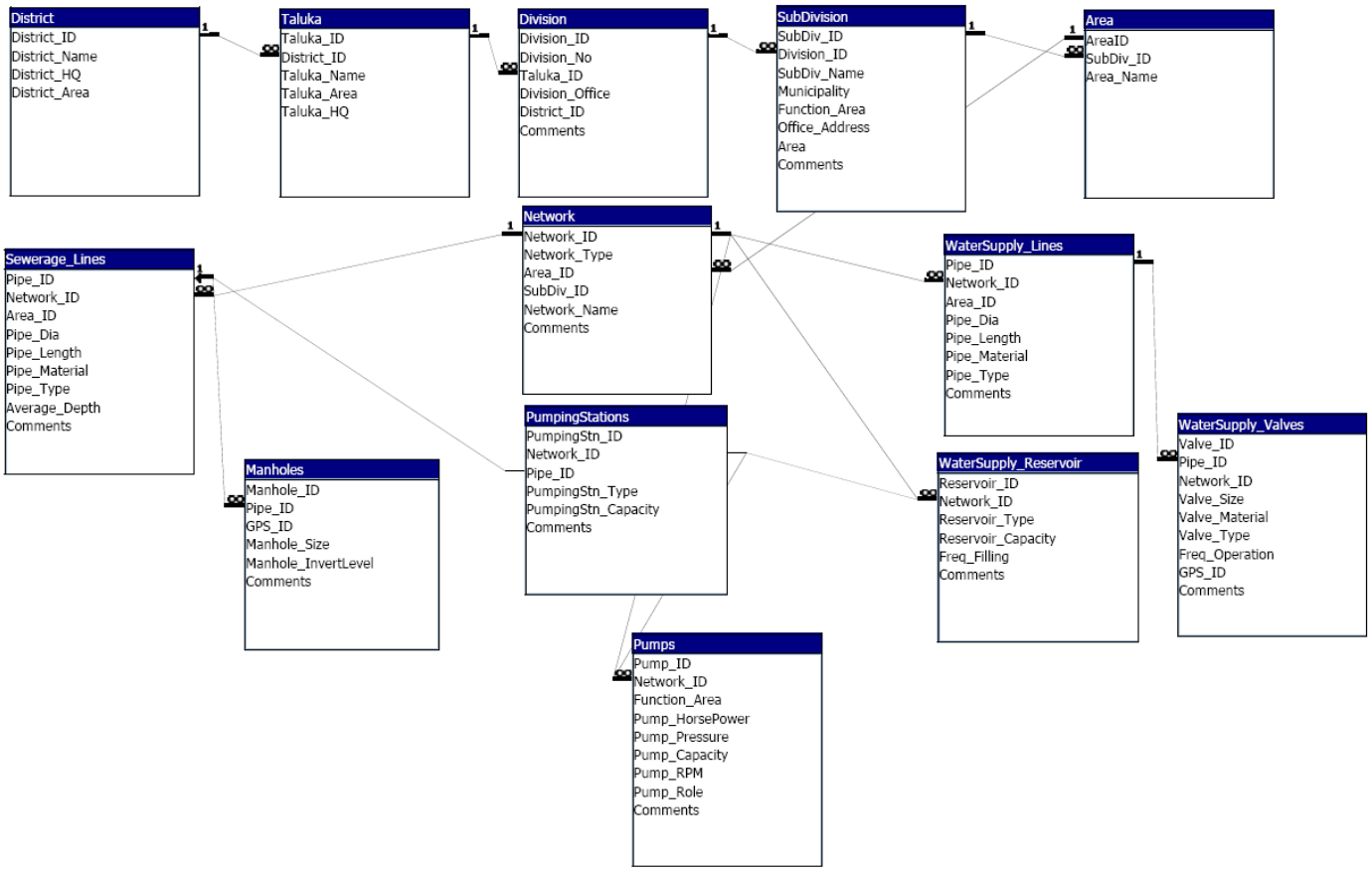

Fig:3 – Data Structure for Asset Management System

During the analysis of requirements for the project, user level categorization was outlined after detailed discussion with the concerned government departments. The proposed asset management system will have three categories of users: End Users (general PHE/municipal staff), Authorized GIS Users (few of the staff members selected for modifying the system) and WebGIS Portal Administrators (web designers). The users will be able to perform several functions as depicted in Figure 4.

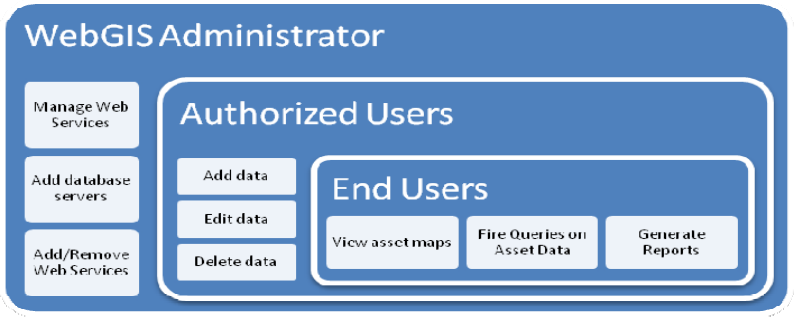

Fig:4 – User Categories and Privileges in WebGIS system

The system will try to achieve Query Level Integration, wherein the asset database and customer database will have a common map layer, but will be managed in different web services. In order to design queries and customize the looks, feel and other aesthetic aspects of the web services, the customization capability of ArcGIS Server technology shall be used in .NET programming environment.

Conclusion

With the implementation of enterprise GIS solution powered by ArcGIS Server, staff members from the maintenance departments will have easy and accurate access to information about the water distribution network and sewerage systems. This will considerably reduce the time taken to locate the problem areas and will also help in designing and further expanding the system. Maintenance and upkeep of paper maps shall also be eliminated. With the powerful web based GIS solution for asset management, employees will be able to query vector data in the form of asset layers and generate useful reports.

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