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Spatial decision support systems: definitions and futures

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Introduction

Geographic Information Systems (GIS) have been used for a variety of tasks since their humble beginnings in the automated mapping arena of the 1960's. With the advent of more advanced spatial analytical functions, GIS users have been able to pose increasingly complex questions of the data they hold. The increase in the power of desktop computing and the recent rise in functionality of Browser based GIS (Intra/ Internet) has also accelerated the advance of a subset of GIS known as Spatial Decision Support Systems or SDSS.

Definitions

The term Spatial Decision Support System has come to encompass a broad range of GIS computing tools which assist in the solution of spatial problems.

- store location,
- emergency service provision,
- route management and
- infrastructure/ network design.

Such problems typically include locating a new facility in order to serve the demand for a given service or optimising existing situations (Densham 1991: 1996).

Other application areas include, examining the impact of proposed development schemes on a neighbourhood, or determining where zones should be created in order to divide a population into administrative areas. Geographic Information Systems (GIS) and SDSS are often seen as complimentary in pursuit of these goals. Indeed, GIS functionality is usually a key element in an SDSS. SDSS however, are more than just standalone GIS though GIS technologies have an important role to play within SDSS, as vast amounts of time and money have been invested in improving GIS's analytical functionality and usability - particularly since the early 1970's (Coppock and Rhind 1991).

As SDSS encompass a wide range of application areas they draw upon a range of technologies allied to GIS as well as spatial analytical functions. To date the following have been employed in various projects.

Multimedia, such as sound and video have been applied to gauge reaction to planning and aircraft routing scenarios (Shiffer 1995). Video footage and sound projections have been linked to base maps so that citizens can assess the impact of aircraft flight paths with regard to their community.

Visualisation software and rendering techniques including VRML and 3d panoramas to answer 'what if' architectural scenarios (Batty *et al* 1998) or route planning. UCL's virtual prospectus is a good example, see www.ucl.ac.uk/virtual/

Interactive and collaborative design tools have been deployed to non-expert users (Smith *et al* 1998) www.onlineplanning.org. This has allowed communities in which urban regeneration is occurring to explore and visualise architectural developments.

Thematic and 2d surface mapping within GIS has been used extensively in a range of application areas and to discrete audiences (Smith *et al* 1998). The work of the Centre for Neighborhood Technology's GIS Team uses the latest mapping technologies available to make maps. These are seen as vital tools that highlight the connections that can change environments and then demonstrate the value of those connections to others (non-experts) http://www.cnt.org. The AGI award winning Medway Council (UK) also use the web to provide thematic maps to decision makers in the public sector.

Figure 1: GIS for Medway Online (GISMO).

Regardless of the 'type' of technology used, all of the above technologies require two important factors to be resolved in order to reach a successful outcome.

'*which decision is being supported?'* and

'who does the software tool(s) support in order to decide 'where?'.

Questions of this nature help hold systems in check, as GIS by themselves cannot identify a problem or subsequently create, and successfully conclude, a decision making process. This may be obvious but GIS are often cited as a *panacea* for locational issues and their abilities can be oversold (Aangeenbrug 1991).

The SDSS therefore can be broken down into its literal parts as a Spatial System which, Supports a Decision made *via* the use of spatial data. They also have to be 'fit for purpose', *e.g. "Effective decision support requires that the message of the map is readily interpretable in the mind of the decision maker."* (Longley *et al* 2001, p.248).

SDSS Futures

Whilst we have established that SDSS are not GIS *per se*, the more successful and well known examples apply the correct amount of GIS functionality to a problem. An end-user may never know that they are 'doing' GIS, it may not be important. Indeed many SDSS designers and academics promote a simple end-user interface that allows users to experiment within a decision making process with ease and speed. By far the biggest growth area for SDSS is the Internet. This environment requires simple yet effective interfaces in order to streamline decision making processes and to optimise delivery time.

At present many vendors offer customisable desktop GIS or Active X (OCX) components which allow programmers and developers to build a spatial element into their own systems, and to an extent, these can eventually evolve into bespoke SDSS on deployment. However, SDSS are more about broader issues. These issues include the type of data used, the number and expertise of analysts and decision makers, the time-scale and cost of coming to an appropriate decision. These are all contributory factors in arriving at a satisfactory spatial decision. GIS vendors and academics have channelled large amounts of time and resources into web-enabled applications. From which SDSS will no doubt evolve further.

The last five years has seen an enormous uptake in Internet connectivity. The GIS community, ranging from academics to government agencies and authorities and vendors have all to varying degrees, harnessed this new technology. Indeed many vendors offer shrunk-wrapped Internet GIS (IGIS) or customisable Internet enabled GIS components. These products are both creating and serving the demand to deliver spatial data and mapping *via* the internet Browser. Whilst still in the hands of 'GIS experts' or developers, these IGIS are beginning to offer basic or very specific GIS functionality to non-expert GIS users at a mass scale or with minimal deployment cost.

Whilst IGIS will not replace high-end GIS 'seat for seat' it will impact upon the way basic GIS functions are performed. This area will, and to an extent already does include, basic data viewing, simple geometry creation and 'find the nearest' type queries. This will (and already does) affect the GI and GIS market enormously as the GIS user-base increases and as spatial data and associated analyses move into the mainstream. This uptake in digital computation represents a revolution in the way government, business, and citizens will communicate and also how they take their knowledge and exposure of spatial data forward.

Case Study

Cadcorp SIS Active Server Component (ASC) has recently been deployed to provide a delivery mechanism for Ernst and Young's European Investment Monitor (EIM). Ernst & Young is one of the largest professional services firms in the UK with 20 offices and 7,000 staff. In Summer 2000, Ernst & Young commissioned Cadcorp to produce a simple to use thematic mapping interface for investment analysts interested in the European economy. The service is aimed at analysts who have little or no expertise with GIS who would normally access megabytes of data *via* postally delivered spreadsheets.

The interface aids decision making in the investment arena, so that users can make informed decisions as to 'where to invest' or 'which markets are performing poorly or well'. The types of questions which can be asked are channelled in order to increase the speed of use. The types of queries range from simple *'where are the investment sites for Sony Corporation?'* through to *'where and when did automotive and chemical sector investments occur, show me the trends across the last three years, report by thematic map and bar chart'*.

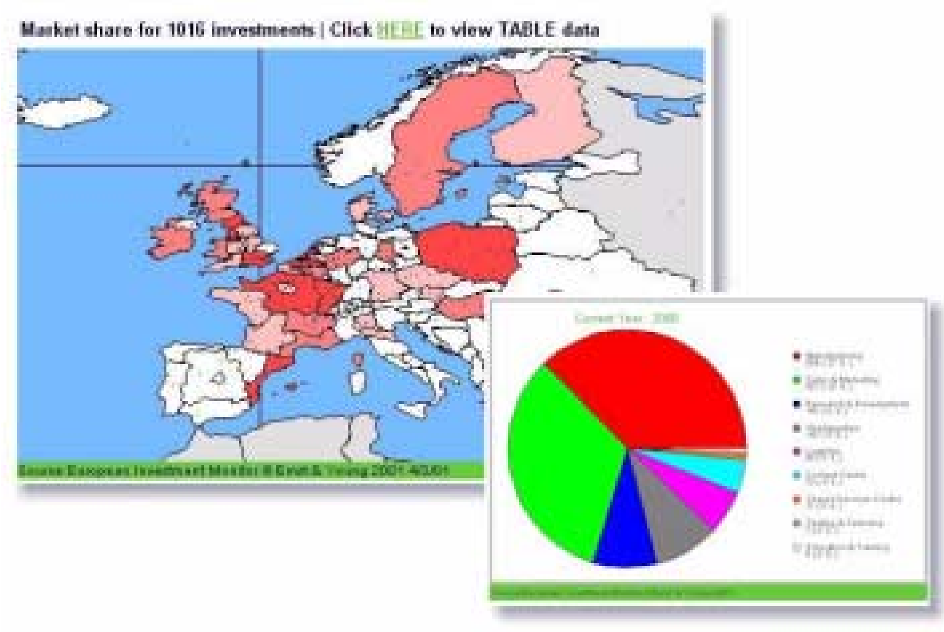

Figure 2: Results from Ernst & Young's European Investment Monitor Decision Support System

In this case, the GIS component acts as a tool to show investment locations and is integrated with Active Server Page technologies to provide a range of Internet deliverable data outputs and reports. These reports answer the same questions which were asked of the data previously, but because they are couched 'spatially' the answers are more readily delivered. The site also allows new questions to be posed and new answers delivered. Within the system a user's previous queries are stored in order to provide a knowledge base for future use.

This type of decision support system will be commonplace in other application areas given time. The major obstacle will be institutional, as the hardware, software and networking factors that prohibited development 10-20 years ago are no longer an issue. Future discussions on the role of SDSS abound recent commentary from the US Army Corps of Engineers has identified interoperability and standards as key elements of any future seamless DSS (for scenario management and creation).

This is concordant with the Open GIS Consortium's agenda which is slowly being adopted by mainstream GIS. Web Map Servers (www.opengis.org) follow this tenet so as to allow users to access remote services and data from multiple locations across the web. The next stage for SDSS is to determine how best to manipulate this heterogeneous network environment. The USACE also identifies Stakeholder access, metadata/ catalogue services and knowledge management tools as key elements in future SDSS implementations (Case *et al* 2001).

These are all areas of complexity but framed correctly *i.e.* placed in a 'decision space' users will be able to achieve their goals – better decisions. To investigate these issues the Centre for Advanced Spatial Analysis (CASA), UCL and Cadcorp are working on an Economic and Social Research Council (www.esrc.ac.uk) CASE project to build Decision Support techniques into emergency vehicle location and routing strategies. Issues to be addressed will include;

Which GIS or spatial analytical methods are most applicable bearing in mind, we may need low-level interfaces to potentially high-level problems and techniques.

How would an Internet based SDSS differ from desktop GIS/ SDSS?

How collaborative can these systems be?

The work will build upon Location-Allocation decision support systems previously pioneered with the NCGIA (Densham 1992*: Densham 1992**). The work will attempt to bring together Data, modelling techniques, computational methods and visualisation strategies to serve distinct users in an emergency service context.

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WWW Resources

Software:

www.cadcorp.com

Research:

www.casa.ucl.ac.uk

www.esrc.ac.uk

www.omlineplaning.org

Interoperability:

www.opengis.org

Case study:

www.ey.com

http://195.26.229.10/eimonline/