Overview and Analysis of the Impact of Geo-ICT Developments

Geo-ICT Technology Push versus Ma

The first Product Survey to address RDBMS was published in GIM International in February 2002. Over a relatively short period of time, spatial databases have developed a comprehensive technology which includes representation and manipulation of spatial objects, access methods and specific query languages. Apart from developments in database technology, a series of other Geo-ICT developments relevant to spatial data management may be recognised. The author gives an overview and analysis of the impact of these developments.

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The developments looked at here concern information system modelling standards, database technology, global positioning systems, Internet development, wireless communication and acceptance of geometry standards within general ICT tools, including their use in geographic information systems. Efficient design, development, testing and maintenance based on these new geographic information systems technologies allow the introduction of such systems within acceptable time-scales and budgets. A basic condition for system development is analysis of user requirements. Such requirements may change over time, e.g. due to changes in legislation, governmental policy or new tasks set organisations or technology. It is therefore important to design generic and flexible information systems: to follow on from (data) Model Driven Architecture (MDA).

A user may be anyone who is interested in geo-information

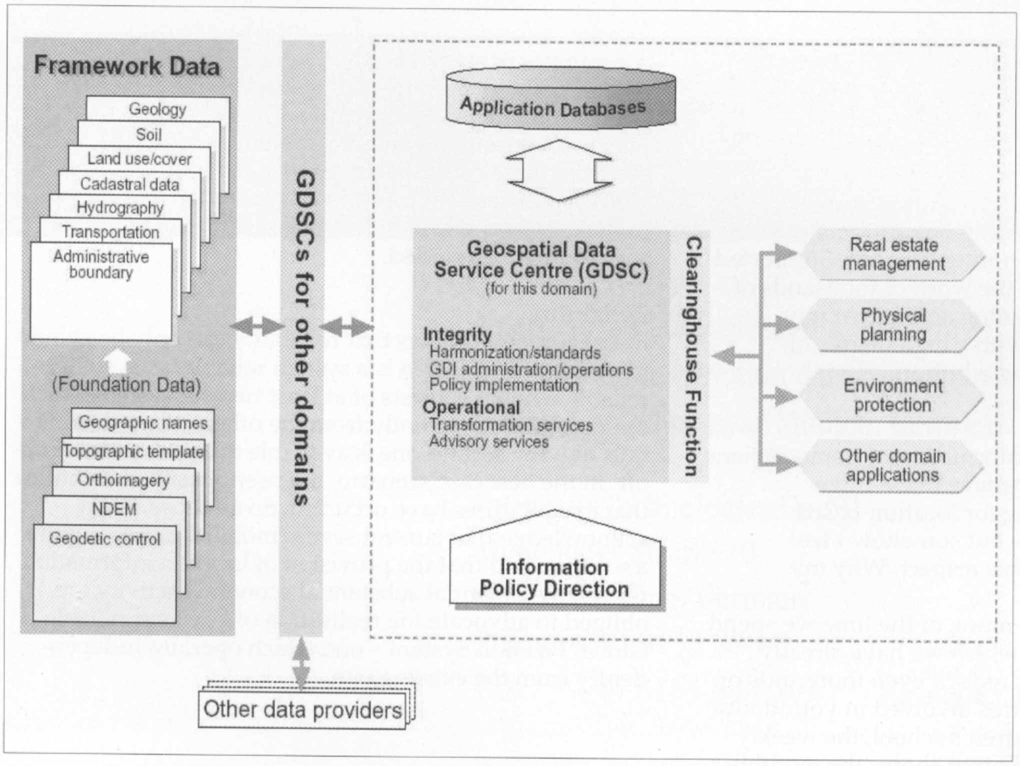

Figure 1, *The foundation data for Spatial Data Infra-structures in relation to the Geo Spatial Data Service Centre of the Environment and Physical Planning Domain according to Groot and McLaughlin*

Geo-ICT

These developments in Geo-Information and Communication Technology (Geo-ICT) have provided a tremendous push towards the development of cadastral and topographic information systems and Spatial Data Infrastructures (GSDI). Both theoretical and practical developments in ICT, such as the ubiquitous communication (Internet), Data Base Management Systems (DBMS), information system modelling as demonstrated in Unified Modelling Language (UML), and global positioning systems will improve the quality, cost effectiveness, performance and maintainability of geographic information systems. Furthermore, both users and industry have accepted standardisation efforts in the spatial area generated by the OpenGIS Consortium and the International Standards Organisation, for example the ISO TC211 Geographic Information/Geomatics. This has resulted in the introduc-

rket Pull

tion of new versions of general ICT tools with spatial capabilities; for example, eXtensible Mark-up Language/ Geography Mark-up Language (XML/GML), Java (with geo-libraries) and object/relational Geo-DBMS, including support of simple geographic features.

Global Acceptance

This is the first time ever that such a set of globally accepted standards and development tools have been available. The new situation creates fresh perspectives in both the development of new geographic information systems and in the improvement in, or extension of, existing systems. At this moment in time the first Internet-GIS applications are already operational. In the near future this will be extended to mobile GIS applications, sometimes also called location-based services. Imagine the user of a mobile phone or a personal digital assistant (PDA), such as a local government civil servant, a real estate broker or a policeman using it to access, for example, up-to-date cadastral information for their day-to-day tasks in the field: "Who is the owner of this building?"... "When was this building sold and what was the price?"... etc.

User Requirements

On the 'market pull' side, new requirements aimed at user satisfaction have emerged due to changes in government policies, legislation, newly emergent organisational and user tasks and so on. Products and services must certainly satisfy user needs. A user may be anyone who is interested in geo-information. Again, taking the cadastral example, assessment of user needs should be made not only at the outset of the development of a new land administration system, but also throughout its lifetime. Questions need to be asked about the categories of data that will be required in the future. It may be an attractive idea to collect some types of data for some possible use in the future but if it is not necessary at present moment then few resources should be allocated for this purpose. A step-by-step approach may be more cost-effective. There will be a need for co-operation over who collects and co-ordinates data, what technology should be acquired so that all components of the system are compatible, how common standards and procedures can be developed and other system-related decisions. Data protection has to be covered.
The application of new technology, such as GPS, should be assessed from an economic rather than a technical perspective. Provisions must also be made to accommodate possible future changes in the network occurring as a result of technical improvements. These may affect all coordinate-based systems.

Life-span

The foregoing requirements are of a more general nature. Some may also be interpreted as conditions for the development of stable systems to run for a long time. Here it should be remembered that the life-span of data is fifty years or more, of software ten years or more and of hardware three years or more. The flow of geo-information between different government agencies and between these agencies and the public has to be encouraged. Whilst access to data, its collection, custody and updating should be facilitated at a local level, the GSDI should be recognised as belonging to an (inter) national uniform service for the promotion of sharing within and between nations.

Migration to New Architectures

Until recently, spatial data management was handled by GIS software outside the DBMS. As DBMSs become spatially enabled, more and more GISs (Arc/Info, Intergraph Geomedia, Smallworld, MicroStation GeoGraphic) have, or soon will, migrate towards an integrated architecture: all data, spatial and thematic, being stored in the DBMS. This marks an important step forward, the culmination of many years of awareness, creation and subsequent system development. Many organisations are currently in the process of migrating towards this new architecture.

> *'When was this building sold and what was the price?'*

There is a lot of work involved in this and it will take many years yet. The next step will be the creation of a common GSDI for related organisations; so-called information communities. The concept of GSDI is presented in Figure 1. This may, in the long run, replace the exchange of copies of datasets between organisations. It will require good protocols: standardisation such as the OpenGIS web mapping specification. But, in addition, the role of the Geo-DBMS will increase in significance due to the fact that not only a single organisation will depend upon it, but a whole community. Its main use will be query-oriented rather than update-oriented; only the owner of the data will conduct updates

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http://b-map-co.com/servlets/mapservlet?WMTVER=0.9&REQUEST=map&
BBOX=-88.68815,30.284573,-87.48539,30.989218&
WIDTH=792&HEIGHT=464&SRS=4326&
LAYERS=AL+Highway,AL+Highway,AL+Highway&
STYLES=casing,interior,label&FORMAT=GIF&TRANSPARENT=TRUE
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Figure 2, Example of a GetMap query

whilst others will be using it for queries. Here enters an essential component for the realisation of such query processes: the network infrastructure (bandwidth) itself.

Obtaining Geo-data

One of the most time-consuming tasks when implementing a GIS is obtaining geodata. Relevant datasets and sources have to be located. The various reasons why this process is so time-consuming include difficulties in finding data, discrepancies between source data model and that of the model implemented by the local system, and differing supported exchange formats of source and destination. Much effort is needed to create a GSDI to improve this situation.

More and more GISs will soon migrate towards an integrated architecture

OpenGIS Standards

The OpenGIS Consortium (OGC) and official standardisation organisations (ISO and CEN) have addressed several aspects of the interoperating framework. The first OpenGIS implementation standard was called Simple Feature Specification (SFS) and it standardised the basic spatial types and functions. The implementation specification for the SFS is described for three different platforms: SQL, Corba and OLE/COM. What is still missing is an implementation specification for complex features, such as those based on a topology structure. The abstract earth imagery and implementation grid coverage specifications have been developed for raster data modelling. Much attention on the part of the OGC has been paid to the aspect of catalogue services describing how to access metadata. This standard can and will be used in realising clearinghouses for geo-information. Closely related to the previous standards, metadata and catalogue services represent activities in the area of Internet GIS (or web-mapping). This may be seen as an interactive (and ultimate) form of interoperability, as data from multiple sources may be retrieved and combined in the web-browser. However, instead of simply querying and receiving metadata, now the geodata itself is queried and received. In this area, the OGC has created the implementation specification Web Map Server Interface for query aspects using three basic functions: GetCapabilities (what is available on the server), GetMap (raster images, graphic primitives or data) and GetFeature_info (fetch attributes). In addition, the Web Feature Server Interface can be used for updating information, has functions for locking and committing transactions and utilises the Geography Markup Language (GML) (simple features in XML) for vector data transfer. The query from a client uses the well-known structure of an Internet URL. The OGC has specified the names of query parameters (e.g. BBOX, LAYERS, FORMAT) as well as their meaning, and has also allocated values to them. One example of a GetMap query may be found in Figure 2. With respect to different types of clients, the OGC has developed a model for their comparison (Figure 3).

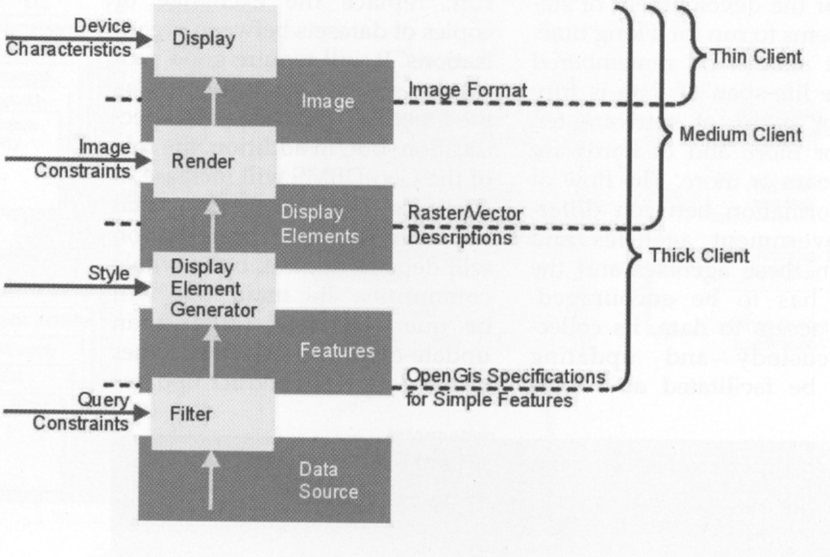

***Figure 3**, OGC: different levels to exchange geo-information. Thin clients (which display only raster images JPEG and PNG), medium clients (with graphic primitives WebCGM and SVG) or thick clients (data in the form of simple features XML, that is GML), is processed at the client side)*

UML

We have reached the stage of worldwide acceptance of a standard modelling language: the Unified Modelling Language (UML). This supports a rich set of graphical notation describing classes, objects, activities, states, workflow, use cases, components, nodes and the relationships among them. It provides significant benefits for system designers and organisations in facilitating the building of rigorous, traceable and maintainable models supporting developmental life-cycles. It is used for modelling both the data (structural) aspect and the functional (behavioural) aspect of information systems, supporting both external and internal requirements. There are a number of very important components in UML: the case diagram to capture external environments (user requirements and behaviours), the activity diagram to show how a used case can be realised, an object model (system behaviours) showing interaction between actors and entity objects, and an information model (commonly known as the 'class diagram', which resembles well-known entity-relationship diagrams). Since it is based on object-oriented technology, UML may effec-

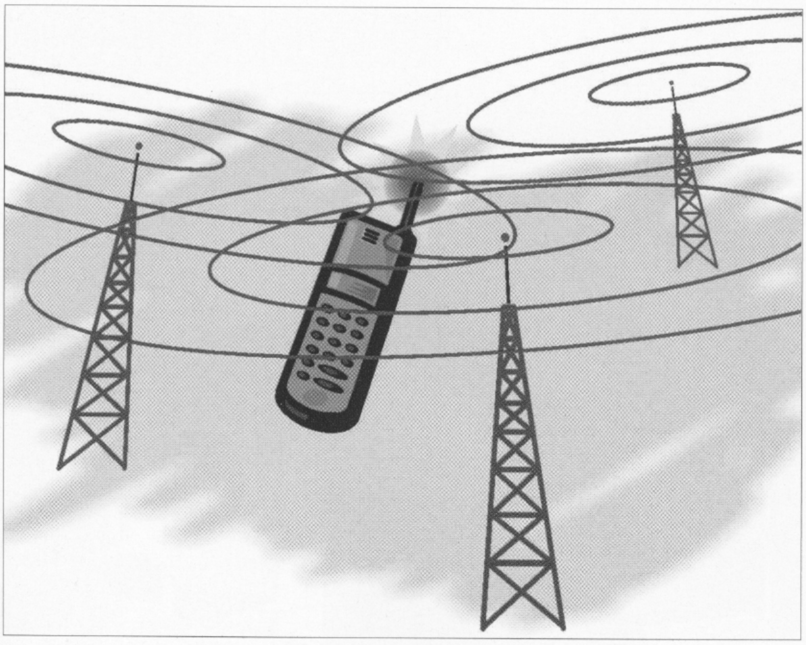

Figure 4, The transmission senders and the positioning of the mobile phone

tively be used to design a generic model. An international consortium promoting the use of object-oriented information technology, the Object Management Group (OMG), is responsible for maintaining the UML standard.

XML

eXtensible Markup Language (XML) is the standard for the exchange of structured information and plays an important role in the Internet. Data models may be described either within a Document Type Description (DTD) or a more advanced XML Schema document. For example, the OGC GML is based on XML Schema for modelling of the spatial aspect of features. XML Schema has a 'connection' to UML: the data part of the (UML) model can be transformed into the XML Schema, either by hand or automatically.

Location Based Services

A mobile information society is rapidly developing as mobile telecommunications move from second (GSM) to third (UTMS) generation technology. The Internet and its services are arriving at wireless devices. Location-Based Services (LBS) and personal navigation are becoming part and parcel of mobile multimedia services. Personal navigation is a service concept in which advanced mobile telecommunications allow people to find out where they are, where they can find the products and services they need and how they can get to a certain destination. The architecture of LBS consists of components from three different disciplines:

- Positioning of the mobile terminal, either based on the mobile phone network or on a positioning system such as GPS, GLONASS or Galileo
- Wireless communication network, either based on GSM, GPRS or UTMS
- Geo-information and geo-services based on GIS technology

These three disciplines have one thing in common: in one way or the other the concept of location is important.

Concluding Remarks

A series of new, globally accepted Geo-ICT tools, such as UML, XML, GML, allow the development of Geo-DBMSs and efficient data distribution within a framework of GSDI. The development of Location Based Services greatly depends upon the performance of spatial databases within a framework of Geo-Spatial Data Infrastructures. This type of service is generally recognised as the impetus behind inclusion of spatial data in the 'mainstream' of Geo-Information and Communication Technology worldwide. The further development of (industrial) standards and their implementation is a condition for the maintenance of an essential balance between 'technology push' and 'market pull'.

Further Reading

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Biography of the Authors

Prof. Peter van Oosterom has held a chair in 'GIS Technology' at Delft University of Technology since 2000. His previous employers were the TNO Physics and Electronics Laboratory (1985-1995) and company staff of the Netherlands Kadaster (1995-2000). His main research topics are geo-databases, generalisation, distributed GIS architectures and cadastral applications. Professor van Oosterom received his PhD from Leiden University, with a thesis entitled 'Reactive Data Structures for GIS'.

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