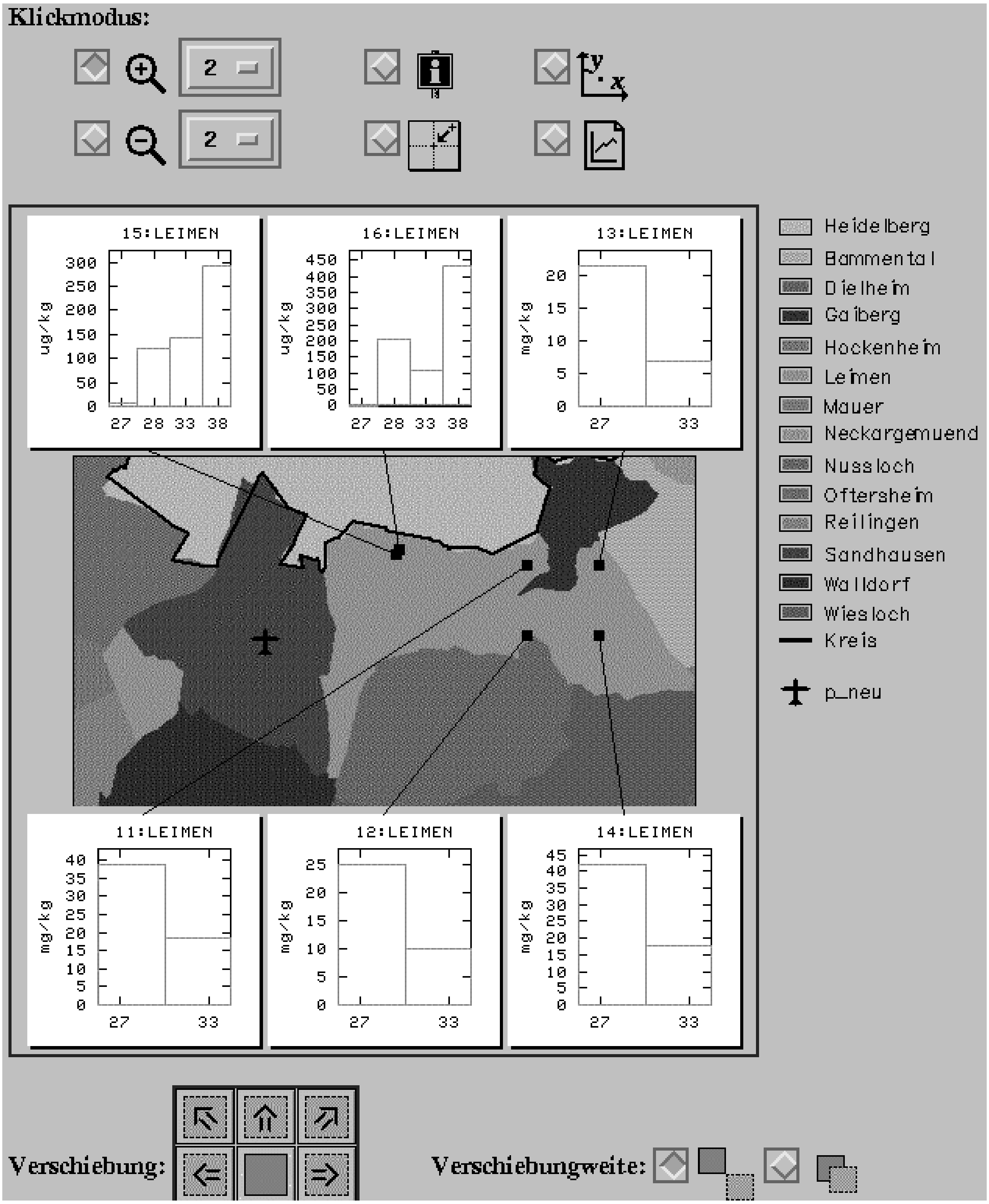

Figure 4: Example map with charts

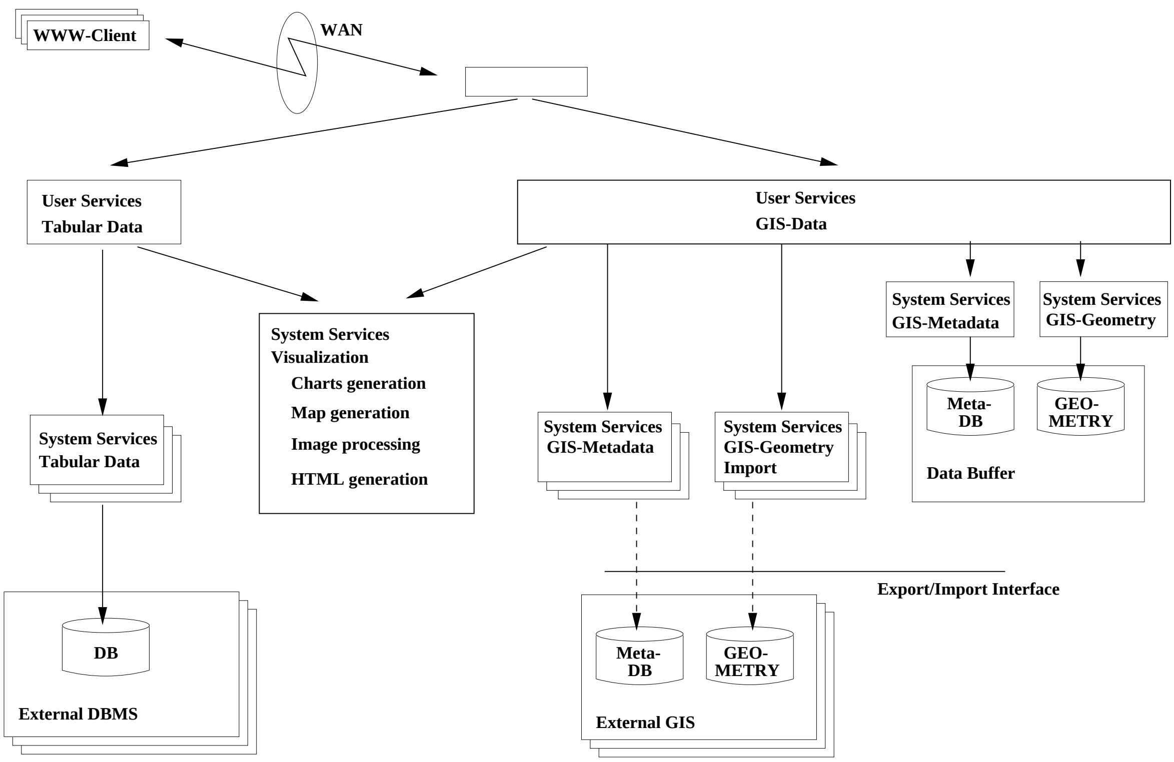

Figure 2: GIS/Graphics architecture

Mayer-Föll, R. and Jaeschke, A. (1995). In Mayer-Föll, R. and Jaeschke, A., editors, *Projekt GLOBUS Konzeption und prototypische Realisierung einer aktiven Auskunftskomponente für globale Umweltsachdaten im Umweltinformationssystem Baden-Württemberg - Phase II*, number FZKA 5700 in Wissenschaftliche Berichte. Umweltministerium Baden-Württemberg, Forschungszentrum Karlsruhe.

Object-Management-Group (1995). The common object request broker: Architecture and specification 2.0 edition. Technical report, Object Management Group, Inc.

Ousterhout, J. K. (1994). *Tcl and the Tk toolkit*. Addison-Wesley, Reading, MA.

Umweltministerium-Baden-Württemberg and McKinsey (1987-1990). Konzeption des ressortübergreifenden Umweltinformationssystems im Rahmen des Landessystemkonzepts Baden-Württemberg. Technical report, Umweltministerium Baden-Württemberg.

USA-CERL (1995a). Grass manuals and sources. Technical report, U.S. Army Corps of Engineers USA-CERL. ftp://moon.cecer.army.mil/pub/grass/grass4.1.

USA-CERL (1995b). Grass users mailing list. Technical report, U.S. Army Corps of Engineers USA-CERL. mailto://grassu-request@moon.cecer.army.mil, "HELP" within the mail body.

Wiesel, J. and Hagg, W. (1995). Visualisierung von Umweltdaten. In Mayer-Föll, R. and Jaeschke, A., editors, *Projekt GLOBUS Konzeption und prototypische Realisierung einer aktiven Auskunftskomponente für globale Umweltsachdaten im Umweltinformationssystem Baden-Württemberg - Phase II*, number FZKA 5700 in Wissenschaftliche Berichte, pages 239–270. Umweltministerium Baden-Württemberg, Forschungszentrum Karlsruhe.

chart drawing facility. GNUPLOT also creates its results as PPM raster files on the server.

To combine the output of GRASS and GNUPLOT we need further tools to combine the results and merge them together for displaying as a thematic map. The process is outlined in figure 3. The PBMPLUS-programs (Anonymous, 1995) are used to convert PPM-files to GIF and Tom Boutell's gd-library (Boutell, 1995) and Martin Gleeson's Fly-Tool (Gleeson, 1995) are used to patch together and mark up the various images to get a final map as shown in figure 4.

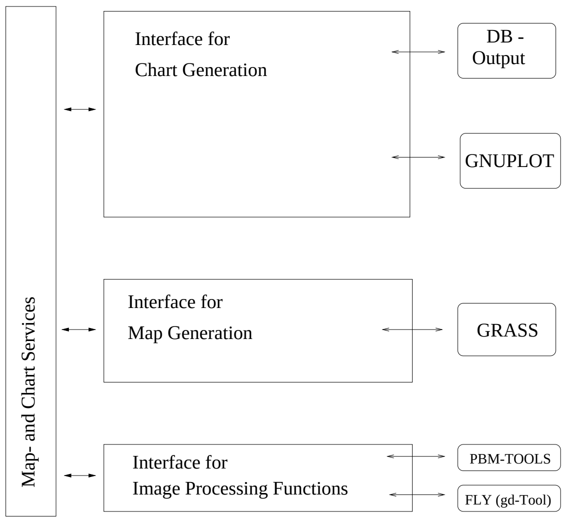

Figure 3: Map composition and preparation

5 CONCLUSIONS AND FUTURE WORK

In this paper we have presented some aspects of an Environmental Information System based on WWW. A more detailed description can be found in (Mayer-Föll and Jaeschke, 1995) where the work of other GLOBUS team members has been published, e.g. on line hypertext documents on toxic waste deposits, keyword tools, in depth evaluation of some CORBA products and CCI applications.

At a client's workstation, only a Web Browser is used - no further software components are needed for browsing hypertext documents, accessing relational and other databases, the display of maps and tabular data as business graphics charts.

The current Web Architecture has some drawbacks, which severely limit the interactivity of graphically oriented and forms based applications, creating a big load on the WWW server.

To address this we are currently evaluating JAVA and JAVA enabled browsers to move some processing steps back to the client. For example JAVA will allow us, to perform some local error checking, drawing of vector data on the client screen and perform local interactions like zooming and panning without any server involvement.

On the server side we are looking at the OGIS (Buehler, 1994) and ISO activities to implement a CORBA encapsulation for certain GIS operators and data access methods. This will - in the long run - make the WWW based EIS independent of proprietary GIS software systems.

5.1 Acknowledgements

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REFERENCES

Anonymous (1994). Gnuplot manual and sources. Technical report. ftp://ftp.dartmouth.edu/pub/gnuplot.

Anonymous (1995). Pbmplus manuals and sources. Technical report. ftp://sunsite.unc.edu:/pub/Linux/apps/graphics/convert.

Boutell, T. (1995). Gd-library manual and sources. Technical report. ftp://isis.cshl.org/pub/gd.

Buehler, K. (1994). The open geodata interoperability specification. In *Draft base Document - OGIS Project Document 94-025R2*.

Bussmann, M., Schuch, A., Tischendorf, M., and Schmidt, F. (1995). Benutzerhandbuch Kommunikationsinterpreter. Technical report, Landesanstalt für Umweltschutz Baden-Württemberg, ITZ, Karlsruhe.

December, J. and Randall, N. (1994). *The World Wide Web Unleashed*. Sams Publishers, Indianapolis.

Eager, B. (1994). *Using The World Wide Web*. Que Corp., Indianapolis.

Gleeson, M. (1995). Fly-tool manual and sources. Technical report. ftp://www.unimelb.edu.au/pub/cwis/tools/unix.

Hess, G. and Schultze, A., editors (1995). *Umweltinformationssystem Baden-Württemberg*, Dokumentation des UIS-Workshops am 15.5.1995. Umweltministerium Baden-Württemberg, FAW Ulm.

Hofmann, C. (1996). Ein Toolkit für die Entwicklung interaktiver WWW Applikationen. Technical report, IPF, Universität Karlsruhe. Unveröffentlichte Studienarbeit.

Koschel, A., Kramer, R., Nikolai, R., Hagg, W., Wiesel, J., and Jacobs, H. (1996). A federation architecture for an environmental information system incorporating gis, the world wide web, and corba. In *Proceedings Third International Conference/Workshop on Integrating GIS and Environmental Modeling*. National Center for Geographic Information and Analysis (NCGIA), Santa Fe, New Mexico, USA.

Kramer, R. and Spandl, H. (1995). Metadatenzugriff in weitverkehrsnetzen: Eine realisierung am beispiel des umweltdatenkatalogs udk. In Huber-Wäschle, F., Schauer, H., and Widmayer, P., editors, *Herausforderungen eines globalen Informationsverbundes f"ur die Informatik; 25. GI-Jahrestagung und 13. Schweizer Informatikertag*, Informatik Aktuell, pages 610–617. Springer.

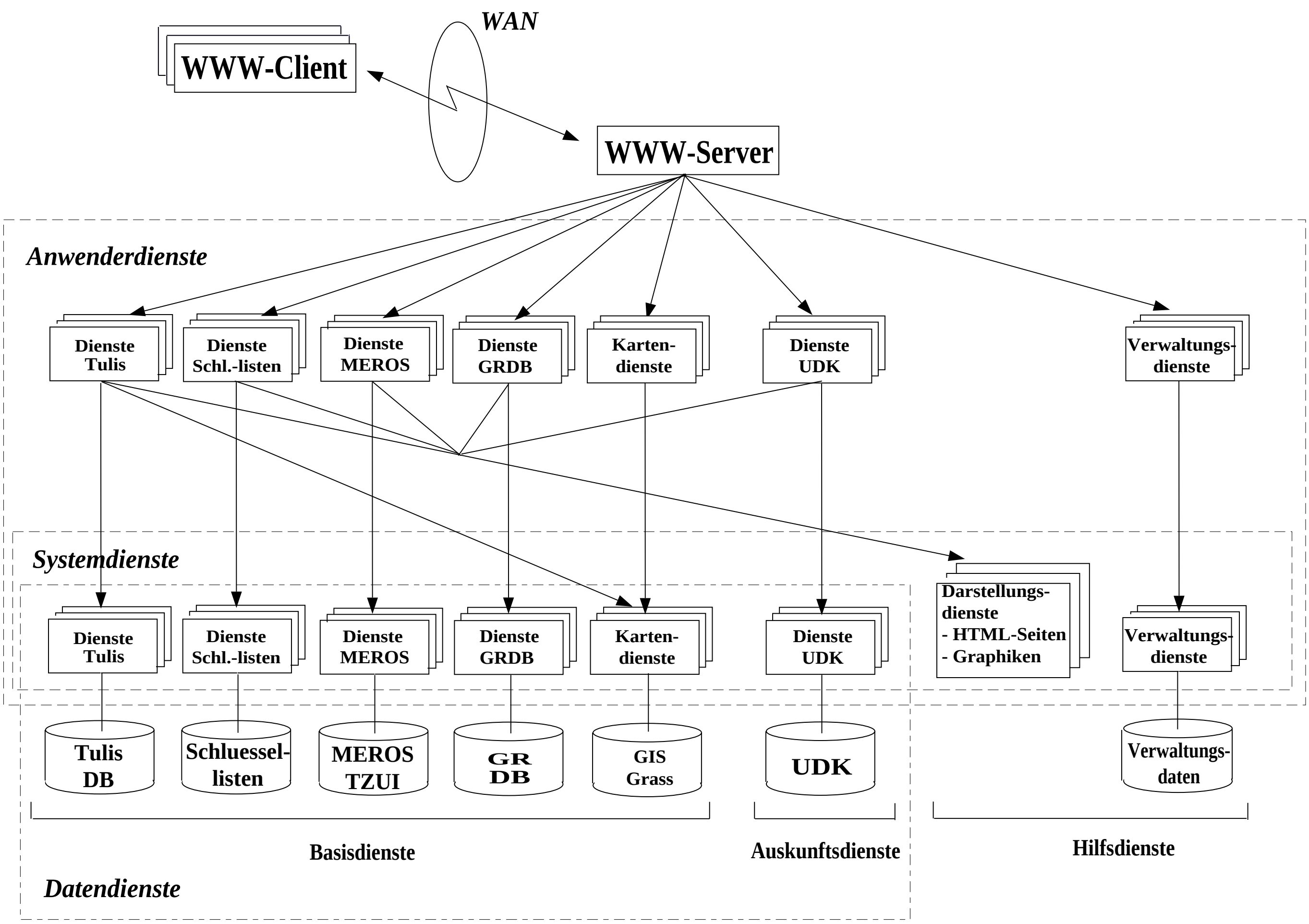

Figure 1: EIS service oriented architecture

HTML utility services. User level services combine one or more system level services into higher level services, directly accessable to users. A possible generalization and extension of this model has been decribed in (Koschel et al., 1996).

3.1 Services based approach

The services based approach offers the possibility to implement well defined services (interfaces, methods, data) in different ways.For example the access to the MEROS database has been implemented by using a batch oriented access TZUI (Bussmann et al., 1995) while UDK (Kramer and Spandl, 1995) and GRDB accesses have been realized by ORACLE ESQL programs.

3.2 Outlook

Currently system services are more or less located on fixed servers. The systems are based on different technology as outlined in section 3.1. To make these services accessable in a distributed manner a middleware layer based on CORBA should be introduced (Object-Management-Group, 1995). This will ideally make the system services part of the EIS-architecture independent of location, low level access and administration technology. Our future work will concentrate on these aspects of an EIS.

4 VISUALIZATION FACILITIES

Visualization of datasets is an essential task in information systems. In an EIS it is necessary to handle tabular and spatial data. Tabular data are georeferenced also.

From a user's point of view a visualization facility should offer the possibility to select several layers from existing map themes and add non graphical data (e.g. pollution measurements) to create a thematic map.

4.1 Requirements

In UIS-BW all geographical data are stored in the RIPS (Spatial Information and Planning System). RIPS has been implemented as a SmallWorld GIS application, archiving raster and vector data of scales 1:5000 to 1:1000000. Access to these data was mandatory.

Non spatial (tabular) data is being stored in several different database systems based on ORACLE and ADABAS running on VAX/VMS and Unix systems. Data from these systems had to be visualized as line and bar charts.

It should be possible to patch together maps and charts into one thematic map.

Final maps, other graphics and tabular data should be exportable to the file store of a client workstation. Further massaging and integration into reports using existing office automation software was a must.

4.2 Implementation

The current WWW facilities for graphically oriented interactions are quite limited. Imagemaps allow a single click only. It is not possible to select areas of interest or even bounding boxes.

GIF raster images have been the only graphical data type available for display by then current WWW browsers.

At the start of the project an online programmatic interface to the SmallWorld datastore did not exist, so we had to find a different solution for accessing the spatial data.

The basic idea - guided by the current WWW functionality - is, to paint maps on the server into a raster file. A user has to select areas of interest, map themes, tabular data and define mapping attributes. The task is then carried out by server side CGI applications.

In order to generate maps and to provide complex GIS functionality we use the public domain tool GRASS, which is a raster oriented GIS that supports digital image processing, map generation and several vector operations. GRASS is implemented in C and is available on UNIX platforms (USA-CERL, 1995a). The use of a public domain GIS enables error-debugging at any time and the extension of the existing pool of methods, since the source code is available. There is also a lot of documentation, including a beginner's, a reference and a programmer's manual, where most of the GRASS library functions and formats are documented. In addition the GRASS mailing list (USA-CERL, 1995b) is helpful in solving problems.

Another problem to solve was the connectionlessness of the HTTP. GRASS uses a mapset concept, where maps and results belong to a certain user. As an unknown number of UIS-users will access the system simultaneously, we had to implement a user session concept. This allows to create temporary and persistent results by introducing a workspace model.

We decided not to use hidden variables to transfer the session context but to create a server side database storing all HTML page contexts. We are using TCL (Tool Command Language) (Ousterhout, 1994) to write all CGI scripts and administration programs. TCL has proved to be very rich in functionality for this task, but not being as demanding on computer resources as PERL is. Details of the implementation have been published in (Wiesel and Hagg, 1995). A library of TCL functions (Hofmann, 1996) has been developed to facilitate writing of interactive HTML application pages without specific knowledge of HTML. This toolkit is based on a callback mechanism similar to the X Windows system. It could be adapted to other page description languages quite easily.

4.3 Map Display Functions

Figure 2 shows the overall architecture of the mapping service. GIS data are imported from an external GIS (RIPS in our case) into GRASS. Geodata and metadata are stored inside the GRASS mapset system. Users communicate with the GIS services by selecting themes (GIS-Metadata service). Currently raster and vector data can be combined by selecting map names and theme names. Geographical regions have to be specified by the name of an administration unit (e.g. a county name) or by entering coordinates, map names or bounding boxes. After selection of input data, the map contents are painted on the WWW server by a heavily modified version of `ps.map`, which creates a PPM (Anonymous, 1995) raster file. Colours and other map layout attributes can be specified, but default values are supplied as well.

4.4 Business Graphics

To draw line, bar and pie charts we are using GNUPLOT (Anonymous, 1994). GNUPLOT offers a rich set of functionality for plotting of scientific data and mathematical functions (1D, 2D, 3D), but unfortunately it is not very efficient in drawing business graphics. We had to write a fairly big amount of programs in the GNUPLOT macro language to adapt it to our needs. We are still looking into something better suited to the task of visualizing tabular data similar to the MS-EXCEL

A CLIENT/SERVER MAP VISUALIZATION COMPONENT FOR AN ENVIRONMENTAL INFORMATION SYSTEM BASED ON WWW

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KEY WORDS: Environment, GIS, Database, Mapping, On_line

ABSTRACT

Since more than 6 years an integrated EIS has been developed in the State of Baden-Wuerttemberg, Germany, managed by the Ministry of Environmental Protection (UIS-Baden-Württemberg). As technologies improved, the basic architecture of UIS has been revised from a somehow centralized to a distributed system based on the concept of services and objects. Services can be offered and used by various state agencies, which are all connected to a state wide inter-agency computer intranetwork (LVN). To improve the accessability to UIS by state officers and citizens World Wide Web (WWW) has been selected as the basic technology to move the user interface part to. Several projects had been set up recently to convert major components of UIS from proprietary solutions to WWW. One important service in this context is to visualize thematic maps and business graphics. A WWW-based solution has been developed as part of the GLOBUS- and WWW-UIS- Projects, financed by the Ministry. Vector and raster data are being visualized using a WWW browser (Mosaic, Netscape) with the possibility to select map layers, themes, colours and scale. Business graphics, like charts, histograms and graphs can be added to these maps by on line access to databases via WWW. The server side part of the system is based on a modified version of GRASS for map painting, layout and legends, while business graphics are rendered by GNUPLOT. A set of Gnuplot-Macros has been written to automatically scale and layout these graphs. A user session concept has been designed and integrated into the system, which allows for individual setup and management of private maps and data sets including work space management on a per user basis. To facilitate and accelerate CGI-script programming (CGI= Common Gateway Interface), we decided to use TCL instead of C or shell script programming. These components have been integrated into WWW-Server side CGI scripts, controlled by TCL (Tool Command Language) scripts for generating HTML-pages, including forms, selection boxes, radio buttons, sliders and other user interface components needed by the map painter. To facilitate the creation and modification of HTML-pages, a comprehensive TCL-library was developed, allowing to easily generate new pages without specific HTML-knowledge using simple TCL-function calls. The system has been installed in the Ministry's network and is being used in day to day work.

1 INTRODUCTION

Since more than 6 years an integrated, interagency EIS has been developed in the State of Baden-Wuerttemberg, Germany, managed by the Ministry of Environmental Protection (UIS-Baden-Württemberg) (Umweltministerium-Baden-Württemberg and McKinsey, 1990) (Hess and Schultze, 1995). It is used to document, supervise and manage data and processes relevant to the environment. Geodata are a fundamental part of Environmental Information Systems (EIS). They are needed to visualize and model processes, measurement and management data. A major component of UIS is a subsystem for storing, integrating and analyzing spatial data. This system (RIPS) is currently based on proprietary GIS and commercial Data Base Software.

2 THE WORLD WIDE WEB

The World Wide Web (WWW) is a client/server based architecture (December and Randall, 1994) for distributing and accessing data on internets. It is based on the HTTP (Hypertext transfer protocol) and the HTML (Hypertext markup language) for describing documents. WWW has been developed at CERN, Geneva as a tool to share documents on the HEPNET, but is now in widespread use. It gained a lot of popularity since the NCSA published the first graphical Web browser - NCSA Mosaic - running on all major computer platforms (Eager, 1994). HTML is a special dialect of SGML. The language specification is controlled by the W3-consortium (http://www.w3.org), with HTML 2.0 being the current version and 3.0 to be released at the end of the year 1996.

The current HTML 2.0 specification allows to integrate text and raster graphics into a document. To build user interfaces several WWW facilities can be used:

- HTML 2.0 forms
  - radio buttons
  - scrolling lists
  - text input fields
- clickable image maps
- WWW-GIS interface
- dynamic map generation

HTTP is a connectionless protocol. This means, every transaction is atomic; there is nothing like a logon procedure or a user context, which is normally needed for access verification or user identification.

3 ARCHITECTURE OF A WWW-BASED EIS

In figure 1 we describe a UIS architecture using a services based view: Horizontally we divide the system into user services and system services. System level services provide kernel functionality, like data base access, geo data access and basic