# Appendix A: Abbreviations and acronyms

| | |
|---|---|
| ACGM | Active CGM |
| ADO | ActiveX Data Objects |
| API | Application Programming Interface |
| ARPA | Advanced Research Projects Agency (a.k.a. DARPA) |
| ARPANET | Advanced Research Projects Agency Network |
| ASP | Active Server Pages |
| AVIMS | ArcView Internet Map Server |
| CBS | Centraal Bureau voor de Statistiek (Central Bureau of Statistics in the Netherlands) |
| CD | Compact Disk |
| CERN | European Laboratory for Particle Physics |
| CGI | Common Gateway Interface |
| CGM | Computer Graphics Metafile |
| CLUT | Colour Look Up Table |
| CMDF | Compiled Map Definition File |
| CSF | Coordinate System File |
| CSS | Cascading Style Sheets |
| DARPA | Defense Advanced Research Projects Agency (a.k.a. ARPA) |
| DB | DataBase |
| DBF | DBASE file |
| DGI | Distributed Geographic Information |
| DHTML | Dynamic HyperText Markup Language |
| DNS | Domain Name Server |
| EMF | Enhanced Windows Meta file |
| ESRI | Environmental Systems Research Institute |
| FRAMME | Facilities Rulebase Application Model Management Environment |
| FSM | GeoMedia Font SyMbol |
| FTP | File Transfer Protocol |
| GDI | Geospatial Data Infrastructure |
| GIF | Graphics Interchange Format |
| GIS | Geographic Information System |
| GPS | Global Positioning System |
| GUI | Graphic User Interface |
| GWM | GeoMedia Web Map |
| HSV | Hue Saturation Value |
| HTML | HyperText Markup Language |
| HTTP | HyperText Transfer Protocol |
| IDE | Internet Development Environment |
| IIS | Microsoft Internet Information Server |
| IMS | Internet Map Server |
| IP | Internet Protocol |
| ISAPI | Internet Server Application Programming Interface |
| ITC | International Institute of Aerospace Survey and Earth Sciences (formerly known as International Training Centre = ITC) |
| JPEG | Joint Photographic Experts Group |
| JPG | Joint Photographic Experts Group |
| JVM | Java Virtual Machine |
| MDF | Map Definition Files |
| MGE | Modular GIS Environment |
| MMC | Microsoft Management Console |

| | |
|---|---|
| MSIE | Microsoft Internet Explorer |
| MWF | Map Window File |
| NC | Netscape Communicator |
| NCSA | National Center for Supercomputing Application |
| NSAPI | Netscape Server Application Programming Interface |
| OCX | OLE Custom Control (see OLE) |
| ODBC | Open DataBase Connectivity |
| OGC | OpenGIS Consortium |
| OLE | Object Linking and Embedding |
| OS | Operating System |
| PC | Personal Computer |
| PWS | Personal Web Server |
| RDS | Remote Data Service |
| RSC | MicroStation ReSourCe |
| SDF | Spatial Data File |
| SGML | Standard Generalised Markup Language |
| SHP | (ArcView) Shape |
| SMB | (Autodesk MapGuide) SyMBol |
| SMTP | Simple Mail Transfer Protocol |
| SP | Service Pack |
| SQL | Structured Query Language |
| TCP/IP | Transmission Control Protocol/Internet Protocol |
| TFW | Tagged Image File Format World |
| TIFF | Tagged Image File Format |
| URA | User Requirements Analysis |
| URL | Uniform Resource Locator |
| USA | United States of America |
| VRML | Virtual Reality Modelling Language |
| W3 | World Wide Web |
| WebGIS | Web-enabled Geographic Information System |
| WMF | Windows Meta File |
| WWW | World Wide Web |
| WYSIWYG | What You See Is What You Get |
| XML | Extensible Markup Language |

# Appendix B: WebGIS - technical details

## Task 1: Handling geospatial data

The geospatial datasets about the province of Overijssel are available as ArcView themes. Since ESRI's WebGIS software package, ArcView Internet Map Server (IMS), is a plug-in for ArcView, it natively supports the SHP file format. Its Webmapping capabilities are fully integrated with core ArcView GIS.

Intergraph's Geomedia Web Map (GWM) has an elegant solution to handle foreign geospatial data formats. Its data server technology enables GWM to simultaneously access multiple heterogeneous geospatial databases without conversion of the data to a proprietary data format. The standard GWM versions supports Intergraph data formats only. To access ArcView the data formats, there is a comprehensive data formats version of GWM.

Whereas GWM allows access to foreign file formats using data server technology, Autodesk MapGuide and MapXtreme require geospatial data to be in a native file format. MapXtreme imports each theme into MapXtreme Geoset Manager. A "geoset" is the set of themes that makes up the Webmap ("project" in ArcView GIS). MapXtreme Geoset Manager only imports MapInfo Table files. Autodesk MapGuide Author only supports the SDF (Spatial Data File) format. Whereas MapXtreme does not

have a conversion module, Autodesk MapGuide provides an SDF-Loader for conversion of all major mapping formats on the installation CD-ROM. This programme is command-line driven, scaring off some developers.

To incorporate the forest areas in Overijssel into the Webmapping application, the WebGIS software must be able to handle the TIFF raster graphics file format. In order to display TIFF images in ArcView GIS, it is necessary to convert the image co-ordinates to real-world co-ordinates. This transformation information is typically stored with the image, but can be stored in a separate ASCII format world file. Geo-referenced GeoTIFF is supported with core ArcView GIS. The other WebGIS software packages also support the GeoTIFF raster file format.

The strength of GIS is the combination of spatial and thematic data. Geographical objects are represented as map features on the map. These map features have specific attributes that can be accessed by users to derive more information from the map. One of the options to load thematic data into ArcView GIS is to connect to a database server using ODBC. Records are retrieved from the ODBC driver running an SQL query and these are subsequently stored as a table in the ArcView project.

When setting up a map layer in Autodesk MapGuide Author, thematic data can be linked to the geometric data that are stored in the SDF file by selecting an SQL Data Source. An SQL data source is an ODBC data source that can be accessed by Autodesk MapGuide Author as is permitted by Autodesk MapGuide Server Administrator.

For adding a new theme to a Webmapping application using GeoMedia Web Map, cartographers have to specify the data source in the Warehouse Connection Wizard. In this window, they select the geographic data servers that have been installed. These are accessed through an ODBC connection.

The Demographics example application that comes on the MapXtreme installation CD-ROM, shows how to integrate data from ODBC sources into the Webmapping application. Whereas Autodesk MapGuide Author and GeoMedia Web Map have a menu driven interface to define the ODBC data sources, this is not available in MapXtreme. Adjusting the example application to the specific requirements of the cartographers is difficult as lots of scripting is involved.

## Task 2: Displaying the topographic map of Overijssel

In ArcView GIS, the theme containing the municipal boundaries can be assigned a cartographic visualisation by double-clicking its legend box in the “Table of Contents”. This opens the “Legend Editor”. The colour fill for this theme can be set by selecting the Single Symbol Legend Type. All municipalities will have the same cartographic visualisation. Double-clicking the “Symbol”-entry of the “Legend Editor”, cartographers assign a colour from the loaded Colour Palette to a legend box by hand. Colours can also be defined in the HSV colour model. To be sure colours are Web-safe, they must be selected by hand from a customised colour palette that contains only the Web-safe colours. The solid fill for the municipal territories and the hatched fill for the settlements can be defined in the Fill Palette. However, the colour fill that is assigned to the settlements applies to the pattern, not to the background colour. To define line style that marks the actual boundaries of the municipalities, cartographers select from the Pen Palette.

Setting the cartographic visualisation for the themes in MapXtreme, cartographers use the Layer Control window in the Geoset Manager. Clicking the Display button opens the Display Properties window, where the fill and stroke of the polygon map features can be defined. Since MapXtreme NT WebGIS software runs on the Windows NT platform, cartographers can select from the 256 colours of the Windows colour palette. The software does not allow cartographers to set the RGB values respectively, nor are these values indicated in the interface of the Geoset Manager. Selection takes place by means of the keyboard arrows, not the mouse pointer. Cartographers can easily set the fill style. For the settlements, cartographers can define both the colour of the hatched pattern and of the background colour. To mark the boundaries of the municipalities themselves, cartographers can set the line style and its width.

On the programmatic level of developing a Webmapping application in MapXtreme, colours are specified according to OLE_COLOR values. An OLE_COLOR value is a BGR (Blue, Green, Red) value. To determine a BGR value, cartographers have to specify blue, green and red (each of which has a value

from 0 - 255) in the following formula: BGR value = (blue * 65536) + (green * 256) + red. This distances the application even further from what cartographers are used to.

In Autodesk MapGuide Author, cartographers define the cartographic visualisation of a theme in the "Attribute" tab of the "Map Layer Properties" window. This window contains various pull-down lists to specify the fill style and colour, line style and colour, background, and line thickness used to draw polygon map objects. Cartographers can select a solid fill for the municipalities and a hatched fill for the settlements. In the "Color" list, the colour to use for the solid fill or hatch lines can be specified. In the Background area, cartographers specify the colour for the background behind the hatch lines. For the municipal boundaries, cartographers have to check the "Edge" box, to specify the line style, colour, and thickness to use to display the edges of the polygons. The colour palette cartographers can chose from is derived from the RGB 256-colour Windows platform model. Each colour is assigned a number to facilitate colour selection for different themes with regard to the one that is being specified at that moment. However, this number neither gives insight into the RGB-values, nor is there is an option provided for cartographers to set the RGB-values themselves.

The cartographic visualisation of themes using GWM Administrator is defined on the Display Rule tab of the Map Properties dialog box. For polygon map features, cartographers can set its fill colour in the Fill Color area of the window, not in the Feature Color area. The Feature Color area allows cartographers to set the line colour of the municipal boundaries. Since GWM is a Windows-based product, it draws its CLUT from the internal RGB 256-colour palette of Windows. Cartographers can select the colours from a colour palette, or they can set the respective RGB values for the colour, allowing for a strict control over the colour assignment. For the municipal boundaries, the colour is set in the Feature Color area, its width and style in the Other area. No hatched pattern can be defined for the fill of the settlements.

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. In ArcView, the line symbols representing the infrastructure can be set in the "Legend Editor" by the Pen Palette. Their width is defined by point size (1/72 of an inch). There is a full range of options available to define the form of the line.

On GWM Administrator's Display Rule tab of the Map Properties dialog box, cartographers define the colour, the width and the style for linear map features. The "Weight" property specifies the width of the linear map features, just as it does for the stroke of polygon map features, the municipal boundaries. GeoMedia Web Map is the only WebGIS software package that has the pixel as its unit of measurement for this property. The form of the line can be selected from a list of only 7 options.

Defining the cartographic visualisation of linear map features is a straightforward process in MapXtreme's Geoset Manager. First, cartographers assign a line style from a list of 117 different options. Subsequently, they select a colour from the colour palette. Finally, the width of the linear map features can be selected from a drop-down list with 7 options. The unit of measurement is not clear, but the angular separation is sufficient.

The cartographic visualisation of road network can be defined in an Autodesk MapGuide MWF file extensively. First, there are six basic line types to choose from to define the style of the line. Second, the width of the lines can be defined. However, the unit of measurement does not show. Third, it is possible to create complex line styles by defining multiple display attributes for the same scale range. (Autodesk, 1998b, p.106). Autodesk MapGuide Author draws each display attribute on top of the one that precedes it in the Attribute list, creating a more complex display than a single attribute can produce. This option makes up for the meagre provision of line styles.

For displaying smaller settlements in Webmaps, they can best be represented as point map features. Assigning one cartographic visualisation to all point map features in an ArcView GIS theme, the Single Symbol has to be set as the Legend Type in the Legend Editor. The Marker Palette allows the cartographer to choose from the TrueType fonts available an appropriate marker symbol. Their size can be defined by any font size. Furthermore, this window provides options to set any type style (**bold**, *italic*, ***bolditalic***, and normal) and type colour without taking into account any of the limitations that stem from the characteristics of the Web as visualisation environment. It is also possible to import a bitmap image to be used as a custom marker symbol (ESRI, 1996, p.118).

Just like in ArcView GIS, point map features may come both as bitmap and as type in MapXtreme. Using bitmap symbols, the symbols that appear on the Webmap can be easily customised. Within a single bitmap symbol, many different colours can be used, unlike TrueType font characters, which are monochrome. Bitmap symbols can be incorporated into the Webmap exactly as they were created, or the appearance can be altered, e.g. making the symbols transparent, or applying an override colour to all pixels of a specified colour in the bitmap. However, bitmap symbols cannot be rotated. The option to represent symbols as bitmaps is not available in the Geoset Manager, but has to be scripted.

In the case of representing symbols by type, typeface can be selected from the list of TrueType typefaces available. Type size can be set in points, selecting a value from the pull-down list or by entering a custom type size. Type can be bold, italic and bolditalic. For further embellishment, there are options to set a drop shadow and to have a halo or box around the text.

Apart from defining point symbols in pixels, GWM allows for the representation of point features by fonts. The Display Rule tab provides several options to define point features, the so-called "Symbol types". The first option, "Point Geometry", uses a colour and a weight. This has been discussed already in relation to size definition of linear features. The second option, "GeoMedia FSM File", uses a colour, a weight, a size, a GeoMedia symbol (.FSM) file name, and a symbol name. The third option, "Font Character", uses a colour, a size, a TrueType font name, and a font character for a point symbol. The last option, "MicroStation Resource File", uses a colour, a weight, a MicroStation resource (.RSC) file name, a MicroStation font name, and a character. The size for text or symbols (used to display point features) is defined in the GWM Map Server's co-ordinate system storage units or as a percentage of the width or height (whichever is less) of the map view.

Autodesk MapGuide Author can use various symbols to represent point map features. The software comes with predefined symbols that are grouped by type in a number of symbol (SMB) files. Symbols can also be imported that come in the Windows Metafiles format (WMF), the Enhanced Windows Metafiles (EMF) format, or as pictures from the Clipboard. This Clipboard options can be used to have point map features represented by typeface. Additionally, custom symbols can be created in AutoCAD Map, and imported into Autodesk MapGuide Author. The size of point symbols uses the map units as the unit of measurement.

There are several map features that require lettering. Selecting a theme for labelling in ArcView GIS "Table of Contents", cartographers can select the Auto-Label command from the Theme pull-down menu. The Auto Label menu defines the parameters for the automatic labelling. ArcView GIS can find the optimum placement for the toponyms itself. Furthermore, cartographers can specify, that labels must not overlap, nor must there be repetition of the toponym, if more polygon map features make up the territory of only one municipality. Leaving the Scale Labels check box blank, the labels will remain of constant size when users are zooming in or out.

Before running the automatic labelling process, cartographers specify the typeface, type size, style and colour of the text labels in the Font Palette, just as for type symbols. This Font Palette is accessed through the Show Symbol Window command in the Window pull-down menu. Cartographers can select all TrueType fonts available in the Windows font library. The type size can be selected from a pull-down list. Furthermore, the Font Palette enables the setting of the type style.

For lettering MapXtreme-generated Webmaps, cartographers have to check the Automatic Labels checkbox in the Layer Control window. Clicking on the Labels button next to the checkbox opens another dialog box in which cartographers define the settings for the automatic labelling of the map objects. First, the geospatial dataset and the column that holds the attribute used for labelling are specified. Then, the settings have to be specified that determine at which scales the labels are displayed, and whether they may overlap and if there can be duplicated of a toponym in case different map features have the same toponym. When the scale changes, the size of type does not change. The Style area enables cartographers to control over the type that is used for lettering. The Text Style window has many options. The typeface can be selected from the TrueType fonts available in the Windows font library. Apart from selecting type size from the pull-down list, cartographers can also enter the type size themselves. In this dialog box the 256-colour palette of Windows is available. To distinguish the text from the background, a halo or box can be put around the text string. Its colour can be also be specified. There is also a range of options for type styles. The final settings of the Label

Properties dialog window are specified in the Position area. Here, cartographers specify a fixed location for the label with respect to its associated map feature.

Cartographers use the Labels And Overposting area on the Attributes tab of the Map Layer Properties dialog box to specify the font, size, colour, and map scale range to label SDF files automatically in Autodesk MapGuide Author. These labels are derived from the name value that is specified during conversion of the files into the SDF file format. All TrueType fonts from the Windows font library are available in all text styles (bold, italic, bolditalic). Cartographers can select colours from the 256-colour palette of the Windows platform. To have the labels stand out from the background, cartographers can specify the spaces in between the text to be Opaque, or Ghosted (draws an opaque border around each character) and the colour drawn between or around the characters. To maintain the same size for the labels at all scales, cartographers must tick off the "Constant Size" check box. Autodesk MapGuide Author then displays text always at the same size, regardless of zoom changes.

Furthermore, they can control overlapping of labels and map features. To minimise overlapping labels, the default setting prevents a label from being drawn at a specific zoom level if it will obscure other labels or objects on the Webmap. However, the programme will display the label when zoomed in far enough to allow sufficient space to display it. This leads to the curious event that "Enschede" is not shown whereas "Bathmen" is, although the former place's population is far larger than that of the latter. With regard to text alignment, the automatic labelling provides few options for fine-tuning. If the text map layer comes from SQL data sources, the type size may be derived from a column in the database table, specified on the Map Layer Properties dialog box Setup tab.

Whereas the previous WebGIS software packages can label map features automatically by entering the parameters in a graphical interface, in GeoMedia Web Map, the parameters have to be entered programmatically. The "Symbolize a Text Feature" example shows how to create a **FeatureSymbology** object and define the cartographic visualisation. Cartographers can specify the source from which to derive the labels. Then, they can define the colour (256-colours), the typeface (TrueType) and the type size. The type size can be specified as a percentage of the width or height (whichever is less) of the Webmap. The location relative to the corresponding map feature can not be specified.

Changing scales is not only an issue for displaying lettering. In order not to display the smaller settlements and less important roads at smaller scales, cartographers can set the "Theme display property" in ArcView GIS. This enables them to introduce scale-dependent layer visibility, by setting the minimum and maximum scale of the theme (ESRI, 1996, p.46). These parameters of the "Theme display property" are also used by ArcView IMS. Whenever the view's scale is outside this range, the theme will not be displayed in the Webmap.

In ArcView GIS, point and line features do not scale on zooming in and out on the map by default. However, it is more realistic these map features appear larger on zooming in and smaller when zooming out. Cartographers can introduce this generalisation process by means of scalability, i.e. setting the "Reference Scale" (ESRI, 1996, p.113). At the Reference Scale, scaling marker and line symbols appear at the same size on the view as they appear in the "Legend Editor". Text labels are scaled by default in ArcView GIS. Due to the integration of ArcView IMS with core ArcView, the same settings are assumed by AVIMS.

In MapXtreme, developers use the Layer Control window to change the display of the themes in the "geoset" that is visualised in the Webmap. They can determine which themes are displayed, removed, added, selectable, zoom layered, labelled, and they can set or change the order of the themes. From this window, the Display Options window can be used to specify the cartographic visualisation for the map features that are in each theme. Zoom layering is the term used in MapXtreme for the process of setting the minimum and maximum scale at which the selected theme will be visible on the Webmap: scale-dependent layer visibility. The scale is determined as the width of the Webmap in mapping units.

Scale-dependent visibility is also the approach taken by GWM to simulate generalisation. Via the "Display Threshold" tab, GWM Administrator allows the setting of a display rule to control the map scale for which the map includes a feature set, assigning a range criterion to the display rule. This criterion determines the minimum and maximum map extents at which the map includes the feature set associated with the display rule.

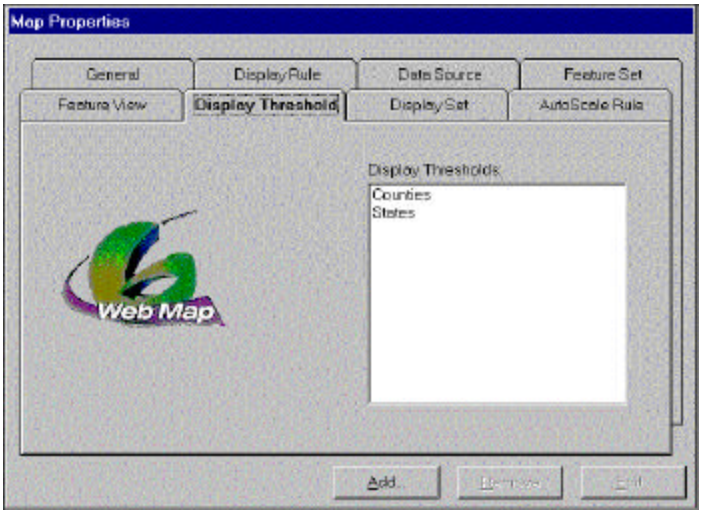


**Figure 35. GWM Administrator interface: the "Display Threshold" tab. Source: GWM Administrator Help**

MapGuide provides several ways to handle the problem of displaying too much detail at a too small scale or vice versa. One can set the visibility of a theme for a range of map scales in the "General" tab of the "Map Layer Properties" window. On the "Attribute" tab of this window the properties that control how the data appears on the Webmap can be specified. The scales at which the theme is visible can be set, and the cartographic visualisation depending on the current scale. For example, one cartographic visualisation displays the roads with thick lines on zooming in, and a second cartographic visualisation that displays roads with thin lines on zooming out.

Autodesk recognised that the Web is a different visualisation environment from paper or computer screen. This has led them to consider the detail of maps developed for these visualisation environments with regard to Webmaps. To alleviate the problem of illegibility, Autodesk MapGuide SDF Loader provides two operations to reduce detail in the geospatial input-files to generate legible Webmaps. On importing the foreign data file formats, authors can specify the maximum number of points (or vertices) per map feature. If a feature exceeds this value, Autodesk MapGuide SDF Loader generalises the object to reduce the number of vertices and displays a warning. Reducing the number of points is an important issue, because the Autodesk MapGuide Viewer plug-in has limitations on the number of polyline and polygon vertices it can display. If these limitations are exceeded, the shape will not display. Authors can also specify a degree of generalisation on converting the foreign file format. The point (or vertex) count of each map feature is reduces to the specified percentage of the original count. Both conversion operations make use of the Douglas-Peucker generalisation algorithm (Autodesk, 1998a, p.29).

## 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 first map type for which the software packages are tested is chorochromatic map. Each place (choros) is assigned a colour (chroma) based on an individual, unique value. In this case, each municipality must have its own colour fill. The basis for the classification is its toponym or key variable.

Since ArcView IMS is an extension of the core ArcView GIS software package, cartographers can exploit its mapping capabilities to serve chorochromatic maps on the Web. Double-clicking on the legend entry of the theme containing the municipalities, pops up the Legend Editor in ArcView GIS. Cartographers select the Unique Value option from the list for the Legend Type. Each map feature is assigned a unique class value for the variable that is entered in the Values Field area. A pre-defined range of colours can be selected from the Color Scheme pull-down menu to asssociate a class with a cartographic visualisation. Cartographers can also specify a colour by double-clicking the Symbol entry for each municipality in the Legend Editor. The map legend of ArcView GIS, the "Table of Contents", then displayes all classes for this variable.

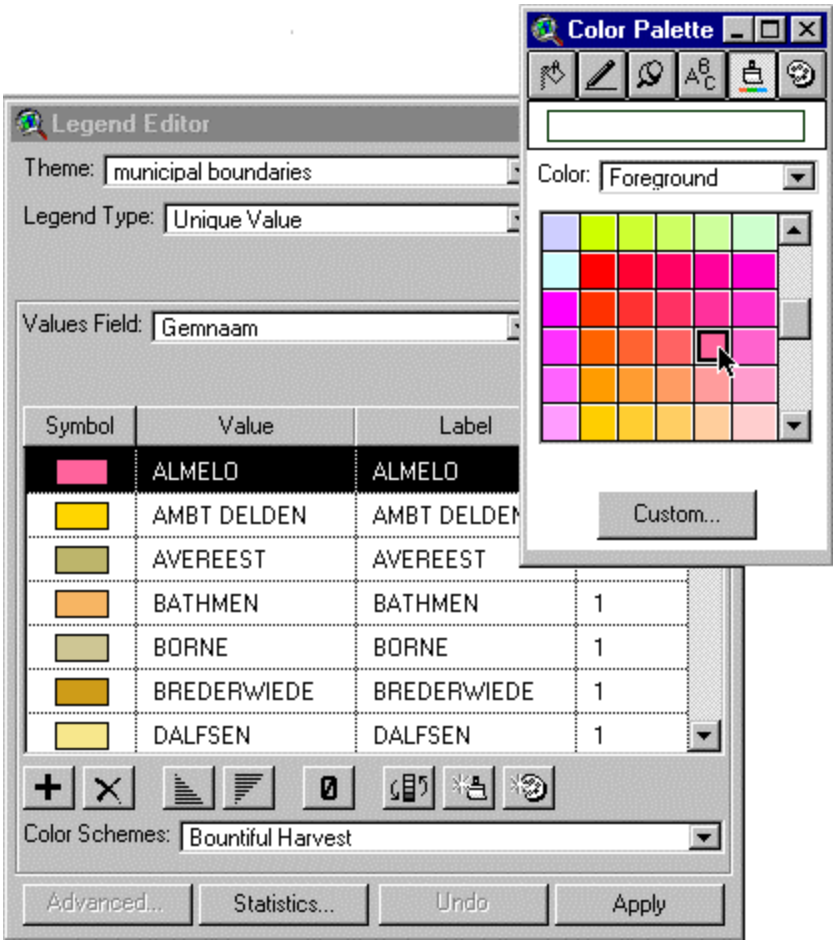


**Figure 36. Defining and assigning colours in ArcView**

ArcView offers five classification methods for making a choropleth map and proportional symbol maps: natural breaks, quantiles, equal area, equal interval, and standard deviation (ESRI, 1996, p.103). It is also possible to specify custom class ranges directly into the Legend Editor's Value field.

MapXtreme emphasises the strength of Webmaps as a means to transfer the results of Web-based analysis over the Web in the Demographics example Webmapping application that comes on the MapXtreme installation CD-ROM. This example application exposes many settings that control the creation of thematic maps, amongst others the chorochromatic and choropleth map, and the proportional symbol map. These settings include colour, classification schemes, dot size, and the number of classes, allowing users to select one or more columns from a table and create a thematic map for these columns. From the menu, users can select one or multiple data fields. Each field in the menu represents a demographic variable from a database, e.g. an ODBC data source. After selecting one or more fields, the form is submitted to the Web server, which re-execute the ASP scripts in the Web document, detecting which of the datasets the theme is being created against. After the theme is added, the preference controls, such as the number of ranges are checked and any appropriate settings are applied to the theme object. Adjusting this example application to the specific requirements of the Webmapping application is difficult as lots of scripting is involved.

Thematic map generation is not possible in GeoMedia Web Map Administrator. However, based on the Automation Model, cartographers may develop a Webmapping application that serves thematic maps by programming. The "Display by Markers" example in the Programmer's Guide uses the GWM Marker object (query on a data source) to create a Webmap that only contains states with an annual rainfall greater than 50 inches. The Marker object extracts map features based on queries on a data source. These map features are stored in the Markers object. From the demonstration Web site, it also becomes clear that it is possible to generate a thematic maps (GeoMedia Web Map Version 3.0 Demonstration Web Site, URL). Users set a random colour scheme and define the number of classes. Based on this selection a server-side ASP script is run to generate a map. These VBscript and ASP scripts could be modified and extended to disable the client-side customisation and set the attribute to be the name of

the statistical area and set the number of classes to equal the number of statistical areas to generate a correct chorochromatic map. One of the properties of the Markers object is Count, the number of objects in the collection. Together with scripting in the "Find Highest and Lowest Values" example on the installation CD-ROM, a Webmapping application can be developed to generate choropleth and proportional symbol maps by assigning each Markers object a DisplayRule object that describes the cartographic visualisation. Examples of these map types can be found on the demonstration Web site (GeoMedia Web Map Version 3.0 Demonstration Web Site, URL). Here, the choropleth maps are generated incorrectly: the higher the percentage, the lower the value of the colour. There are no options to set the classification schemes.

Whereas GeoMedia Web Map and MapXtreme do not provide an interface in the development software to generate thematic maps, Autodesk MapGuide Author specifies the attribute data source in the "Setup"-tab of the Map Layer Properties window. Subsequently, in the "Attributes"-tab, cartographers tick off the "Theme"-checkbox and select the attribute that should be represented in the thematic map (i.e. name of the municipality) and specify the map type (= based on individual values). To generate choropleth maps, cartographers select the classification scheme to "Based On Range Of Values". The colour range can be set for the entire theme so it renders a colour scheme automatically, but it is also possible to specify the colour of each attribute value separately, i.e. to specify the colour of each municipality manually. For the choropleth map, the number of classes can be set as well. There is only one classification scheme available: equal size categories.

Autodesk MapGuide does not provide an option to generate proportional symbol Webmaps directly. However, cartographers may exploit the possibility of this software package to specify the height of text based on an attribute in an SQL data source. To generate a proportional symbol map, a new text layer is added to the map view. In the "Setup" tab, the source for the text layer is defined as an SQL data source. Then, an Object Table should be selected that has columns containing a key variable, a latitude value, a longitude value, an height value representing the quantative data, and a column containing the name-value. The name-value is the string of text that is displayed on the Webmap at the location specified by the latitude and longitude values. In the case of generating a proportional symbol map, the name value is a "one-character" string that is displayed as a circle in the specified typeface. The proportion of the circle is the quantative data specified as the height value. This height value then defines the size of the typeface, in this case the circle.

### Task 4: Output of hardcopy maps

The default interface of a Webmapping application generated using ArcView Internet Map Server, the MapCafé Java-applet, contains a "Print" button. This button lets users print out the Webmap view or save it to disk. Clicking the button opens a separate Web browser window containing a Web document with the current Webmap view, a title, and the map legend. Choosing Print from the browser's File menu allows users to print this map. Alternatively, clicking with the right mouse button on either the map legend or the Webmap displays the standard Web browser pop-up menu so that the image can be saved to disk in GIF or JPEG file format. Webmapping applications developed with GeoMedia Webmap shows a proprietary pop-up window that contains a print command when clicking on the ACGM Webmap.

The Autodesk MapGuide Viewer enables users to print the current Webmap view as well. Both the standard toolbar and the pop-up window that open when users right-click on the Webmap contain a "Page Setup" command. Selecting this command displays a dialog window, where users can specify settings for printing the Webmap. By default, users can enter a title for the map, define the scale at which the Webmap should be printed and they can decide whether to add a legend. The "Print" command then lets users actually print this document. The provision of the Page Setup command allows for more customisation of this document by the users themselves then in ArcView IMS or in GeoMedia Web Map.

MapXtreme does not offer cartographers an option to add a ready-to-use print tool to the Webmapping applications that are generated using this software. Nevertheless, with standard Web scripting languages, cartographers can easily derive a printable Web document from the Webmapping application. Printing itself is performed using the tools provided by the Web browser.

### 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.

MapXtreme can generate GIF-formatted Webmaps to be embedded into Web documents. Cartographers can define the output format. Apart from the preferred GIF format, MapXtreme can also generate Webmaps as JPEG, BMP, and PNG. To judge their quality, the Geoset Manager shows one instant of the MapX, MapInfo's ActiveX control. Because MapXtreme allows MapX to run on the server-side, Web browsers do not require a plug-in.

Other WebGIS software packages do not have such an elegant way to generate Webmaps for Webmapping applications for public visual communication. Both ESRI and Intergraph provide a thick-client solution by default, but with some customisation, these WebGIS software packages generated a thin-client solution.

As described before, ESRI developed a Java applet, MapCafé, to provide the client-side interface to ArcView IMS (AVIMS). Usually it takes long for Java applets to be sent over the Web. The code needs to be interpreted by the Web browser's Java Virtual Machine (JVM) each time the Web server is accessed. It is not a very user-friendly solution.

One of the topics in the ArcView GIS Help, "Creating your own IMS client applications", describes how to create a custom AVIMS Webmapping application. Instead of using or customising MapCafé, Avenue scripts generate a Webmapping application of a raster graphics Webmap (GIF or JPEG) embedded in a Web document together with HTML forms, providing a user interface for the Webmap. This option is preferred over the Java applet implementation for this type of Webmapping applications.

Geomedia Web Map (GWM) also requires customisation to implement a user-friendly solution to display Webmaps in a Web browser. The default setting for GWM is to create the Webmap in the ActiveCGM (ACGM) format that requires plug-in. However, by setting the "OutputType"-property of the script calling the API, Webmaps can also be in a raster graphics file format, namely JPEG. Web browsers natively support this format, making GWM a suitable option to develop a Webmapping application for public visual communication. However, the GIF file format would have been an even better option.

Autodesk's WebGIS software, MapGuide, generates Webmapping applications only in the Map Window File (MWF) format. Web browsers do not support this file format natively. This requires extension of the Web browser capabilities by a plug-in. In the context of this benchmark, Autodesk MapGuide is no option for developing a Webmapping application for public visual communication.

When embedding a thin-client solution Webmap using AVIMS, the example scripts in the ArcView Help topic "Creating your own IMS client applications" allow the explicit statement of the size of the Webmap itself as part of the HTML `<IMG>` tag.

Geomedia Web Map takes a dual approach to developing Webmapping application. It makes a distinction between the Webmap itself and the functionality of the Webmapping application. Only the Webmap itself is a JPEG or ACGM file. The functionality of the Webmapping application makes use of standard HTML forms. When the GWM Webmapping application serves JPEG images, the Webmap is embedded using the HTML `<IMG>` tag that also has attributes defining its dimensions.

MapXtreme generates Webmaps in raster graphics file formats that are supported natively by Web browsers. Although the HTML `<IMG>` tag has attributes to define its size, the size definition of the Webmap takes place in MapXtreme's map engine at the Web server. For developers to modify the dimensions, adjustments have to be made to the ASP script that call "miMapEngine.asp". This library of routines uses methods and properties from the MapX object model for accessing the map engine.

To move around a raster graphics Webmap that is generated in AVIMS, cartographers have a means to access ArcView GIS over the Web through HTML forms that are embedded into the Web document together with the Webmap itself. Attached to the HTML forms are URLs. The parameters of the URLs invoke Avenue scripts in ArcView GIS. The Avenue scripts return a new raster file Webmap, using the extent co-ordinates contained in the URL.

For thin-client Webmapping application, MapXtreme and Geomedia Webmap also rely on scripting and programming to develop the functionality of the Webmapping application. Since these WebGIS software dynamically generates Web documents, cartographers not only have to be familiar with basic Web development languages (HTML and JavaScript) and a native scripting language (e.g. Avenue), but knowledge of Active Server Page (ASP) technology is necessary as well.

## Task 6: Transferring geographical knowledge

A scale bar can be easily included into a GWM-generated thin-client Webmapping application. This orientation tools does not come as a standard utility in GWM Administrator, but the set of examples on the installation CD-ROM contains a "Scale Bar Example" that serves as a guide to develop a scale bar in a customised Webmapping application (Intergraph, 1999II, CD-ROM). This example displays a scale bar for the Webmap and the number of meters the width of the scale bar represents. The scale bar that is generated in the ASP script is raster graphics file (*scalebar.jpg*). The width of the image is adjusted according to the current Webmap size and the scale factor of the map's co-ordinate system.

The WebGIS software of both MapInfo and ESRI indicate the mouse position and the scale of display in the development environment, Geoset Manager and ArcView GIS respectively. However, when generating the Webmaps for the Webmapping application, this information is not included. In the Hello World example application that comes with MapXtreme, the scale of the Webmap view (in map units) is passed to the users in a separate HTML form element. The example application in ArcView Help does not provide this functionality.

To indicate the location of the mouse pointer, both MapXtreme and ArcView IMS have to take the similar development approach. The two-step map-based approach for basic display requires the capture of the mouse pointer's location when the users click on the Webmap. This position in screen co-ordinates is translated into map co-ordinates. These translated values are input for changing the view of the Webmap according to the selected basic display tool. They can also be used as input of a script to display the mouse pointer's location as co-ordinates in map units. This approach of customisation is not applicable when developing a thin-client solution with GWM. It is not possible to derive the location of the mouse pointer as it moves over the JPEG Webmaps, because they are not clickable maps (Intergraph, 1999II, CD-ROM). This can be concluded from the discussion of basic map display tools. In GWM-generated Webmapping applications these tools are implemented in a one-step tool-based approach, not map-based.

Another item that helps users in their navigation and orientation is an index map. However, ArcView IMS is the only WebGIS software package able to generate this tool for Webmapping applications developed for a thin client-configuration. An example of this functionality can be viewed at (World Gazetteer, URL). Depending on the zoom level, the extent of the main view is indicated in the index map either by a red rectangle or a red dot. Both Webmaps are embedded into the Web document as GIF raster images.

The example application in ArcView Help generates a Web document with HTML forms and a JPEG/GIF Webmap using Avenue scripts. There is no provision of a legend in this example application. The documentation that comes with ArcView IMS does not provide any suggestions how to generate a JPEG/GIF-format legend with the Webmapping application. With Avenue scripting, it might be possible to generate a legend embedded into a Web document in the same way the Webmap is embedded.

The map engine of MapXtreme, MapX, embeds a legend in the GIF or JPG image on top of the Webmap by default. This arrangement obscures portions of the actual Webmap, and is especially problematic when there is more than one legend. Therefore, MapX's ExportLegend() method creates individual raster graphics files for each theme in the Webmap. This legend is an HTML table containing the cartographic visualisation for every active theme as GIF raster file. To create this legend, no tools are provided in the development environment of MapXtreme. The example applications give some indication of how to create this orientation tool by means of extensive ASP scripting.

The tools available in GWM do not provide an out-of-the-box solution to generate a legend for the Webmapping application automatically. Neither the documentation, nor the templates and examples available on the installation CD-ROM give suggestions for scripting this functionality. Nevertheless, the demonstration Web site provides this navigation and orientation tool for thematic maps (GeoMedia

Web Map Version 3.0 Demonstration Web Site, URL). Other Web sites that use GWM provide a legend as a raster image embedded into the Web document (Amazon Basin, URL; Louisiana DOTD, URL).

The example application in ArcView Help does not provide suggestions how to implement a tool to find particular objects. This tool is however implemented at the GIS Day Event Locator Web site (GIS Day Event Locator, URL). Entering a location and a search distance, the Webmapping application returns a JPEG image of the World centred on the location where a GIS Day event takes place that is within the specified distance of the location that was entered.

The documentation with GWM is more helpful. The "Create Marker By Recordset" example application that comes with GWM explains how to combine HTML, ASP, and VBscript scripting to generate HTML forms in the Web document, which input is used for querying the geospatial database.

The development environment of MapXtreme does not have a straightforward solution to develop a tool for the Webmapping application to find a particular map feature. The "SimpleQuery" example application that comes with MapXtreme is a Webmapping application that enables users can construct a simple query, using HTML forms as part of the Web document containing the Webmap. Clicking the "Show Highlight" button, the Webmapping application constructs an appropriate SQL query, and sends the query to the Web server. The query results are superimposed on the Webmap, so that the customised records that meet the criteria appear highlighted. Customising this example application, cartographers need to modify various ASP scripts.

The other query tool enables users to see the geospatial data behind the Webmap. They want to know what a particular map feature is, or they want to know the attributes of the map feature. Only MapXtreme and ArcView IMS can implement this functionality for a thin-client configuration, because the JPEG Webmaps generated in GWM do not have clickable map features.

The example application that comes in ArcView Help contains this tool to identify map features. After having specified the radio button in the HTML form, clicking on a map feature in the Webmap returns a table containing the attributes of the specified map feature. This tool is implemented in a life Webmapping application for regional mapping (Middle East Maps: HTML Demo, URL).

The "MapExplorer" example application that comes with MapXtreme also has a tool to obtain information from map features. Just like ArcView IMS, users tick the radio button and then they click on a map feature in the Webmap. The Webmapping application then displays information about that map feature in a table below the Webmap. Life Webmapping applications with this tool can be viewed at the demonstration Web site (BBGI MapInfo MapXtreme Demonstration, URL).

## Task 7: Webmapping application interface for exploration

Both ESRI and Autodesk provide a Java applet configuration to extend the Web browser's capabilities. Webmaps that have been generated by ArcView IMS (AVIMS) are displayed in the Web browser using the Java-based applet MapCafé. Since the latest release of Autodesk MapGuide, there is a Java-edition of the Viewer to serve those running Mac OS or Sun. The Java applet is based on Autodesk MapGuide Release 3.0. Implementing the Java applet, the Webmapping application cannot use the new features in Release 4.0.

With regard to the plug-in/ActiveX control configuration, this implementation has the disadvantage, that the Java applets to be sent over the Web and the code needs to be interpreted by the Web browser's Java Virtual Machine (JVM) each time the Web server is accessed. It is not a very user-friendly solution, but in the case of ArcView IMS, the advantage of interaction with the Webmap outweighs this disadvantage. Customising the MapCafé applet with Java can alleviate part of this disadvantage. By default, the Webmap has the same size as the canvas sub-component in MapCafé applet. Setting the **scaleFactor** argument of the object **Map Virtual** larger than 1.0, each Webmap retrieved from the Web server is larger than this canvas in the client-side application. When users pan the Webmap, the portions of the Webmap, which are otherwise outside the canvas, are dragged into view. By using this function, larger Webmaps are transmitted over the Web, but fewer requests are made if the users pan the Webmap frequently. When developing a Webmapping application for private visual thinking running Windows OS, it is more appropriate to implement Autodesk MapGuide Viewer as a plug-in/ActiveX control.

Like Autodesk MapGuide, to view the GWM-generated Webmaps a plug-in or ActiveX control from InterCAP Graphics Systems has to be added to the standard Web browser (NC and MSIE) running Windows 95 or Windows NT. This is necessary, because these Webmaps come in ActiveCGM (ACGM) format by default, a file format not natively supported by Web browsers.

Installing the ArcView IMS extension, new menu items are added to the "File" pull down menu of ArcView GIS. The "Web Page Setup" menu option enables cartographers to specify the size of the MapCafé Java applet, because the Web document generated by AVIMS contains the html tags that define the dimensions of the applet. This applet does not only contain the Webmap, but also various interaction tools and the legend. The "MapCafé Setup" menu option enables cartographers to specify the contents of the MapCafé applet. With regard to dimensions, only the width of the legend can be specified. The standard AVIMS menu options do not provide direct control over the size of the Webmap itself. However, customisation of the MapCafé applet with Java allows the explicit definition of the canvas sub-component of the applet that displays the Webmap (ESRI, 1997, p.55).

Using the default Autodesk MapGuide Viewer plug-in/ActiveX control, there is the same drawback as when using the AVIMS default options to generate a Webmapping application. The MapGuide Viewer plug-in or ActiveX Control are embedded into the Web document as an HTML `<EMBED>` or `<OBJECT>` tag respectively (Autodesk, 1999, p.192). Both HTML tags provide attributes to define its width and height. However, the default Autodesk MapGuide Viewer also contains the legend and the interaction tools. Therefore, the explicit definition of the size of the tools is not possible for the default set-up of the Viewer.

To display the Autodesk MapGuide Viewer embedded into the Web document, the Viewer refers to a URL. This URL contains a set of parameters that can specify which elements of the Viewer to include in the display. These parameters can also be added, each as a separate value using HTML `<PARAM>` tags between the `<OBJECT>` and `</OBJECT>` tags. Leaving out all the Viewer interface elements except for the Webmap itself, the attributes of the HTML tags that define the dimensions of the Viewer then directly refer to the size of the Webmap.

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.

Both ESRI and Autodesk have developed WebGIS software packages that generate not only the Webmap itself, but also interfaces for the interaction tools. The "MapCafé Setup" menu option provided with AVIMS pops up a dialog window to specify the functionality of the Java-applet. Choosing the Custom Setup allows cartographers to specify exactly which default tools to include into the MapCafé applet. The icons for zooming and panning are the same as come in the core ArcView GIS. For those who are familiar with ArcView GIS, like the GIS professional in the Overijssel provincial office, this is a good point. Their universal, intuitive design directly clarifies their functionality also for those unfamiliar with ArcView GIS. The functionality of the icons is also indicated at the bottom of the Java-applet in the MapCafé Message bar below the Webmap. Clicking the button results in a change of the mouse icon to indicate that the particular function is running. After clicking the Pan icon, holding down and dragging the mouse pointer over the map performs panning. To zoom, one can specify a rectangle that has to fit in the enlarged view, or one can just point and click to zoom and re-centre the view at once.

One of the parameters that are either included into the referring URL or added as separate values using HTML `<PARAM>` tags between the `<OBJECT>` and `</OBJECT>` elements, specifies the display of the toolbar element in the Autodesk MapGuide Viewer (Autodesk, 1999, p.195). This toolbar provides the basic display tools for panning and zooming.

Not always, these tools need to visible to the user. The valuable space the interface takes up could be freed to provide space for more sophisticated interaction tools. To provide these tools nevertheless, they must come as a pop-up menu. In AVIMS, the basic display tools can only be made available as part of the MapCafé applet in the Web document, not as part of a pop-up menu. However, leaving out the toolbar in Autodesk MapGuide Viewer, the basic display tools can still be accessed through the map window popup menu that appears on clicking the right-hand button on the mouse anywhere in the

Webmap. Although this popup menu contains a lot of commands by default, MapGuide Author lets cartographers easily customise this popup menu to contain only the basic

By default, GWM generates ACGM Webmaps. Clicking the right mouse button anywhere inside the ACGM Webmap itself, a pop-up menu of commands will be presented. The commands provided in the standard delivered menu do not invoke server-side processes. Among these commands are the basic display tools.

### Task 8: Background information: available on demand

The main interface of the Webmapping application developed using ArcView IMS, the MapCafé applet, includes the Information bar. In the MapCafé Setup dialog box of ArcView GIS, the Information bar may be defined to contain a scale bar. Like ArcView IMS, Autodesk MapGuide enables cartographers to control the interface elements to include by means of the display parameters of Autodesk MapGuide Viewer. One of these specifies whether to display the status bar. This status bar includes the map scale indicator as numerical notation.

The ACGM Webmaps generated in Geomedia Web Map (GWM) include only the Webmap itself, not any other interface elements, e.g. the interaction tools. To include a scale bar to the Webmapping application, the same approach has to be taken as for the thin-client configuration: modifying the "Scale Bar Example" that comes with GWM to generate a raster graphics file (*scalebar.jpg*) with ASP.

The display of the co-ordinates of the mouse pointer's location is another orientation tool. These co-ordinates immediately communicate the location where the user is interacting with the geospatial database behind the Webmap. The Information bar of the AVIMS MapCafé applet may contain the XY readout of the co-ordinates of the mouse pointer's location. In Autodesk MapGuide Author, cartographers can also specify to display the co-ordinates of the mouse pointer's position on the status bar, just as the scale. The co-ordinates can be displayed in geographical co-ordinates or map units derived from the Webmap's co-ordinate system. On the Security tab of the Map Layer Properties window in Autodesk MapGuide Author can be specified whether Autodesk MapGuide Viewer API users can obtain co-ordinate information from map features in the Webmap at all.

The WebGIS packages from both ESRI and Autodesk generate the orientation tool as a dynamic tool. When users move the mouse pointer over the Webmap, the position is dynamically changed to represent the current location. This is possible, because the Webmap and the scale tool are part of the same object that is embedded into the Web document. Since GWM exclusively generates the Webmap, a dynamic orientation tool cannot be generated automatically. In this case the same approach can be taken as when developing a two-step map-based tool for the Webmapping application for public visual communication using ArcView IMS or MapXtreme. In the thick-client solution of GWM that outputs the Webmaps as ACGM, it is possible to display the location of the mouse pointer after programming using ACGM commands (Intergraph, 1999II, CD-ROM). The co-ordinates are not changed dynamically on moving the mouse pointer over the Webmap as in MapCafé or Autodesk MapGuide Viewer. After selecting a tool from the HTML-form embedded in the Web document, the user is prompted to locate a point in the target window. Then the co-ordinates of this point are returned as part of the plain text in the Web document. This functionality is shown on the demonstration Web site (GeoMedia Web Map Version 3.0 Demonstration Web Site, URL).

Another item that helps users with their navigation and orientation is an index map. None of the WebGIS software packages serves this as a standard tool. In one of the GWM-generated example Webmapping applications however, an index map is provided (Amazon Basin, URL). However, the index map does not dynamically display the location of the map view on the index map. The ACGM pop-up menu option "Magnify" provides a means to brush the map with a magnifying glass. This tool circumvents the absence of the index map tool. Users can see more detail in the Webmap without losing their bearings.

Whereas the example Webmapping application generated by GWM does not provide a dynamic index map, an index map is featured on the Advanced Application demonstration Web site of the Application Development Turorial that can be accessed from the MapGuide Web site [Application Development Turorial/Advanced Application, URL]. The Index Control panel contains the on and off button for controlling the index map. The index map is used for facilitating the navigation of the main Webmap. By turning it on, users can move the mouse pointer across the index map. Digitising a rectangle by

dragging the mouse pointer, the Webmap will be zoomed in to the area of interest. This example makes use of the same technology that is used for generation of the index map in the World Gazetteer example discussed before: object-oriented programming.

In object-oriented programming, one program object can request an action from another object by a message. A message specifies the name of the object to which the request is made, the action (or method) to be performed, and any parameter or value that needs to be specified for this request. Both Microsoft's ActiveX technology and Sun Microsystems' Java technology are object-oriented. Like the Autodesk MapGuide generated example Webmapping application, an index map tool can be developed using ArcView IMS, because MapCafé is a Java applet.

By default, users cannot customise the display of the orientation tools in a Webmapping application generated by ArcView IMS. Once the tools have been included into the Information bar of the Java-applet interface specified in the MapCafé Setup dialog box, there cannot be any client-side control. However, customisation enables cartographers to add scripts or ActiveX controls to the Webmapping application that send object-request statements to MapCafé telling the Java-applet for example to add certain tools.

To allow users to have control over the scale bar, MapCafé class has the object **MapCafe** with the request **Scale**. The Boolean argument **visible** specifies whether the scale bar should be shown. If the scale bar is included, users can control the maximum width for the scale bar by passing another object-request statement that addresses the object **ScaleBar**. Its width (request **Length**) is specified in pixels (argument **numPixels**). However, its width cannot be set larger than a quarter of the applet's width, or smaller than a tenth of the applet's width. Not only its width can be specified but also the measurement unit (request **Units**). The argument **text** displays the unit of measurement to the user, whereas the argument **factor** contains a scale factor that converts map units to the units shown in the scale bar. For example, if the actual map units are meters, users can set the units displayed as kilometres by specifying **text** as "km" and **factor** as 1000, or even as miles using "ml" and 1609.344. Another request, **XY**, of the object **MapCafe** allows users to have control over the display of the XY co-ordinate readout by means of the Boolean argument **visible**.

The parameterised outlook control in Autodesk MapGuide allows straightforward manipulation of the provision of the orientation and navigation tools. If the status bar is included in the Viewer, users can see information about the scale of the Webmap and the location of the mouse pointer. Whereas ArcView IMS requires from cartographers to add scripting and programming to the Webmapping application to allow users to have control over the orientation and navigation tools, Autodesk MapGuide Viewer has a standard option in its pop-up menu to set the user preferences for these tools.

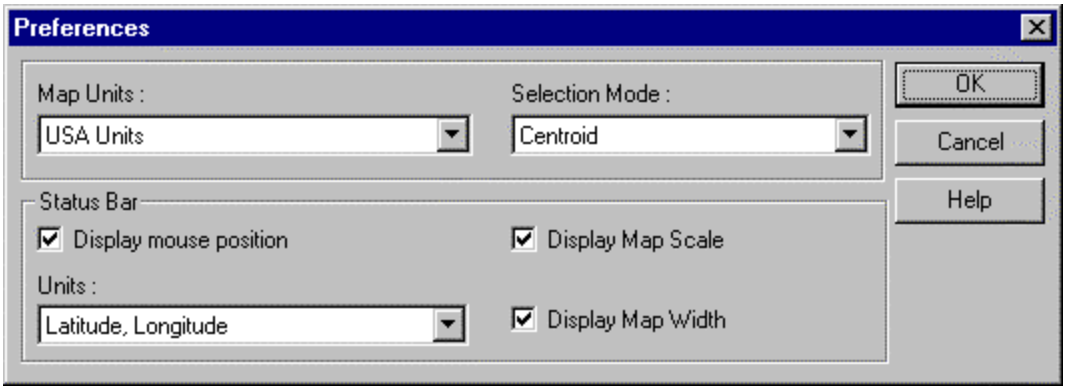


**Figure 37. Preferences dialog window**

Since cartographers have to set the co-ordinate system in the SDF-Loader, Autodesk MapGuide Viewer can easily translate map units to world co-ordinates at will. Furthermore, users can easily specify whether to display the mouse pointer's location and the map scale at all in the Preference box.

Using Geomedia Web Map, the provision of the scale bar is enabled by ASP and VBscript scripts. Customising the scripts, cartographers can implement the scale bar as an optional tool. The way the co-ordinate readout made available is at the demonstration Web site, it is already implemented as an optional tool (GeoMedia Web Map Version 3.0 Demonstration Web Site, URL). Only on selecting the

tool and clicking the Webmap, the co-ordinates can be displayed. The magnifying glass, GWM's solution to the index map, can be made available at will through the map window pop-up menu.

The MapCafé applet, generated in the ArcView IMS MapCafé Setup, allows users to have control over the display of the map legend, the "Table of Contents", but they cannot resize it. When hiding the legend and refreshing the view, the whole canvas is filled with only the Webmap. In the MapCafé Setup dialog boxes, cartographers can specify to leave the legend out of the MapCafé applet altogether.

The default Autodesk MapGuide Viewer comes with a 150-pixel wide legend. However, cartographers can manipulate the size of the legend by adding the **LayersViewWidth** parameter to the URL that defines the outlook of the Viewer, together with a value. A value of zero completely hides the map layer legend. Users can manipulate the size of the legend by dicking and dragging the vertical bar between the legend and Webmap. Since the outlook of the Viewer is parameterised using URLs, users can be given control whether to display the legend at all, by providing an HTML form in the Webmapping application to send URLs to the Web server.

Providing a map legend in a GWM-generated Webmapping application for private visual thinking requires the same approach as for public visual communication: extensive VBscript and ASP scripting. Embedded HTML forms would provide the means to interact with it. No clues are given in the documentation, the templates, or the examples that come with GWM.

## 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 in ArcView IMS MapCafé Setup. From a listing of the themes that are included in the ArcView Table of Contents, cartographers can select the themes that must be hidden from the MapCafé Table of Contents, but still display in the Webmap. In Autodesk MapGuide Author cartographers right-click in the map legend to display the map layer pop-up menu. Selecting the New option, a new map layer can be created containing a new theme for the Webmap. On the General tab of the Map Layer Properties dialog box that opens, cartographers can specify whether the Autodesk MapGuide Viewer legend displays the name of the newly created layer (Autodesk, 1998, p.88). The Autodesk MapGuide Author legend always displays all layers and is unaffected by this property.

Allowing users to control the display of themes in an ArcView IMS generated Webmap, cartographers can specify in the MapCafé Setup, whether the MapCafé Table of Contents contains check boxes for turning themes on and off. These 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. Whereas user-control is an option in MapCafé, Autodesk MapGuide Viewer provides checkboxes to allow users to specify the display of themes in the Webmap by default. If the Webmap displays a thematic map, the classes for that theme appear below the theme's name in the legend. 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.

Since users can control the display of themes in the Webmap, in the same dialog box, cartographers can specify which themes are displayed in the Webmap by default when users log onto an Autodesk MapGuide-generated Webmapping application by checking the "Visible" check box (Autodesk, 1998, p.88). Leaving this box unchecked, users will have to make the theme visible in the Webmap themselves by clicking its check box in the Autodesk MapGuide Viewer map legend. 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).

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. The object **TOC** has a request **SetVisible**. Setting a Boolean value for the argument **isVis**, cartographers can specify whether the theme is to be shown in the same way the legend checkbox is selected.

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. The "Sheet Name and Priority" example that comes with GWM displays several themes in a Webmap. Each theme is on a separate layer as set by the **SheetName** and **Priority** properties. 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.

### Task 10: Information on single map features

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.

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. The icon design is the same as ArcView and directly clarifies its functionality that is also indicated at the bottom of the Java-applet in the MapCafé Message bar. When people use MapCafé's Identify tool, it only lets them identify features in themes made active in ArcView GIS. If they try and identify a feature in a theme that is inactive in ArcView GIS, they get a message saying that no additional information is available for that theme. In this way, cartographers decide which themes users will be able to query by making them active in ArcView GIS before starting to serve the Webmapping application. By default, only one theme can be active at a time in ArcView GIS (ESRI, 1996, p.11). However, users might want to obtain information from multiple layers. Cartographers have to address the object **TOC** with the request **Add** to set the argument **isSearchable** to true. This Boolean argument specifies whether the theme is searchable in MapCafé so users can query this theme with the Identify tool.

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. In GWM Administrator, cartographers can define the text string to display in the Feature View tab of the Map Properties window. Since the Tool Tip can hold an attribute of the map feature from the geospatial database from which the theme is derived, the tool tip can be used to dynamically display toponyms on ACGM Webmaps.

By default, the Autodesk MapGuide Viewer displays the "Name" value of the spatial data file (SDF) that is specified during conversion in a yellow "MapTip" popup that appears on the Webmap when holding the mouse pointer over a map feature for more than a second. The text may also come from the "Name" column in an SQL data source that is specified when adding a theme in Autodesk MapGuide Author. 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. The theme name is listed first, followed by the feature 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).

To find a particular map feature on the Webmap in an ArcView IMS generated Webmapping application, users have the Find-feature button available in the button bar of the MapCafé applet. This button lets them specify the feature by typing in its name or one of its attributes. The dialog box enables users to choose whether they want to search all the searchable themes in the Webmap, or just a particular one. Furthermore, users can specify that the Webmap should be centred on the map feature and zoomed in. When the feature is found it is given another cartographic visualisation, just as in ArcView GIS. The design of the "Find feature" icon does not transfer its meaning clearly. Fortunately,

the Message bar of the Java applet is of help. Since only one theme is searchable by default, cartographers have to customise the applet with Java to change the **isSearchable** argument of the **Add** request of the object **TOC** so users can search more themes.

In Autodesk MapGuide, the query tool also comes as part of the plug-in interface. Hiding the tool bar from the Viewer, it is made an optional tool as it can also be accessed from the pop-up menu. To control its display in MapCafé, cartographers have to customise the **ButtonBar** object with Java.

The "zoom to a location"- tool in Autodesk MapGuide can search all the available layers by default as long as they are not password-protected. First, a theme to be searched is selected. Then, users type the name of the map feature, followed by the map width in the current display units. Autodesk MapGuide Viewer zooms to the specified width using the specified map feature as the centre of the Webmap.

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. The **Marker** object can be used to query the geospatial database. The results from the query can be displayed using the **DisplayRule** object for the Marker. Its availability can not be controlled using the WebGIS software package.

### Task 11: Geometric map comparison

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. An example of a GWM-generated Webmapping application that provides this tool is the demonstration Web site together with other tools for measurements (GeoMedia Web Map Version 3.0 Demonstration Web Site, URL). The "Linear Measure" measurement tool enables users to measure the distance between two selected points. Selecting the tool, users are prompted to point on two locations in the Webmap. After pointing at the second location, the calculated distance is displayed in the top left of the Map frame.

This tool is implemented into the GWM-generated Webmapping application customising the ACGM plug-in. The ACGM command "promptvector" prompts users for one or more points, displaying a "rubberband" graphic to allow users to view where they have clicked. The prompt type "-line" prompts users for two points with rubberband line. The "-polyline" prompt type prompts users for up to 100 points with rubberband line. Repeating the last point to terminates the polyline. Once users accept a data set or abort the command (via the dialog or by using the right mouse button during point entry), the points are output.

Cartographers cannot easily customise the MapCafé applet to add this tool. The start-off for developing this tool would be the co-ordinate display tool in the Webmapping application for public visual thinking. According to the image map paradigm, users were able to derive the world location of the mouse-pointer by clicking on the Webmap. To derive a distance between locations, users would have to click to times on the Webmap. These locations would then serve as input for the calculation of the distance.

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.

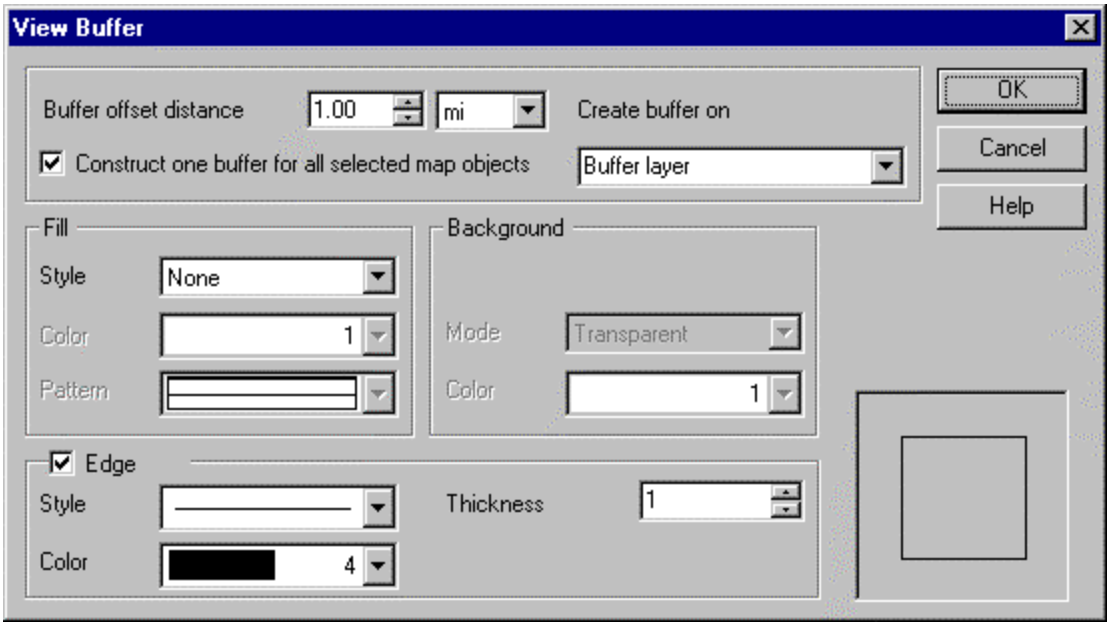


**Figure 38. Autodesk MapGuide enables users to easily generate buffers**

Whereas Autodesk MapGuide generates this tool by default, a lot of customisation is necessary to add this tool to ArcView IMS and GWM. An example of the buffering tool in a GWM-generated application can be viewed at the "PropertyLive" Website of the National Association of Estate Agents (NAEA, URL). This Web application allows users to search a comprehensive property database. One of the search criteria is the distance from a specified location. Although the Web application does not contain WebGIS-generated Webmaps, behind the scenes, a buffering tool is at work. Using ArcView IMS, cartographers would have to add a lot of scripting and programming to the default MapCafé Webmapping application to generate this tool.

## Task 12: Integrating the Web

In the ArcView IMS MapCafé applet, the tool bar contains a Hyperlink tool. This tool lets users display the contents of an URL by clicking on a map feature in the Webmap. The URL for the Web document is defined in the hotlink field for the feature using ArcView GIS (ESRI, 1996, p.134-5). Clicking on the map feature in the MapCafé applet, ArcView IMS displays the Web document in a frame on the Web page or in a separate Web browser window.

Webmapping applications generated in GWM can also have hyperlinked map features in the ACGM Webmap. In GWM Administrator, cartographers can set the **Action for "click" event** in the Feature View tab of the Map Properties window. This is an action for the whole theme, but the string that specifies the action can hold keywords from a geospatial database. These keywords automatically convert to their map feature-dependent values during the generation of the ACGM file.

For each theme in the Webmap, cartographers specify the data source that contains the information to link to the map features on the "Setup" tab of the Map Layer Properties window in Autodesk MapGuide Author. When the map features are linked to an SQL data source, cartographers specify the name of the column that contains the URL associated with each map feature. This enables users to go to a Web document that is related to a map feature simply by clicking on it.

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 Autodesk MapGuide Viewer, if the map feature under the mouse pointer is linked to a Web document, the mouse pointer changes from an arrow to a hand, and Autodesk MapGuide Viewer displays the URL of the linked Web document on the status bar. Furthermore, cartographers can provide the users with the name of the map feature in the same way as for dynamic lettering using the small yellow MapTip popup window so users will know they click on the right map feature.

To let users know they can hyperlink from a map feature in an ACGM Webmap, the mouse pointer changes to a hand-icon. Cartographers can specify a "hotspot-symbology: in GWM Administrator. When the mouse-pointer moves over a clickable map feature, the cartographic visualisation changes dynamically to indicate its clickability. Second, the dynamic lettering tool allows cartographers to define a text that displays at the location of the tool tip when the mouse pointer is over a map feature. This dynamic lettering ensures users click on the right map feature.

Bookmarking of a specific Webmap view in the MapCafé applet is not possible. Taking the URL of the Web document that contains the Webmap performs the bookmarking of a Web document. To retrieve the view, a URL would be sent by the Web browser to ArcView. ArcView would then send statements to MapCafé in response to this URL. However, as HTTP-communication only takes place between one client and a server, only MapCafé (one client) can initiate a request that results in object-request statements being returned back to it, not the Web browser (another client).

Although bookmarking itself is not supported in GWM, it is possible to hyperlink to a specific Webmap from another Web document. The URL specifying the hyperlink opens ACGM or other supported file types (Intergraph, 1999II, CD-ROM). To execute a command when loading an ACGM, a pound sign (#) is added after the file-name in the URL then the command. For example, the "setdisplay" command can be used to specify a certain map view by setting the display scale and location of the target window, using CGM co-ordinates and units.

In Autodesk MapGuide Viewer, users can easily add bookmarks to save a specific view of the Webmap. After panning and zooming to the exact view of the Webmap they want to save, they choose the "Add Bookmarks" command from the popup-menu. In the "Add Bookmark" window, they can type a name to refer to the bookmark. The bookmark is added to the Bookmarks menu. Whenever users want to display this particular view of the Webmap again, they simply choose Bookmarks from the popup menu, and then click on the name of the bookmark. Creating a bookmark means that users are simply saving the URL of the Webmap with a set of parameters that indicate the map width, centre point, and more. Selecting a bookmark, the Autodesk MapGuide Viewer reloads this URL with all of the parameters that indicate exactly how to display the map.