Visualisation
technical

GIS and new mapping for the City of Johannesburg

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The City of Johannesburg (CoJ) covers an area of 1644 km², has more than 600 000 stands and one-million households, of which some 33% are estimated to be housed in informal settlements or in backyard shacks. More than 65% of the City’s residents live in Soweto. 19.7% of the population of South Africa resides in Gauteng and almost 40% of South Africa’s gross domestic product (GDP) is produced there. In area it is the smallest of the metros but has the largest population.

Corporate GIS

The corporate GIS department (CGIS) provides a centralised GIS service and maintains the core or corporate data for the City of Johannesburg’s internal departments as well as its Utilities, Agencies and Companies (UACs). City Power, Johannesburg Water, Johannesburg Roads Agency, City Parks and Pikitup each run their own GIS departments and are subscribers to the services and data of CGIS. Of the city’s departments, the main users are the planning, valuation and billing departments.

The GIS database resides on a SQL server (RDBMS) with ArcSDE that allows for multi-user access. Data capture and manipulation is executed at GIS workstations using ArcGIS 9.1 software, while ArcIMS serves the data to clients via the intranet and internet.

Spatial information provides the foundation for virtually every local government function. Building corporate spatial databases results in improved decision-making, operational efficiency and reduced duplication. CGIS is committed to ensure the timely provision of relevant, accurate and geographically referenced information to its decision-makers (the City and its customers) and thereby accomplishing the goals and objectives of the City.

Relevant information

The framework for information requirements is provided by the City’s integrated development plan (IDP) as prescribed by the Municipal Systems Act and the associated business plans and departmental scorecards.

The mission of the City of Johannesburg is to become a world-class African city by 2010. Some of the strategic priorities identified are:

- Economic development and job creation
- Public safety
- Service delivery excellence, customer care, “Batho Pele”
- Good governance
- Inner city regeneration
- HIV/AIDS awareness and reduction

Customer surveys are conducted annually to provide direction for data capture and maintenance. The results from the last survey identified cadastre, zoning, roads, land use, addresses, administrative boundaries, proposed townships and proposed roads, aerial photography and land ownership as the top ten data priorities.

Accurate information

Data standards and revised operational processes have been implemented to ensure the flow and sharing of information between internal departments and external institutions. Metadata improves the understanding of the data by decision-makers. A standard code has been agreed upon as a property identifier within the City’s four main systems, namely the GIS, billing, valuations and planning systems. Although the integration of these systems is not a reality yet, an electronic customer database (ECD) has been created that provides one view of properties as reflected in the various internal systems. Data as received from the Deeds Office is continuously added to this database and comparisons are made with the data of the internal systems. By resolving the “mismatches” between the various systems, data accuracy is improved.

Fig. 1: Application architecture.
Quality controls have also been built into CGIS’s cadastral data capture tool.

**Timely information**

The currency of the cadastral data is a major challenge because of the City’s dynamic nature. The rate of change is reflected in the following average monthly statistics:

- 120 subdivisions
- 60 to 70 consolidations
- 15 to 20 new township establishments
- 60 to 70 rezonings.

Surveyor-General plans and diagrams are a pre-requisite for cadastral data capture and the challenge is to obtain these diagrams timeously. Improved business processes between CGIS and the national government’s Department of Land Affairs’ SG Office as well as the City’s Planning department are required.

Service level agreements are in place between CGIS and the UACs for the maintenance of core datasets such as cadastre, proposed townships, zoning, road centrelines and street addresses.

Turnaround times are also in place for GIS projects as well as for the supply of information at the department’s information counter.

**Customer base**

The projects section receives almost 800 customers per annum and the Information Counter, 2500 customers per month, while the fax service has more than 300 registered users and the Internet mapping service has more than 300 subscribers. Electronic systems are in place to log information requests.

CGIS’s customer base comprises of the internal COJ departments and the eleven regions as well as the UACs (Water, Sewer, Roads, Electricity, etc.). External customers range from consultants, developers, property related companies, the public sector and ratepayers to students.

The level of integration of spatial information into daily operations of the COJ is increasing. Ideally the customer base would include all levels in the organisation. Typically an employee at the operational level would locate a stand/property or verify a stand number and street address, at managerial level a development application would be tracked and traced and at the strategic level development trends would be identified.

**Products and services**

CGIS makes spatial information available by capturing, maintaining and packaging property information in various formats. Furthermore, creative ways of packaging data are continually being investigated in order to address the diverse needs of the clients.

**Products include:**

- standard maps (e.g. A0 sized for regions, wards, etc.)
- customised maps (e.g. suburban, wall maps)
- digital data (e.g. dxf/shape files, interactive map products, population atlas, zoning CD)
- property information (e.g. zoning, building-line restrictions, etc.)

**Services include:**

- Internet Mapping Service (IMS)
The implementation of the corporate GIS IMS Map Viewer in January 2004 as part of the City’s e-services website http://eservices.joburg.org.za/joburg/eservices/ (click on IMS Online Maps), was an important step in providing external users access to the City’s spatial information via the internet. Within a short period of time the online mapping service gained popularity and became a popular method of obtaining spatial information and maps, quickly and efficiently. It supports CGIS’s goal of enabling as many users as possible to help themselves.

**Rationale for redevelopment**

Based on the success of the IMS viewer, corporate GIS decided to increase the services and data published. The improvement and simplification of the user interface was another objective for the viewer redevelopment as user feedback indicated a need for a simpler interface in searching for information. The majority of users do not intuitively use maps as a starting point when searching for information, but rather as a result of a search.

The following main objectives were defined for the redevelopment:

- Improve the user friendliness of the interface and make it easier for people without a mapping background (non-GIS users) to find information.
- Enhance the functionality for subscription users, allowing for downloading of data, improved printing, exporting and downloading of maps, etc.
- Adding zoning data and extra functions such as the displaying and printing of zoning maps in monochrome and/or colour.
- Improve the capabilities and tools for management of the services by adding layers and searches.

**Implementation challenges**

A number of options exist for the implementation of an ArcIMS solution and they also vary considerably in terms of the underlying architecture and software development environment.

The previous IMS Web viewer was based on the out-of-the-box HTML viewer with customization of the interface and functionality. The initial intention for the redevelopment was to base it on the same platform with the establishment of database structures for easier data management.

The major features of the HTML viewer can be described as follows:

- It is a collection of HTML and JavaScript code that gets loaded onto the client and handles creation of requests to the ArcIMS server and all processing of the response.
- It has a rich set of functionality, but the code is complicated and difficult to maintain. Any customization requires changes of the code on the client side and leads to complicated maintenance scenarios if used for more than one service.
- It has a significant initial downloading time due to the size of the JavaScript code.
- If sequential requests have to be made to the server, they get generated at the client. This leads to several round trips of information between the client and the server and can lead to significant delays if working in a low bandwidth environment, which is still the case for many users in South Africa.
- A number of data structures have to be maintained on the client, which increases the data to be transferred on each request.

After reviewing the new functional requirements and the structure of the spatial data, it became clear that in some cases one would have up to four sequential request/responses to ArcIMS in order to complete a user search or map query. With the HTML viewer architecture this would lead to unacceptable response times, especially with clients using standard modem connections.

It became obvious that a new architectural solution was required to optimize the processing between the client and the server and to improve user satisfaction. Development of a solution in the Microsoft.NET environment was opted for.

**Architectural solution**

As a standard feature, ArcIMS provides a component called .NET Link, which includes basic connectivity functions to the ArcIMS server. This meant that all major communication functions needed to be developed, which lead to significant development effort. However, it is believed that the result is a much better architectural solution which leads to improved user experience. The application architecture is illustrated in Fig. 1.

Another architectural improvement, is the storage of data management information within a structure on the SQL server. It defines the available services, themes and layers as well as searches, stored procedures and
fields to be displayed. Thus the code dealing with queries is generic and the viewer functionality is driven by the information in the database. The main advantage of this is easier maintenance when adding and changing services, layers and searches.

Searches based on attribute values are done through stored procedures, bypassing the ArcIMS server. This leads to improved search speed by utilization of RDBMS technology.

**New functionality**

The redeveloped website was launched in July 2005 with the addition of a number of new features:

- **Welcome page** – which provides an overview of the mapping site, a four-step guide to get the user started, and contact details of the IMS support team.

- **Thematic searches** – they provide a simplified and user-friendly interface to find information about specific entities such as property, transportation and census queries.

- **Multiple identification** – with the identify tool the user can find information about several features at the same location by clicking on the map.

- **Multiple selections** – the user can select several features from the same layer and easily compare information about them.

- **Measure tool** – client based measure tool allowing for simple and quick measurements of length, perimeter and area.

- **Data export tool** – the user can export data from selected layers in shape files or DXF formats.

- **Metadata** – available by clicking on the layer name in the layer list.

As depicted in Fig. 2, 3 and 4, non-GIS users can access the information quickly and easily by selecting a theme and performing a search. After selecting the relevant record they can access a report (if available) or zoom directly to the map of the selected record. Alternatively once a theme is selected, a user may activate the map by clicking on “show map” in the top right hand corner, and then interact with the map using the spatial toolbar.

**Access**

The website offers two levels of access to data and functionality. The first is the free maps which provide basic functionality and information including stand numbers with basic valuation and zoning. The second is a subscription service that has additional layers such as full resolution aerial photography (0,25 m pixels), detailed zoning (A series, B series and amendment schemes) and proposed townships, as well as customised map making tools, multiple feature selection, area and distance measuring, dxf/shapefile downloads (at an additional cost) and enhanced printing to A4 or A3 print sizes.

The subscription service is available at a cost to the user and is based on a periodic access, i.e. a payment is made for a period of time (monthly or yearly) with unlimited access for that period. Users register as an individual or company, and then login on to the e-services website to access the subscription pages. Payment for the subscription service can be made through the secure online ABSA credit card website or by various offline methods such as internet banking transfers, bank deposits or payment at the CoJ cashier.

**Challenges**

GIS has advanced from a "nice-to-have" to a necessity within the City of Johannesburg, increasing the utilisation and demand for spatial information and services.

The most important challenge facing the GIS department is managing organisational and technological change related to business processes and the integration of municipal legacy systems. Other challenges include managing resources for the capture and maintenance of the increasing number and size of datasets such as street addresses, cadastre, informal settlements and imagery.

By being sensitive to customer requirements and staying informed of world best practices, the City of Johannesburg’s innovative GIS team is committed to finding creative solutions which will pave the way to JHB becoming a world-class African city. The redevelopment of the City’s Internet Mapping Service (IMS) website is proof of this.

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