EUROPEAN MINING DATABASE NORTH RHINE – WESTPHALIA (EMD-NRW): A MASHUP FOR INTUITIVE USAGE OF ARCHIVE DATA

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Abstract
The European Mining Database for North Rhine Westphalia (EMD-NRW) has the objective to present information about the industrial heritage of mining in an intuitive web mapping application. With the increasing abandonment of these industrial objects, especially in the area of NRW, the digital preservation of information, locations and relations between and about these objects is important. These historic sites and the transformation from an industrial area to a new polycentric metropolis is also a key focus of the European Capital of Culture 2010 "Essen for the Ruhr". The EMD-NRW system is capable of representing the complex, hierarchical structure of archive data and connecting this data to their geographic location. Comprehensive information is available about every object. A combination (mashup) of own geodata and data of Microsoft’s Bing Maps is used. For beginners and experts information are easy to retrieve because of the intuitive design.

Keywords
data base, web mapping application, mashup, archive data, hierarchical structures

1. INTRODUCTION
The European Mining Database for North Rhine Westphalia (EMD-NRW) is a regional pilot project which connects complex, hierarchical archive data of industrial heritage objects and corresponding geodata in a web mapping application (http://www.emdnrw.uni-koeln.de). This pilot project focuses on representative objects of the coal-mining industry. For this purpose a mashup of own geodata and Microsoft’s Bing Maps (WIKIPEDIA 2010a) is implemented as well as a database, which contains information and structures from archives. The web mapping application allows a user to discover the content of the database by a clear and intuitive design in a web browser. This pilot project is an important contribution to the current state of research in the field of online industrial heritage inventories. Due to increasing abandonment a digital preservation is necessary. Positive effects and synergies for research and planning are expected.

The EMD-NRW system is intended to be a part of a European internet database. In 2004, „The International Committee on the Conservation of the Industrial Heritage - Mining Section“ has proclaimed that such a database should be the top level of several regional databases and should provide generalized information. Each regional database should contain detailed information about mining industry objects and be linked to the upper level.

In cooperation with the Rhineland Regional Council (LVR) office for historic preservation of the Rhineland (ADR), the GIS and Remote Sensing Group of the Institute of Geography (University of Cologne; www.geographie.uni-koeln.de/gis) has started a web mapping application project with comprehensive data for the Rhineland in 2007 (HOFFMEISTER et al. 2009, 2010). In the GIS and Remote Sensing Group numerous spatial data management expertise exist from several research projects, particular on integration of non-spatial data sets to their spatial extent (BAASER et al. 2006, CURDT et al. 2008, LAUDIEN & BARETH 2007, SOYEZ & GELHAR 2003, WILLMES & WESKAMM 2007).
Already, several private websites are representing coal-mining areas with a lot of historic pictures, maps, and stories about shafts and adjacent buildings. These websites are for example:

- www.foerdergerueste.de: a large project with several 3D-models and information from other countries
- www.ruhrkohlebergbau.de: shows detailed, static thematic maps about most shafts in historic and recent relation
- www.fotorevier.net: presents artistic pictures from buildings and events
- www.zechensuche.de: focuses on recent pictures from coal-mining complexes
- www.zechenkarte.de: a Google Maps- mashup with links to according sites

In particular, the state of North Rhine Westphalia is strongly influenced by mining. In the Ruhr area, coal mining can be traced back to the early medieval times, in the region of Aachen even into the Roman period (HERMANN & HERMANN 1990, BUSCHMANN 1998). Since 1957/1958 a decline of the coal-mining industry in Germany started. Only some of the elements are made available to the public as industrial monuments, such as the Zeche Zollverein (BOLDT & GELHAR 2008). Most of the areas are already abandoned. This decline of the coal-mining and adjacent industries lead to the opportunity to reuse large, central areas in the cities, in regard to the industrial, cultural heritage (PROSSEK et al. 2009, GELHAR 2010). This (re-) development and the industrial heritage is a significant theme in all projects and events of the European Capital of Culture 2010 "Essen for the Ruhr" (BUTZIN & NOLL 2010). For example, the project "Schachtzeichen" (www.schachtzeichen.de) will raise huge, yellow balloons above every shaft of the Ruhr region. A digital preservation and documentation from a cultural, technical, and historical perspective is important.

In this contribution, we introduce a system that is capable of presenting complex and large amount of data of historic coal-mining sites in an easy-to-use web mapping application. We demonstrate this approach with a mashup of own geodata and Bing Maps-geodata, as well as a complex hierarchical database. Firstly, we introduce all data which is used in this system and how it is originated. Analog data, like maps and pictures were accurately digitized and converted. Secondly, new and implemented technologies, e.g. APIs and the Ajax-paradigm are explained. Thirdly, the architecture of the web mapping application, the database structure and the functions of the web mapping application are described in detail. Finally, a brief conclusion and future perspective is given, which shows that the EMD-NRW system is capable of an easy-to-use presentation of a complex, detailed digital preservation of industrial sites.

2. DATA

For the established web mapping application different sources of data are used. Own geodata about coal-mining areas and adjacent buildings are established by digitization and referenced by federal geodata. Additionally, data of Microsoft’s Bing Maps is incorporated into the web mapping application. Furthermore, a database is set up containing archive-, metadata and object relations.

So far the inventory and documentation of industrial mining objects in the Rhineland are mainly archived in analog form by the LVR-ADR. Therefore, all data (maps, texts, and photos) for the database EMD-NRW was digitized. For example, pictures were glued on paper sheets, labeled by hand-writing with the name of the mining area, building, photographer’s name and the year recorded (see Fig. 1).
The whole sheet was scanned, assigned with an ID and corresponding information was drawn into tables. Later, the picture of each sheet was clipped, tilted, and saved. According to the inventory structure (see also chapter 3.3) of the LVR-ADR, these scans are also assigned with additional inventory numbers. Currently (April 2010) more than 1,300 objects are incorporated in the EMD-NRW database. The pictures and plans are stored on the web server itself.

Coal-mining objects were digitized in close cooperation with the LVR-ADR from existing maps and aerial photographs. These analog maps assigned with areas and buildings were scanned, georeferenced, and digitized. Georeferencing was supported by the Web Mapping Services (WMS) of the GeoServer NRW (http://www.geoserver.nrw.de). For verification and to identify even more coal-mining areas maps from the 1920s were taken, where available.

Furthermore, the data was compared to recent data, e.g. the German base map (“Deutsche Grundkarte”) 1: 5000 or Digital Orthophotos, to identify all objects which are abandoned. Also, the data from the GeoServer NRW was used. The objects are indicated by different attributes, e.g. buildings under current monumental projection are assigned with a certain code. With regard to the mashup with Bing Maps data, the presentation of all own data is optimized for this purpose. Geodata is projected in WGS84 Web Mercator. The map layout, color and zoom levels are set according to the implementation with Bing Maps. The geodata service is cached in tiles, according to the Bing Maps tiling scheme (ESRI 2009). For example, the mentioned buildings under protection are colored in red.

The map service of Bing Maps is implemented into the web mapping application as the second geodata source. Satellite-/ aerial images and vector data from this map service are usable separately or in combination (hybrid view). Compared to the data contained in Google Earth or Google Maps, the Bing Maps service contains a side viewing perspective (birds-eye-view) of certain areas, which gives a quite impressive presentation of the objects.

3. SYSTEM ARCHITECTURE

3.1 Technologies

The EMD-NRW web application combines several advanced web mapping technologies. The main components are a combination of ESRI ArcGIS Server (ESRI 2006) and Bing Maps technology. The connection between the two is facilitated using the ESRI JavaScript API for Bing Maps (ESRI 2009). The result is a mashup of Bing Maps and own geodata. Additionally, a MySQL database (MySQL 2010) for the handling of comprehensive additional information on all objects, which is connected via AJAX and server side PHP (PHP 2010), is integrated into the system. Technically, all servers and services are provided by the Regional Computing Center of the University of Cologne (RRZK 2010).

A mashup is loosely defined, as a combination of services of several sources, using open APIs. Mashups are closely connected to the advent of web 2.0 (O’REILLY 2005). Freely-available resources can be used and combined in an individual way. In this case, a business mashup is developed, because own data is combined with external data (WOOD 2007, WIKIPEDIA 2010).
Existing tools provided by the ESRI JavaScript API are extended by specific tools for the usage of the database content. These additional tools, which are described in chapter 5, are developed by using the well known Dojo JavaScript framework (Dojo Foundation 2010). Dojo is used by many companies’ websites such as Apple, IBM, and AOL. It has a proven browser compatibility and stability. This framework offers rich client side user interfaces (UI). The communication between the server-side PHP scripts, the MySQL database and the client-side UI is implemented by Dojo. Overall, the AJAX paradigm is utilized for this system.

AJAX is a merge of four constitutive technologies (Garrett 2005; Crane et al. 2006). These four technologies are client-side JavaScript as a scripting language, HTML or XHTML, and CSS (Cascading Style Sheets) for the graphic format of the web interface, DOM (Document Object Modeling) as a model of a web page in a set of programmable objects, and the communication between client and server via JavaScript by a data exchange format. Previously, XML (Extensible Markup Language) was used, now mainly JSON (JavaScript Object Notation) is implemented.

Therefore, the user interface consists of the Bing Maps UI and the Dojo UI part on client side. The communication and interaction between the UI and the geodata service from the ArcGIS Server is implemented using the REST (REpresentational State Transfer) protocol and JSON. This data exchange is an asynchronous background activity to shorten response times of requests from the client and improves the user experience (usability) of the application.

The geodata service of the ESRI ArcGIS Server can also be accessed as an OGC-compliant WMS in version 1.3.0 (Open GIS Consortium Inc. 2004). This enables other developers and users to integrate the EMD geodata into their (Web-) GIS applications. Thus, a linkage to existing and new systems, such as the proclaimed European database (see chapter 1) or KuLaDigNW (Cultural Landscape Digital North Rhine - Westphalia) system is possible. Latter is intended as the first of its kind in Germany, which almost includes all cultural landscape elements (Buchholz 2008).

Overall, the EMD-NRW project follows the current trend to process a large part of the user interaction on the client side through the use of JavaScript, which speeds up response times. The system architecture of EMD-NRW follows a hybrid concept consisting of utilizing a mix of proprietary software and open source products.

3.2 System architecture

The introduced technologies are used to build the EMD-NRW web mapping application. The web browser based client integrates the Bing Maps UI and the Dojo based UI into a HTML and CSS based website (see Fig. 2). All functions are implemented in JavaScript, which at least has to be enabled on client-side to work as intended.

Fig. 2: System architecture of EMD-NRW

The content of the application is provided by three main sources to the client UI:

i. The geodata of the EMD database (EMD Geo-DB), which contains the digitized mining areas and additional attribute data, is provided through the REST API of ArcGIS Server.

ii. High-resolution aerial imagery and comprehensive vector data base maps are delivered through the integrated Bing Maps application.
Comprehensive additional object information, like descriptive texts, corresponding metadata, and links to suitable pictures and plans, is stored in a MySQL backend (EMD MySQL-DB), which is accessed through a server-side PHP script.

The Bing Maps UI is used to access the spatial data of the EMD Geo-DB in combination with Bing Maps content. The Dojo UI connects the data from the EMD Geo-DB with EMD MySQL-DB to enable an integrated UI for browsing the data within its spatial relation. Additionally, a simple PHP-based UI is implemented for accessing only the data of EMD MySQL-DB by SQL-based attribute search.

Within the design of the EMD-NRW system, much effort was invested into usability optimization. Consequently, a very intuitive UI is designed. To keep the response times short, AJAX is facilitated through the Dojo and Bing Maps UIs to handle requests asynchronously. Additionally, we use pre-cached query responses from the MySQL backend stored in a JSON-formatted file, to avoid querying the database too often. This cached object can be updated through an internal PHP-based administrator script.

### 3.3 Database structure

The database structure is essential for the whole system. The archive data is implemented according to the inventory structure of the LVR-ADR. For this purpose, a system of seven hierarchical layers (from geographic regions to equipment in a building) is implemented. Every object can be connected to one or more texts, pictures, and plans. These pictures and plans are stored in a folder system. All files are named according to their ID in the database. Corresponding metadata of the pictures and plans are also stored in suitable tables. The implementation of this database structure follows common guidelines and best practices of database establishment, e.g. avoiding duplicate entries (KOFLER & ÖGGL 2004). Therefore, nearly unlimited information of objects, scans, and texts can be stored.

All information is kept in the database in a corresponding table structure (see Fig. 3). Links between the objects are established by using unique identifiers (IDs). E.g. all buildings which belong to one sub-facility are assigned with the same subfacilitiesID. To link the database objects to objects of the map service, both are assigned with identical IDs. But not every hierarchical layer is represented in the web service, e.g. regions. Therefore, coordinates and zooming stages are applied to these objects (see Fig. 3).

This hierarchical structure is presented in the web mapping application mainly by a tree-list-tool (see chapter 4) and by links in every detailed object view. The relations of the different hierarchical objects to each other are emphasized, e.g. all buildings needed for coal extraction are clustered in this special sub-facility.
4. THE EMD-NRW WEB MAPPING APPLICATION

Through the web mapping application of the EMD-NRW project (http://www.emdnrw.uni-koeln.de) it is possible to retrieve the stored information by several options. As mentioned above, the web mapping application and its functions are simple and designed for an intuitive usability. Easy navigation such as zooming or panning in the map is provided by the navigation toolbar, known from Bing Maps. Also, easy switching between the different view options (map/aerial/birds-eye view) (see Fig. 4) is possible.

![Fig. 4: Side-view of the pit frame of Zeche Zollverein, Essen, indicated by a red rectangle and a building icon as a link for more information.](image)

Enhanced functions are provided by an additional toolbar, which are selecting, searching, and identifying the content from the map service and the database. The toolbar is located on the right side of the web page (see Fig. 5) implemented by using the Dojo framework in combination with an open source icon library. These functions are in detail (from left to right):

- a search tool to find objects or addresses and routes through a geolocation service
- an identification tool, which leads to small pop-ups showing the identification results and a link to more information about the object
- the “list tree” tool (explained later on)
- a swipe tool for deleting selections
- a tool for switching back the view to the full extent of the area under investigation
The geolocation functionality provided by Bing Maps is used to return geolocations (coordinates) for a place name or an address request from the search tool. The search results are shown directly in the Bing Maps UI map, by centering the map on the object and highlighting a shape or point feature. If more than one geolocation matches the request, the user is prompted in a pop-up to decide which location should be shown.

A major feature for getting the comprehensive information is the “list tree” tool which shows a hierarchical tree of all objects. This feature is implemented using the Dojo tree widget, which accesses the precached JSON file (see chapter 3.2) to build the tree object dynamically from the structure of the JSON document. These objects are listed by the above mentioned inventory structure of the LVR-ADR (see chapter 3.3). It starts with the two main regions, followed by overall complexes, facilities, parts of facilities (sub-facilities), and buildings.

As an additional option a search function without the map view is integrated to show just the structure, texts, and scans. It is possible to search the data in several different ways. For administration, some special functions for controlling are implemented.
With all introduced tools, comprehensive information of an object can be accessed by a mouse-click. The information of a selected object is displayed in a pop-up window. Information is sorted by tabs, starting with general information and texts about an object, inventory of a building, pictures, and plans (see Fig. 6). Every picture can be enlarged and additional metadata is displayed underneath.

5. CONCLUSIONS AND OUTLOOK

The EMD-NRW web mapping application is a mashup of self-generated geodata and Bing Maps-data. Additional data from a database is used to deliver comprehensive information about the objects and to connect objects hierarchically. All objects were digitized and converted to the established structure. A lot of work was invested to precisely accomplish this step. This data is now available in a web mapping application which can be accessed by the internet with every browser (http://www.emdnrw.uni-koeln.de). In opposite to existing websites (see chapter 1) a new, intuitive, dynamic web mapping application was developed, which emphasizes the geographic relations of the industrial sites.

Through the usage of new programming possibilities a very fast and intuitive system is generated. As one of several projects connecting larger databases with geodata (e.g. the CampusGIS project, BAASER et. al. 2008), the EMD-NRW design especially focuses on an intuitive user interaction. The mashup development approach is faster as the development from scratch. In this case, no resources had to be spent on establishing topographic data or imagery. With the well known navigation functions from Bing Maps and just a few more additional tools and boxes, a large and complex amount of data is easily accessible online. Saved resources were spent on design questions and functionalities.

In the future, a connection to other projects, an increase of data and locations, as well as more functions are planned. E.g. routing functions and “virtual tours” are possible by using the new version 1.4 of the ESRI JavaScript API for Bing Maps (ESRI 2009).

Most coal-mining complexes in the area under investigation are demolished. Only the most important objects are considered to be preserved, e.g. Zeche Zollverein. Therefore, a system which facilitates the storage and presentation of the complex hierarchical structures of industrial complexes is getting more important.

However, it is also essential that the project will not be the only one in the future. Other regional databases as well as the proclaimed European database should be established. They may benefit from the experience and the functions of the EMD-NRW project.

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BIOGRAPHY:

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Martina Gelhar studied Geography, Geology and Zoology at the University of Cologne. 2004 she received her PhD in Geography for research on industrial heritage tourism in the western Ruhr area (North Rhine - Westphalia, Germany). Since then, she has become an acknowledged expert for the complete Ruhr district. She is currently lecturer in Human Geography at the Institute of Geography at the University of Cologne.