VALIDATION, INTEGRATION AND OPERATION OF GIS DATABASES USING INTERNET/INTRANET TECHNOLOGIES

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Lucrarea reprezintă o soluţie de integrare şi utilizare a datelor GIS, a modelului digital al terenului(DTM) şi a imaginilor aeriene şi satelitare (rectificate – orthoimages) pentru o zonă geografică, utilizind tehnologii avansate de prelucrare a datelor, a comunicaţiilor de date şi a tehnologiilor Internet/Intranet. Aceste sisteme gestionează baze de date grafice (vectoriale) şi descriptive (atribute), precum şi imagini în formate necompresate şi compresate cu algoritmi de compresie pentru formatul optimizat ECW, care asigură performanţe superioare la încărcarea şi utilizarea acestora. În cadrul lucrării sunt propuse soluţii originale de interconectare a subsistemelor componente precum şi pentru mecanismele de control al accesului clienţilor la bazele de date gestionate.

The paper represents a new solution for integration and operation of GIS data, of the digital terrain model (DTM) and the aerial and satellite images (rectified - orthoimages) for a geographical area, by using advanced technologies for data processing, data communications, and Internet/Intranet technologies. These systems operate graphical (vector) and descriptive (attributes) data bases, as well as images on uncompressed and compressed support with embossing algorithm for the ECW optimized pattern, ensuring high performance when loading and using them. The paper proposes original solutions for the interconnection of the component subsystems and also for the control mechanisms of clients' access to the data bases administrated.

Keywords: GIS, orthoimage, digital terrain model, vector data, image webserver

1. Introduction

To use the data resulting from a GIS production technological process, it is necessary to have them validated and registered with the Client-Server Data Base, to enable a concurrent access. In GIS systems, there are being used mainly data representing aerial and satellite images, vector 2D and 3D digital maps and sketches, as well as the digital terrain model which graphically represents, by

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different mathematical models such as TIN or GRID, the survey image of the land. GIS systems have a very important role in ensuring a support so that to take technical or administrative decisions. Consequently, these decision supporting systems use the four types of main data enumerated above. The data types enumerated above are particularly accompanied by descriptive attributes, specific to the mapping elements displayed and filed in the Data Bases [1].

2. Integration of the data in GIS WebServer and Orthoimages

2.1 Loading of Orthoimages in the Filing System of ImageWebServer

To load the images in the filing system of IWS, ER Mapper 7.0 software application will be used, enabling image processing (TILES) resulting from the photogrammetric process for orthoimage outcome, as described in works as [2] and [3]. The primary processing and loading of aerial and satellite orthoimages will be performed for a geographical area whose geographical limits are acknowledged and materialized through a polygon (vector form) attached to the data input structure.

The phases of this process of data loading [4] are carried on sequentially and arranged as following (Fig.1):

- Defining the metadata structure for the primary data;
- Defining the coordinates' systems;
  - Attaching the working geographical area (geographical limit polygon);
  - Defining the types of screen input folders (TIFF, JPEG, GIF, PNG, etc.);
  - Defining the types of screen output folders (ECW, JPEG2000);
- Image embossing (ECW);
- Processing of the images resulted (their filtering and equalizing);
- Making up of the matrix with the images resulted from processing;
- Cutting up of the matrix according to the geographical area limits;
- Transfer of the matrix folder in ECW or JPEG2000 format to the storage system of IWS.

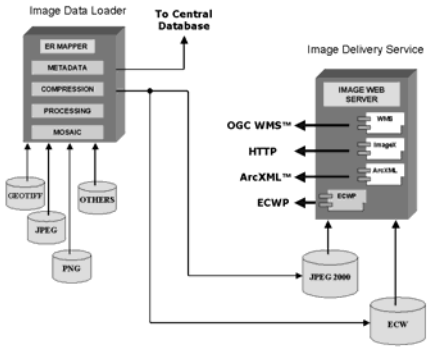

Fig. 1 The basic scheme for image integration and delivery process of data in the Image DataBase

2.2 Loading of the Digital Terrain Model (DTM) into the Storing System of ImageWebServer

Fig.2 presents the basic scheme for DTM validation and integration process in the GeoDataBase.

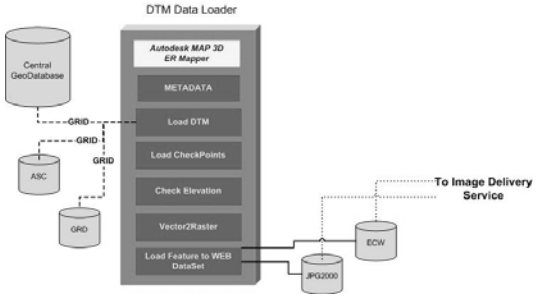

Fig. 2 The basic scheme for DTM validation and integration process

The DTM model is the result of the photogrammetric processing, aerial photograms and satellite images and represents a 3D regulated altitude network (GRID), approximating the survey surface of the land. Every point characterizing the model has metrical coordinates X, Y, Z and reported to a unitary coordinates' system specific to the geographical area under study. Mainly, to approximate the land format according to different mapping displaying scales there are used equidistance comprised between:

$$100\ m > dx > 1.0\ m \text{ and } 100\ m > dy > 1.0\ m$$

The process of loading of the digital terrain model is carried on for a geographical area whose geographical limits are acknowledged and materialized through a polygon (vector form) attached to the data input structure [1].

The phases of this process of data loading are carried on sequentially and arranged as following:

- Defining the metadata structure for the primary data
- Defining the coordinates' systems;
  - Attaching the working geographical area (polygon of the geographical limit);
  - Defining the types of DTM input folders (asc, grd, etc.);
  - Loading of DTM folder;
  - Loading of control points (geodesic points/GPS points);
  - Validating of DTM by establishing the differences of altitudes between the points of DTM network and the control points;
  - Establishing the quadratic average error and the differences resulted;

$$dz = Zdtm - Zpcont$$

$$Emp = \sqrt{\frac{\sum_{i=1}^{n} dZ}{(n-1)}}$$

where: *Zdtm* represents the value of the altitude *(Z)* and load centre of the "eye" of a network where the geodesic point is disposed planimetrically *(X, Y)* and *Zpcont* represents the geodesic control points or GPS.

$$Zdtm = \frac{\sum_{i=1}^{n} Z^2}{(n-1)}$$

  - The converting of the digital terrain model from vector format into ECW compressed screen format [4], with the attributes corresponding to altitude.
  - The transfer of the DTM compressed folder into ECW or JPEG2000 format to the storing system of IWS.

2.3. Loading of GIS Data in Vector Format in the Storing System of GISWebServer

Fig.3 presents the basic scheme for vector data integration and delivery process using the GISWebServer solution.

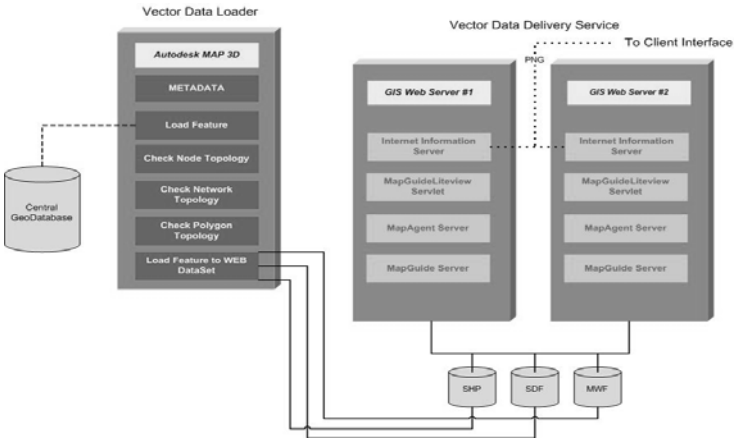

Fig. 3 Scheme for vector data integration and delivery process

In order to be used by GISWebServer system, GIS information has to be stored in adequate formats used by this system [4]. The process of loading GIS data in vector format is carried on for a geographical area whose geographical limits are acknowledged and materialized through a polygon (vector form) attached to the data input structure. This geographical area is identical with the one used to load Orthoimages and digital terrain model [5]. The phases of this process of data loading (Fig. 3) are carried on sequentially and arranged as following:

- Defining the metadata structure for the primary data;
- Loading of the characteristic elements (features) according to the symbols defined in *GeoDataBase* central data base;
- Loading of the topologies (node, network, polygon) corresponding to the features loaded;
- Verifying of the topologies (node, network, polygon) loaded and of the conditions of the interlinking with the descriptive attributes in the data bases;
- The converting and saving of the data (features) loaded into folders with specific working formats of the WEB Server AutodeskMap (SHP, SDF, MWF, etc.);
- The transfer of the folders resulted, into the folder system for storing of data for GISWebServer.

3. Architecture of the system for access to GIS Data Bases and Orthoimages

The system for access to GIS data bases and Orthoimages is oriented on a

client-server architecture (Fig. 4). The server system consists of two subsystems [6], one for the administration of screen format data representing the aerial or satellite images of the geographical area under study, the other, for the administration of graphical (vector) and descriptive (attribute) data for the same geographical area (Fig. 5).

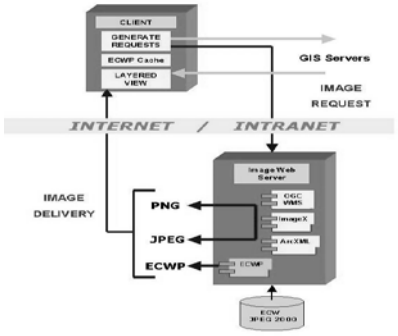

Fig. 4 Scheme for the Client Server architecture of the Image WebServer subsystem

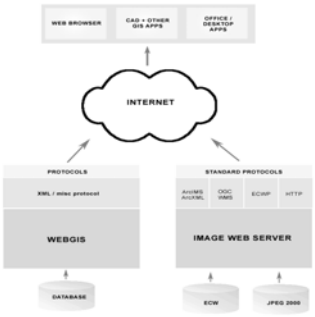

Fig. 5 Scheme for the Client Server architecture for both subsystems GIS and Image WebServer

3.1 Image Server Subsystem

This subsystem is implemented on a ERMapper owner solution – ImageWebServer 7.0 and disposes of connectors for the logical interfacing with GIS data base server.These connectors correspond to the interfacing with different types of GIS data base [6] servers developed for well-known designing entities (Autodesk MapGuide, ESRI, Intergraph, etc).In the solution presented, this server is used to distribute high resolution images (TB type), by means of client/server mechanisms, and by using special interlinking protocols between the order processes/data delivery and basic services, for Internet/Intranet data communications. These protocols make up a specific "stack", adequately implemented into the software architecture of the image server rolling on a MS Windows platform.

3.2 GISWebServer Subsystem

As mentioned above, regarding the solution suggested by this paper, there have been used a GIS data base server, MapGuide 6.5 and a MapGuideLiteView operating the conversion from vector format to PNG format of the data in the GIS data bases, and which will be delivered upon the request of Client application. This process is carried on by means of OGC-WMS protocol implemented at the

level of GIS server [5]. To ensure a concurrent access and optimal feedback (reduced feedback time) upon the clients' request, GIS servers' subsystems was physically implemented through two servers which are accessed by means of a *"Load Balancing"* mechanism. This mechanism ensures a high parallelism of concurrent process execution of order and delivery of GIS data to the image server, and to Client application (Fig. 6).

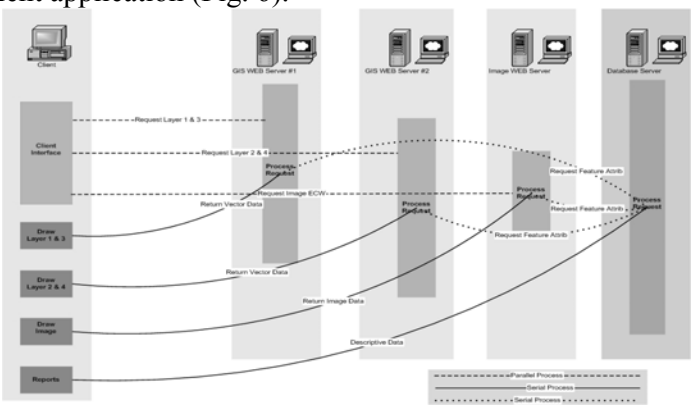

Fig. 6 The diagramme of the simultaneous request model

To ensure a balanced access to the resources of the image subsystems and GIS data bases, "Load Balancing" solutions were used to design the system:

- At the level of network, by means of the adequate configuration of the data communications equipment belonging to access LAN/WAN networks.
- At the level of ImageWebServer and GISWebServer application serve, where, according to the data structure, there were distributed for storage, graphical and descriptive data bases, with equal sizes and almost identical complexities regarding both the graphical elements and their attributes.
- At Client level, by distributing server enquiries, according to the layer structure consisting of mapping elements and their attributes stored in their own storage systems.

Physically, there have been used servers oriented according to Dual Processor architectures with IntelXeon technology – 3.06GHz, with own storage systems of data implemented according to SCSI Ultra 320 technology with HDD interlinked to RAID 5, to ensure the integrity of the data, in case of faults. In order to carry on the interconnection to the local computer network, there have been used Dual network cards on FO fiber optic support, enabling a communication channel of 2x1Gb/sec.The applications used to develop this server subsystem rolls on Windows 2003Server Enterprise Edition platform. These protocols used for the

communication between the processes working in parallel and distributed in the Image and GIS servers are adequately described in the following paragraphs.

3.3 Protocols used for the access and distribution of GIS data and Orthoimages ECW Protocol (Enhanced Compression Wavelet Protocol)

This protocol was developed in order to enhance the operation of high resolution images. Thus, it consists of mechanisms implemented for advanced technologies of "Streaming Imagery" with local cache and real time mechanisms for PAN and ZOOM functions. From a logical point of view, in the protocol stack, this protocol is overlapped on the HTTP protocol and operates as providing to the client, upon his request, of images (or different parts of an image), stored in a compressed ECW type folder [7]. Due to "Streaming Imagery' technology used to implement the protocol, the client benefits from a quick feed back upon the request, and a reduced traffic on the computer networks representing the physical and logical support of bidirectional transport of data from the server to the client. As it has optimal efficiency, both at the level of application, and at the level of data transport in the networks, this protocol is used in the big systems, where there are processed the big folders of images and those having concurrent access to these for a large number of users.

Let mention also that Open GIS Consortium (OGC) developed a standard for the Client/Server interaction in the applications in GIS field [5], regarding the distribution of geospatial data and information, known as Web Map Service (WMS).According to this open standard, a protocol of software interface specifications was implemented for a wide range of WebGIS solutions. ER Mapper-ImageWebServer (IWS) ensures WMS support for the processing of images stored in ECW format, (request such as *GetCapabilities* and *GetMap*) according to 1.1.1. version of WMS implementation. These new features of IWS ensure facilities of combined use of compressed images in ECW format and GIS data distributed, and compatible with WEB OGC services.

4. Access control and users' authentication within GIS and Orthoimage Data Base Systems

4.1. Control of access at the level of image server

The control of users' access to the images stored will be carried on by means of a security mechanism implemented in IWS [8], and restricting the access depending on:

- Client's IP address;
- Pair of name_user/password;
- Geographical area requested to be visualized;

- Resolution of requested image.

The security system accesses a data base especially designed in the data base server of the system, where there is defined and implemented a relational structure with stored data regarding the system's users, belonging to groups of users and the corresponding access rights to each ECW folder or groups of ECW folders stored in the subdirectories. Every user has the following attributes defined: *username, password, a token* generated every time the user is accessing the system.We should mention the fact that every user defined in the data base may belong to one or several user groups.The *Image* table includes a list of ECW images or directories with ECW images, from the storage system of images for IWS, which he may access. The difference between the access to one image folder or to a directory including several images results by means of the *IsDir* boolean attribute.The report between the user groups and the images they may access results based on the *Group-Images* table, which specifies the method for access to a certain image (*ECW, ECWImage*) and the scale for the image to be visualized. *AREA* table is used to store the values of the preestablished visualization resolutions of a part of an ECW image.These processes for the control of access to IWS are administrated by an application (ASP) (*AutServ.asp*) which receives a XML request from the IWS server, carries on an enquiry of the data base and provides a feedback corresponding to the user and the images requested [9].

4.2 Control of Access to GIS Server (GISWebServer)

To increase the security and control level of GIS data bases for the users authorized to carry on enquiry processes (extracting of the data) or enquiry and amendment and updating (amendment of the data) two mechanisms of control and authentication were used additionally:

- The security mechanism implemented at the level of Windows 2003 Server system of which user groups were established for the processes mentioned, with rights for writing, reading, amending, over the folder structures, system folders specific to GIS server;
- The internal security mechanism implemented at the level of GIS server – Autodesk Map Guide Server [10]; at this level, three working groups are defined as:
  - system administrators of GIS server;
  - data administrators (Map Author in charge with defining; data structures and patterns, and design geographical data bases);
  - Internet/Intranet users.

In order to implement the security and control structures for access at the level of GIS server, two authentication mechanisms are used with the resources of GIS data base:

- The use of the access keys to ensure the transaction security;
  - depending on the time (or period);
  - depending on the graphical information corresponding to the user;
- The use of the combination users-group/password to ensure the security for each working session (session-best security) for independent and active geographical areas (maps).

The mechanism of authentication by means of the access keys (Access Keys) are defined as passwords which the map designer (Map Author User) specifies when defining a layer of the map. Every time when the layer of the map is accessed by client application, a request of data is carried on to GIS server, while prior to distributing the data as feedback to such request, there will be verified and compared the validity of the access key in the request with the list of access keys stored and administrated in the server, by means of the security internal mechanism. It is worth mentioning that the validity of these access keys may be done for a period of time set up by the server system administrator.

5. User Interface for the access from Internet/Intranet to the Image GIS Server Systems

The Client application for access to GIS data bases and the images corresponding to the respective geographical area was implemented on WEB technology, by using HTML pages with ASP applications comprising functions defined and implemented by means of JAVA Script language and programming libraries provided to the developers by the designers of ImageWebServer and MapGuideServer solutions [10]. The basic scheme of this Client Application is shown in Fig.7.

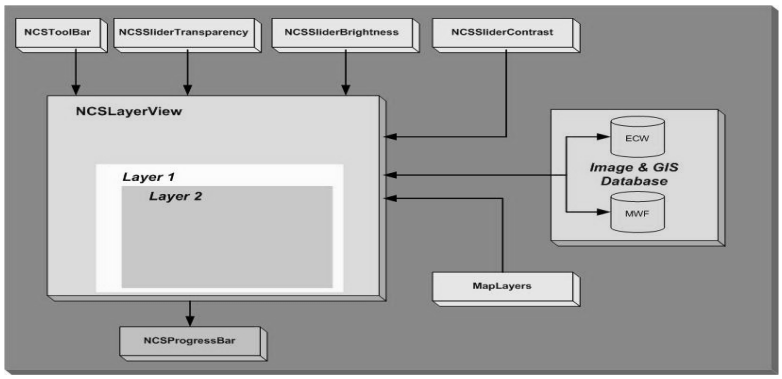

Fig. 7 The basic scheme of the Client Application

According to the internal mechanisms for execution and interlinking of Client-Side and Server-Side processes, implemented in the two dedicated Image and GIS servers, when developing the application there was taken into account an important feature of both solutions, i.e. the creation of a "distributed" and "balanced" processing between the Server and Client, of GIS images and data. The two types of dedicated servers leads to an important part of real time processing of GIS images and data to be carried on Client machine (Client-Side) by an active ActiveX or AppletJava "PLUG-IN". This "PLUG-IN" is automatically installed when accessing for the first time the WEB page, resident on the application servers. This Plug-In consists of logical interfacing mechanisms, with their functions accurately developed in JAVA and defined in the dedicated WEB pages. In Fig. 8 there are materialized the main parts of Client application integrated in the WEB page of the application, and described below.

NCS Layer View Part – enables compressed images in ECW format to be loaded from the storage system of Image Web Server and displayed on the client's interface, from a data source selected by means of an URL address, with the following format:

ecwp://srvimage/orthoimage/xxxx.ecw

The functions of this part in the application are the following:

- Loading and display from a specified data source, of the compressed image in ECW format [11].
- It enables several images to be opened in the same plug-in.
- It enables the organizing of the data displayed on layers. The layers have two types:
  - *ECW layer* for the display of the compressed images;
  - *GIS layer* (GIS Overlay) for the displaying of GIS information type: *point, line, polygon, accompanied by attributes text type generated by GIS data bases;*
- It disposes of implemented "roaming" and "zooming" type mechanisms which allow the modification in real time of the image visualized.
- An important feature is that "multiple" viewers may be integrated in the same web page, and differentiated depending on the name corresponding to every view.

This part generates events which are attended by Java functions, especially implemented in the program.

6. Conclusions

The paper offers technological solutions for defining and implementing systems dedicated for:

- data validation-integration in a GIS Data Base (Geodatabase);
- data processing, by means of Internet-Intranet technologies.

The concepts carried out in our study regarding data validation, integration and processing have been used in practice on different projects with real cases which helped to develop new working methodologies. The main contributions are the design of the software architectures that allow to integrate both GIS and Image WebServer subsystems, in order to valorize the facilities offered by standard software products like GIS data base server, Autodesk MapGuide 6.5 and MapGuideLiteView, the implementation of the OGC-WMS protocol at the level of GIS server and the particular data processing solutions that ensure mapping information and the user's access rights. In addition, the Client Application solution presented may be corroborated with different GPS positioning systems, which may provide the users with real time integrated solutions, for traffic monitoring, fleet controlling, and other applications. The use of Mobile GIS technology is based on a mobile data communication infrastructure (GPRS, UMTS, CDMA2000), and may access these resources in real time, for different users whose applications require a proper mapping support, together with descriptive information (attributes) corresponding to the application.

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