Conceptual Solution for Mobile Applications Using Virtual Globe Software

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Geospatial software and applications has a huge potential applicability in the fields of agriculture science, natural resource management and spatial planning. Main features of geospatial software and applications are based on several concepts as: coordinate systems, map projection, data types and geodatabases. We analyze software criteria for digital globe selection, based on six categories, with adequate detailed criteria, and we choose several solutions for virtual globe products, in order to select proper software for mobile application. In the present paper the authors propose a conceptual solution for integrate MultiMap UK Microsoft in a mobile application, based on Caramba solution adapted to the objective of MC Locator. This solution was implemented in MC Locator mobile application, which aim is monitoring and management of the auto fleet activities through the use of location and communication equipment based on GPS and GPRS.
***Keywords**: virtual globe products, geospatial concepts, mobile application space, multilayer application.*

1 Introduction

According to Riedl (2007) virtual hyperglobes or virtual globes, or digital globes, and earth browsers are scale-bound structured models of planets from virtual space in their undistorted three-dimensional wholeness. Virtual globes incorporate features and functionality that provide significant advantage over traditional spatial data mapping interfaces, by allowing the visualisation of digital images on a three dimensional virtual globe structure. These advantage can be bound in three major features: the earth imagery displayed on a globe structure is free of distortion, data displayed in virtual globes can be viewed at any scale and from any angle, a large degree of interactivity, allowing the user to move to different locations and visualise different type of spatial data (Riedl 2007). Former US Vice President Gore's concept of a Digital Earth is: 'a multi-resolution, three-dimensional representation of the planet, into which we can embed vast quantities of geo-referenced data' (Gore 1998).

After software companies decided to offer freely downloadable virtual globes, which providing access to online imagery repositories, public interest was increased and all the people understand the role and huge importance of geographical information sciences. In Buttler opinion the ease of use of virtual globes and their capacity to display spatial information offers a strong potential to communicate spatial data and it is believed that virtual globes could lead to a democratisation of GIS technology (Butler 2006). Virtual globes offer an proper tool for publishing spatial information, by underlying high quality satellite and aerial imagery, aiding the teaching of earth sciences and communications, offer a huge accessibility to decision makers based on virtual data and landscape models, increase the opportunities for research community and the public (Lisle 2006).

In a simple approach geographic information system (GIS) is computer-based data storage and analysis tool that combines previously unrelated information into a comprehensive picture (Rapport, 1999). "Location intelligence uses geographic information system

(GIS) tools and techniques to transform and analyze data that becomes valuable information to make more informed and rational business decisions. Thus, location intelligence is neither simply an analytic technique nor business process; but a discipline that encompasses both." (Steiner, 2008).

GIS can be applied to: crime reduction, public safety enhancement, sitting new schools, redistricting, floodplain mapping, growth management, disaster recovery, tax mapping, economic development, school bus routing, fire station location, land conservation, environmental impact studies, water & sewer expansion, superfund cleanup (Wiki). Graphic presentations and direct access of some types of GIS offers opportunity and power to understand complex relationships, to plan for the future or tomorrow, based on an accurate picture of today, to present data in a clear, compelling way, to make informed decisions and to save time, money and even lives (Encyclopedia of GIS).

A several data accessibility solutions that can be implemented for many types of GIS data, which require that the data is presented in an alternative, text-based format as well as graphically for accessing and displaying the information depending on the nature of the information being offered (Dimitriu, 2005). Simple data might be presented as a table or series of tables in addition to the map presentation but complex data might have to be sumarised, and key elements of the data presented in tabular form (Shankland, 2008).

Now day a huge application offers powerful interactive mapping while hiding the complexity of spatial data queries and the cartographic rendering process from application developers (Butler, 2006). Users and developers can customize the appearance and behavior of the map; they can control visual map characteristics – such as the background color, the title, the symbiology used to portray features such as roads, store locations and property boundaries, and so on using extensible metadata stored in database tables, incorporate dynamically obtained geospatial data, customer locations, and plot these on top of a base map (Steiner, 2008).

Our paper focused on digital globe technologies and these features and facilities for mobile applications. After an introduction in virtual hyperglobes and geographic information system (GIS) tools, we focused on features of geospatioal software. In next section we will present software criteria for digital globe selection, based on six categories, with adequate detailed criteria, focused on hardware requirements, type and quality of data provided, capacity to import and data manipulation, sharing grade of data, degree of openness and customization potential, overall performance and stability. In next section we use SWAP analyze for a case study approach of six major digital globes: Google Earth, NASA World Wind, ESRI ArcGIS Explorer, Skyline Globe and Dapple Earth Explorer and MultiMap UK. We show the strength and weaknesses of them and evaluate their potential applicability in the fields of mobile application in monitoring and management application of the auto fleet activities. In next section we develop a functional model using MultiMap UK as a digital globe, embedded in distributed application. This model is focused on middleware layers and remote communication

2. Features of geospatial software

Main features of geospatial software and applications are based on several concepts as: coordinate systems, map projection, data types and geodatabases. *Coordinate systems* is a fixed reference framework superimposed onto the surface of an area to designate the position of a point within it. Common coordinate systems are *geographic* (three-dimensional), in which locations are measured in degrees of latitude and longitude, and planar (or Cartesian), in which the earth's surface is projected onto a two-dimensional plane and locations are measured in meters or feet. For representing and access data we need *projections* - a method of representing the earth's three-dimensional surface as a flat two-dimensional surface. There are many different map projections, all of them distort shape, area, distance or direction (ESRI, 2003). For instance the Mercator projection

maintains shape and direction, the Sinusoidal and Peters projections both maintain area, but look quite different from each other and the Robinson projection does not enforce any specific properties but is widely used because it makes the earth's surface and its features "look right."

Data management uses different data types: *tabular databases*, join with vector file by common attribute, mapped as points using coordinate points such as latitude and longitude gathered from a GPS Geocode for associate address field with street file, *vector* (points, lines, polygons), *raster* - a model of the world as a surface that is divided into a regular grid of cells, arranged into rows and columns, in which all cells must be the same size, *images* (aerial photographs), *grids* (derived data representing continuous values such as an elevation surface or categories such as vegetation types).

As an XML-based language schema, *Keyhole Markup Language (KML)* is used for expressing geographic annotation and visualization on existing or future Web-based, two-dimensional maps and three-dimensional Earth browsers. Born history started with Keyhole[1], Inc, and Google acquired Keyhole in 2004, and use KML with Google Earth, with originally name Keyhole Earth Viewer. KML geodetic reference system uses 3D geographic coordinates: longitude, latitude and altitude, horizontal coordinates given according with definition by the World Geodetic System of 1984 (WGS84). The vertical component (altitude) is measured from the WGS84 EGM96 Geoid vertical datum. If altitude is omitted from a coordinate string, then the default value of 0 (sea level) is assumed for the altitude component. Open Geospatial Consortium OGC KML 2.2 Specification has given a formal definition of the coordinate reference system (encoded as GML -Geo) used by KML. This definition references well known EPSG CRS components as an open standard for all geobrowsers. The Standards Working Group define KML 2.2 specification, which became an official OGC standard from April 14, 2008. The MIME type associated with KML is application/vnd.google-earth.kml+xml and the MIME type associated with KMZ is application/vnd.google-earth.kmz (OGC, 2007).

As an extension of XML, other common standard - KML was embraced in many applications such: ArcGIS Explorer, Feature Manipulation Engine (FME), Flickr, Earth-Spector GIS, Geomedia, Google Earth, Google Maps, Google Mobile, Live Search Maps, Microsoft Virtual Earth, Map My Ancestors, Mapufacture, Marble (KDE), OpenLayers, Ossimplanet, Platial, QStarz Travel Recorder, RouteBuddy for Mac, WikiMapia, World Wind, Yahoo Pipes, SuperMap iServer (SuperMap IS) .NET and Java, OpenLAPI, an LGPL implementation of the Location API for Java ME (Shankland, 2008).

3. Software selection for mobile applications

3.1. Virtual globe software products

Based on importance of geographic information systems a lot of companies developed several solutions for software and business in GIS domain. Representative and most popular GIS software are: ArcView® products, Global Mapper GeoExpress for mapping, digitizing (Steiner, 2008), www.rockware.com a modern GIS software www.manifold.netGIS for sharing personalized maps, design, manage, publish maps on the Web, www.korem.com with a Maps Online for creating online mapping applications from ArcGIS projects (www.geo-strategies.com), www.alta4.com, Automated Forex Income a brand new forex software[2], DeLorme professional GIS Software[3] and mapping products maker of GIS software, GPS mapping tools for government or professional use, datasets, geospatial solutions and custom geographic information systems, XMap 4.0 Software, GPS Tracking Unit, AutoCAD Map 3D on Citrix - a great GIS mapping features now with virtualized deli-

[1] the name "Keyhole" is a homage to the KH reconnaissance satellites, the original eye-in-the-sky military reconnaissance system first launched in 1976

[2] http://www.Automatic-Forex.com

[3] http://www.delorme.com

very, www.citrixandautodesk.com , Professional GIS Services, Cutting Edge Web Based GIS and Applications[4].
Several GIS solution "requests for proposals": http://www.onvia.com for data management software (DMS), which offer opportunity to compare DMS using Capterra's free, comprehensive directory, and for data management software: Captera[5], Bowne Management Systems [6] as a producer of GIS and data conversion software. In precision agriculture software domain we find again Urban Information Systems[4] a GIS service provider and software developer, www.u-i-s.com Virtual Landscape Technologies as a reseller of GIS and GPS equipment and software. For GPS systems we mention http://www.geowarehouse.com Virtual Landscape Technologies a reseller of GIS and GPS equipment and software(Lisle,2006).
This process yielded a list of six virtual globe applications: *Google Earth*, *NASA World Wind*, *ArcGIS Explorer*, *SkylineGlobe* and *Dapple Earth Explorer*, *MultiMap UK* (Table 1). The first widely publicized was *Google Earth*[7], a virtual globe software product launched in 2005 by Google™ that offer maps the earth by superimposing satellite imagery, aerial photography and GIS data over a three-dimensional globe. This software uses the Keyhole Markup Language (KML) for describing three-dimensional geospatial data and its display in application programs (Wikipedia 2007). Another virtual globe software product is *NASA World Wind* an open source program[8] from 2004, developed by NASA Learning Technologies, which provides three-dimensional interactive globes of the Earth, the Moon, Mars, Venus and Jupiter (including its four moons). Based on Microsoft.NET technology, Extensible Markup Language (XML) and Web Map Services (WMS) is the first popular virtual globe along with Google Earth, which offers topographic maps and several satellite and aerial image datasets.
ArcGIS Explorer is developed by ESRI[9] designed to access online GIS content from *ArcGIS Server*, *ArcIMS®*, *ArcWeb Services*, and *Web Map Service* (WMS) and work on a three-dimensional globe. A three-dimensional web portal *SkylineGlobe* is developed by Skyline Software Systems and is designed to be a 'turn-key' solution for businesses to add their targeted content and tools in a virtual globe environment, was launched in 2006 and makes use of the *TerraExplorer* plug-in[10] to display its three-dimensional maps in a web browser.
A virtual globe derived from the *NASA World Wind* open source project is *Dapple Earth Explorer*[11], based on the *Geosoft* open source software. It is designed to visualize, present and share geo scientific data in a three dimensional environment, and is primarily targeted towards professional earth scientists since 2006. In December 2007 Microsoft has bought online mapping company *MultimapUK*, presented "a huge opportunity to expand our platform business beyond the UK and globally" said Sharon Baylay, general manager of the Online Services Group at Microsoft. Managers hope that the acquisition "will play a significant role in the future growth of our search business" because Multimap has offices in America, Australia, South Africa and Turkey, London, and has a presence in 48 countries. Microsoft's internet empire includes services such as Virtual Earth, Live Search and Windows Live. Microsoft Virtual Earth 3D, is a 3D interface for Live Search Maps, runs inside Internet Explorer and Firefox, and uses Nasa Blue Marble Next Generation.

3.2.Virtual globe products analyze

Virtual globes software products offer several features and capacities for developing mobile application, but we use a set of evalua-

[4] http://www.gisdynamics.com
[5] http://www.Capterra.com
[6] http://www.bownemgmt.com
[7] download source: http://earth.google.com/
[8] download source: http://worldwind.arc.nasa.gov/download.html
[9] download source: http://www.esri.com/software/arcgis/explorer/index.html
[10] download source: *TerraExplorer* 5.0.2 from http://www.skylineglobe.com/SkylineGlobe/WebClient/PresentationLayer/ Home/Index.aspx?
[11] download source: *Dapple Earth Explorer* 1.020.0 http://dapple.geosoft.com/

tion criteria, which encompassed in: hardware requirements, type and quality of data provided, capacity to import GIS features, ability of data manipulation, sharing grade of data, degree of openness and customization potential, overall performance and stability (Aurambout et all, 2007). For every category authors offer detailed criteria.

Hardware requirements: Platform (Windows, MAC, Linux), price and accessibility: availability of pro versions and availability of support, computer requirements, online or application on hard drive, Internet speed requirements, *type and quality of data provided* analyses: data type available, quality of underlying data, number of layer databases available, match with the underlying imagery data (boundaries, lines features) and recognize address information and give road directions. For third category - *capacity to import GIS features* have many criteria: import modules and editing modules, recognition of KML and quality of import and number of files imported, import of shape file, import of image and grid file, ease of import, capacity to support three-dimensional objects with texture and underground elements, capacity to interact with existing GIS software, possibility to import GPS coordinates and recognition of the spatial reference of the data exported.

Ability of data manipulation consist in: possibility to create data within the software: polygon, lines, place markers, capacity to move data layers in the display, allow font and color editing, gives a legend, capacity to have labels on roads and rivers, capacity to export data straight from GIS and keep legends and other elements, flexibility of legends and color, flexibility to have clickable links, images and other links, perform data analysis or run data models and possibility to display time series.

Sharing grade of data means: share data with client (KML or other file format) export, capacity to share data with client (if they can download it and use it), possibility to import from virtual globe to GIS, ease of export and *degree of openness and customization potential* focused on: availability of extensions to simplify exports and imports, degree of openness and possible customization and ease of customization and script writing, estimation of knowledge level necessary to use the tool for natural resource management, compatibility with other software (VSN, objects, xml etc.) and simplicity of export (Aurambout et all, 2007).

Software products / Criteria	Google Earth	NASA World Wind	ArsGisExplorer	SkylineGlobe	Dapple Earth Explorer	Multimap UK (Microsoft)
Price	Google Earth Pro: $400: Google Earth Plus: $20 Google Earth Enterprise: $100,000	Free	Free	Free SkylineGlobe Pro, Business Solution, Integrator Solution, Local Government Solution and Enterprise Solution (unknown cost)	Free	Free
Computer Requirements	CPU: 2.4 GHz, RAM: 512 MB Hard disk: 2 GB	CPU: 1 GHz RAM: 256 MB Hard disk: 2 GB of disk space	CPU: 1.5 GHz RAM: 512 MB Hard disk: 52 MB free space Graphic card:	CPU: none RAM: 256 MB RAM Hard disk: none	CPU: 2.4 GHz RAM: 512 MB Hard Disk: 2 GB free space	CPU: 1 GHz RAM: 512 MB Hard disk: 2 GB of disk space Graphic card:

Software products / Criteria	Google Earth	NASA World Wind	ArsGisExplorer	SkylineGlobe	Dapple Earth Explorer	Multimap UK (Microsoft)
	free space Graphics Card: 3D-capable with 32 MB of VRAM	Graphic card: 3Dcapable	24-bit capable and 32 MB memory	Graphic card: 32 MB of memory	Graphics Card: 3D-capable with 64 MB of memory	3Dcapable with 32 MB of VRAM
Internet speed Requirements	768 KB/sec	Broadband (unspecified)	Broadband (unspecified)	Broadband (unspecified)	768 KB/sec	768 KB/sec
Imagery resolution	High over urban and rural areas	High over urban and low over rural areas	Low over urban and rural areas	Low over urban and rural areas	High over urban and rural areas	High over urban and rural areas
Transportation network and place finder	Detailed transportation layer and address matching place finder	Transportation layer and address matching place finder (no address matching)	Basic transportation layer and address matching place finder (no address matching)	None (available only in USA)	Transportation layer network but no place finder	Transportation layer and address matching place finder
Availability of other data	None	Yes, global clouds, scientific visualisation, Landsat7, Geocover data	None	None	Yes, Geosoft data	Yes
Shape file import Module	No	Yes	Yes	Yes	No	Yes
Recognition of KML data	Yes, full compatibility. Complex KMZ Supported	Yes partial compatibility Complex KMZ not supported	Yes partial compatibility, Complex KMZ	Yes partial compatibility, Polygon colors not supported	No	Yes partial compatibility, Complex KMZ
Import of GPS coordinates	No (Posible in Google Earth Plus)	Yes (GPS tracker plug-ins)	No	Yes	No	Yes
Data format Supported	Raster image format (jpg, bmp, tga, png, gif, tif)	ESRI shapefile Raster image format (jpg, png)	ESRI shapefile Raster image format (img, bmp, jpg, gif, tif, ArcInfo, DTED, ERDAS, ECW) Geodatabase	ESRI shapefile	Raster image	Raster image format (jpg, bmp, tga, png, gif, tif)

Table 1. Software analyze results

Common features and particularities:

- *Application Type* all of these are installed on hard drive and locally caching data except *SkylineGlobe* which reclaim online application, no data cashed
- *Imagery:* Satellite and aerial imagery for all of software products
- *Support of 3D objects* is offer by all software products except *Dapple Earth Explorer.*

- *Image import module* present at all of these

If we analyze display and data manipulation characteristics, absent in *Dapple Earth Explorer* we can prove that beside it: *creation of GIS data* is a common characteristic, but *NASA World Wind* offers point features only, *creation of a legend* is offered only in *ArcGIS Explorer* and all of rest have *support clickable hyperlinks* and are able to c*reation of fly-through*.

Based on these criteria and particular features for each software product (Table 1.), we select Microsoft MultiMap UK as GIS software for a street and location data, geocoding, and routing with the existing functionality for develop a mobile application with web-based location management system. Our prototype offer an application integral for flagship in-vehicle navigation solution, using GPS and GPRS devices and geocoding and reverse coding features of MultiMap UK.

4. Mobile application prototype (MA) in collaborative environment

MC Locator is a monitoring and management application of the auto fleet activities through the use of location and communication equipment based on GPS and GPRS with the following features: on-line position locating, speed and movement direction of vehicles, checking of vehicles route, automatic generation of individual journey forms and detailed roadmap reports, monitoring the fuel level in the tank and / or the fuel consumption, monitoring other parameters of the vehicle (open / closed doors, refrigeration room temperature, etc.), switching on / off certain parameters(htttp://www.gisdynamics.com).

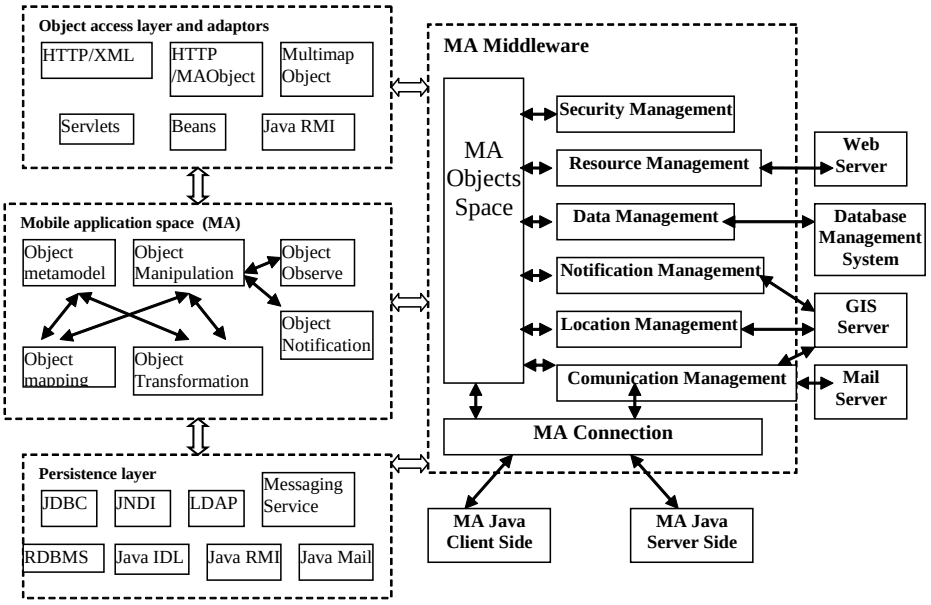

Fig.1. Mobile application conceptual architecture

With web map components, MC Locator can incorporate map visualization, proximity analysis, location-directed search, and real-time web services into the same infrastructure, and with no greater complexity than what is required for other visualization and analytic tools. Another factor influencing the cost and effort of implementing location-aware business intelligence applications is the expense associated with managing the data itself.

Software architecture include components, connectors and configuration, linked together in a decomposed system, focused on well decomposed set of components with clear responsibilities. Major interest was middleware part, as a adapted solution of collaborative environment, offered by Caramba solution (Dudstar, 2004).

Conceptual architecture was divided in four parts: middleware, client side server side (including administration module) and persis-

tence store, which embedded web server, database management system, GIS server and mail server.

Storing position information in a GIS is not suitable solution to large amount of position-series databases for monitoring vehicle in time. Using a migration solution to MySQL 5.0.38 – as a Database Management System (DBMS) which has a relational and distributed features have some advantages including:

- Standard connectivity tools as ODBC and SQL because most commercial GISs support both technologies and in this case we obtain a portable prototype across multiple GIS platform;
- Significant reduces of the amount of data that needs to be stored in management model run;
- Multiple possibilities for query results and complex questions usefully in monitoring and optimization rutes;
- Capability to store spatial objects and positions (points, lines, polygons) in explicit mode rather than coupling in unique identifier with GIS;
- Spatio-temporary complex queries using DBMS databases (Zerger et all, 2004).

Middleware solution was divided in three layers: Object access layer and adapters, mobile application space as a middleware core, and persistence layer using metamodel framework for manipulation and description of content, and offer flexibility, concurrent remote access at persistence resources, enable customization and extensions, embedded new technology and mobile devices.

Object access layer and adapter serves as a access solution at objects and services, depending on client request and observed parameters. By separation between presentation, logical and data stored this layer provide facilities for object observe and notification services and all the customized services are implemented based on object observers and changing positions, given by GIS server and this objects and methods' implementation. This layer is composed by protocols and standards: HTTP and XML, package and java enterprise features: Java Remote Method Invocation with specific methods implementations, servers and beans for persistence objects and them instances, mobile application objects for auto, positions, maps, and Multi-Map Object.

Mobile application space provide a shared object space, require a relevant context of information, performed activities and sub-activities related with business process and normal and special events appeared. It composed by a object metamodel, and object manipulation, which interact with object mapping and object transformation. As a mobile application, based on position information given by Multimap GIS software, this space include special object: observe and notification. In order to providing functionalities for security and confidential access, remote communications and control, feedback of auto parameters we need several middleware components as: security management, resource management, data management, notification management, location management and communication management.

Our prototype solution is based on platform independence solution and we chose the Java J2SE programming language with jre 1.5 and Eclipse SDK version 3.2.2 programming environment. Regarding the database, it was built using Database Management System MySQL 5.0.38 – as a relational and distributed solution. Using one of the many schemes available for the MySQL API, we have write a Java applications to access MySQL databases. MySQL is an integral component of LAMP platforms or WAMP (Linux / Windows-Apache-MySQL-PHP / Perl /Python). The operating system on wich it was worked was Linux Ubuntu, version 7.4.

We used GIS paradigms and exchange data with XML features from MultiMap, and implemented XML Reverse Geocoding service offered by UK MultiMap GIS solution for solving the objective of MC Locator, a monitoring and management application of the auto fleet activities through the use of location and communication equipment based on GPS and GPRS (www.wscomm.com).

4. Conclusion

The capacity to display and access spatial information of digital globes software and simplicity of use them was a real challenge in communication, making data accessible to a range of users. We focused on digital globes features as a potential for the communication in collaborative companies, especially for monitoring and management application of the auto fleet activities through the use of location and communication equipment based on GPS and GPRS. After we analyzed six major digital globes (Google Earth, NASA World Wind, ESRI ArcGIS Explorer, Skyline Globe and Dapple Earth Explorer, MultiMap UK Microsoft), we mentioned the strength and weaknesses of them, than we evaluated potential applicability in our mobile application based on a set of evaluation criteria, according to Aurambout et all. For our prototype we have choose MultiMap UK Microsoft and we developed a conceptual model to communicate information and share the results and feedback of auto feet using complex models for operate or access at spatial technologies such as GIS, remote sensing and position and auto parameters visualization of fleet. This paper presents an conceptual architecture, by adapting Caramba model, and was divided in four parts: middleware, client side server side (including administration module) and persistence store, which embedded web server, database management system, GIS server and mail server.

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