

Generalisation, Web Mapping and Data Delivery over the Internet

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ABSTRACT

We are moving at breakneck speed towards an age where information is available on almost any subject, on-request, wherever you are. As the majority of information has a location component, it is natural to use mapping as a prime medium for provision of information, and such maps have to be generated on-demand to suit the particular request and the display capability. Even more value can be gained by bringing together information from separate data sources, and presenting them as a unified map.

This paper overviews an active object approach to generalisation and visual presentation of location-related information. It also covers mapping interoperability standards, which allow combination of spatial information from disparate Internet sources.

1. INTRODUCTION

1.1 The Internet as Information Source

Although the Internet has existed for over 25 years, it has undergone dramatic growth in the last five years, fuelled by cheap hardware and by the 'World Wide Web' as an application. As the majority of human-related information has a location component, it is natural that map display should become a preferred way of finding and presenting information. This has led to the rise of 'web mapping', as exemplified in the CamMap site (<http://www.CamMap.com/>) shown in Figure 8 and described later in this paper.

1.2 The Wireless Handheld Information Appliance (WHIA)

If the growth of the Internet has been dramatic, that of the cellular telephone has been explosive. Dataquest reported by news channel CNNfn [CNNfn2000] calculated that 283 million cellular handsets were sold in 1999, with the estimate for 2000 being 410 million. As well as its initial role as a person-to-person communication tool, it is rapidly gaining ground as a means of enquiring for information. There has been recent hype over WAP (Wireless Access Protocol), and a WAP phone is shown at Figure 1, being used for "WAP mapping", within the limits of its screen resolution of 100x50 monochrome pixels.



Figure 1 - WAP phone



Figure 2 – PDA



Figure 3 - GPS - Casio

The third strand of technology contributing to the information revolution is specialised hand-held devices. The most common is a 'Personal Digital Assistant' or PDA, such as the Psion 5mx, Palm V, and Compaq Aero (see

Figure 2). Other related devices are the GPS (Global Positioning System) receivers. These were bulky, but modern design is reducing them to very portable (see Figure 3).

The future will bring a new generation of devices, the “Wireless Handheld Information Appliance”, or WHIA. This will meld features from mobile phones, PDAs, palmtops and GPS with new screen technologies to give a single optimal tool for communication, location, and information retrieval. Such devices will become as common as the wristwatch is now. The capabilities of such devices can already be simulated by combinations of existing tools, such as using a PDA to access the Internet through an infra-red link to a mobile phone to access on-demand mapping (see figure 4).

Although much more capable than any one existing handheld device, the WHIA will still have limitations enforced by the conflicting requirements of less weight, longer battery life against better screen, faster access. This means that intelligent presentation of information will become a vital lever for usability.

1.3 Location questions and answers

The WHIA will give the answers to the set of location questions: “Where am I? Where is the nearest...? How do I get to...?”, and various techniques can be used to deliver the answers:

- Synthesised voice (“at next junction, turn left”)
- Text messaging (“in 250m turn left, then ...”)
- Graphical map displayed on screen
- Graphical map plus instructions sent to paper by fax

However, in all such cases, the primary source of answers will be a geographic information server. This paper contends that an active object database is key to finding and presenting the requisite geographic information in a clear and concise manner.

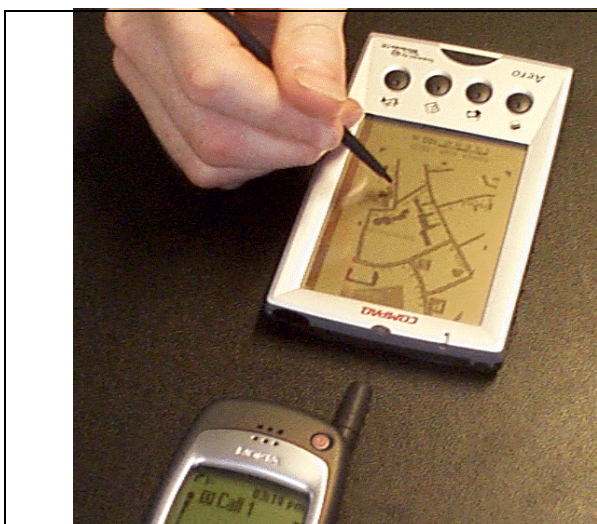


Figure 4 – Combine to simulate WHIA

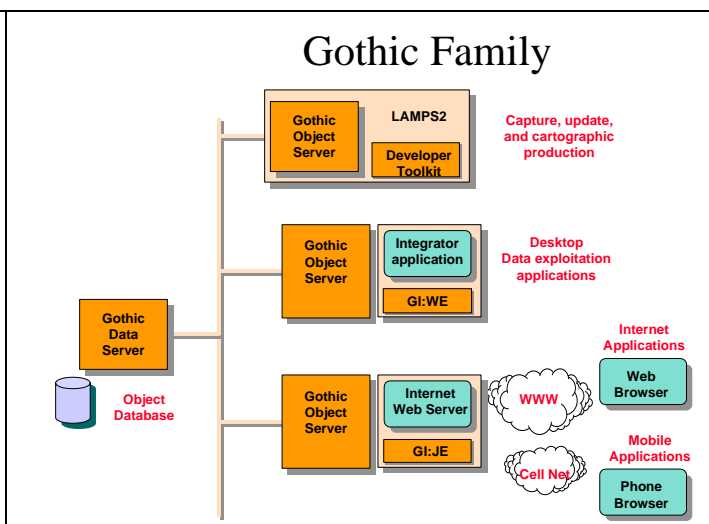


Figure 5 – Laser-Scan Gothic Family

2. ACTIVE OBJECTS

2.1 What are Active Objects?

The object-oriented (O-O) paradigm has been sweeping through the software industry for many years. O-O is a logical way of modelling the real world within a computer software system. All modern software-engineering languages (C++, Java) are built around the four key O-O concepts, of encapsulation, referencing, inheritance, and polymorphism.

- Encapsulation means that data and behaviour are not separated, but encapsulated together within objects that respond to messages sent to them.
- Referencing means that objects can have direct knowledge of related objects (a river ‘flows from’ a spring).
- Inheritance means that the object classes can gain capabilities from multiple superclasses, such as canals inheriting from ‘transportation’, and from ‘water’. This allows modelling the family structure of the world (a church is a kind of a public building, which is a kind of a building, which is a kind of a man-made structure).
- Polymorphism means that different classes can respond to the same message with an appropriate behaviour (click on a factory and click on a road, and get different description types and different highlighting).

A new generation of spatial database, GIS and mapping systems is adopting O-O concepts and applying them to storage, retrieval, analysis and display of location-related information. This paper concentrates on the Laser-Scan Gothic family (see Figure 5) of spatial software, built around the Gothic O-O spatial database. More detail on this family is available in the paper on “Active Object Techniques for Production of Multiple Map and Geodata Products from a Spatial Database” [Hardy 1999b].

2.2 Characteristics of active object spatial database mapping system

A Gothic database mapping system has the following characteristics:

- Object database - provides efficient storage and retrieval of spatial objects
- Object Data Model (Schema) - allows modelling of the real world entities and their relationships.
- Continuous mapping (no sheet boundaries) - provides the area wanted at the scale requested.
- Topological structure – knows about connectivity, adjacency
- Object database views allow intelligent selection of subsets of objects for current purpose
- Active representation provides good cartography (see below)
- Active object generalisation methods derive appropriate map features for current scale and need.
- Validation methods ensure data integrity
- Open architecture allows access from workstation, desktop, web browser, or WHIA.

3. ACTIVE DISPLAY

3.1 Display Methods

A key aspect of O-O mapping is the use of display methods for all visualisation. Instead of the application having fixed rules about representation, or using a static table of styles, all drawing is done by sending a message to each relevant object saying ‘draw yourself’. The response to the message is to execute the object’s ‘display method’, which can use the power of the object database and spatial toolkit to decide what to do. It can:

- Decide to draw or not to draw itself, dependent on scale, specification, and surroundings
- Use a rich set of representation styles (line patterns, area fills, symbols)
- Change type according to scale – area object may draw itself as point symbol if it is too small at this scale.
- Use a different ‘geometry’ (shape) according to scale, showing less detail at smaller scale.
- Draw itself more than once in different styles, e.g. to achieve road casings, or text labels
- Move itself into clear space to avoid edge of map or other collisions.
- Modify its representation according to scale and surroundings; e.g. shorten label to match length of road.

All of these techniques are applicable to Web mapping and WAP mapping, as in the examples below.

4. GENERALISATION

4.1 Active Object Generalisation

Generalisation is the science (and art) of exaggerating those aspects that are important for this particular map purpose and scale, and removing irrelevant detail that would clutter the map and confuse the user. Generalisation has traditionally been a hard task to automate, being dependent on the skills of the human cartographer. People have tried for years to build centralised ‘knowledge bases’ of generalisation rules, with very limited success. In such systems, the map features themselves have just been passive items containing coordinates and attributes, acted upon by the centralised rules [McMaster, 1991].

In the object-oriented world, this is turned upside down. The map features themselves become objects that have generalisation behaviours defined in the database schema. The application itself becomes much thinner, and contains no knowledge about what, how, or when. It merely provides a framework for invoking and sequencing the generalisation processes by sending messages to selected objects [Ormsby and Mackaness 1999].

Gothic LAMPS2 includes an object-oriented generalisation facility, which allows the user to define the strategy for generalisation in terms of methods on the object classes [Hardy 2000]. Generalisation base object classes are provided which supply generalisation process methods for multi-object combinatorial operations (aggregation, typification, and displacement) and others for single object generalisation (collapsing, refinement, exaggeration and simplification). Note that these are implemented as behaviours of the objects in the database, not as commands within a program.

Kort & Matrikelstyrelsen (the Danish state mapping agency) is using LAMPS2 in this way to derive 1:50K mapping from a 1:10K sourced database. The generalisation flowline makes considerable use of active object

views using spatial query, to identify objects for generalisation. An example is to delete all minor roads less than 2km long which have a dead end and do not have buildings within 100m of the dead end (see Figure 6).

In the future, increased computational power and improvements in software techniques will allow such active object generalisation to be done in real time, on-demand to satisfy a user request for appropriate mapping on his Internet browser or WHIA. Until then, the techniques are still very useful, but need to be applied in advance to produce a set of 'usages', and the results stored. The object database allows storage of multiple alternative geometries, so you can have one object (e.g. Trinity College), with one set of attributes, but with several alternative sets of coordinates, each suitable for a particular scale band.

4.2 Agent Generalisation

The power of object generalisation is being greatly enhanced by the AGENT project on multi-agent generalisation. This project [Lamy et al, 1999] is a collaboration under the ESPRIT programme (LTR/24939) involving Laser-Scan as providers of object technology together with a national mapping agency (IGN) as prime contractor, and academic partners (Edinburgh & Zurich, INPG). Some partners provide in-depth knowledge of generalisation algorithms, while others provide insight into multi-agent modelling. The contract involves 48 person years of effort over a 3-year period. The fruits of the project are being implemented in the Laser-Scan Gothic LAMPS2 mapping software.

In this context, agents are self-aware active software objects that co-operate, subject to a set of constraints, to achieve a goal. For map generalisation, it is the geographic objects such as houses and roads, which become active agents and co-operate through simplification, typification and displacement of themselves to achieve a cartographically acceptable generalised result. Figure 7 shows co-operating meso-agents handling urban blocks, communicating with the micro-agents that are the buildings and roads.

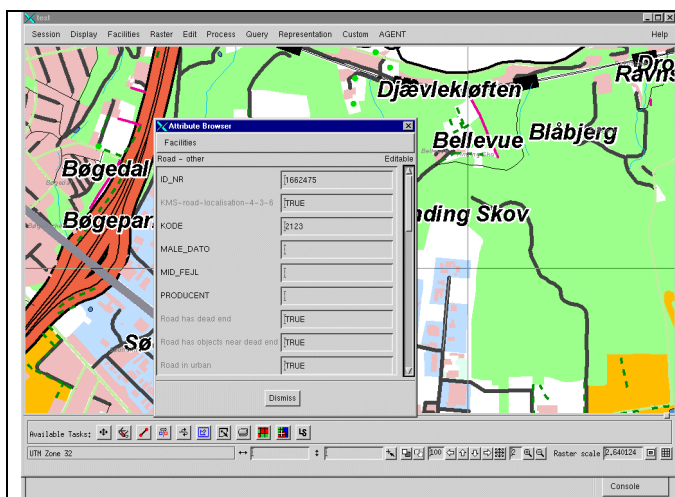


Figure 6 – KMS Active Object Generalisation

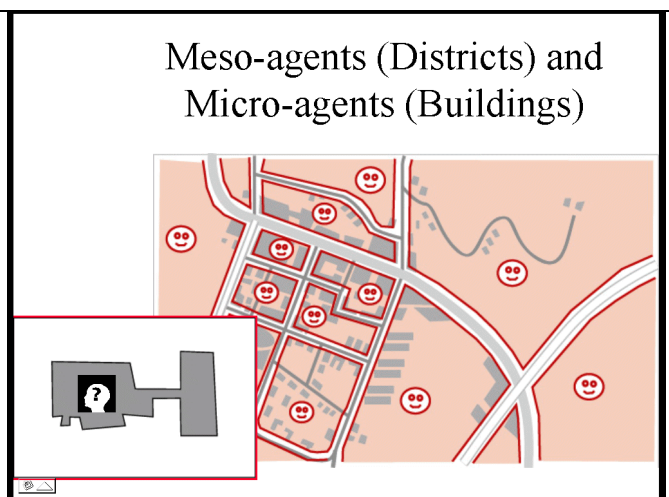


Figure 7 – AGENT Generalisation

Agent-based generalisation achieves two major steps forward:

- An individual micro-agent (e.g. a building) tries different algorithms, keeping the results if the situation is better, discarding and trying different ones if the situation is worse, so avoiding using the same tool globally.
- Meso-agents coordinate generalisation across sets of objects, so avoid consequential conflicts and retain gestalt (the overall coherence).

The philosophy underlying the AGENT project generalisation mechanism is for the designer to define how the map should appear rather than defining how to achieve it (declarative rather than imperative). Each agent then tries to improve its happiness during an agent life-cycle which encompasses:

- Measures – implemented as object methods, these assess the tangible state of the feature.
- Constraints – implemented as objects, these return the degree of unhappiness for each aspect of state.
- Algorithms – implemented as methods, these change the state, and (hopefully) improve the situation
- Plans – dynamic lists of values, these determine the choice and order in which algorithms are executed.
- Re-evaluate – part of the lifecycle method, this determines if the previous plan was a success or not, and if not will backtrack the state in order to try another plan.

See the paper referenced at the head of this section and the paper by Anne Ruas to be given at this conference [Ruas 2000] for more information on the Agent project.

Like the active object generalisation techniques described in the previous section, these agent techniques are to be used at present in preparing generalised versions of objects to be used for different scale enquiries. In the future, they will be applied in real-time to satisfy mapping requests from Internet browsers or WHIAs.

5. WEB MAPPING EXAMPLES

5.1 CamMap

CamMap is a highly interactive web map of the area around Cambridge UK. In it, all the objects can be asked to describe themselves, and many (including all pubs, colleges and many public buildings) do so by providing web links to images and related web sites (e.g. for Kings College as shown in Figure 8). The site is free, so try it out yourself (<http://www.CamMap.com>). It uses a variety of active object generalisation techniques to present data from a continuous object database at different scales while retaining clarity.

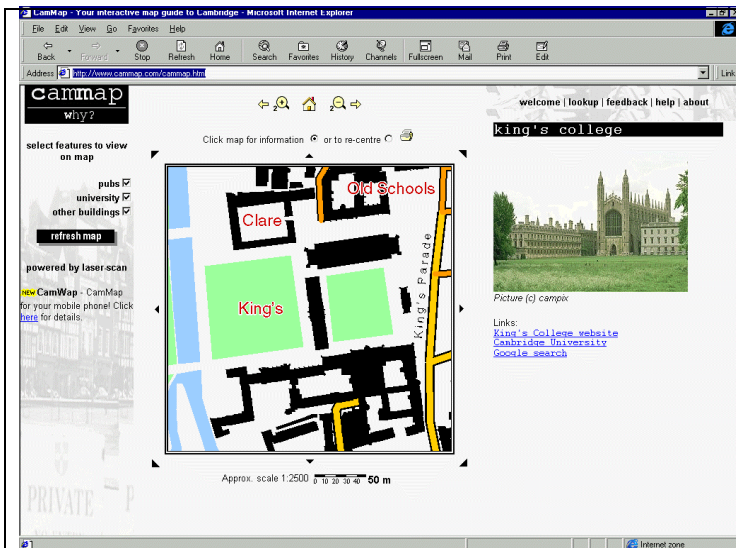


Figure 8 – Web Mapping – www.CamMap.com



Figure 9 – Text labelling

Figure 9 shows intelligent generalisation and positioning of text labels. Road numbers have been dropped where there is insufficient room. Road and pub names have been positioned so that they don't fall over the edge of the window or over important detail. Figure 10 shows automatic selection of appropriately pre-generalised geometry for a college according to viewing scale. The combination of these techniques produces a legible map presenting the maximum information, for any requested location at any requested scale, within seconds.

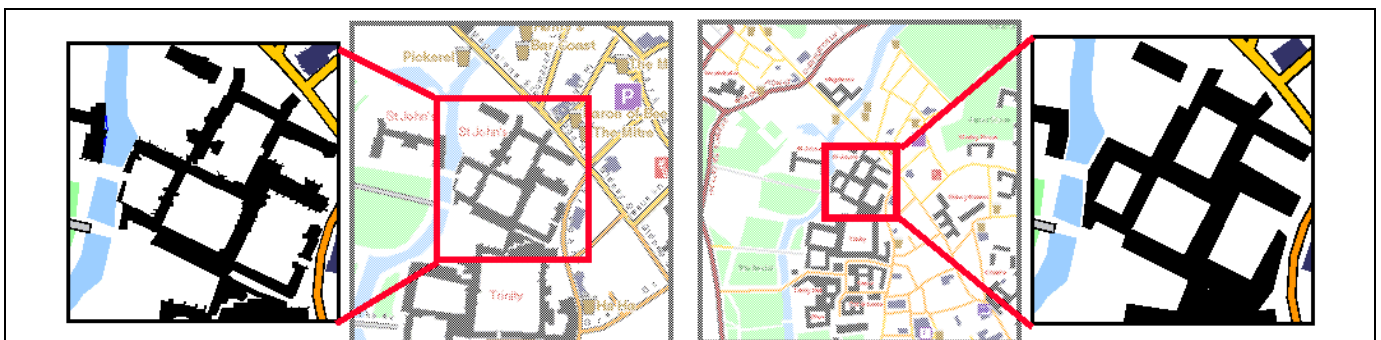


Figure 10 – Use of generalised geometry for college building outline according to viewing scale

5.2 Location Mapping

A commercial web site is currently being prototyped to provide location mapping. It has national coverage sourced and derived from Ordnance Survey digital map data. It allows lookup of an address by text or by postcode, and can provide a sequence of location maps at increasing scales in a layout leading the user to the desired location. As well as the on-screen version (Figure 11), the user can request a print-quality map which is delivered in Adobe Acrobat PDF format, for printing at A4 (Figure 12). Both map types are produced using active object representation and generalisation from a continuous object database.

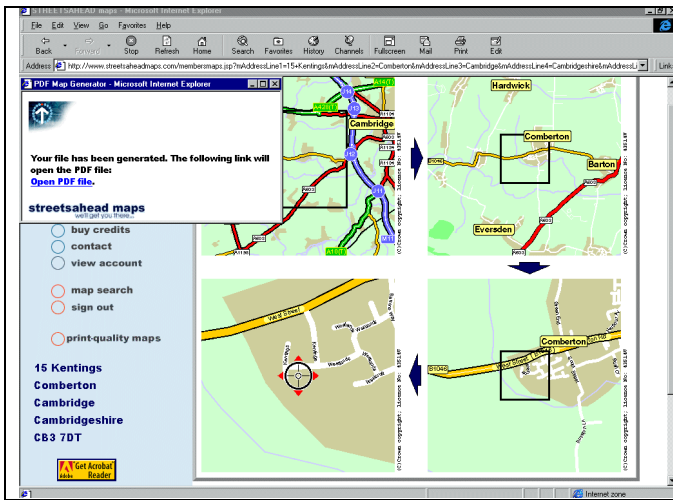


Figure 11 – Location mapping web map

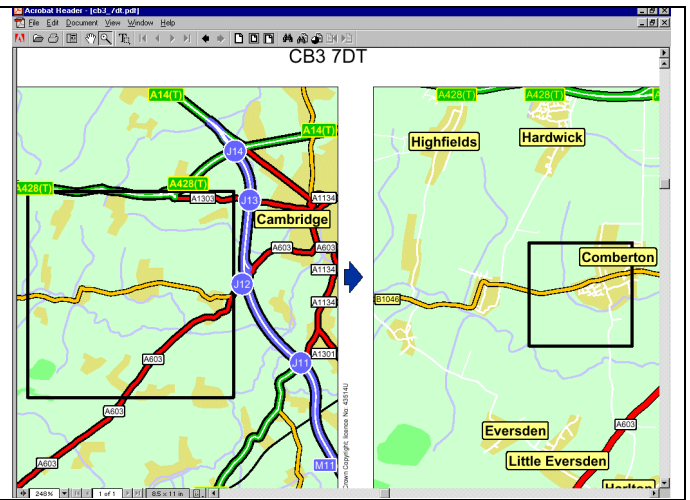


Figure 12 – Location mapping PDF map

5.3 LINZ

Land Information New Zealand already hold the master data for their 1:50K national topographic database in a single continuous Gothic dataset administered with LAMPS2, supporting on-demand hardcopy mapping. More recently, they have asked Laser-Scan to serve a copy of the data from Cambridge England to the Internet for use by NZ government departments. The web application uses a Java applet for better interaction than can be achieved with just HTML. Hardcopy output is still available via download of a generated PostScript file covering the area of interest. Display methods on the objects in the database choose if and how to draw themselves, to provide a clear map at a variety of scales (See Figure 13). NZ has recently chosen to make its topographic data freely available (as in the USA) rather than charging copyright fees. Topographic mapping of this type will become a valuable framework and backdrop for handheld spatial information retrieval in the future, for those countries that have the foresight to release their mapping in this way.

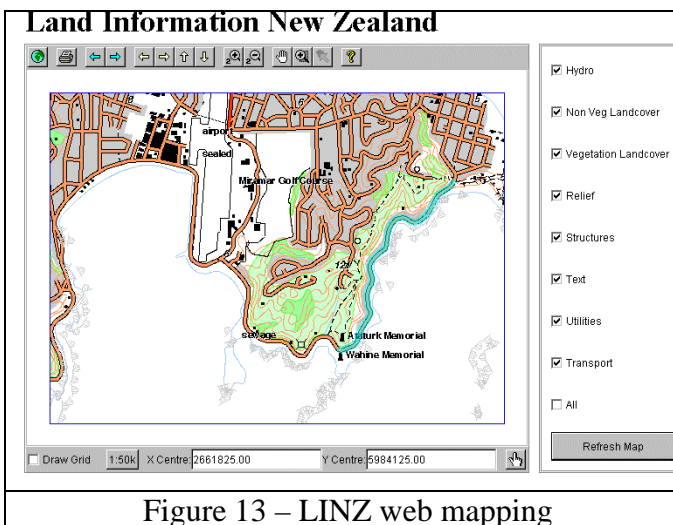


Figure 13 – LINZ web mapping

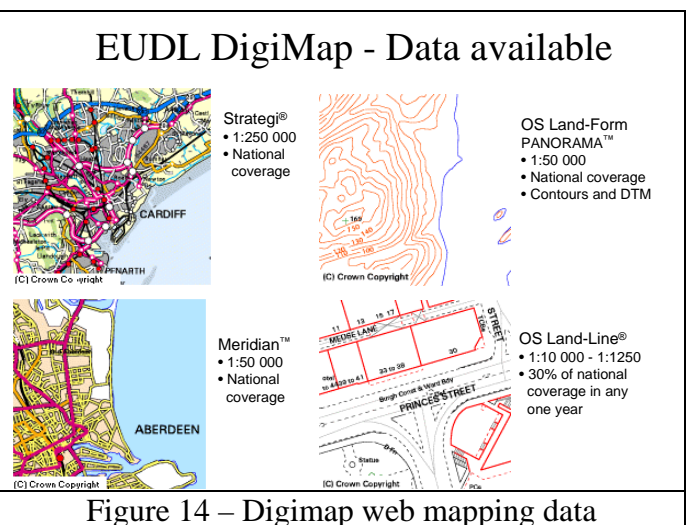


Figure 14 – DigiMap web mapping data

5.4 EDINA Digimap

EDINA Digimap, which is hosted at Edinburgh University Data Library (EUDL), provides on-line access to OS digital mapping (250,000 map sheets worth) for the UK Higher Education Community (Universities and Colleges). The current system is a limited prototype and EDINA is currently re-engineering Digimap to use Laser-Scan Gothic software, for deployment early in 2001. The active object dataset (Figure 14) underlying the new Digimap will be one of the largest continuous map databases in the world and will be an excellent testbed for future access to such information from WHIAs. The continuous dataset and active object representation are key to providing good cartographic quality for demands for arbitrary sized areas of mapping at different scales.

An important capability of the Digimap system is that when the user has browsed and chosen the needed area, scale and content, then the results can be provided in different media forms. In addition to the browser screen, the map (complete with legend and other marginalia) can be downloaded in PostScript or Acrobat (PDF) format for quality printing, or as feature data in common formats (Shape, DGN, MapInfo, NTF) for further analysis in a GIS.

6. INTEROPERABILITY

6.1 OGC Web Mapping

The OpenGIS Consortium (<http://www.opengis.org/>) brings together software suppliers, spatial data suppliers, and major government agencies to define protocols and interfaces for interoperability. In particular, it has defined three APIs (GetCapabilities, GetMap, and GetFeatureInfo), that together allow spatial data from multiple sources to be displayed together in a web browser. These APIs evolved in Web Mapping Testbed 1 (WMT1) and subsequently refined and adopted as the OpenGIS Web Map Server Interface Implementation Specification.

In WMT1, transportation data from a Laser-Scan Gothic object database was combined with satellite imagery, terrain models, flood predictions, and emergency capabilities, in a simulation of a hurricane landfall over Mobile, Alabama (Figures 15,16). Once again, the active object selection and representation of Gothic allowed clear display. In the future, Internet Browsers and WHIAs will be a central way of disseminating such emergency information, and presenting it to the user in a clear manner.

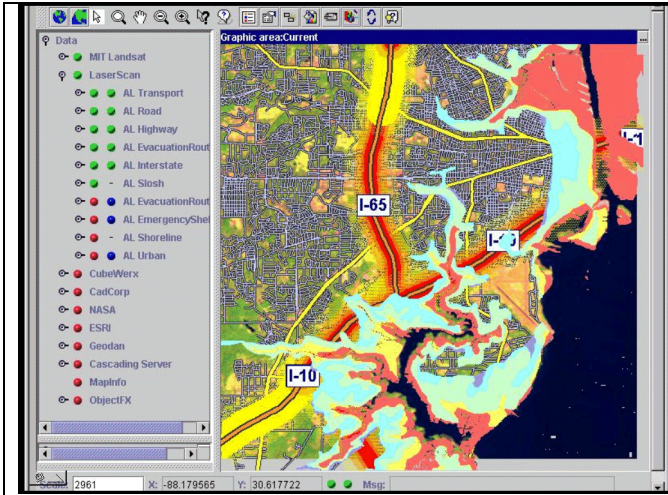


Figure 15 – OGC Web Mapping Testbed - Flood

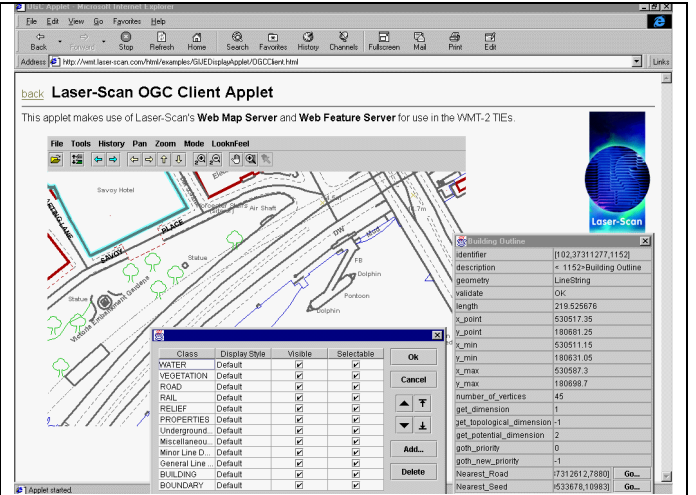


Figure 16 – OGC WMT2 – Feature access

The second round of OGC testbed activity is now under way. Figure 16 shows OSGB data being served from an object database using OGC protocols. WMT2 will be extending the scope of interoperability beyond the original ‘map overlay’ to cover feature retrieval, update access, portrayal of symbology, catalog metadata, and security.

7. MOBILE MAPPING

7.1 WAP maps

The small screen of current WAP phones limits their use for presenting location information graphically, but with intelligent object selection and representation as described in earlier sections of this paper, useful results can be shown. Figures 1 and 17 show a WAP phone displaying information from CamWAP (<http://wap.CamMap.com>), an alternative view of the CamMap web mapping site. CamWAP uses the same active object dataset, but different display methods, to enhance clarity on the low-resolution monochrome screen. An example is the use of automatic text halving (Figure 18) to erase background and clear space for the important text labels. The CamWap implementation builds on research collaboration between Laser-Scan and the Department of Geography at Edinburgh University.

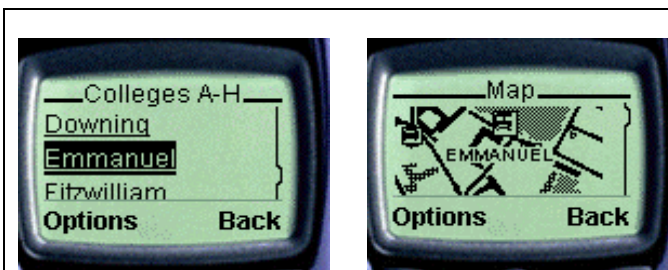


Figure 17 – CamWAP- lookup college to get map

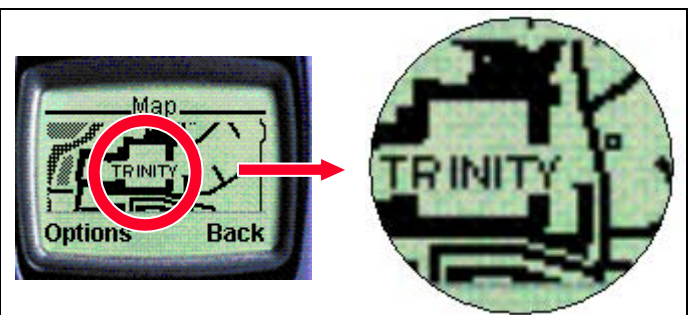


Figure 18 – Text Halo for clarity

8. CONCLUSION

The rise of the Internet has already changed the way that many users access spatial information. No longer is the printed map the primary medium. The union of the mobile phone with the PDA and other new technology will produce the 'WHIA', a Wireless Handheld Information Appliance, providing the 'mobile Internet'. WHIAs will become over the next few years the central medium for information retrieval, particularly location-related information in the form of active maps.

This shift from paper hardcopy to mobile screen softcopy will greatly affect the nature of the cartographic business. Major parts of the knowledge and skill of human cartographers will need to be embedded in real-time generalisation software (using active representation and intelligent spatial feature generalisation) and in pre-prepared generalised 'usages' within digital databases.

Object-Oriented generalisation and software agent techniques provide an exciting new framework for generation of clear derived mapping products from detailed master spatial databases. Active object technology in the information server is crucial to on-demand retrieval and clear presentation of the requisite information in the form of an active map on the Internet browser or WHIA, tailored to the user's current need.

REFERENCES

- CNNfn, 2000, "Nokia extends phone lead", online article at <http://207.25.71.61/2000/02/08/worldbiz/nokia/>, dated 8 Feb 2000.
- Hardy P.G., 1999a, "Map Generalisation - The Laser-Scan Way", on-line paper at <http://www.Laser-Scan.com/papers/lamps2mapgen.htm>
- Hardy P.G., 1999b, "Active Object Techniques for Production of Multiple Map and Geodata Products from a Spatial Database", ICA/ACI Conference Proceedings, August 1999, Ottawa, Canada, or online at <http://www.Laser-Scan.com/papers/ica99gwg/pghica99gwg.htm>
- Hardy P.G. 2000, "Multi-Scale Database Generalisation For Topographic Mapping, Hydrography And Web-Mapping, Using Active Object Techniques", IAPRS, Vol. XXXIII, ISPRS Amsterdam, Netherlands, July 2000, or online at http://www.Laser-Scan.com/papers/isprs2000pgh_1436.pdf
- Lamy, S., Ruas, A., Demazeau, Y., Jackson, M., Mackaness, W.A. and Weibel, R., 1999, "The Application of Agents in Automated Map Generalisation", 19th ICA/ACI Conference, Ottawa, 160-169.
- McMaster, R.B., 1991, "Conceptual Frameworks for Geographical Knowledge" in Buttenfield B.P. and McMaster R.B. "Map Generalisation: Making Rules for Knowledge Representation", Longmans.
- Ormsby, D., and Mackaness, W. A., 1999, "The Development of Phenomenological Generalisation within an Object Oriented Paradigm": Cartography and Geographical Information Systems, v. 26, p. 70-80.
- Ruas A., 2000, "Project AGENT: Overview and Results of a European R&D Project in Map Generalisation", ICA Workshop, Barcelona, Spain.

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