Chapter
6

Benchmarking WebGIS software

WebGIS, a growing market

AS THE WEB becomes more and more accepted in society as a means to disseminate and gather information, also the communication of geographic information over the Web using Webmaps will find its position is the evolving medium. Most major leading GIS companies hooked onto this trend and developed their own WebGIS software packages to put Webmapping applications on the Web, still providing access to the geospatial data behind it.

This research looks into four WebGIS software packages among the various initiatives: Environmental Systems Research Institute (ESRI) ArcView Internet Map Server 1.0, MapInfo MapXtreme 2.0, Autodesk MapGuide 4.0, and Intergraph Geomedia WebMap 3.0. This particular selection covers the four major GIS vendors, both in the field of cartography and geo-engineering. The software has been reviewed before, but not with particular emphasis on their cartographic capabilities.

This chapter draws attention to the cartographic capabilities of these packages following the list of benchmark items set up in the previous chapter. First, this chapter discusses these four software packages in general. This discussion provides an overview of the software as how they fit into the network architecture and serves as a background for the next part of the chapter that describes the proficiency of the software to meet the challenges set by the benchmark items.

ArcView Internet Map Server

Environmental Systems Research Institute Inc. (ESRI) has created several products to enable developing Webmapping applications for the Internet (ESRI, 1999, URL). Whereas for example MapObjects IMS is a stand-alone product, ArcView Internet Map Server (AVIMS) comes as an extension for the desktop GIS software programme ArcView GIS.

To add these Webmapping capabilities to ArcView GIS, an installation wizard guides one through the installation of the several components.

Figure 19. Internet Map Server is an extension to core ArcViewGIS

First, there is the Internet Map Server (IMS) extension itself, that enables ArcView GIS, installed on the development platform, to communicate with a Web server. The second part is the ESRIMap Web server extension and is installed on the Web server platform. It enables the Web server to communicate with one or more ArcView GIS sessions running on one or more development platforms, administer these connections and balance the server load between them. Since the ESRIMap Web server extension is compliant with both ISAPI and NSAPI, AVIMS Webmapping applications can be served from both Microsoft and Netscape Web servers.

Due to its integration with the core ArcView GIS software itself, the cartographic visualisation of the Webmap and the functionality of the Webmapping application in general is determined to a great extent by the capabilities of ArcView GIS. To tackle the vector-raster barrier between GIS and the Web, ESRI takes a server-side approach: it uses vector and raster data for geo-processing, but uses raster images (GIF or JPEG) for display purposes (ESRI, 1997, URL). First, raster images are particularly good for Webmapping applications and for displaying the results of GIS operations: raster maps look more like "real maps" (i.e. paper maps) because of the use of shaded areas and colour tones. Second, ESRI research has shown that by using the highly compressed GIF and JPEG raster graphics file formats for data transmission, transfer can actually be much faster than vector transfer for a given Webmap. By default, AVIMS uses the JPEG format, but GIF support can be provided. Since the GIF compression technology is a patent of Unisys Corporation, a licence must be obtained first from them before ESRI can supply the necessary software for AVIMS.

These Webmaps in the JPEG or GIF format are embedded in the Webmapping application using the MapCafé applet. This Java-based applet provides a ready-built GUI for displaying Webmaps in a standard Web browser. The MapCafé applet is installed on the Web server platform. To customise the MapCafé Java applet for specific user groups, the installation of this extension should be performed in "Custom" mode. Additional directories of resources for customising MapCafé with Java can be thus installed. When users visit the Webmapping application, the applet downloads automatically from the Web server onto the client-side to be interpreted by the Java Vitual Machine (JVM) of the Web browser. Users do not have to install anything on their system before they use the Webmapping application. The Webmaps can therefore be accessed by anyone on any computer platform who is browsing the Web with any Web browser that supports Java.

To publish the ArcView-generated Webmapping application on the Web, the Internet Map Server (IMS) extension is added to the currently running ArcView project by ticking off the box in the "Extension" menu, accessed through the "File" pull-down menu. The AVIMS extension adds three items to the "File" pull-down menu:

- Serve/Stop Serving
- Web page setup…
- Mapcafé setup…

These items are provided in reverse order, because the cartographer's first concern is the interface that serves the Webmap itself: the MapCafé applet. The MapCafé setup dialog box provides the cartographer with a choice to serve the map on the Web as-is using the "Default" option, or the cartographer can choose which components appear in the interface, thus defining the functionality of the Java applet. After this, the overall environment of the Webmapping application is developed using the Web page setup. The dialog box input generates well-documented and clear HTML documents, which are easy to edit. In order to create the Web documents, ArcView IMS needs to have information about the server type: either Microsoft or Netscape. Only then ArcView is able to serve the Webmap to the Web server. After selecting the "Serve" option from the "File" pull down menu, the IP-address of the Web server on which the ESRIMap Web server extension is installed has to be specified. Within the interface of the ArcView GIS application, the project view window changes: the map legend, the "Tale of Contents", disappears, indicating that the ArcView project is in serving mode.

A major drawback is that the implications of the parameter setting in the dialog boxes of the MapCafé setup and of the Web page setup are not dynamically fed back to the author. Not until after publishing on the Web the implications of the specific setting are apparent.

Autodesk MapGuide 4.0

Another WebGIS software package to generate Webmapping applications is Autodesk's MapGuide 4.0. It is a piece of software for Webmap publishing, from simple thematic Webmaps to full-fledged multimedia Webmapping applications. The suite of Autodesk MapGuide consists of the Server, the Author and the Viewer.

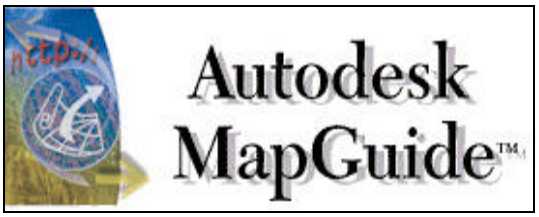

Figure 20. Logo of Autodesk MapGuide

The Server handles requests for maps and data from either the Author or the Viewer. The Author is a piece of software for the creation and publishing of maps according to pre-set display specifications. The Viewer is a plug-in for map display and lets the client perform many actions locally.

Before the Webmapping application is up and running, all geospatial data has to be converted into MapGuide's native SDF (Spatial Data File) format. The installation CD provides an SDF-loader for conversion of all major mapping formats. The latest version supports arbitrary X and Y co-ordinates, whereas in the past versions, de SDF format only supported latitude and longitude co-ordinates. This enables developers to use native reference systems. Then, by means of the Server, the data source directories have to be configured and database access has to be specified.

As this has been taken care of, the intuitive WYSIWYG interface of Autodesk MapGuide Author lets cartographers develop Webmaps in the Map Window File (MWF) format to be incorporated into the Webmapping application. Functions include thematic map symbol settings, customisable pop-up menus, bookmarking and linking. By customising the pop-up menus, cartographers can safe the users from the more difficult GIS functionalities, or they can introduce even more complex functionalities for the more skilled users. The functions of bookmarking and linking exploit the characteristics of the Web to its full extent. Other features of MapGuide Author include the support for transparent black and white raster images and easy access to printer set-up. The former feature facilitates overlay of multiple raster files by turning off the background in the images; the latter helps you customising the map output for printing. Whereas MapGuide Author is the development environment for the Webmaps only, Allaire's ColdFusion 4.0 (which comes with on the installation CD) or ASP can be used as the IDE to create the overall Webmapping application, customised to the client's requirements using server-side applications that generate HTML documents dynamically.

The Viewer is an easy to use, intelligent client-side application, provided as Netscape plug-in, Microsoft ActiveX Control, or as Java applet. Even the technically faint-hearted user feels at ease. Users can control the display of theme layers themselves, customise the Webmap view to their own needs. A new feature is that the users can even control the layer structure and they can even delete layers from the Viewer. They can also create new layers by selection and buffering. This allows users to query and analyse the published data to find an answer to their geographic questions. To store their results they can print maps and make customised reports of the database.

MapInfo Corporation MapXtreme NT version

To provide developers and users with Web documents containing integrated Webmapping capability, MapInfo has developed MapXtreme. Using MapXtreme, users can display Webmaps to visualise geospatial data that would otherwise be lost in the rows and columns of a typical database.

MapXtreme is a tool to create Web documents and to add Webmapping capability to deliver Webmapping applications via the Internet or an Intranet.

Figure 21. MapInfo Corporation MapXtreme

The core of the Webmapping capability is MapX, MapInfo Corporation's mapping component. It is a server-side ActiveX control for Windows 95 and Windows NT that supports ActiveX compatible environments.

Several pieces of software and tools enable a Web application to serve Webmaps. These pieces of software work in conjunction with the current Web server. There are two groups of software that come on the installation CD: development tools and server software. The development tools are used to write and modify application scripts. Development tools include an Internet Development Environment (IDE), e.g. HAHTsite or ASP, MapXtreme example applications, and MapXtreme code libraries. Server tools include the MapX ActiveX control, MapXtreme data, Remote Geocoder, Server Administrator, and Geoset Manager. The Remote Geocoder allows site administrators to geocode the base map locations. The Server Administrator is used to test and change the server configuration after installation. Geoset Manager is a tool to create new Webmaps, so-called "geosets", and to modify existing ones. It allows cartographers to add and remove layers, set zoom levels, set label properties, and alter other layer settings.

Once the MapXtreme script has been created using the development tools, it is placed on the Web server. It will be run when the appropriate request is submitted from the client-side. When the script runs, a call is made to the objects and their methods and properties that provide access to MapX: the map engine. Once the script interacts with the map engine, the map engine returns a raster graphics file that can then be placed on an HTML document and returned to the client-side browser. The map engine can generate various raster graphics file formats. However, Web browsers support only the GIF, JPEG and PNG formats. Since the MapX map engine runs on the server side, the client-side standard Web browsers do not require plug-ins.

Intergraph Geomedia Web Map 3.0

Intergraph's Windows-based GeoMedia Web Map (GWM) enables the dissemination of geographic information, combined from multiple data sources, to be distributed through smart Webmaps over an Intranet or over the Internet (Intergraph, 1999a, URL). The software is designed to serve geographic information to users running Windows and a standard Web browser.

In 1997, Intergraph introduced GWM to publish geospatial data on the Web as a standard extension to traditional GIS applications. Unlike other Web applications at that time, GWM dynamically

Figure 22. Logo of GeoMedia web Map

created Webmaps based on the moment-to-moment state of the GIS database. Providers could distribute real-time data and information. It broke from the traditional standard of delivering a GIF image of the geospatial data. Using technology from a third party (interCAP Graphics Systems, Inc.), GWM creates smart, vector-based maps on the fly, directly from a live, operating GIS database. The Webmaps are in ActiveCGM (ACGM) format. This is a compact and customisable format, suited for delivering vector data over the Internet. Because vectors appear at the client-side of the Web, local intelligence (hyperlinks and animation) and functionality can be created not readily achieved with the more standard raster-based map implementations.

To publish Webmaps with GWM, pre-installed templates help cartographers on their way distributing data to the users. They can customise GWM to fit their unique requirements using standard Web development and authoring tools and development languages such as Java, and Active Server Pages (ASP) to further enhance both the Web server and browser's effectiveness. The preferred implementation of GWM uses Active Server Pages (ASP). Besides this technology, Intergraph uses geographic data server technology to simultaneously access multiple types of databases, combining their data into a single integrated Webmap on request. This ability to handle many different types of geospatial data makes developing specific Webmaps and Webmapping applications easier - especially where heterogeneous external data from commercial and government sources is added to the mix. Central to GWM is its ability to distribute geographic information using Webmaps that contain hyperlinks on vector-based smart features within the Webmap. These hyperlinks are customisable, and permit a variety of interactivity to be applied to the features. Using templates delivered with GWM, developers can create and edit map definition files (MDFs) through the GWM Administrator Module to serve many different end-user needs. The MDF can be used in lieu of ASP code to define the various geospatial data sources from which GWM will publish data as well as the resultant Webmap's cartographic visualisation, content and characteristics.

From the client-side, the Webmapping application can be accessed through standard Web browsers running under Windows 95 or Windows NT. GeoMedia Web Map provides an ACGM plug-in for NC and an ActiveX control for MSIE for interaction with the Webmaps. When users click on a map feature, GWM provides associated information about that feature from the database. Since the Webmaps are re-created every time geographical information is updated on the server, they always view current information. Since these Webmaps are very compact and compressed, they reduce the needed Internet bandwidth and improve the response times. With optional browser-neutral output, GWM provides Webmaps as JPEG images to the entire Web audience, whether or not they are able to accept the Web browser plug-in. However, only those running Windows 95 or Windows NT benefit from the extended client-side functionality.

WebGIS software: an architecture overview

In the previous paragraphs, each of the four WebGIS software packages has been described separately, emphasising the technological aspects behind it. This paragraph on the other hand, presents a coherent picture of the various approaches GIS vendors have taken in developing their own, specific WebGIS software package.

	Server-side		Client-side	
	Web-as development	Web-as/Web server	raster graphics file format	Web browser as plug-in
ArcView Internet Map Server	ArcView avs extension	esriMap Web server extension	JPEG (GIF)	MapCafé Java-applet
Autodesk MapGuide	MapGuide Author	MapGuide Server		MapGuide Viewer
MapXtreme	Geoset Manager	Server Administrator and MapX ActiveX control	JPEG GIF	
GeoMedia Web Map		GWM Administrator	JPEG	ActiveCGM Viewer

Figure 23. WebGIS software: an architecture overview

Whereas ArcView Internet Map Server comes as an extension, integrated into the core ArcView GIS software package, the others are stand-alone software packages, although they

can seamlessly import data from other software packages of the same GIS vendor. For example, Autodesk MapGuide Author is able to import AutoCAD Release 14 DWG and DXF files.

MapXtreme and Autodesk MapGuide follow a distinct tripartite structure: a developer module, a server administrator module and a client-side viewer. ArcView IMS and GeoMedia Web Map on the other hand, have the developer module and the server administrator module closely integrated. This latter structure requires cartographers not only to focus on the cartographic aspects of the Webmapping application, but also on the technical aspects at the same time. The wizards that come with ArcView IMS do not take this requirement too far.

All these WebGIS software packages have to deal with the barrier between vector-oriented GIS and the raster-oriented Web. Each package comes with its own approach. More detail on this topic follows in the next part of this chapter. At this point in discussing WebGIS capabilities, it can be said, that both MapXtreme and ArcView IMS reach the broadest possible audience. The former WebGIS software package takes a server-side approach to generating raster graphics files, whereas the latter uses a Java-applet to display raster graphics Webmaps at the client-side and to interact with it. The two remaining packages on the other hand require users to install a plug-in themselves to be able to treat the point, linear and polygon map features as individual graphic objects.

In the following part of this chapter, a closer look is taken to the capabilities of the various WebGIS software packages. Based on the overview presented in this part, the various steps of disseminating geospatial data to users to communicate and explore geographical information are used as a guiding principle in benchmarking the four WebGIS software packages.

Benchmarking

THE WEBGIS SOFTWARE described in the previous paragraphs have been developed by GIS vendors to generate Webmapping applications. The software each has its own background, its own architecture and its own abilities. To make a decision which software to choose in once own organisational context, specific user requirements have to be derived from a User Requirements Analysis (URA).

The previous chapter described two Webmapping applications from which user requirements were derived. This paragraph looks into how each WebGIS software package is able to satisfy the requirements that were set for the various benchmark tasks. This overview is accompanied by a description of the way the specific certain software package copes with the benchmark item.

Task 1: Handling geospatial data

File formats

Both ArcView Internet Map Server (IMS) and GeoMedia Web Map (GWM) can easily access the geometric data in the ArcView shape files without conversion of the data. To access the geometric data, MapXtreme and Autodesk MapGuide need to convert the data into a proprietory data format. Autodesk MapGuide comes with a conversion module, whereas cartographers have to convert the shape files into a MapXtreme readable data format using third-party software. The GeoTIFF raster file format is supported by all WebGIS software packages. The attribute data stored in an Open Database Connection (ODBC) source can be tied to the geometric data (geo-coded) in all the WebGIS software packages.

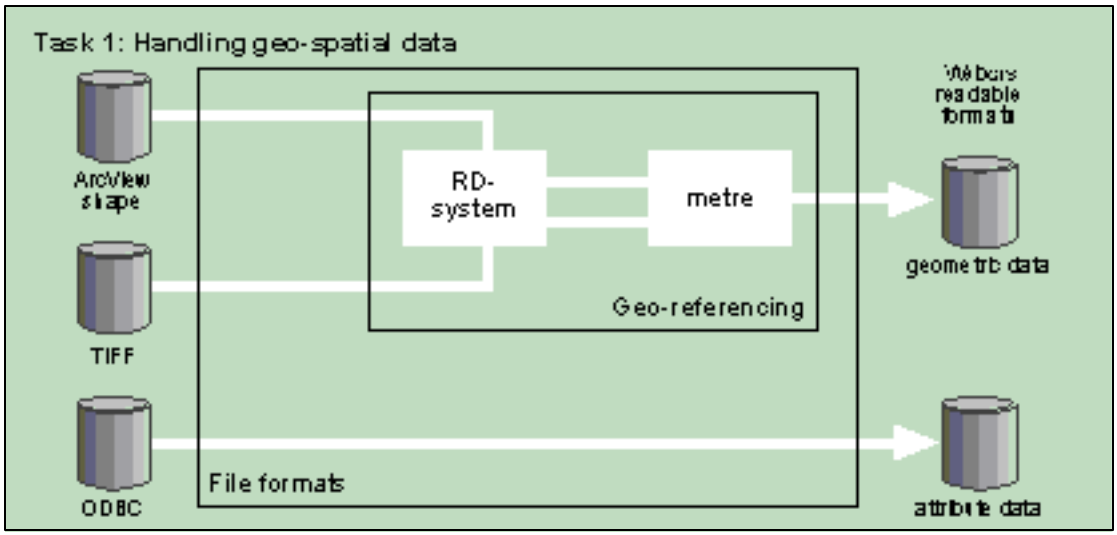

Figure 24. Flow diagram task 1

For georeferencing the geometric data, ArcView does not require input of the reference system. In Autodesk MapGuide's SDF Loader, the reference system is one of the conversion parameters to be supplied to the command-driven programme. The reference system is supplied to GeoMedia Web Map in a separate file. This file has been generated in a separate software programme that is menu-driven. In MapXtreme, the reference system is input in Geoset Manager itself, where cartographers develop the Webmapping application. The Dutch reference system is an option in all WebGIS software packages. Cartographers can set the metre as the unit of measurement as well.

	AVIMS	MapXtreme	MapGuide	GWM
ArcView shape	10	- 10	- 5	10
TIFF	5	5	5	5
ODBC	5	5	5	5
RD-system	5	5	-10	-5
Meter	5	5	5	5
Total	**30**	**10**	**0**	**20**

Task 2: Displaying the topographic map of Overijssel

Municipalities and built-up area: polygon map features

Polygon map features, the built-up areas and the municipalities, can be generated using WebGIS software. To distinguish between the built-up areas and the municipalities, the polygon fill has to be different. The map features representing the municipalities must have a solid fill, the ones represnting the built-up areas must have a hatched fill. All WebGIS software packages are able to assign a solid fill to the polygons of the municipalities. However, the hatched fill can not be generated by all packages. MapXtreme and Autodesk MapGuide allow cartographers to set both the colour of the background fill and of the hatches themselves. In ArcView GIS, the colour settings are assigned to the hatches, not to the background. In GeoMedia Web Map, only solid fills can be assigned. The boundaries of the municipalities can all be assigned a stroke that is different from the continuous line to distinguish them from the linear map features that represent road network.

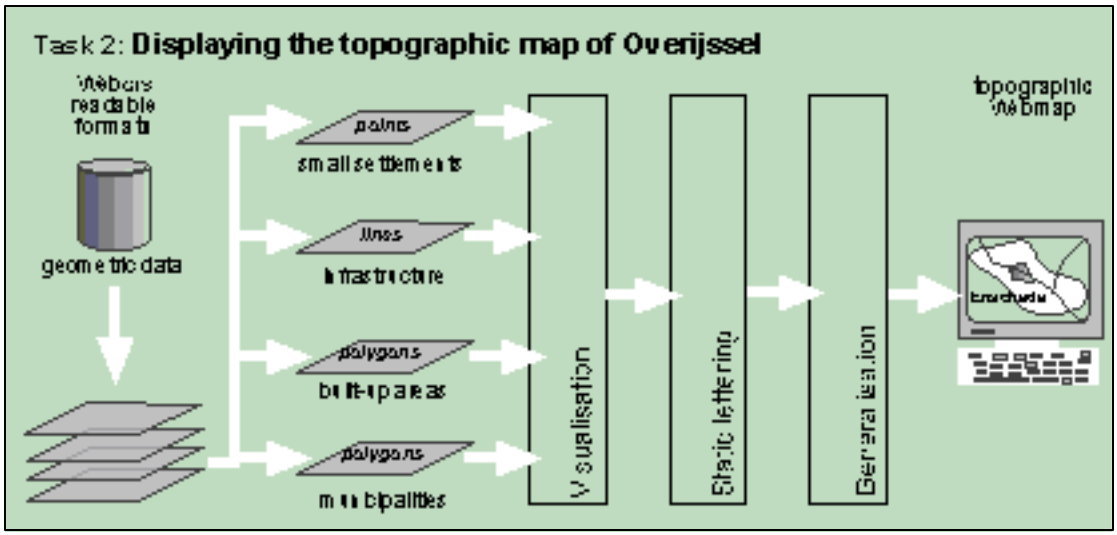

Figure 25. Flow diagram task 2

Colour definition and selection has not been adjusted to the Web in most WebGIS software packages. In ArcView GIS, colours are not even defined in the RGB colour model. Cartographers can select from the 256-colour Windows palette in the other software packages. However, selecting a colour is difficult in MapXtreme, because the colours can only be discriminated based on the colours themselves, whereas Autodesk MapGuide has a number for every colour, so cartographers can be sure they select the right colour. GeoMedia Web Map enables cartographers to select colours from the 256-colour Windows palette. The RGB-values for every colour are passed to the cartographer in the interface. Defining the colours themselves, the RGB colour model can even be extended beyond the 256 colours. None of the WebGIS software packages limits the colour selection to the Web-safe colour palette nor shows its hexadecimal values.

Road network: line map features

Another available ArcView theme contains the road network within the province of Overijssel. There are three different classes of roads: national highways, provincial roads and municipal roads. The WebGIS software packages are able to generate the linear map features that represent the road network. With regard to the form of the lines, GeoMedia Web Map has only few options. Especially Autodesk MapGuide Author provides cartographers with a lot of options to define line forms by means of composite line styles. Both ArcView IMS and MapXtreme have a moderate list of options to choose a line form.

The size of the lines, the stroke width, is best adjusted to the Web as a visualisation environment in GeoMedia Web Map, because cartographers can define the size in pixels. Here, the integration of ArcView IMS with core ArcView GIS is again obvious. The size can be defined in pica points. This is a viable unit of measurement for hardcopy output, but not for publication on the Web. In MapXtreme and Autodesk MapGuide Author, cartographers can define the size of the line, but the unit of measurement is not shown. Whereas Autodesk MapGuide allows cartographers to set the size, in MapXtreme they can chose from a list of 7 options.

Apart from the line size, linear map features can be given a line colour to emphasise the difference in importance between national highways, main thoroughways and secondary roads. Since cartographers cannot define a composite line style in GeoMedia Webmap, the linear map feature can only have one colour. The linear map features generated in MapXtreme and ArcView IMS can have two colours. The cartographers can define one colour; the other colour is part of the line form definition. The ability to generate composite line styles enable cartographers to customise the colours of the linear map features extensively using Autodesk MapGuide.

Smaller settlements: point map features

GeoMedia Web Map (GWM) provides the broadest range of typefaces that can be used to represent point map features. Apart from the TrueType fonts that can be selected in ArcView IMS and MapXtreme, GWM also comes with a set of proprietory fonts from GeoMedia and Microstation. In Autodesk MapGuide Author, type can only be imported via the Clipboard option to paste text strings from the Windows clipboard.

However, GWM cannot represent point map features as images. ArcView IMS and Autodesk MapGuide can import bitmaps without modification. The latter can also import the Enhanced Windows Metafile raster graphics file format. This is also possible in MapXtreme. Although the option is not available in the Geoset Manager, scripting enables cartographers to add raster graphics to the Webmap with further modification, e.g. transparency of particular colours.

Static lettering

There are several map features that require lettering. GeoMedia Web Map does not have functionality for positioning the toponyms with the map features. Autodesk MapGuide Author allows for some control over the positioning of the labels. In MapXtreme's Geoset Manager, cartographers define a fixed position for the label with regard to point and polygon map features. Only ArcView GIS finds the most suitable position itself. Except for GWM, the WebGIS software packages allow control whether to display multiple labels for one geographic object and whether to have overlapping labels.

For the text strings themselves that label the map features with their toponyms, cartographers must first define the typeface. In all WebGIS software packages, the TrueType typefaces of the Windows font library can be chosen, including the serif typefaces. None of them takes into account that serif typefaces are hard to read on screen. Both MapXtreme and ArcView specify type size by means of pica points, whereas the other two take the map unit as the unit of measurement. Only using MaXtreme and Autodesk MapGuide cartographers can put a box around the text to distinguish the text from the other map features. These texts can be given a colour in all the WebGIS software packages. The labels of the map features must not scale with when users zoom in and out. This is possible with all the WebGIS software packages.

Generalisation

Changing scales is not only an issue for displaying lettering. All WebGIS software packages enable cartographers to set the scale dependent visibility of themes. Only in Autodesk MapGuide a different cartographic visualisation for each scale interval. Furthermore, lines can be generalised on conversion with the Douglas-Peucker algorithm.

	AVIMS	MapXtreme	MapGuide	GWM
Solid/hatch fill	5	10	10	- 5
Colour	- 10	- 5	5	10
Stroke	5	5	5	5
Stroke form	5	5	10	- 10
Stroke width	- 5	- 10	5	10
Stroke colour	5	5	10	- 5
Point as type	5	5	- 10	10
Point as bitmap	5	- 5	10	0
Text placement	10	10	5	0
Prevent overlap	5	5	5	0
Prevent repetition	5	5	5	0
typeface	5	5	5	5
Type size	- 10	10	5	5
Type style halo	0	5	5	0
Maintain size	5	5	5	5

Generalisation algorithm	0	0	5	0
Scale-dependent visibility	5	5	5	5
Scale-dependent visualisation	0	0	5	0
Total	**40**	**60**	**95**	**35**

Task 3: Displaying attribute data of Overijssel

Webmapping applications serve not only topographic maps, but thematic maps as well. In the context of this benchmark, the capabilities of WebGIS software packages to generate three different thematic maps are compared. The three map types can be generated with all WebGIS software packages. For GeoMedia Web Map and MapXtreme, a lot of scripting is required using ASP or VBscript. Cartographers have a user-friendly, menu-driven interface in Autodesk MapGuide and ArcView IMS to generate the maps. In Autodesk MapGuide, the proportional symbol maps can be generated using some tricks. Only ArcView IMS enables cartographers to choose a classification scheme.

	AVIMS	MapXtreme	MapGuide	GWM
Classification	10	0	5	0
Chorochromatic map	10	- 5	10	- 5
Choropleth map	10	- 5	10	- 5
Proportional symbol map	10	-5	5	- 5
Total	**40**	**-15**	**30**	**-15**

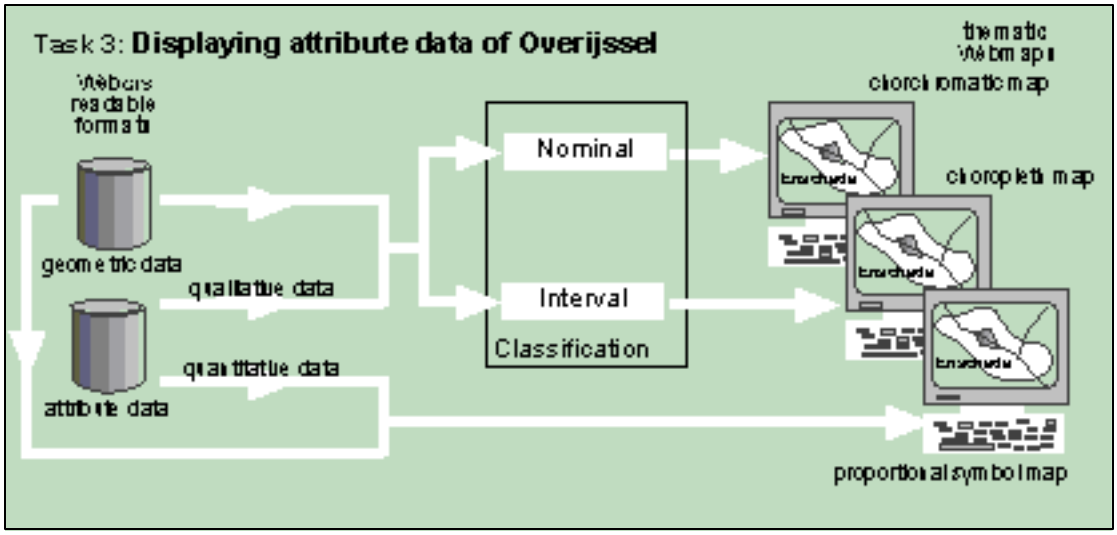

Figure 26. Flow diagram for task 3

Task 4: Output of hardcopy maps

Except for MapXtreme, all WebGIS software packages provide a standard tool to enable users to print the current Webmap view. Users can even customise the Web document that is being printed easily in the default Autodesk MapGuide Viewer.

	AVIMS	MapXtreme	MapGuide	GWM
Hardcopy output	5	- 10	10	5
Total	**5**	**-10**	**10**	**5**

Task 5: Webmapping application interface for communication

A Webmapping application for public visual communication requires the interface of the Web document to be easily displayed in a uniform way on all platforms. Webmaps provide the

main graphical user interface. Their inclusion into the Web document displayed by the Web browser should be as easy as possible.

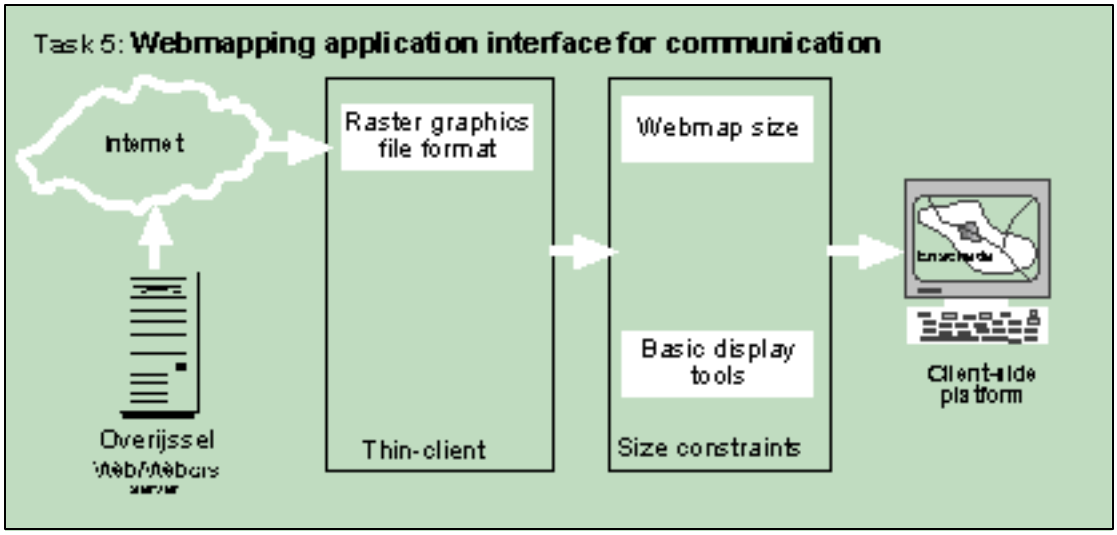

Figure 27. Flow diagram task 5

The GIF raster graphics file format is the default output format for MapXtreme. With some customisation, also ArcView IMS and GeoMedia Webmap output JPEG raster graphics. Having obtained a licence from Unisys, the former WebGIS software can also output GIF raster graphics. Autodesk MapGuide can only be viewed on the Web using a plug-in.

The size of the Webmap can be scripted in ArcView IMS and GeoMedia Web Map in a straightforward matter. MapXtreme also requires scripting, but this is not as transparent as in the former packages.

In the case of AVIMS and MapXtreme, the example applications embedded the basic display tools as a two-step map-based approach. First, users select the basic display tool from the HTML form. Then users click with the mouse pointer on the centre for the next view. After the appropriate server-side processing has been performed, a new Webmap is returned to the client. The example applications that come with GWM have a one-step tool-based approach. The basic display tools are embedded into the Web-document not as HTML form, but as raster graphics. Clicking the icons, the server-side processing is performed for zooming or panning returning the new Webmap. Not clicking on the Webmap, but on the basic display tools changes the Webmap's view.

This one-step tool-based approach taken in GWM, can also be implemented in MapXtreme-generated Webmapping applications. The example applications developed that come with MapXtreme allow users to pan around the Webmap by re-centring. After selecting the re-centre tool from the HTML form, clicking anywhere in the Webmap re-centres the Webmap on the point where the mouse pointer clicked on the Webmap, maintaining the dimensions. Customising the ASP scripts, MapXtreme generates a Webmapping application with one-step tool-based panning (see for example Insite, URL).

	AVIMS	MapXtreme	MapGuide	GWM
Raster graphics file format	- 5	10	0	- 5
Webmap size	5	- 5	0	5
Basic display tools	5	5	0	10
Total	**5**	**10**	**0**	**10**

Task 6: Transferring geographical knowledge

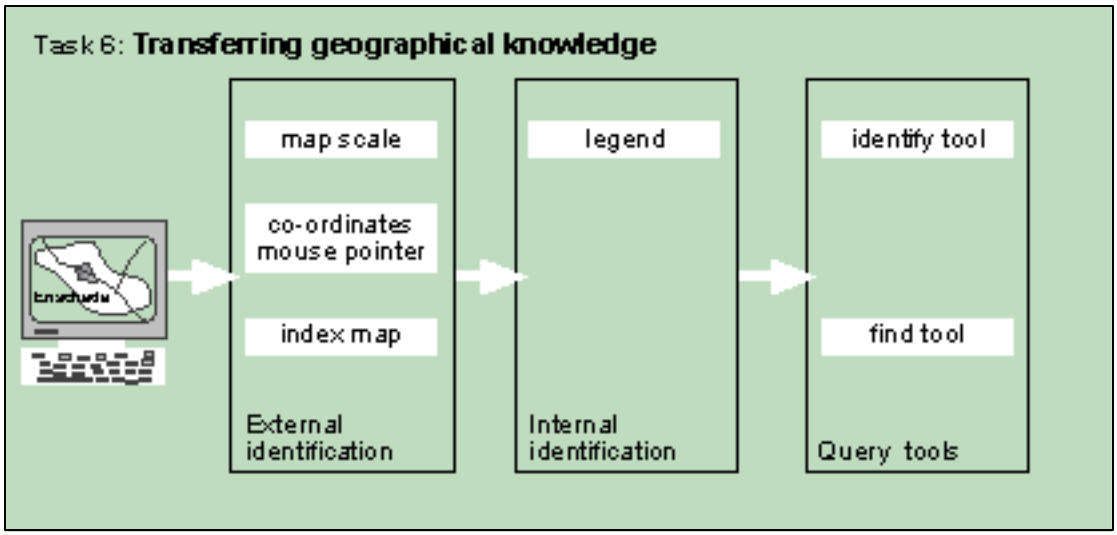

Figure 28. Flow diagram task 6

External identification: scale, co-ordinates, and index map

The WebGIS software packages do not pay much attention to the tools for navigation and orientation with regard to the external identification. Only GeoMedia Webmap comes with a scale bar. In MapXtreme generated Webmapping applications, the users are informed on the scale of the Webmap by means of its width measured in the number of map units. In ArcView IMS, no means are provided to indicate the scale, when developing a Webmapping application for a thin client. The co-ordinates of the mouse pointer's location cannot be derived from the interface directly, but since MapXtreme and ArcView IMS enable users to click on the Webmap, the image location can be converted into map co-ordinates. Only ArcView IMS shows a Webmapping application that comes with an index map.

Internal identification: the map legend

All three WebGIS software packages that can generate a thin-client Webmapping application do not have a straightforward means to generate the map legend as part of the interface automatically. MapXtreme provides the best option to implement this orientation and navigation tool.

Query tools

Two query tools have to be included into the Webmapping application for public visual communication. First, there is the tool to find a particular location in the geospatial database. As the Webmap only displays a small part of the extensive geospatial database behind it, the basic display tools take too long for users to change the view of the Webmap to see a particular location.

Implementing simple query tools in Webmapping applications for public visual communication is not generated by default in the WebGIS software packages. The example application that comes with MapXtreme gives cartographers the most insight in developing these tools. The lack of clickable features in GWM makes the software unsuitable to develop an identification tool. Both MapXtreme and ArcView IMS do have clickable map features. Users can click on these map features to derive information that is stored in the geospatial database behind the Webmap.

	AVIMS	MapXtreme	MapGuide	GWM
Map scale	0	- 5	0	5
Co-ordinates mouse pointer	5	5	0	0
Index map	10	0	0	0

Legend	5	10	0	0
Find tool	5	10	0	5
Identify tool	5	5	0	0
Total	**30**	**25**	**0**	**10**

Task 7: Webmapping application interface for exploration

Plug-ins

Three of the four WebGIS software packages use either a Java applet or a plug-in/ActiveX control to extend the capabilities at the client-side. Only MapXtreme takes a server-side approach and generates JPEG/GIF graphics at the Web server after each request from the client for a change of the Webmap's view. This approach does not facilitate rapid interaction, making MapXtreme an inappropriate WebGIS software package to develop Webmapping applications for private visual thinking. The Java-applet generated by ArcView IMS puts some more processing on the client-side. Only GeoMedia Web Map and Autodesk Map Guide provide a plug-in or ActiveX control to extend the client-side capabilities permanently. Users have to install this extension only once on their platform and then they can use the extra tools smoothly.

Webmap size

Geomedia Web Map is the only WebGIS software package that by default enables cartographers to directly specify the size of the Webmap itself. Since the ACGM plug-in or ActiveX control only contains the Webmap, its size is defined by the values assigned to the attributes of the HTML tags that embed these in a Web document.

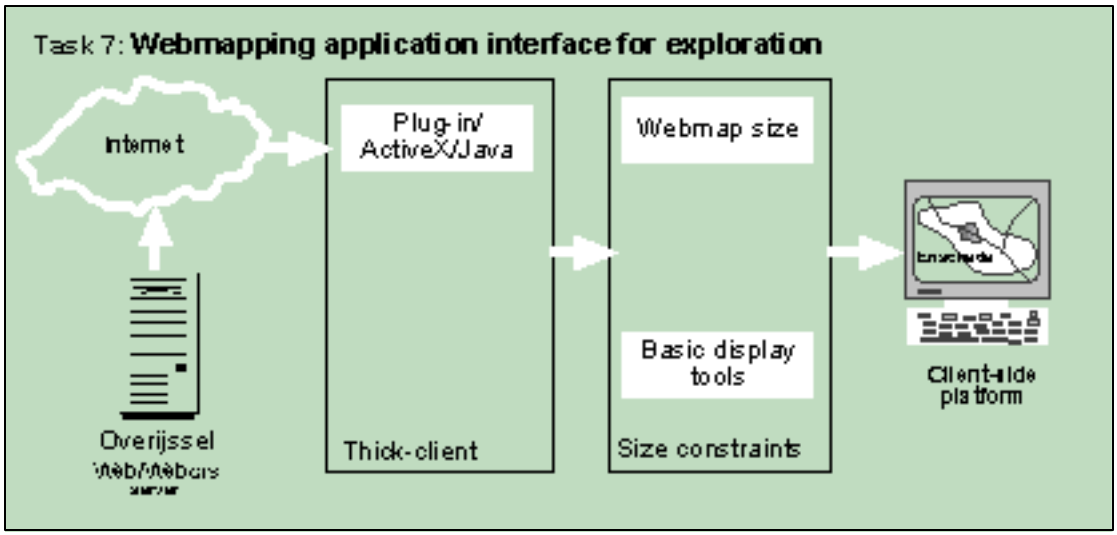

Figure 29. Flow diagram of task 7

Basic display tools

Only Autodesk MapGuide and GeoMedia Web Map provide the basic display tools as part of a pop-up menu so users can control their availability themselves. In the MapCafé applet of ArcView IMS these tools are provided permanently as defined by the cartographer at the server-side. Additional scripting would be necessary to implement the basic display tools as client-side controlled tools in MapCafé.

	AVIMS	MapXtreme	MapGuide	GWM
Plug-in	-5	0	10	5
Webmap size	5	0	5	5
Basic display tools	5	0	10	10
Total	**5**	**0**	**25**	**20**

Task 8: Background information: available on demand

External identification: scale, co-ordinates, and index map

The orientation and navigation tools come as standard tools in the MapCafé applet and Autodesk MapGuide Viewer. The former software apckage provides a scale bar, whereas the latter provides a nummerical notation of the scale of display. GeoMedia Web Map requires even addtional scripting and pogramming to implement this tool in the interface of the Webmapping application. In Autodesk MapGuide Viewer, users can even control in which reference system the co-odinates of the mouse-pointer's location are displayed. For this tool, GeoMedia Web Map requires again scripting and programming, but it is the only software package that comes with a solution for users to see more detail of the Webmap without losing their bearings: the magnifying glass. Nevertheless, an index map can be developed easily with ArcView IMS and Autodesk MapGuide, but no clues are provided with the software.

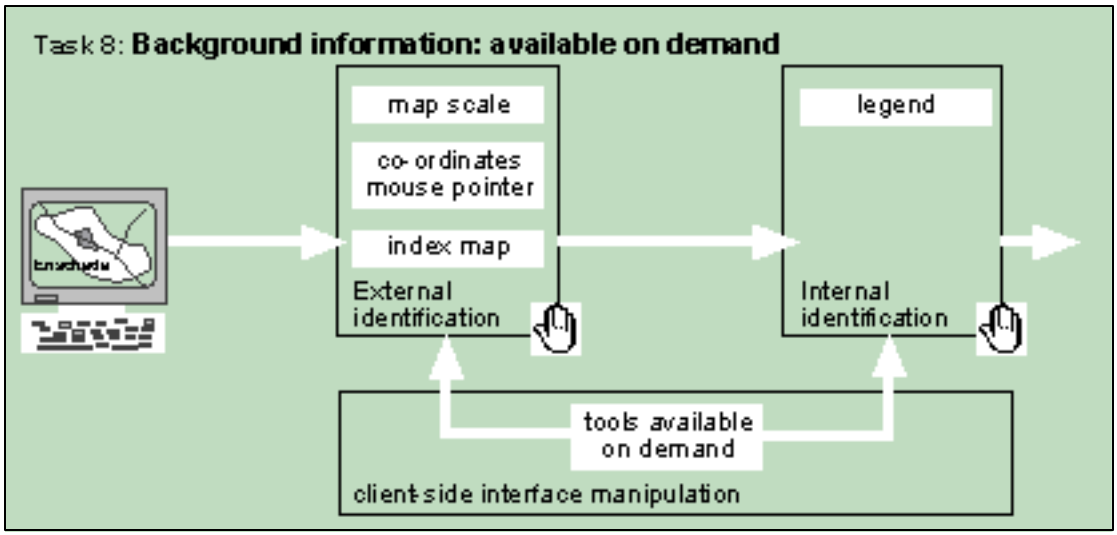

Figure 30. Flow diagram of task 8

Available on demand

Using Autodesk MapGuide, cartographers have an easily customisable client-side application that enables users to control the display of interface elements. The MapCafé Java applet can also be customised, but this is more difficult. To give users control over the interface of a Webmapping application developed with GeoMedia Web Map, cartographers have an even more difficult task.

Internal identification: the map legend

To include a map legend into the Webmapping application can best be implemented with Autodesk MapGuide, because this software allows users to have optimum control. A smaller degree of interaction is possible with ArcView IMS MapCafé, because users cannot resize the map legend. They can only control whether to hide or display the map legend. GeoMedia Web Map does not generate a map legend automaically. This would require some scripting and programming. User-control can be implemented using HTML-forms.

	AVIMS	MapXtreme	MapGuide	GWM
Map scale	10	0	5	-5
Co-ordinates mouse pointer	5	0	10	-10
Index map	- 5	0	- 5	5
Available on demand	- 5	0	5	5
Legend	5	0	5	- 5
Legend display	5	0	10	- 5
Total	**15**	**0**	**30**	**-15**

Task 9: Webmap theme control

Both the ArcView IMS MapCafé Setup dialog windows and Autodesk MapGuide Author automatically generate a map legend with the Webmap to embed into the Webmapping application based on the themes that are included into the Webmap. Cartographers can specify whether to include themes into the map legend or not. Check boxes in front of the theme labels in the map legend enable users to control whether to display a theme in the Webmap by ticking the corresponding checkbox. If the Webmap displays a thematic map, the classes for that theme appear below the theme's name in the legend. In Autodesk MapGuide Viewer users can choose whether to display the names of these classes in the legend by expanding the list or compressing it. When the list is compressed, the classes are still active on the Webmap.

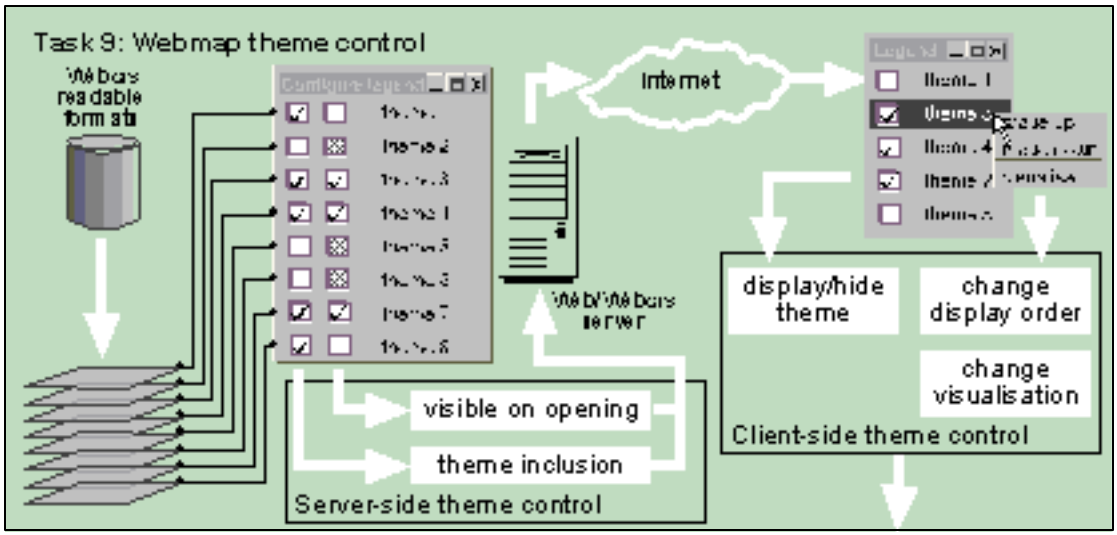

Figure 31. Flow diagram task 9

Since users can control the display of themes in the Webmap, cartographers can specify which themes are displayed in the Webmap by default when users log onto an Autodesk MapGuide-generated Webmapping application (Autodesk, 1998, p.88). The default MapCafé interface immediately displays all themes that are visible at the display scale at which the Webmapping application is logged onto first. However, cartographers can customise the MapCafé applet. In the case of displaying a thematic map, cartographers can specify whether each class should be listed separately in the legend or whether all classes should be compressed into a single line (Autodesk, 1998, p.110).

Whereas ArcView IMS and Autodesk MapGuide allow users to customise the display of themes in the Webmap through the map legend, GeoMedia Web Map provides this client-side control through an HTML form. Check box controls are included to hide and display each theme. Extending this script would allow users to change the order of the themes in the Webmap as well.

Changing the order in which the themes display on the Webmap is not enabled by default in the legend that is generated by ArcView IMS, nor can users change the cartographic visualisation in ArcView IMS generated Webmapping applications by default. However, this tool can be made available by customising MapCafé using Avenue. In Autodesk MapGuide, cartographers can easily specify on the Security tab of the Map Layer Properties window whether users can access the Webmap layer set-up. This allows users to change the order of display of themes and users can customise the cartographic visualisation.

	AVIMS	MapXtreme	MapGuide	GWM
Theme inclusion	10	0	10	- 5

Display/hide theme	5	0	10	- 5
Theme visible on opening	- 5	0	5	0
Change display order	- 5	0	5	- 5
Change visualisation	0	0	10	0
Total	**5**	**0**	**40**	**-15**

Task 10: Information on single map features

Dynamic lettering

Dynamic lettering enables users to find their way around the Webmap easily, without the labels obstructing the display of other map features and cluttering the Webmap. Users get information about their location on the Webmap and about the map feature they are viewing at will.

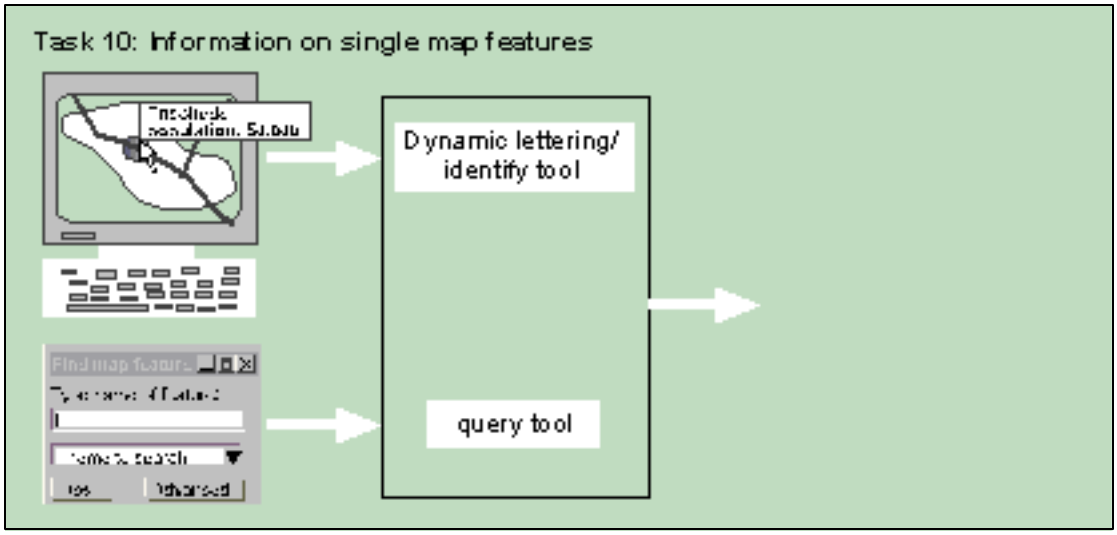

Figure 32. Flow diagram task 10

In ArcView IMS, dynamic lettering by moving the mouse pointer over a map feature is not possible. However, the Identify tool lets users get attribute information about the feature they click on. To incorporate dynamic lettering in Webmapping applications generated by Autodesk MapGuide and GWM, cartographers can define a text that displays at the mouse pointer's location when it is over a map feature. The status bar of Autodesk MapGuide Viewer also displays information about individual map features. Pointing with the mouse to a map feature, the status bar displays the feature's theme and name.

A drawback of the approach to dynamic lettering is the positioning of the label at the location of the tool tip. Sometimes this results in the placement of lettering near or in the wrong map features, because the mouse pointer moved further over the Webmap while at the same time the tool tip was generated on the server-side. A solution would be to have a fixed position for the placement of the toponyms when moving over the map feature according to cartographic theory to ensure correct association (Keates, 1989, p.49-58; Kadmon, 1992).

Querying map features

To find a particular map feature on the Webmap, both ArcView IMS and Autodesk MapGuide provide a query button in the interface. The users themselves can manipulate its inclusion into the interface only in the Autodesk MapGuide Viewer, not in the MapCafé applet. Despite GWM's plug-in approach extending the client-side capabilities, the pop-up window that can be accessed when viewing ACGM Webmaps has no query tool. Cartographers have to do extensive VBScript and ASP scripting, combined with HTML forms to add a query tool.

	AVIMS	MapXtreme	MapGuide	GWM
Dynamic lettering/identify tool	- 5	0	5	- 10
Query tool	-5	0	10	-5
Total	**-10**	**0**	**15**	**-15**

Task 11: Geometric map comparison

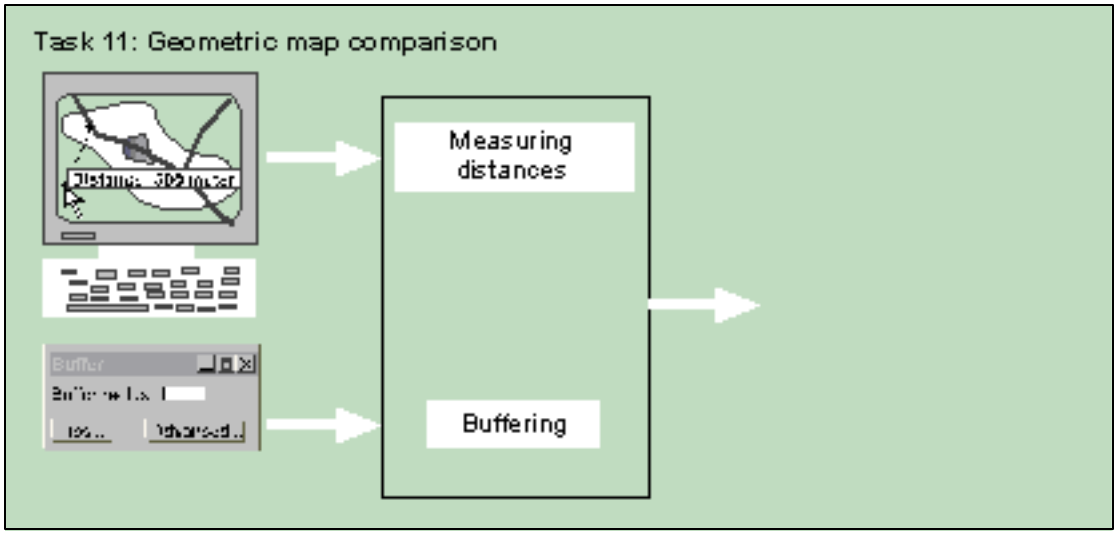

Figure 33. Flow diagram task 11

Measuring distances between map features

In Autodesk MapGuide, a measuring tool comes as a standard functionality of the Viewer pop-up menu. This is not the case for ArcView IMS and GWM. For these WebGIS software packages, cartographers need to customise the Webmapping application that is generated by default to add this tool.

Buffering

Cartographers can implement a buffering tool in a Webmapping application best using Autodesk MapGuide. In its Viewer pop-up menu the buffering tool comes as a standard option. No additional programming or scripting is required. The dialog window that opens after selecting the menu option allows users to specify not only the input parameters for the buffer operation, but also the cartographic visualisation of the buffer that displays on the Webmap. Whereas Autodesk MapGuide generates this tool by default, a lot of customisation is necessary to add this tool to ArcView IMS and GWM.

	AVIMS	MapXtreme	MapGuide	GWM
Measuring distances	- 10	0	10	5
Buffering	- 10	0	10	5
Total	**-20**	**0**	**20**	**10**

Task 12: Integrating the Web

Hyperlinks

The three WebGIS software packages suitable for thick-client implementation can all add hyperlinks to map features in the Webmap. The Web document that is referred to displays in a frame on the original Web page or in a separate Web browser window. The URLs are derived from the ODBC data source

Clickability

The hyperlink tool as an integral tool of the Webmapping application can only be implemented in Autodesk MapGuide and GWM. These WebGIS software packages serve clickable map features at all times, whereas ArcView IMS only allows users to hyperlink after selecting the Hyperlink tool. Even then, there is no visual cue that tells users whether map features are clickable. In both Autodesk MapGuide Viewer and GWM, the mouse pointer changes from an arrow to a hand if the map feature under the mouse pointer is linked to a Web document. Cartographers can specify a "hotspot-symbology" GWM Administrator. When the mouse-pointer moves over a clickable map feature in an ACGM Webmap, the cartographic visualisation changes dynamically to indicate its clickability.

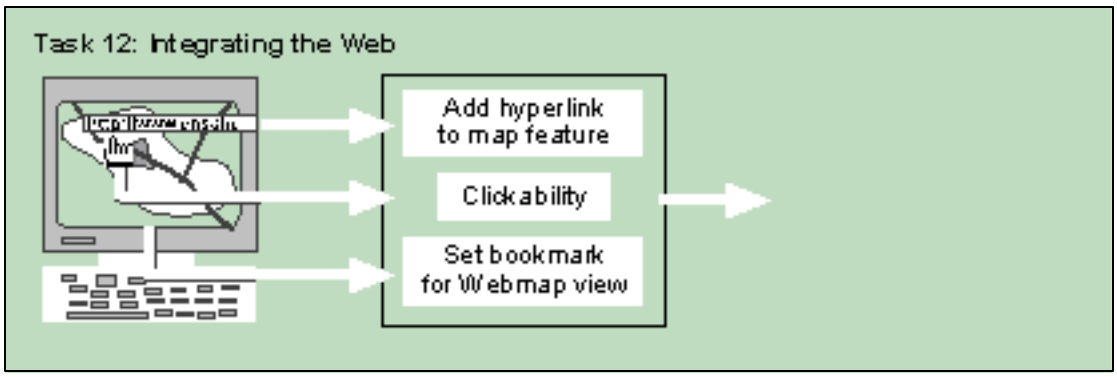

Figure 34. Flow diagram task 12

Bookmarking

Bookmarking of a specific Webmap view is not possible in the MapCafé applet, nor in a ACGM Webmap. However, in GWM it is possible to hyperlink to a specific Webmap from another Web document. Autodesk MapGuide Viewer is the only client-side WebGIS plug-in that enables users to easily add bookmarks to save a specific view of the Webmap.

	AVIMS	MapXtreme	MapGuide	GWM
Add hyperlink	5	0	5	5
Clickability	- 10	0	5	10
Bookmarking	- 5	0	10	- 5
Total	**-10**	**0**	**20**	**10**

Benchmarked

In the previous paragraphs, the three different aspects of WebGIS software have been tested. The software packages have been tested for their ability to access different geospatial data sources and to produce both softcopy and hardcopy maps based on geospatial data. Other aspects that have been tested were the abilities of the WebGIS software packages to generate Webmapping applications to disseminate the geospatial data visually over the Web customised for a specific map use goal. These aspects were subdivided into smaller tasks. The software packages have been tested for all these tasks. Based in their performance they were given a rating. In the next chapter, these ratings will be discussed. This discussion will provide a foundation for the conclusions and recommendations.

Chapter 7

Conclusions and recommendations

Cartography and the Web

IN TODAY'S SOCIETY, information plays an important role. The evolution of the Internet and the World Wide Web contribute to the disclosure and dissemination of this information to the public. New means of communicating the information have to be developed to ensure a correct interpretation of the information by the receiver, exploiting the visual characteristics of the Web. If the information is of geographical nature, cartographers play an important role in this process. Over time they have developed an enormous knowledge on how to communicate geographical information in a graphical way.

The role of cartographers becomes more and more important in the context of Geospatial Data Infrastructures (GDI). Webmaps are the main interface between the users and these GDIs, because these are generated based on the geographical information stored in geospatial databases. WebGIS software provides the technology to generate these Webmaps. In this thesis, the cartographic aspects of this software have been studied to establish a foundation for deciding which WebGIS software is most suitable to generate a specific Webmapping application.

For cartography, the Web is a visualisation environment in itself, different from paper maps and on-screen maps production. An important factor in evaluating the WebGIS software packages has been the ability to deal with the characteristics of the Web in so far as these influence the cartographic design when developing Webmapping applications. The mapping constraints, e.g. the technical limitations and scale of map display, have structured the discussion of these characteristics. First, the attention has been focused on the general characteristics of the Web, because most mapping constraints can be attributed to the client/server architecture of the Web as it puts severe constraints on the Webmap and its functionality. Later the emphasis turned towards the specific user characteristics that play an important role for cartography on the Web to establish specific requirements for cartographic visualisation for the different Webmap use goals: visualisation strategies. These visualisation strategies provided additional requirements for designing the benchmark.

Benchmarking WebGIS software

THE CONTEXT FOR benchmarking the WebGIS software packages is the regional government for the province of Overijssel in the Netherlands. Another source of input for benchmark requirements is the literature review about cartography and the Internet.

Two different requirements for Webmapping applications have been distinguished. First, the officials themselves have to analyse and explore geospatial data over an Intranet (private visual thinking). Second, the office needs to communicate geographic information to the general public over the Internet (public visual communication). These requirements define specific Webmap use goals, each requiring a particular visualisation strategy. In this thesis,

three different aspects of the WebGIS software packages have been tested, the ability to access the available geospatial datasets and to produce softcopy and hardcopy maps, and the ability to generate Webmapping applications for the two Webmap use goals.

The various WebGIS software packages that have been benchmarked all have their specific approach towards developing Webmapping applications. Two approaches have become apparent during the benchmark. There is a deconstuctivist approach and a constructivist approach. Both ArcView IMS and Autodesk MapGuide take a deconstructivist approach. They provide developers with the full interface by default. This interface can be deconstructed into smaller pieces for customisation. The other two WebGIS software packages take a constructivist approach. They provide developers with all the small parts. Developers combine these small parts to construct a Webmapping application. From the start, the resulting Webmapping application will be a customised product.

To arrive at a robust cartographic design of the Webmapping applications, cartographers must be well aware of the special characteristics of the Web. The WebGIS software hardly provides cartographers with guidance in this matter. For the most part, these packages enable GIS applications to be ported to the Web, without recognising the special characteristics of the Web as a visualisation environment for cartography.

The dichotomy mentioned previously is also apparent in benchmarking the WebGIS software packages on their performance in accessing and outputting geospatial data (task 1 through 4). In total, the scores of ArcView IMS and Autodesk MapGuide for these tasks are higher than the scores of MapXtreme and GeoMedia Web Map. Despite the sophisticated geographic server technology of GWM and MapXtreme's cartographic origin, both ArcView IMS and Autodesk MapGuide have higher scores, because they perform better in generating topographic and thematic Webmaps from the available geospatial datasets. These software packages provide a user-friendly, interactive development environment (IDE). Especially Autodesk MapGuide provides nice features.

For developing Webmapping applications targeted at as wide an audience as possible, both ArcView IMS and MapXtreme provide the best options. Although GeoMedia Web Map is able to generate raster graphics Webmaps as well, it does not perform sufficiently with respect to human-map interaction. Even the thin-client option of ArcView IMS scores higher, although it is a stripped off version of its full-fledged MapCafé Java applet implementation. Autodesk MapGuide must not be considered, because it requires users to install a plug-in, which cannot be expected from them.

The scores of the WebGIS software packages with regard to their performance in generating Webmapping applications for private visual thinking are varying more. This is obvious, because the software packages have to perform more tasks than is the case for public visual communication. This introduces more degrees of freedom in the scores.

MapXtreme certainly must be avoided for implementing a Webmapping application that entails a lot of geo-processing for analysis and exploration of the geospatial data as is the case for private visual thinking. This software package generates new raster graphics Webmap views only on the server-side. The MapCafé applet interface element generated by ArcView IMS scores only for the most elementary tasks. Therefore, ArcView IMS is an option if not too much sophistication is required, for the default generated Java applet does not perform well beyond what is expected from a Webmapping application for public visual communication.

Due to their plug-in implementation, both Autodesk MapGuide and GeoMedia Web Map take a map feature-oriented approach, instead of a graphic-oriented approach towards Webmap generation. This is especially suitable for Webmapping applications for private visual thinking. Autodesk Mapguide's scores indicate firmly in this direction, but GWM fails in this

respect. The scores of this WebGIS software package suffer from the disadvantage that GWM requires a lot of programming and customisation of the available templates before the Webmapping application suits the requirements of the users. Whereas Autodesk Mapguide has been able to free itself from its origin in computer-aided design, GWM still sticks with its background of large-scale mapping, providing for only few cartographic visualisation requirements.

Discussion and future

This thesis has treated various aspects important for developing Webmapping applications using commercially available WebGIS software packages. The characteristics of the Web in general and as a visualisation environment for cartography have been discussed. Furthermore, the attention was drawn to Webmaps and the users of the Webmapping applications. These elements founded a basis for evaluating the WebGIS software packages. The findings of the evaluation have been discussed in the previous paragraphs.

At this point, it must be stressed that the findings should only be interpreted in the context described in this thesis. The scores of the WebGIS software packages should therefore not be taken as a strict verdict of their performance in general. To increase the relevancy of the research presented in this thesis it should have been better to take a real-life work environment as a context for the benchmark. Furthermore, more care should be taken in assigning the scores to the performance of the WebGIS software packages. This would result in more viable outcomes. Finally, the pace of developments in both Web technologies in general and WebGIS software packages in particular is so fast, that the cartographic visualisation requirements will change continuously. Future research in the area of cartographic aspects of WebGIS software packages should take these observations certainly into account.

Coming versions of WebGIS software packages must adapt their functionality to the specific characteristics of the Web. The interactive development environment of the software must assist cartographers in developing robust Webmapping applications, because the developments in Web technology follow each other so fast, that cartographers cannot keep up with them. However, these same developments will in the future enable map feature-oriented Webmapping applications to be easily available through Web browsers without the need for plug-ins.

People will be more and more become Web-savvy. The interface of the Webmapping applications will therefore have to change accordingly. On the one hand, the basic display tools can be removed from the interface to free space for more sophisticated interaction tools. On the other hand, Webmapping applications will become more and more available to users, without them actually realising this. Although there is WebGIS software running behind the scenes, the interface of the Web application does not show a map at all.

To maintain its important role in disseminating geographical information in a visual form, cartography must extend its activities to the Web as well. This thesis has shown that WebGIS software is a promising enabling technology to publish maps and the geospatial data behind it on the Web. For WebGIS-generated Webmapping applications to be effective and user-friendly, cartographic visualisation strategies must be considered when developing them, because Webmaps make up an important part of the Webmapping application interface.