TOPOCAD - A UNIFIED SYSTEM FOR GEOSPATIAL DATA AND SERVICES

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Abstract

"E-government" is a leading trend in public sector activities in recent years. The Survey of Israel set as a vision to provide all of its services and datasets online. The TopoCad system is the latest software tool developed in order to unify a number of services and databases into one on-line and user friendly system.
The TopoCad system is based on Web 1.0 technology; hence the customer is only a consumer of data. All data and services are accessible for the surveyors and geo-information professional in an easy and comfortable way.
The future lies in Web 2.0 and Web 3.0 technologies through which professionals can upload their own data for quality control and future assimilation with the national database.
A key issue in the development of this complex system was to implement a simple and easy (comfortable) user experience (UX). The user interface employs natural language dialog box in order to understand the user requirements. The system then links spatial data with alpha-numeric data in a flawless manner. The operation of the TopoCad requires no user guide or training. It is intuitive and self-taught.
The system utilizes semantic engines and machine understanding technologies to link records from diverse databases in a meaningful way. Thus, the next generation of TopoCad will include five main modules: users and projects information, coordinates transformations and calculations services, geospatial data quality control, linking governmental systems and databases, smart forms and applications.
The article describes the first stage of the TopoCad system and gives an overview of its future development.

1. Introduction

In the last two decades, we have witnessed the internet revolution as a "disruptive technology" influencing work activity patterns. Many organizations distribute data products, information and services via online web tools. At the same time we have witnessed the proliferation of location-based services (LBS) and their integration with IT systems. LBS utilise geographic information systems and GPS and unify the processes of search and retrieval of spatial data. Thus the standard workflow that deals with people, actions, and time has changed and today it includes the question of the "where?" or the question of place as demonstrated by the logo of Facebook company (Figure 1).

Figure 1: Facebook Places logo

Additional examples for public systems that integrate LBS and information technologies include:

- The American Geo Spatial platform at http://www.geoplatform.gov which is a publically accessible information portal which provides geographic information of US public agencies.
- The Victorian Government in Australia developed an Electronic Conveyance (EC) system for online settlement and lodgement at http://www.ec.land.vic.gov.au/ec/index.html. This project allows real estate transactions on the web.
- The Integrated Land Information Services (INLIS) of Singapore Land Authority (SLA) at http://www.inlis.gov.sg/Layout/HomePage.aspx enables end users to request and view many different types of information from different sources about assets and properties using the Web.

These are just a few examples of the trend of on-line systems that integrate different software tools and database applications with GIS.
The TopoCad project is the flagship project of the government of Israel in the field of geographic information systems. The project was selected in 2010 by the Central IT Committee of the Ministry of Finance as a critical infrastructure project with broad impact on national computing.
The project's goal is to provide an on-line access to all the database applications and computing services of the Survey of Israel. The TopoCad project is realized as auser-friendly software (TopoCad System) which is built in a modular approach that would allow adding further services and database applications from other governmental agencies.
Moreover, the project is a continuation of a set of on-line computing projects as describes in Szancer, Felus and Lavan (2012), and it is a key component of the Israeli Spatial Data Infrastructure as describe in Srebro, Felus and Tal (2010).

1.1. TopoCad System goals

The general goal of TopoCad project is to create a modern web based system for searching and retrieval of geodetic, cadastral and topographic information of the Survey of Israel.
The Survey of Israel (SOI) databases contain a variety of data types including alpha – numeric datasets, vector-spatial databases, raster data, images and aerial photographs, and scanned surveying and cadastral documents. Moreover, some SOI datasets are free of charge while other products and services are provided with varying fees and charges. As a result, the TopoCad system has been developed to consolidated and unify various systems and combine myriad types of information into one shell with a customer-oriented business logic, and simple user interface.

Thus, the four questions (objectives) taken into account during the design and development of the system were:

- Surveying workflow improvement - How can surveyors and land professional improve their response time and working procedures by efficiently using SOI geo-spatial data for design, cadastral setting, constructing and land registration.
- One Stop Shop - How to integrate different services in one system? How can customers get all the information they need from one place without having to know or look in the various Survey of Israel systems or in other Israeli government systems?
- Simple User Interface – How can we design a user experience (UX) that will allow every user to efficiently use complex software without long trainings or extensive use of a user-manual.
- Modular system – How can we build a platform (shell) that will allow for incremental addition of more modules and software tools?

1.2. TopoCad 1st Generation System modules

The TopoCad system combines eight different software modules including:

- The Survey of Israel National Map Archive: an ECM (enterprise content management) system, containing more than a million scanned cadastral documents. This module enables geographically and alpha numeric querying of cadastral documents.
- The National geo-spatial portal: This module is the geographical interface for generating maps and graphical display.
- The National Geodetic Database: This module is used for querying and retrieval of geodetic information (control points, benchmarks, etc.) by using the National geo-spatial portal as a graphical interface.
- The National Cadastral Database: This module contains all the cadastral information about settlements, mutations, and related activities (e.g; land parcels division and unification).
- Data Products Distribution: This module produces user defined vectors and raster GIS products in different formats. The module cuts and produce the products using the National Topographic Database.
- National Aerial photographs archive: This module is used to retrieve historical photographs.
- Professional Information centre: This module is an information portal that contains technical guidelines, professional articles, acts and regulations that pertain to the work of land professionals.
- Metadata Centre : this module contains information about data and geo-spatial layers of different public organizations (governmental offices, municipalities, public companies etc.)

These modules are managed by four administrative systems:

- Login and Authentication: This system employs a smart card for Single Sign On (SSO). The TopoCad System manages users' permissions and enables a unified access to a variety of tools and databases (some require payment).
- Government Payment Server: The national payment server manages user payments with credit cards and other financial transactions.
- "Merkava" : The governmental ERP (Enterprise resource planning) system which is a SAP database system that oversees governmental resources (human resources, budget, bids and contracts, projects, products and services, spending, income, assets etc.). The system has been installed in all the government offices.
- System management unit: This important component performs user management, user's activity monitoring, database updates, catalogue management, products delivery mechanism and activity reporting.

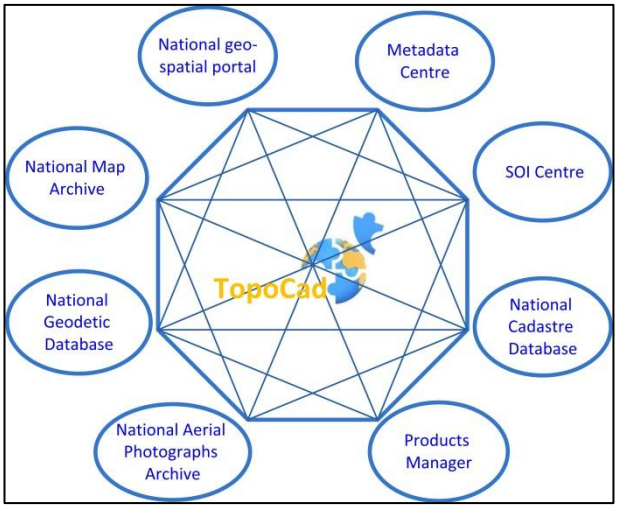

Figure 2: TopoCad modules

2. User Interface Development

2.1. Customer oriented user experience

The main challenge in developing a system that integrates different databases and systems is the design and development of user experience (UX). The user experience should be simple and intuitive but still meet all the functional requirements. The project approach was to place the user in the centre, study the user and his needs. Based on these insights, we came up with the design of the software user-interface.

The user interface creates a mash-up of different tools and datasets using a simple, user-friendly presentation. The interface employs a natural language interface with the ability to understand simple text requests. Moreover, the interface uses geographical (graphic) tools and alpha - numeric functions to define queries for data search and retrieval. Basic principles that guided the design of the interface are:

- Optimal number of options for every query function is 5 (± 2).
- Accessibility rules – The system was designed according to World Wide Web Consortium (W3C) rules for accessibility, including the choice of colours that consider the colour-blind (not using red and green), clear and readable fonts (type san – serif), mouse and keyboard settings for comfortable use.
- Hierarchical structure for data presentation - The structure helps the user in navigating in the system tree and reveals only information relevant to each stage.
- Optimal use of screen space - adaptation of the size and location of each component including the map and the alpha – numeric results table.

2.2. Principles of user experience development

User experience and software interface were developed in three stages as shown in figure 3 and describe below:

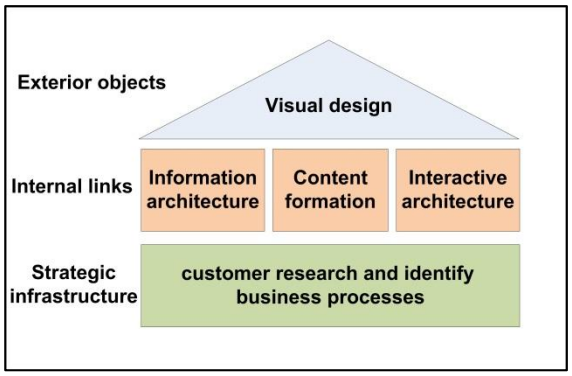

Figure 3: Principles of user experience design

2.2.1. Strategic infrastructure - customer research and business processes identification:

The TopoCad system was designed mainly for professionally users: licensed surveyors, architects, appraisers, lawyers, municipal workers, government employees, etc. Nevertheless, some modules were designed to be used by the public. It was assumed that about 1000 users will be using it per day.
The stage of customer research and business process identification started with a series of interviews with potential system users. About 50 users were interviewed using a standard questionnaire to learn about the main business processes that the system should support.
An analysis of user's response to the questionnaire showed that user's followed a similar workflow and their search and retrieval activities are centered on the use of a map.

2.2.2. Internal links - content, information and interaction between entities:

TopoCad system combines data with diverse characteristics and no apparent linkage. The customer research and business process identification revealed that the most important link between these components is the cadastral block number. The block number is a unique number that identify a specific piece of land.
Thus each search process focused on the cadastral block then it could percolate to the parcel number than to individual documents that pertain to the area.

2.2.3. External objects - design principles:

Following the analysis process, the TopoCad development team drew multiple screen layouts for each step. The design of each screen was based on the following rules:

- Simplicity – functions should perform in an intuitive manner that require minimum steps and minimum number of command buttons.
- Unified approach – all the function where designed in a similar style.
- Optimal use of natural language tools including Soundex and language understanding tools.
- Graphic tools to search on a map.
- Interactive display to switch between alpha - numeric tables and graphic entities.
- Hierarchical display of data, that filters information according to a specified order.
- User's feedback mechanism to identify system and data faults.
- A modern "shopping cart" interface for product selection and

These three steps led to user interface design which is described in the next chapter.

3. TopoCad 1st Generation system – demonstration of major query results

The TopoCad system allows the user a wide range of querying capabilities to obtain topographic, geodetic and cadastral information. Here are some examples and screenshots selected queries:

3.1. Home page screen

The first screen of the TopoCad system was designed as a search bar of Google/ Bing/ Yahoo employing a natural language search bar as the main querying component (see figure 4).
The natural language search bar utilizes an automatic word completion mechanism. This mechanism analyzes the first typed characters and use a dictionary, logical functions, soundax and grammar-oriented engine to detect the remainder of a sentence and the possible input options for example, when typed Block 6345 parcel 7…the search bar display a list of the possible parcel number 71, 72, 73.. in the combo box.
On the same main screen, however, there is also the option to search by quering a graphical user interface.

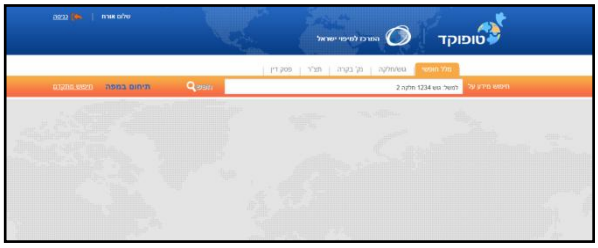

Figure 4: TopoCad system – Homepage screen

3.2. Instant Search Results – search for a information using the cadastral block number

The sentence from the natural language search bar is parsed and converted into a meaningful search command. This command searches for information and data about the Cadastral Block in eight different systems using a Web-Service (WS) interface. The information is then retrieved and instantaneously displayed in one screen as shown in Figure 5.
As can be seen from Figure 5, the map of the selected area is displayed in the center of the page while the side menu presents

preliminary data and information about the Block as was retrieved from the eight systems.

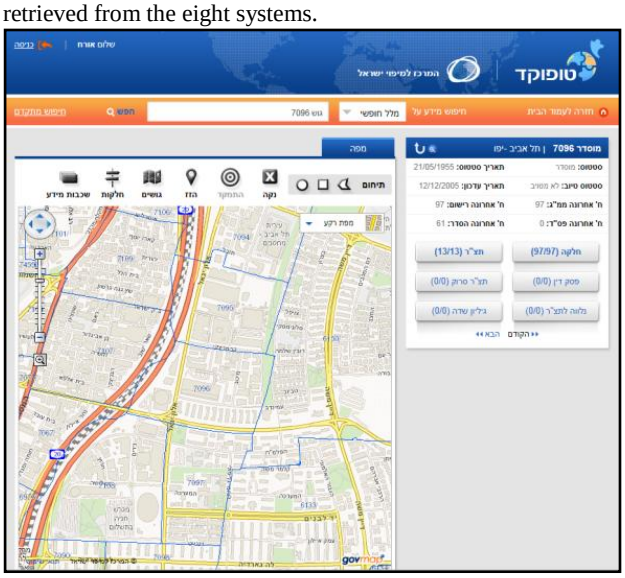

Figure 5: Block search results

3.3. Retrieval of detailed information

Following the display of all the available information about a cadastral block (Figure 5) the user has the ability to select particular item and retrieve more information about this item. For example if the user selects a specific subdivision plan, the system zooms-into the specific plan area (Figures 6) and provides a table of alpha - numeric data about the plan and the relevant process that have let to its creation (e.g. coordinate of each parcel corner) as show in Figure 7.

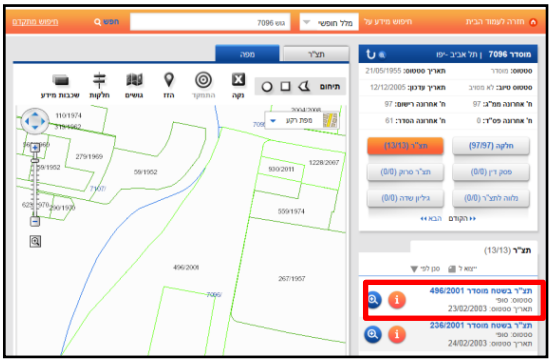

Figure 6: Zooming in to the area of the subdivision plan

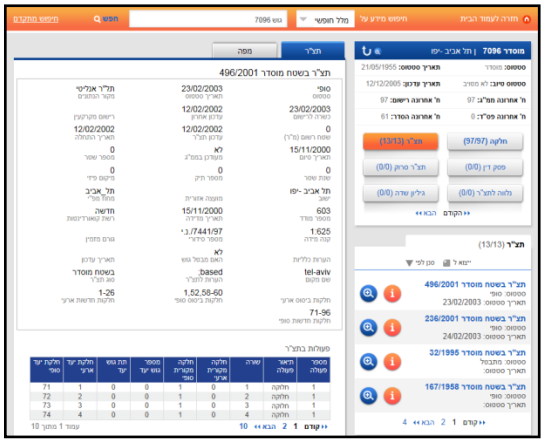

Figure 7: Retrieving alpha-numeric information about the subdivision plan

In addition to the map and the alpha-numeric data the system can present scanned map and document from the National Cadastral Archive as shown in Figure 8.

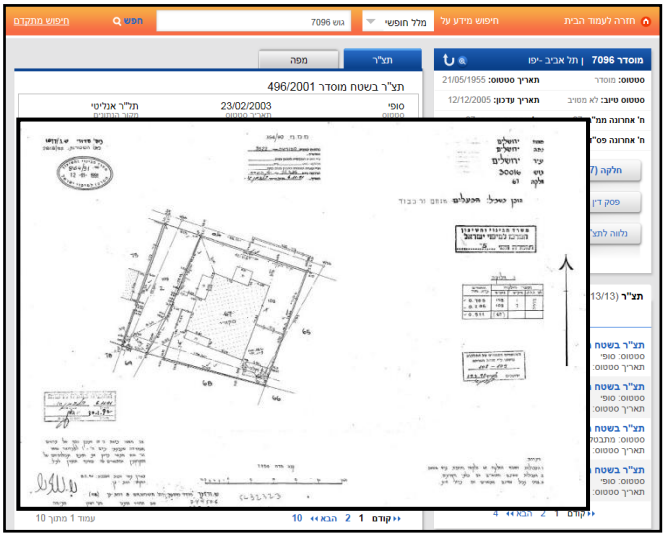

Figure 8: Displaying a scanned document

4. Future development of the TopoCad System

The first generation of the TopoCad system is based on Web 1.0 technology, where the users can only view webpages but not contribute to the content of the webpages.

The second generation of the TopoCad system will be based on Web 2.0 technology, where users (mainly surveyors and land professionals) can interact with the system (or webpage) and upload their own data to the system.

This will allow the government to utilize expert knowledge and data (expert sourcing) and integrate this data into the national databases following an automatic quality control process. Moreover, the second generation of the TopoCad system include Web 3.0 concepts of linking databases and systems via semantic tools.

The design of the TopoCad 2nd generation system was already approved and the future system will contain the following five modules (see also Figure 11):

- Metadata Center - That stores metadata information at ISO19115 format obtained by surveyors mapping experts, government agencies and local authorities.
- Coordinates Transformations module - That provides geodetic calculations services and transforms coordinates from different Israeli networks into geographic and UTM projected coordinates.
- Quality Control module – That contains a set of tools to check and validate digital uploaded cadastral and mapping files. These files should be named and structured in an Israeli standard
- Knowledge Center - This module is an organized library of professional documents to assist the user including: regulations, articles, books and guidelines about surveying and mapping.
- National Database Linking Module - This module connects diverse governmental land management systems and creates one viewport that tracks a land unit (parcel) through all its phases. The following workflow describe some of the governmental offices and systems that deal with a parcel:

- The Ministry of the Interior (Mavat system) defines the parcel in a County Master Plan
- The Survey of Israel (National Cadastral Database) accurately delineates the parcel and approves the cadastral process.
- The Ministry of Justice(Rimon System) register the parcel and its ownership
- The Ministry of Construction and Housing manages parcel construction and development.
- The Municipality, local authority and utility companies provide water, electricity, sewage etc. services
- The Ministry of Finance and the local authority manage taxation and various land fees

This long and complex process is managed by many systems (some are on-line) and requires considerable efforts in creating interoperability and connections between systems and between organizations.

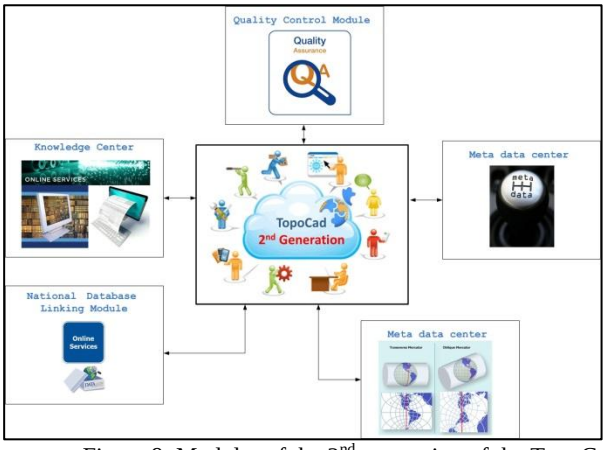

Figure 9: Modules of the 2nd generation of the TopoCad system

5. Summary

The TopoCad project succeeded in connecting multiple systems with diverse data types (alpha - numerical, archive documents, geographic systems, administrative) in a uniformed manner.
The project overcame a number of challenges including

- Technological challenges such as the challenge of disseminating large data files on-line, the difficulty of meeting the Israeli government web security regulations, and the challenge of working with different computer technologies.
- Management challenges concerning coordinating with many Departments and the Survey of Israel operating units. The development of the system required intensive team work of the Cadastre Division people, the Geodesy Division people, The GIS Department, The Accounting Department, The Costumers Support Department, The IT Department, Legal Department and many more.

The TopoCad will continue to develop and automate, expedite and improve many governmental processes. It is hoped that the TopoCad system will become an important and integral part of the surveyor work.

6. References

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