The UDK Approach: the 4th Generation of an Environmental Data Catalogue Introduced in Austria and Germany

Walter Swoboda
Fred Kruse
Ministry of Environment of Lower Saxony
UDK coordination center
Archivstrasse 2
D-30169 Hannover, Germany
phone: +49-511-120-3480/-3445
fax: +49-511-120-3697
udk@mu.niedersachsen.de

Ralf Nikolai
Wassili Kazakos
Forschungszentrum Informatik
Haid-und-Neu-Strasse 10-14
D-76131 Karlsruhe, Germany
phone: +49 721 9654 744
fax: +49 721 9654 709
{nikolai, kazakos}@fzi.de

Detlev Nyhuis
Holger Rousselle
BVG mbH
Menkestrasse 7
D-26419 Schortens, Germany
phone: +49-4461-985-152
fax: +49-4461-985-299
{nyhuisD, rousselleH}@bvg-fri.de

ABSTRACT

In order to make public access to environmental databases easier, German and Austrian authorities have introduced an environmental data catalogue (= Umweltdatenkatalog, UDK). During the last two years, the fourth generation of UDK was developed based on a careful user requirement analysis. Two UDK applications are presented: WinUDK 4.0 for convenient metadata input and retrieval, and WWW-UDK 4.0 for publishing metadata on the Web. As main retrieval tools, the UDK-Explorer, the Thesaurus-Navigator, and the Geographical Search are offered.
Special emphasis is given to updating procedures and retrieval functions using decentralized databases.

1.0 INTRODUCTION

Since 1990, the member states of the European Community have to fulfil the requirements of the Directive on access to environmental information (90/313/EEC). While libraries offer - and have done so far for a number of centuries - excellent access to their information pool (books), the mentioned Directive revealed a clear lack of instruments that allow a quick and reliable access to environmental databases on a governmental level.

In order to close this gap, the Ministry of Environment of Lower Saxony, Germany, carried out a research project from 1991 to 1995. The result of this project, funded by the Federal Environmental Agency (Umweltbundesamt), was the so-called Umweltdatenkatalog (UDK = environmental data catalogue). At that early stage, a Windows application for metadata collection and a Web-based retrieval application were presented (PC-UDK 3.0 and WWW-UDK 3.0) including prototype catalogues [1] [2]. An important achievement of this project was that the German federal state, 13 of 16 German states (Bundeslaender), and Austria joined the UDK cooperation program, which was formalized in 1996 and which guarantees the progress of the UDK approach. Already in 1994, Austria passed an Environmental Information Law that introduced the UDK as the official navigation tool for all environmental information on record.

Up to now, about 9,000 (Germany), and respectively 12,000 (Austria) UDK records have been registered. UDK is compatible to other international initiatives like GELOS (Global Environmental Locator Service) [3] or CDS (Catalogue of Data Sources) [4] [5].

The results of the research project, the experiences gained during the last years, and a large-scale systematic user requirement analysis in 1997 lead to a re-design of the datamodel and the applications (1998/99). The resulting new UDK generation - UDK 4.0 - is presented in this paper.

2.0 THE USER REQUIREMENT ANALYSIS

In several German and Austrian state authorities, UDK 3.0 had provided since 1995 an excellent opportunity for a survey of the concepts and the software by experienced users as well as by users which intended to introduce UDK. Main objectives of the survey and requirement analysis were to improve the user acceptance for environmental catalogue systems and thus improve the quality and quantity of metadata records.

Two main user groups were identified: data owners in governmental administrations who provide UDK metadata (in the following called metadata providers), and people who demand access to environmental data (in the following called information seekers). The information seekers may be divided into three subgroups: citizens with environmental interests ('What about pollution in my home town?'), members of non-governmental organizations ('Where are the data to verify political promises?'), employees in administrations or private enterprises ('Do data exist corresponding to my current task?').

The user requirements were collected on several workshops and via an email survey. The analysis lead to a large number of results. The most important are:

- The metadata providers want to describe several types of data sources (databases, maps, documents, information services). They also want to describe projects and tasks which 'produce' environmental data.

- In particular in local administrations, very few metadata providers have access to the Web. They prefer offline metadata input, which can be authorized by the leading staff before it is published on the Web.

- Most of the information seekers in the administrations, who have access to the Web, require simple HTML applications avoiding firewall conflicts. E.g., they do not want to make an effort in convincing their firewall administrators to open ports.

- Some of the information seekers require advanced retrieval engines with highly interactive graphical user interfaces. Mostly, they have advanced Web browsers at their disposal and sufficient technical know how.

- The general approach in a country with a federal structure like Germany is to collect and maintain the environmental metadata decentralized. I.e., each of the participating states has its own catalogue. To get information from different states a distributed search accessing these catalogues is needed.

- Another challenge of distributed metadata collection is to keep the different metadatabases consistent. A mechanism for automating this process is strongly required.

- From the international perspective of an European and a World-Wide Network of Environmental Data Catalogues interoperability issues shall be considered more intensively than before.

Taking into account the results of the user survey and requirements analysis, it was decided to re-design the UDK datamodel and applications.
Keeping the known general concept of more or less manual metadata collection and providing two applications for metadata collection (Windows-based) and metadata dissemination (Web-based), respectively as well as providing an improved and enhanced datamodel together with new and modern user interfaces promises to greatly improve user acceptance. This decision also allowed the development of the software tools using new technologies such as Visual Basic 5.0 (instead of MS Access for the PC-based software) and Java Servlets and Java Applets (instead of CGI scripts written in C for the Web-based software) and therefore to ensure the safety of the investment.

3.0 THE UDK 4.0 DATAMODEL

The UDK was developed for collection and retrieval of environmental metadata. The metadata should inform about 'who' holds 'where' 'what sort' of data in 'which format'. Both digital and analog data are of interest. The metadata records are stored as so-called UDK objects. The attributes of UDK objects are related to the identification of the object (object name, general description, key words, etc.), and to the technical, spatial, and time coverage

of the data to be described. Corresponding to various types of data/tasks to be described, the following UDK object classes are offered:

- dataset / database
- service / application / information system
- document / report / literature
- geographical information / map
- organizational unit / task
- project / programs

These classes reflect the most important types of environmental data to be described by UDK objects as well as environmental data producing tasks and programs identified during the last couple of years. As a result of the user requirement analysis the definition of the classes was - compared to the previous version UDK 3.0 [6] - refined and restructured.

A new feature of the technical datamodel is the unique object identification (OID), which is automatically generated when a user creates a new UDK object. Based on the OID, UDK objects may be linked hierarchically (parent/child relation) as well as arbitrary (related object relation).

To fulfil the needs of the various metadata providers an extensible datamodel is introduced. An optional administration module UDK-Z allows to define up to three additional classes and to add attributes to existing classes. This development reflects the use of UDK not only in state authorities concerned with environmental issues but also in further authorities such as geodetic authorities. Altogether the UDK datamodel consists of a GELOS data model which comprises all GELOS fields, the general UDK datamodel which comprises the common UDK fields and the extended UDK datamodel which can be customized for the different UDK installations.

In addition to the management of UDK objects the UDK also provides a simple address management tool and a polyhierarchical thesaurus. Each UDK object can be linked to one ore more addresses, which are administrated separately. This method avoids multiple input of addresses. The controlled vocabulary of the thesaurus as well as free terms can be used for indexing UDK objects and addresses.

4.0 WinUDK 4.0: WINDOWS BASED METADATA COLLECTION AND RETRIEVAL

In December 1998, a new Windows software (running on 32 bit operating systems) has been presented [7]. This software is written in Visual Basic 5.0 and is available as a stand alone application (using the JET Engine) or as a Client / Server application with an ODBC interface.

The relational database management systems Oracle, Informix, MS-SQL-Server, and Ingres are supported.

WinUDK is designed both for advanced retrieval and data collection. Three main retrieval functions are offered:

- UDK Explorer
- Thesaurus Navigator
- Geographical Search

4.1 THE UDK EXPLORER

The UDK Explorer allows comfortable navigation through the tree structure of UDK objects and addresses (see Figure 1). The design is very similar to the MS-Windows Explorer which is well known by the users. A UDK object respectively a UDK address correspond to a file of the Windows-Explorer. The main difference is that UDK has no directories, i.e. UDK objects and UDK addresses can be structured by their own.

A preview window displays the most important information when the user navigates through the database. When detailed information is of interest the user can open a dataset (UDK object or address) directly from the UDK Explorer.

Additionally, a powerful, easy-to-use search engine is implemented in the UDK Explorer. In order to support the user, a picklist with search terms is offered. Depending on the user options, this picklist contains a list of defined keywords or a list of indexed terms generated from all textual fields in the database. Further search filters can be defined specifying object classes, spatial or time reference. Additionally, an expert search is offered which allows a field by field search including AND / OR combinations or - for specialists - SQL queries.

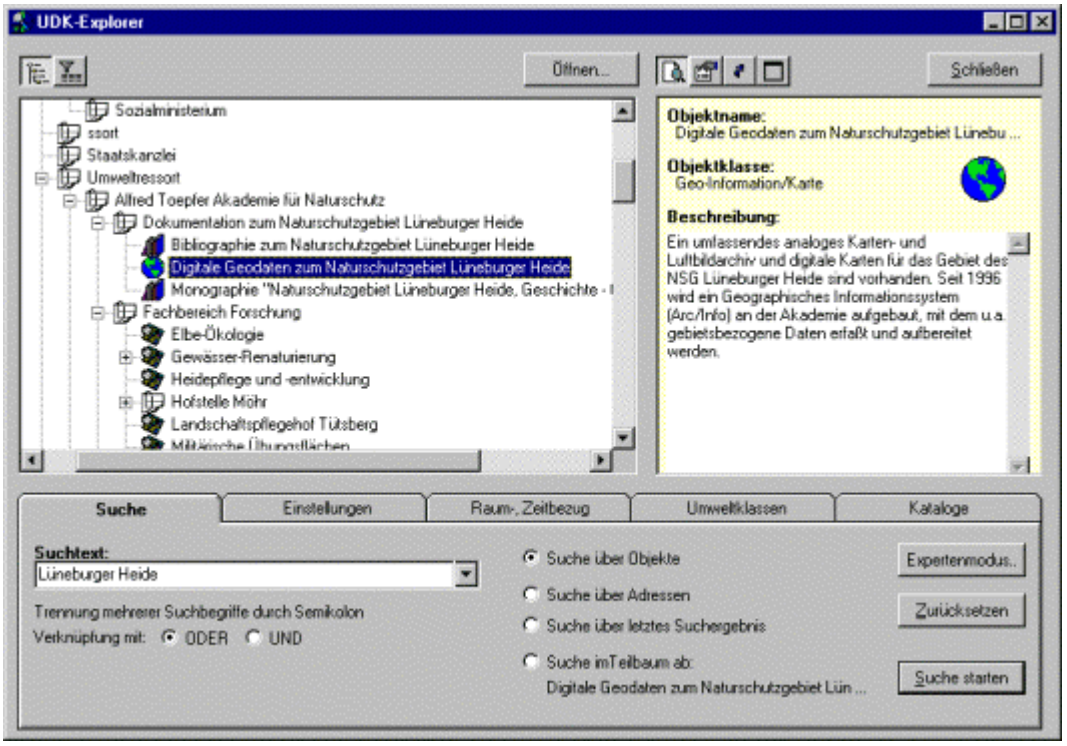

Figure 1: The UDK Explorer

4.2 THE THESAURUS NAVIGATOR

The Thesaurus Navigator enables the user to navigate along a structured set of environmental terms (see left window at the top of Figure 2). The highest term level consists of about 30 general terms (for example climate, nature protection, environmental politics). The following levels contain more detailed terms. If the user is looking for a special term he can switch to an alphabetic list. Selecting a term in the alphabetic list and going back to the structure tree the selected term will be highlighted automatically in the hierarchy.

Each environmental term which has a link to at least one UDK object is tagged with a UDK symbol. If such a term is highlighted by the user, a list of the related UDK objects are presented in a separate window (see left window at the bottom of Figure 2). A preview to each UDK object is given in the right window at the bottom.

Due to the polyhierarchical structure of the Thesaurus, broader and narrower terms of a selected term are presented in a separate window (right window at the top). A double click on such a term highlights this term in the hierarchy in the left window.

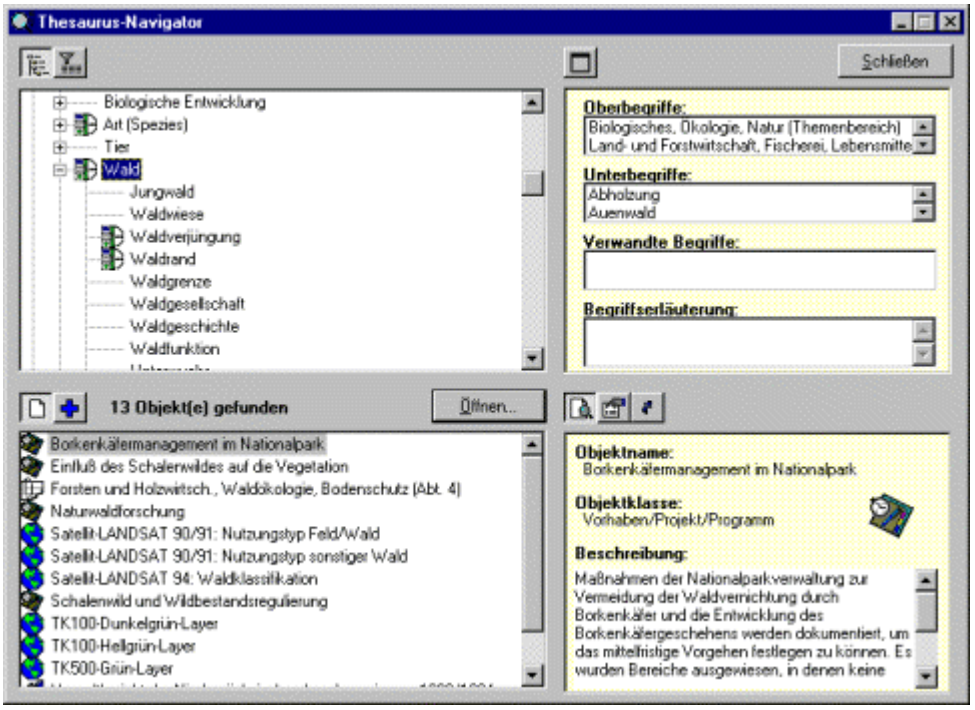

Figure 2: The Thesaurus Navigator

4.3 THE GEOGRAPHICAL SEARCH

The Geographical Search offers a spatial navigation through the database using scaleable maps (see Figure 3).

When the user registers a UDK object, he can define the spatial reference. This can either be done by selecting an administrative unit (for example district of Hannover) or by entering geographical coordinates (Gauss-Krueger) of a rectangle, which is including the spatial reference of the UDK object (the input of the coordinates is supported by scaleable maps as well).

The Geographical Search allows to locate UDK objects by selecting administrative units or by defining rectangles. According to the other navigation tools, the list of related UDK objects and preview information are presented in separate windows.

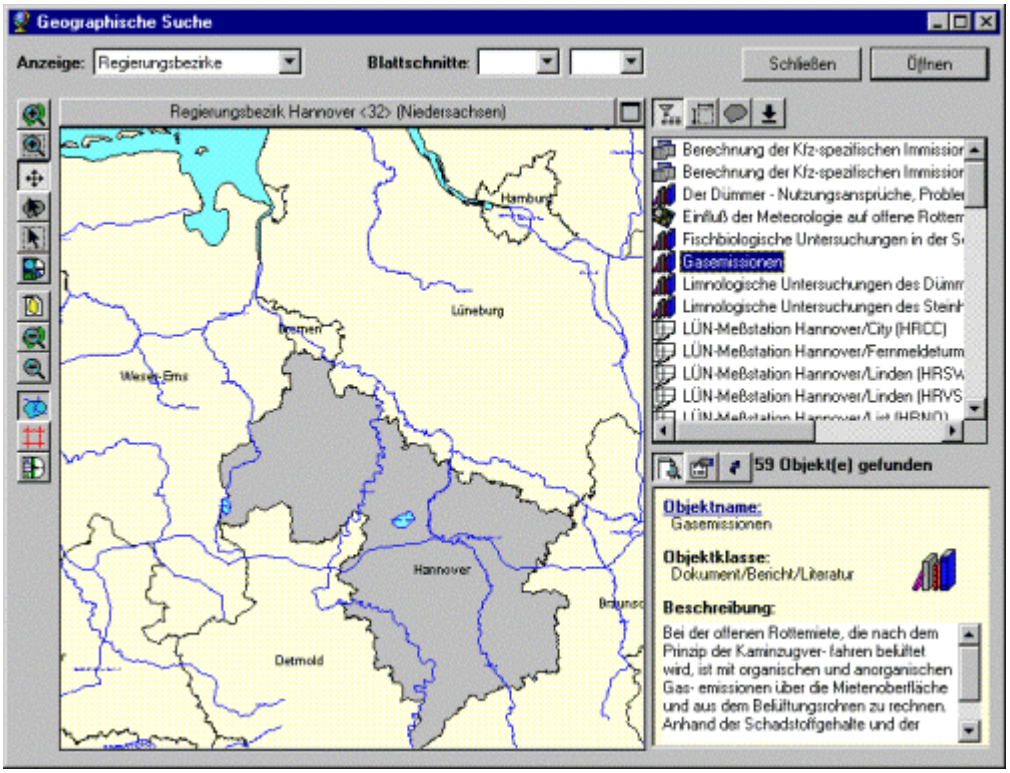

Figure 3: Geographical Search for UDK Objects

4.4 DECENTRALIZED METADATA COLLECTION AND MAINTENANCE

The most serious problem of a metainformation system is the question how to get metadata. Due to the fact that at the time being only few environmental databases generate metadata automatically, most UDK metadata are collected manually. The strategy of the UDK cooperation is that in a first step the metadata are collected by a small team, based on interviews and database descriptions. In a second step the data holders receive the UDK filled with "their metadata". UDK has to ensure that these metadata can be maintained by the data holders, and of course, that they can enter new entries as well. A practical problem the authors were confronted with, is that a lot of local authorities do not have sufficient access to the WWW. Furthermore, a lot of dataholders prefer offline input combined with a quality check by colleagues or superiors before their entries are published in the Web.

Therefore, conventional technologies had to be chosen to solve the problem of maintaining decentralized databases. An updating procedure was developed which is managed by a central administrator (see Figure 4). Each new or updated entry in a local UDK database is indicated with a special flag. The administrator of the local database exports only these entries and sends them to the next higher level. The entries are imported resulting in an update of the database on this level. This process is repeated until the highest (central) level is reached. The central administrator disseminates export files of the central (updated) database so that all participants have the same status.

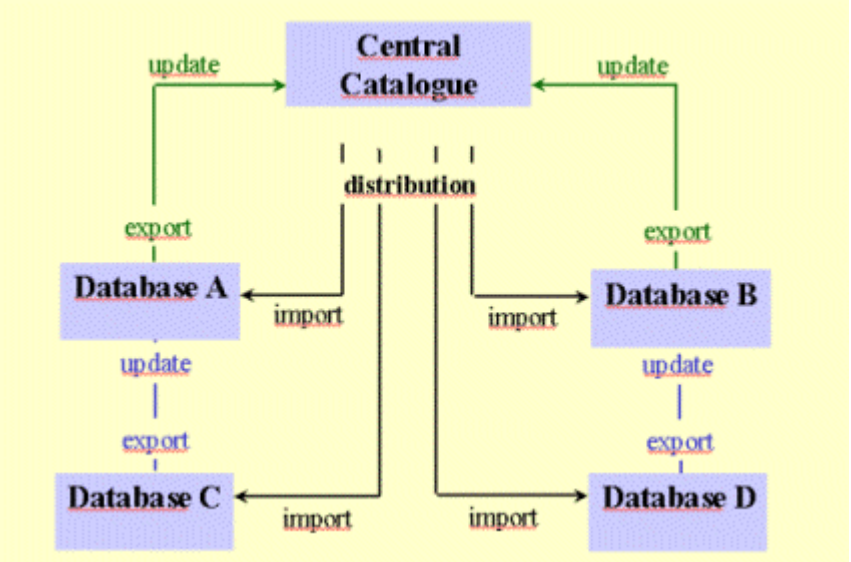

Figure 4: The UDK updating procedure

The new version UDK 4.0 offers a tool to automate this procedure for those participants who have email access (see Figure 5). A so-called UDK agent checks the status of the database by user request or - if requested - automatically in a predefined interval (e.g., once a day). If there are new or updated entries the UDK agent exports these entries to ASCII files. These files are send to the central administrator automatically via email. Here another UDK agent checks incoming emails. The ASCII files are imported in the central database automatically. The same technical solution is implemented to propagate the updates of the central database to the local installations. The central database is published in the Web via the WWW-UDK (see below).

Running the UDK agent on his site frees the UDK administrator from all additional effort concerning the export of his data for other UDK instances and the import of data from these sites. Depending on the options offered by the UDK agent, the user can publish his entries in the Web as soon as he wants.

In addition, it is still possible that a user sends just a floppy disk to the central administrator (which is still important in practice due to limited access to on-line services!).

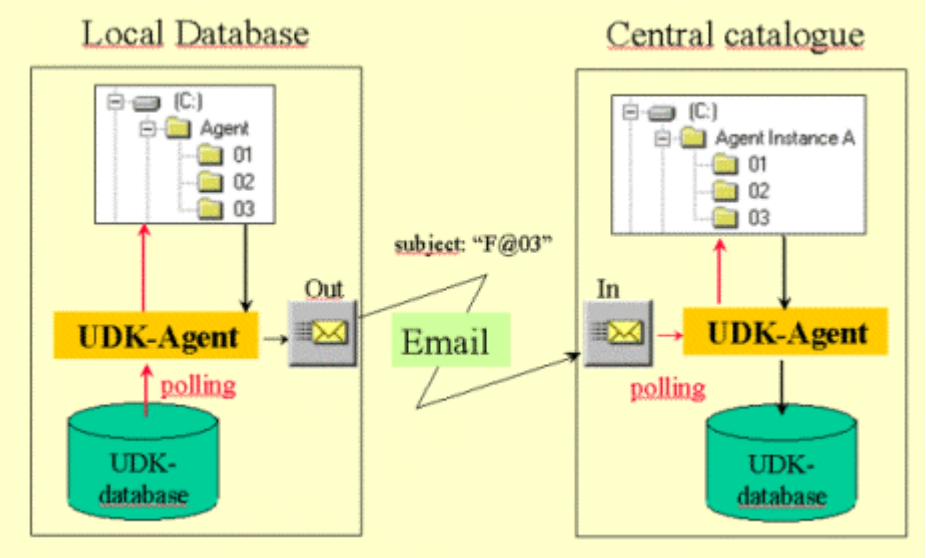

Figure 5: Automation of the updating procedure using the UDK agent

5.0 WWW-UDK 4.0: WEB-BASED METADATA RETRIEVAL

Up to now, the WWW-UDK is designed mainly for metadata dissemination via the Web. The new version WWW-UDK 4.0 provides re-designed functionality and a new user interface and will be available in April 1999 [8].

In order to satisfy the heterogeneous technical and functional user requirements, the application is divided into a basic application providing a fully-fledged retrieval engine (HTML-based user interface) and an advanced, highly interactive and graphical application (Java applet).

5.1 GENERAL ARCHITECTURE

The general approach of the architecture of WWW-UDK (see Figure 6) is based on the experiences we gained during the design and employment of WebCDS [17]. It corresponds with this architecture except for some minor changes regarding the dynamic generation of HTML pages. The main ideas behind this architecture are to achieve reusability of components, to allow distribution of the services (see also Section 5.4), and to support different client and server platforms.

The central component of WWW-UDK is the UDK object and query server which manages client requests, queries the underlying database and maps the results to the UDK business object. In order to provide a call interface for local and remote clients, the object and query server is designed as a Java remote method invocation (RMI) server. JDBC (Java database connectivity) is used to access the UDK meta-database.

Currently, WWW-UDK foresees two types of clients of the object and query server. Further types can be added, if necessary. The HTML client is designed as a Java Servlet [18] and is

executed in the runtime environment of a Servlet enabled web server. The UDK Servlet actually maps the CGI parameters of a HTTP request to a query object and uses the result delivered by the UDK object and query server to build an HTML page (see Section 5.2). The Java-based J-UDK client does not need to communicate via the Servlet. It directly communicates with the object and query server via RMI. Both applications use the same database engine to access the database.

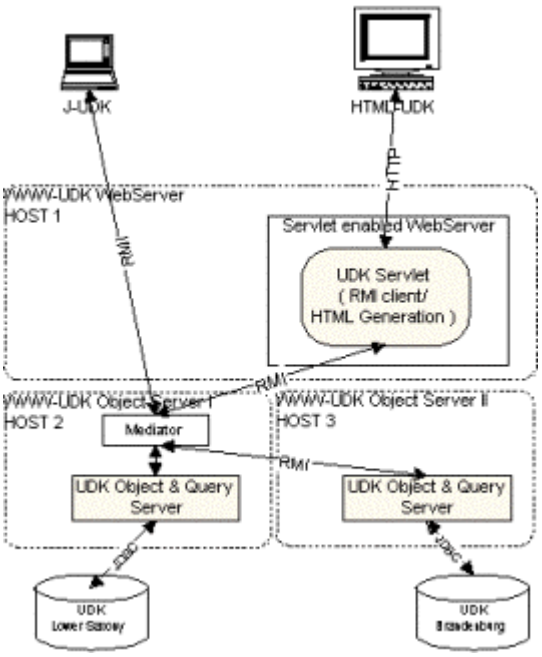

Figure 6:General Architecture of WWW-UDK 4 (left) and enhancements of this architecture to provide a distributed search facility (right).

5.2 HTML-UDK

HTML-UDK is primarily designed for users who want to find environmental information without wasting too much time for the search and have only few experiences with metadata ("show me all information to soil contamination in my hometown"). This user group is similar to the "common" user group of Web search engines. Therefore HTML-UDK's functionality and user interface has many similarities to Web search engines.

5.2.1 FUNCTIONALITY

The basic application provides a quick search, an expert search (with various search filters, e.g., concerning the spatial, the temporal or the thematic relations of the UDK objects respectively addresses), and a thematic navigation along the thesaurus structure (see Figure 7). Both quick search and expert search can be used to search for UDK objects and for

addresses. They correspond to the simple and advanced search modes of Web search engines. The thematic navigation guides the user to UDK objects.

Whereas quick search and expert search enable access to the data by formulating descriptive queries, the thematic navigation provides an explorative entry to UDK objects. This approach is comparable to Yahoos "Browseable Directory" [10]. The categories or directory entries are the thesaurus terms, linked to the UDK objects, which are indexed by them. The different directory levels reflect the hierarchical structure of the thesaurus (see also Section 4.2). This kind of employment of the thesaurus is the result of our experience with more complex user interfaces to the thesaurus which were not accepted by most of the users [9]. The implemented approach provides a simple but efficient thesaurus search.

5.2.2 USER INTERFACE

In contrast to most Web search engines the GUI is divided into three frames. In the left frame the user can directly start a quick search or he can choose a link to the expert search or the thematic navigation which are presented in the middle frame. The search results are displayed as a list
of UDK objects or UDK addresses in the right frame. By selecting one list entry the full information stored in the catalogue - which is usually much more as the information of a Web search engine about a document and why an additional display area is needed - is shown in the middle frame. Since URLs are provided for UDK objects or addresses, it is now possible to go directly to the data described by the displayed metadata object or to the homepage of the address. In this case the user "exits" the UDK system and the corresponding document is displayed in another browser window.

Due to the fact that HTML-UDK will be installed on different Web sites, e.g., of the different German and Austrian state authorities, HTML-UDK has to be integrated into the different corporate Web designs. Therefore most parts of the user interface are customizable. The general structure cannot be changed.

5.2.3 TECHNICAL REQUIREMENTS

At client site there should be no browser or firewall problems when using the basic functions: An HTML 3.2 enabled Web-browser and Web access is all the user needs. The communication between server and clients is strictly based on http. Since some firewall administrators restrict the transmission of JavaScript the use of this language is avoided.

At server site the use of JavaServlets and pure Java guarantees platform independence concerning the hardware, the operating system, and the Web server. The first version of the server is tested for Windows NT, Sun Solaris, and HP-UX.

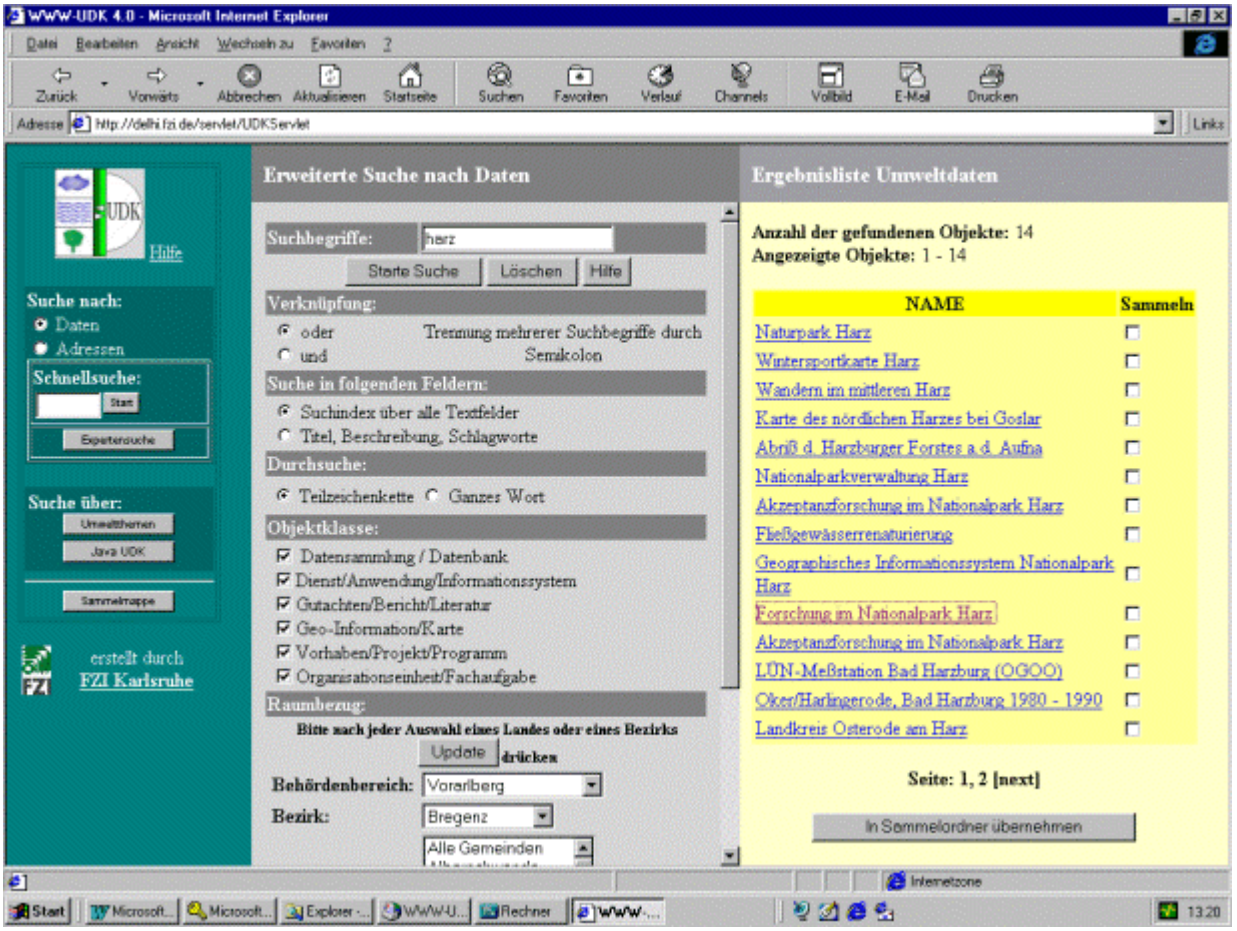

Figure 7: The three frames of HTML-UDK

5.3 J-UDK

More ambitious information seekers users may need more advanced search tools than HTML-UDK. Especially interactive user support and Windows-like graphical user interfaces as required e.g., for map-based searches can be hardly provided by HTML user interfaces. To overcome this limitations of the "HTML and http" approach Java components have been developed for different European catalogue systems [4], [9], [12]. To use synergy effects with this projects it was decided to build an integrated retrieval tool with Java GUI based on these Java components. In contrast to former systems the full process from query formulation, query refining, and result presentation is supported by this integrated tool.

Currently, we see Intranets of state authorities as the most important working field for J-UDK. The broad coverage of metadata from different domains makes the UDK data interesting for various departments. J-UDK provides a comfortable retrieval tool for casual users with all the advantages of Java. Higher network bandwidth and standard Java 1.1 and SWING support by Web browsers will make J-UDK also very interesting for the advanced WWW-UDK users in the Internet.

5.3.1 FUNCTIONALITY

The enhanced WWW-UDK 4.0 application J-UDK is oriented towards the retrieval functions of WinUDK: a UDK Navigator (based on the CDS Navigator [12]; corresponding to the UDK Explorer of WinUDK, see Section 4.1), a Thesaurus Navigator (called GenThes [9]), and a geographical search (called GeoView). For result presentation a result list component and an object and address presentation component have been newly developed. The result presentation component allows to join the results of different queries by using common set operators (intersect, union) corresponding to combining the query with "and" or "or". The object and address presentation component displays HTML pages produced by the HTML generation of HTML-UDK. This avoids the need of two different data preparation services.

5.3.2 USER INTERFACE

J-UDK provides Windows-like look and feel. Whereas the GUI of the main components is oriented by WinUDK (see Section 4), the specific conditions of an Intranet/Internet application had to be considered additionally. E.g., pick-lists of several thousand entries are avoided or partitioned into smaller groups and the precision of the maps for the geographic search is decreased in order to reduce network traffic.

The J-UDK GUI is fully implemented in Java making use of the SWING classes [14] for advanced user interfaces. The Multiple Document Interface (MDI) approach well-known from Windows application is realized by the use of SWING Internal Frames.

5.3.3 TECHNICAL REQUIREMENTS

J-UDK needs a Java and SWING enabled Web browser at client site. To avoid the problems of different Java runtime environments (with different bugs) of different browsers we strongly recommend to use the Java Plug-in [11]. The communication between client and server is done via Java RMI (Remote Method Invocation). Firewalls between client and server have to open two ports for proper communication. If a rigorous firewall policy of a state authority does not allow to open these ports for RMI communication, J-UDK still can be used in the Intranet of the authority. In such cases the information need of other state authorities and the general public can be served through HTML-UDK (see Section 5.2).

J-UDK uses the same database engine as HTML-UDK and no additional server components. Therefore J-UDKs requirements on server site are the same than the requirements of HTML-UDK.

5.4 DISTRIBUTED SEARCH: THE VIRTUAL UDK

A distributed search across various WWW-UDK servers is required due to the fact of autonomous catalogues of the Austrian and German states. I.e., that the update procedure for decentralized metadata collection and maintenance (see Section 4.4) is mainly foreseen to be

used by the different authorities in one state. There is no central catalogue - comprising all UDK data of all states - foreseen. The distributed search provided by the "Virtual UDK" enables the information seeker to query for distributed UDK metadata as if they are stored in a central catalogue.

In a first phase HTML-UDK only provides the distributed search. The goal of this phase is to get experiences and to test the user acceptance regarding the Virtual UDK. Based on these experiences and the user feedback additional "distributed features" will be implemented by HTML-UDK as well as by J-UDK.

The architecture of WWW-UDK and the homogeneity of the catalogues (currently, we do not consider state specific enhancements of the UDK datamodel) which will be accessed by the Virtual UDK does not require complex protocols such as Z39.50 [16] or CIP [15] to implement the distributed search. Instead of this, we base our distributed system - as already done for the "single database access version" - on Java RMI (see Figure 6). At server site two additional components, a robot and a mediator, have been developed:

- The robot collects statistic information from the distributed UDK catalogues such as "which thesaurus terms are used for indexing of how
- many UDK objects on this server". This information is needed to provide almost the same functionality as a "central" catalogue. The actual
- UDK metadata are not transferred to a central site.

- The mediator sends the queries to the available catalogues, merges and sorts the results.

Distributed searches concerning further related catalogues are discussed in [13].

5.5 PROTOTYPE WEB-BASED METADATA COLLECTION TOOL

Prototype Web-based metadata collection tools have been developed for the previous UDK version (WWW-UDK 3) and for the Catalogue of Data Sources (CDS) [4]. It is intended to develop such a Web-based metadata collection tool for UDK 4 based on the experiences gained during the development and employment of these prototypes, the developed software components of WWW-UDK 3 Update and WebCDS Update as well as of J-UDK (for retrieval functionality which is also necessary in an Update module). This tool will allow casual metadata providers to insert and maintain their metadata without the need of local installations of a UDK database and the UDK software.

6.0 CONCLUSIONS

The UDK has become a quasi-standard for environmental metadata in Austria and Germany. Being in use since several years a user survey of the UDK concept and applications showed the general acceptance and necessity of the UDK but also the need for an improved and flexible data model and more user-friendly applications for metadata collection and dissemination. These requirements resulted in a major re-design efforts providing state-of-the art, highly user-friendly tools as well for metadata providers as for information seekers. To

reduce costs, synergy effects with related projects were used. The improvements of the tools are supposed to result in future improvements of the quality and quantity of the metadata records. Therefore, the federation of the decentralized UDK databases ("Virtual UDK") will provide a valuable basis for providing access to heterogeneous, distributed environmental information in Germany and Austria.

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