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THE SMART CITY INFRASTRUCTURE DEVELOPMENT & MONITORING

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Abstract
The smart city infrastructure is the introductory step for establishing the overall smart city framework and architecture. Very few smart cities are recently established across the world. Some examples are: Dubai, Malta, Kochi (India), Singapore.
The scope of these cities is mainly limited to construct a technology park converting the industrial real estate to state of the art information technology using the evolution in the telecom and IP networks including insignificant asset management automation system. The development background is to create an operational platform that would manage the power consumption and operational resources in order to reduce the overall running operational cost. This paper will debate the smart infrastructure development framework and the surveying positional accuracy of locating the assets as a base of the smart city development architecture integrated with all the facilities and systems related to the smart city framework. The paper will discuss also the main advantages of the proposed architecture including the quantifiable and non quantifiable benefits.
Keywords: Smart Infrastructure, GIS, Smart City, Geopsatial application, Infrastructure Development, Infrastructure Monitoring

1. Introduction

Infrastructure has several meanings depends on the term of context used in. in terms of utility and facility functional operations, the infrastructure represents the underground and aboveground cables and pipes networks supported with all related assets. While civil engineers concerned with other urban area service functions such as road networks, bridges, train/bus stations, schools, hospitals, universities and other public services.

The conventional infrastructure networks are composed of main and major assets connected to pipes or feeders. Thomas C. O'Reilly et al. (2001) define the majority of these assets are not talking each other and have very limited control and monitor operational functionalities. The primary concept of establishing the digital infrastructure networks is to distribute a sufficient number of sensors that meet the needed level of assets connectivity and control. Thomas et al. 2001, debates the smart concept of network of infrastructure for the ocean observing system. The debated concept deal with the network observation platforms and sensors deployed over a wide geographic area, distributed throughout the oceanic water column. The network utilizes a variety of communication links, including optical fiber, microwave, packet radio, satellite, and acoustic, resulting in diversity of throughput, latency, and intermittence throughout the network. The network membership is highly dynamic and unpredictable, as links go "up" and "down", and devices are added to and removed from the network.

The implementation of the enterprise resource planning (ERP) system is the base of creating the smart concept either in the city or infrastructure level. The idea beyond implementing the ERP is replacing the existing legacy systems and available interfaces into a single functionally rich system application product (SAP. The purpose of the SAP is to standardize all possible business models and all operational processes in one platform, SMART GIS/IT (2007). The construction activities for the facilities such as electricity, water, Gas, district cooling, irrigation, sewerage and communication networks need to be fully monitored on daily basis, in order to utilize the huge resources and man power. These resources are allocated only to concave the operational status for the construction and execution sections that will do the required maintenance. The need for a system that will serve all managerial people in following up all these activities with a proper geographical representation will definitely reduce the man power for the long term.

Several governments and master real estate developers start implementing an enterprise GIS project for their world wide projects in order to facilitate the project management processes within the digital infrastructure concept. Working Group of the Smart State Council, (2006) depat the smart concept implementation in queensland goverment. In order to provide a high level advisory services on emerging the smart state issues and trends. The potential in the master real estate developers are the scale of the projects and the huge man power that they are utilizing in their real estate development projects. Accordingly they are building several cities across the world. Due to these wide range real estate development activities, a detailed study of the existing systems with all associated database engines and business platforms are need to be tackled. The study aims to build up the model of operating the infrastructure/utility networks frameworks.

2. Research Background

The research method statement is essentially to modularize the structure of the utilities and create a system for following up the activities electronically that would manage all assets up to the house connections. The remote communication using sophisticated configured sensors and Programmable Logic Controllers (PLC) will be used to covey the network status in a predefined integrated framework that would support the networks operational platform. The background is to develop an automation system and accordingly reduces the running cost through saving energy. The GIS operational platform will be the base for managing the infrastructure sensors and programmable logic controllers with the systems interoperability for all available/related systems. The GIS operational platform will debate all possibilities of systems integrations such as SCADA systems and digital sensors. The concentration will be on the available utility networks in order to develop a comprehensive, common, standardized geospatial data models. The networks are represented the positional location for all network assets such as pressurized, gravity pipes and system valves attached with all information's including the connectivity assets rules.

The research will utilize the geographic factor to tie in all these disparate elements and present a single unified common operational platform, where GIS can be a great support in allowing the users to visualize properties locations, managing all city infrastructure networks. The system will be used for managing all available assets in all aspects with all required/feasible systems interoperability. The facility management, projects tracking with all spatial activities will be the core for this research. Figure 1 represents the smart city infrastructure framework with the interaction with all related components either for updating and communicating the smart concept of the city infrastructure.

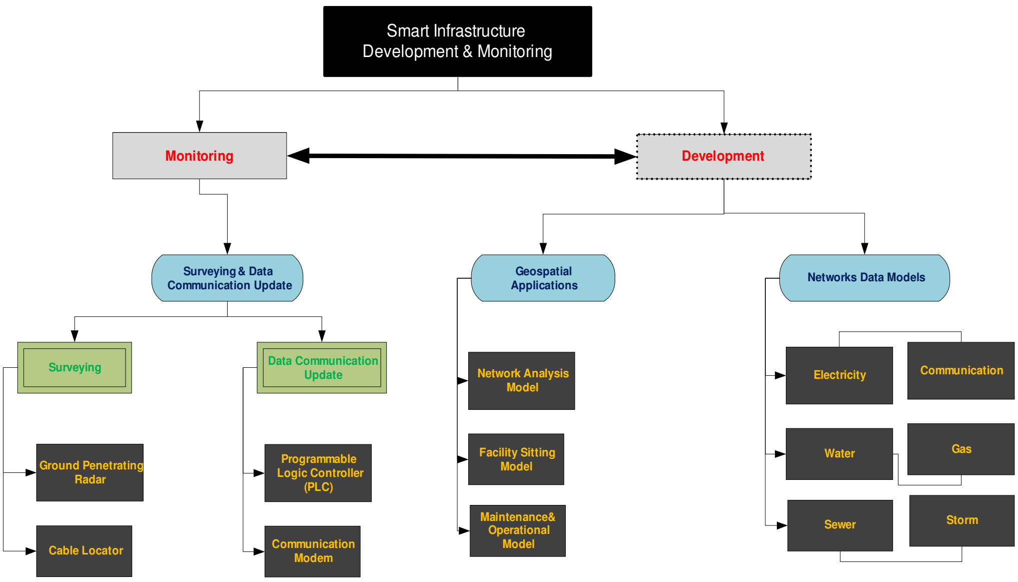

FIGURE 1. SMART CITY INFRASTRUCTURES DEVELOPMENT & MONITORING FRAMEWORK

The research is an Enterprise GIS utility Solution that is based on utilizing the latest state of the art GIS technology, ensuring efficiency, scalability, sustainability and integrity in a way that provides an efficient interface for information retrieval and analysis. The research would shrinkage utmost any discrepancies, duplications and no homogeneity in the existing and future systems.

3. Data modeling & Buildig up an accuract infrastrucutre geo databases

Wikipedia, (2009) narrate the history of the Geodata which it extracted from the Geoinformation that is an abbreviation of geographic information. Geographic information is created by manipulating geographic (or spatial) data (generally known by the abbreviation Geodata) in a computerized system. Systems can include computers and networks, standards and protocols for data use and exchange between users within a range of different applications. Figure 2 represents the data modeling and the process of building up the infrastructure Geodatabase. Typical applications are land registration, hydrology, cadastral, land evaluation, planning or environmental observation. Geodata comes in many different forms, such as maps or images taken from the air or from space, i.e., remote sensing data. Geodata may be stored in a database, which may possibly have special extensions for storing, handling, and manipulating spatial data. The environment in which a GIS operates (machines, people, networks) is called a "spatial information system", and is designed and created to respond to the strategic spatial information needs of people or organizations.

As for the city infrastructure Geodata or Geodatabase, there are two ways of building up it in a suitable way in order to meet the required GIS standards and levels of accuracy. The first way is to use the Geophysical surveying technologies; this procedure will take place if the reliability of the data is very poor due to the non standardization of the generated as-built drawings, or due to the non network completeness and oldness. The non standardization obvious in the positional accuracy of the as-built features components rather that the detailed information that need be included in order to reflect the physical status of the network. The Geophysical surveying is the costly and timely consuming way which requires sophisticated equipments and specialized man power to run out the surveying and interpretation activities after words.

The second way is to standardize the data updating of all possible modifications may implemented on the city infrastructure networks, such as maintaining, upgrading, excavation, relaying and replacement. This procedure is subjected to the level of accuracy of the existing city infrastructure networks (table 1). If the positional accuracy is at certain level accepted then the standardization of the data submittals is essential and effective.

The positional accuracy of all city utility/infrastructure assets is the base essential component of reflecting the city infrastructure features into the GIS environment. All available attributes with all associated information's/documents and photos are need to be attached as well. The database management is extremely important in this kind of applications due to the huge size of databases that might be tackled in one process. The high level of professionalism is required while designing the domains, sub domains and feature ranges during developing the city infrastructure data models and accordingly building up the master Geodatabase in order to reduce the size of the Geodatabase.

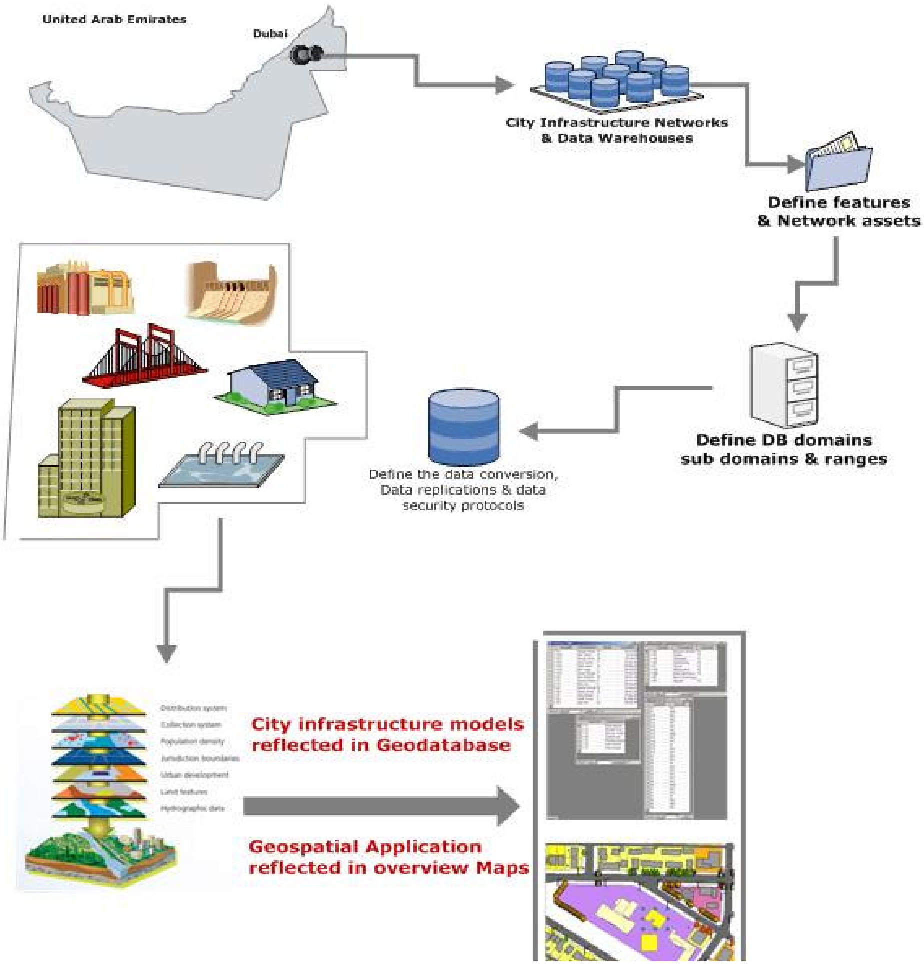

FIGURE 2. DATA MODELING AND BUILDING GEODATABASE ARCHITECTURE

TABLE 1 SURVEYING ACCURACY SPECIFICATIONS STANDARD

Network Component	Surveying tolerance (Absolute/Relative)
Major network structures i.e. primary substations, distribution substations, pumping stations, etc…	+/-50 cm
Overhead poles, chambers, manholes and network devices such as hydrants, valves	+/-20 cm
Network horizontal positioning (Transmission and distribution) – See note below	+/-10 cm
Network vertical positioning (Transmission and distribution) – See note below	+/-10 cm or +/-10% of the depth whichever is higher

As a result of ever increasing demands on the city infrastructure, the city networks are continuously changing with time. This poses an additional challenge for the concerned authorities, which has to track all the changes (in a timely and accurate manner) and upload them in the final GIS platform. Therefore, in order to synchronize the networks changes and keep the digital Geodatabase always updated and current, the need to implement a procedure to standardize the as-built drawing submittal from local contractors, and to make them in a format compatible with the enterprise GIS Geodatabase.

Another aim of this research is to formulate a procedure with standardized data formats, accuracy specifications, and templates that can be implemented by the authorized establishments. As a means to manage the as-built drawings data, generated and submitted by the local city infrastructure contractors. These data reflect the changes to the city infrastructure networks that take place throughout the country or project area, on daily basis.

4. Infrastrucutre As-Built data update wrokflow

The city infrastructure Geodatabase can be created by standardizing the data submittal of the city infrastructure database, see the figure 3 for more clarity.

The workflow manages the existing city infrastructure networks, and keeps all the data both the exiting and the new modifications in the same level of completeness, positional accuracy, confidence and data format. The workflow starts when initiates a new request for a service (e.g. maintenance, upgrade, excavation, relaying, replacement, modification, etc.). The Scope of Work (SOW) for the proposed service/construction including the GIS data specifications will be defined. The base maps in digital format which includes GIS data layers of all available databases and existing city infrastructure networks will be provided. Then prepare the design drawings for the proposed project with all estimations of the Bill of Quantities for budgeting purpose.

Following to that, tender document includes SOW, base map and design drawings (as part of the supplied information) will be released. After short listing the qualified bidders, the project will be awarded to successful bidder(s).

The utilities infrastructure geo-database has to be updated in the same format (and with the same accuracy specifications), in order to maintain the reliability and consistency of the network data, and to maximize the return on investment. Without a standardized the enterprise GIS-compatible updating procedure, the continuous changes taking place in the network will result accumulated backlogs of “incompatible” and inconsistent data (in the form of As-built drawings) structure.

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This in-turn necessitates repeated geophysical surveys, which will be both expensive, time consuming, and difficult to manage. The most cost effective way to do the updates will be to ask each contractor to collect the positional coordinates and attribute data of the exposed utilities (after service completion) while the trench is still open. This way only "land/surface surveying" will be required, as opposed to "buried" utilities which require the more expensive and time consuming geophysical survey (by underground detection and tracing techniques).

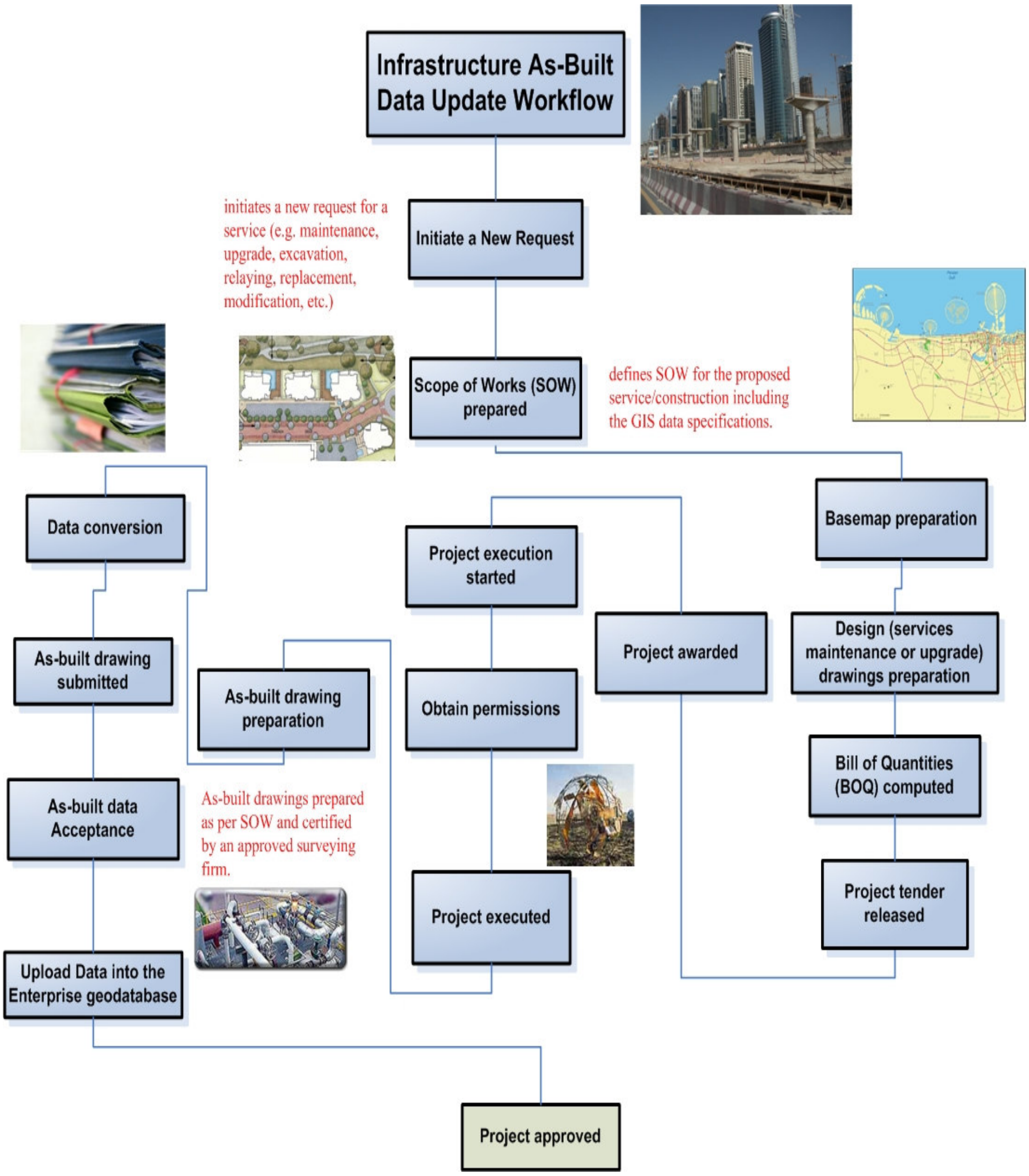

FIGURE 3. CITY INFRASTRUCTURES MONITORING AS-BUILT DATA UPDATE WORKFLOW

Obviously, still some additional direct cost involved, particularly for:

- Surveying of the utilities coordinates (by a certified surveying firm) to meet the accuracy specifications required,
- Converting the collected coordinates and the attributes into a GIS format compatible with that of the enterprise GIS. This will have to be done by a GIS service provider who is very familiar with GIS, and particularly with ESRI geo-database. However, the benefits gained in this case far exceed the cost, which is any case will be much less when compared to the option of repeated geo-physical surveys.

5. System advantages

The main advantage of implementing such a system is obviously reflected in the amount of energy saving and accordingly the reduction in the both operational and capital cost. The smart systems not only developed to reduce the cost but also designed to facilitate the maintenance and physical activities adopted in the municipal service. At level of investment, this system would obviously enhance the return of investment at a shortage period of time. On the other hand the smart environment used to attract the users by giving them more control and property resources management.

The comfortable built environment would increase the building facility availability where it would enhance the productivity for all parties. The smart systems would deploy a better skilled people and it will increase the knowhow of the users. In terms of data exchange, the data communication will be transferred faster due to the systems integration and common communication protocols used along the city/community and premises programmable controllers. The proper controlling and monitoring environment would provide an automation level which would require less tenant's interaction with maintenance and operation call center which means less complaints.

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