ProNet – an intranet-based 3D information system

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ABSTRACT: An increasing number of safety installations, monitoring devices and innovative process control components lead to a rapidly growing amount of data. Technical planning systems, complex calculation results and numerous databases add even more substance that has to be dealed with. It is obvious that currently used technology for collecting, storing and analyzing this flow of information is more and more overloaded. This is particularly true, if a clear and predictable visualization of all relevant details and their relations is required.

The research and development project “ProNet” is intended to be a contribution for improving the quality and availability of such visualization and data evaluation systems. Since summer 1998 the “Computer Aided Engineering” team within the Institute of Mining and Metallurgical Engineering (RWTH Aachen, Germany) is cooperating with the German hard coal mining company “Deutsche Steinkohle AG” to develop concepts and software solutions for optimized handling and evaluation of process data sources, technical planning data sources and the relationships between them. In the long run this will lead to advancements regarding both operational safety and economic efficiency in the mining business. Making such software solutions available within the mining company’s intranet can also be understood as an approach to a new kind of information management.

The implementation of all software modules benefits from a state of the art internet and browser environment. All "ProNet" features are available through web browsers, e. g. Microsoft’s Internet Explorer.

1 INTRODUCTION

For several years the German hard coal mining industry utilizes efficient electronic data processing (EDP) equipment. This includes standardized office applications as well as specialized planning, monitoring and diagnosis systems tailored to the needs of the mining business. Networking infrastructure has been introduced along with these hardware and software components in the production as well as administration departments. Some examples for the different areas of EDP application are:

- PC workstations (e. g. for use with office applications and SAP/R3) including databases and intranet web servers.

- Specialized process control equipment with visualization terminals in the central mine control room; this includes ventilation control equipment for monitoring the underground mine air condition.

However, despite that all these logical areas are physically linked together via computer networks, usually only a little information exchange takes place between them. Discrete specialized EDP components are working on jobs that are not related to each other, whilst the available network technology remains partially unused. Figure 1 gives a portrayal of this.

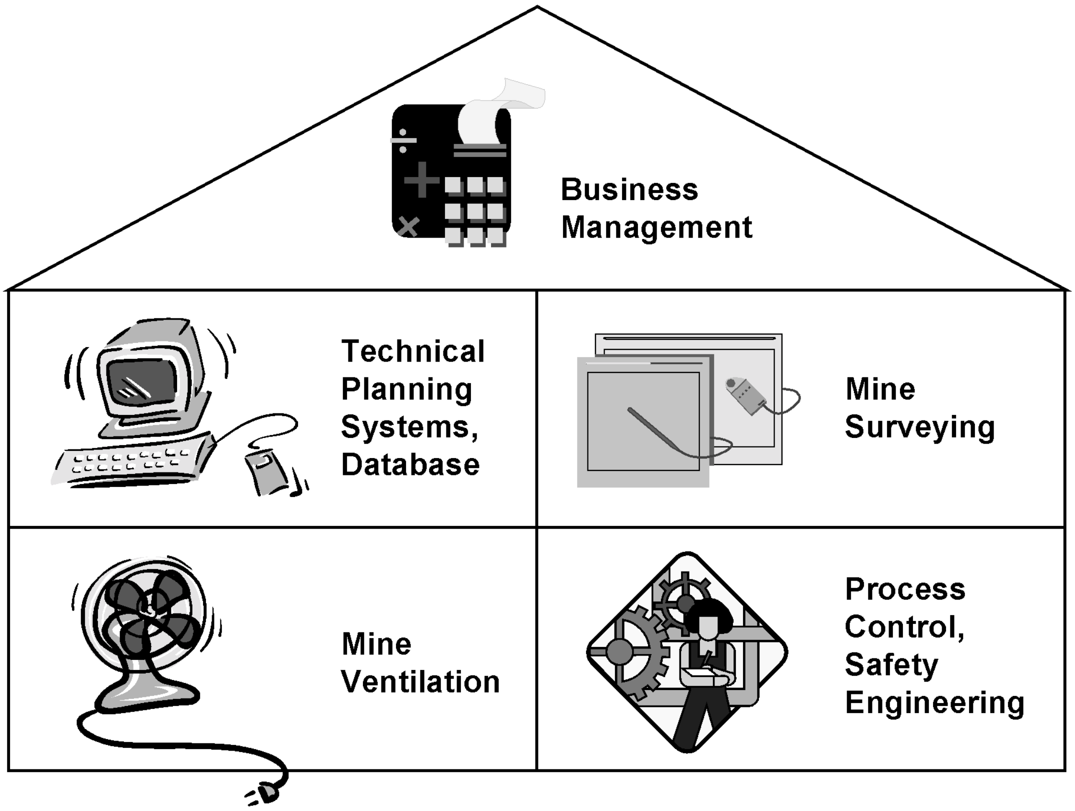

Figure 1. Separate logical areas of data processing.

An unfavourable consequence is however, that distributed sources of information cannot be linked together easily. Two examples are given as an illustration:

- An alarm is triggered because too much mine gas (methane) was detected by the ventilation safety control system. Are there any old, caved areas which could have caused the gas emission? What other kinds of sensors and telephones are located nearby? What are the telephone numbers?
- Work is in progress to open up a new connecting passage between two existing roadways. The underground workers need detailed information regarding road distances and gradients. How can this information be obtained in the short term? Is it necessary to find a member of the planning staff first (which would take at least two hours) or are additional means of data retrieval provided?

Resulting out of the “ProNet” research and development project an intranet-based information system has been designed as a contribution for improving the visualization and evaluation of such distributed sources of information. Making this system available within the mining company's intranet can also be understood as an approach to a new kind of information management.

It has to be pointed out that "ProNet" is neither a registered product name nor a trademark. Instead it is used only as a synonym for the research and development project described in this article.

2 DESIGN PARAMETERS AND INTERNAL STRUCTURE

The ProNet information system is designed to improve communication between the different logical areas that can be found within the EDP infrastructure. The following sections give a detailed overview of the different ProNet components. A description is given of how the new information system relates to other hardware and software that is already existing in typical hard coal mines. Finally an in-depth introduction into ProNet's internal structure is given.

2.1 *General requirements*

Design and implementation of the ProNet system can only occur at the hand of some general requirements. These have already been listed up at the very beginning of the research and development process:

- The three-dimensional mine geometry should be used as the central element of all ProNet visualizations. The only way to introduce distributed information sources (e. g. measuring devices, locations of telephones, business administration data files) into the scope of the ProNet system, is by attaching them to this 3D mine geometry.
- All information about the 3D mine geometry is provided by a central database system. This database is usually called "Geometric and Technical Planning Database" or "GTP-DB". The 3D positions of information carriers are part of this particular database, too. (This database has been named GTP-DB mainly because of it's central position within the so called "Geometric and Technical Planning Systems". These are not covered by this article.)
- ProNet should be integrated into the company's intranet environment. This means that all visualization clients have to be "web browser capable".
- Another consequence of the intranet integration, is that the central ProNet server has to be based upon a standard web server. This ensures that all PC workstations within the company's intranet can access the information offered.
- The ProNet server components have to be implemented platform-independently. It should not be necessary to install a specific version of a web server or operating system (e. g. the Microsoft Internet Information Server running on a Microsoft Windows server system).
- In addition to a web browser based visualization, the ProNet client components should provide an open programming interface as it is planned to integrate them into external programs, too. These programs should not have to rely on the existence of any web browser and might be developed using Microsoft Visual Basic or Borland Delphi.
- The visualization clients have to support at least the following operating systems: Microsoft Windows NT and Windows 2000.

2.2 *Integration into the existing information technology infrastructure*

Figure 2 schematically shows the integration of the ProNet system into the already existing EDP infrastructure.

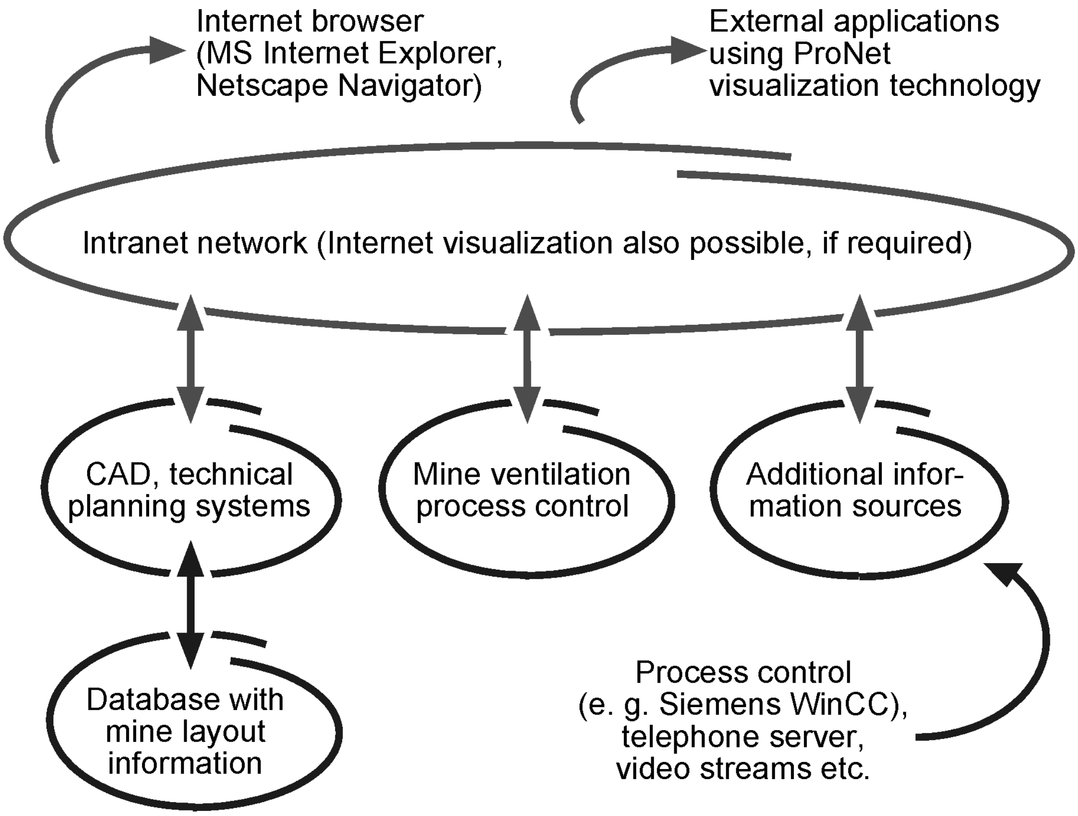

Figure 2. ProNet's position within the existing EDP infrastructure.

The different sources of information – shown at the bottom of this figure – correlate to the different logical areas of EDP application that have already been mentioned. The ProNet system is built on top of these sources. Three main components – as shown at the top of this figure – have to be distinguished.

1. For each logical area a specific information exchange interface has to be provided. These interfaces connect the ProNet system to all of it's data sources. It has to be noted that the interfaces may be implemented either mono- or bi-directionally. Thus a transfer of data back to (some of) the underlying logical areas might occur.
2. A standard web server forms the central part of the ProNet system. All different sources of information as well as the 3D mine geometry are combined and linked together here. On the other hand, this central component provides all necessary services needed by the distributed visualization clients. In case of very large networks or if there is demand for some sort of redundancy – e. g. because of security considerations – the parallel operation of more than one ProNet web server is possible.
3. Distributed ProNet visualization clients are available to the users either as integral parts of the company's intranet web pages or as independent programs. It is not necessary to install a web browser prior to utilizing the ProNet information system.

2.3 *Internal structure*

The introductory overview of the ProNet information system that has been provided in the preceding sections will now be supplemented by a description of the internal structure and the flow of information taking place within the system.

2.3.1 *Three-dimensional mine geometry visualization*

The three-dimensional mine geometry visualization implicates high amounts of calculation that must be done by the visualization clients. It must be kept in mind that in almost every case those calculations are carried out by ordinary office computers without powerful graphics cards or fast processing units. This requires the clients' design to have an undemanding behavior regarding calculation speed and visualization power, thus being able to guarantee acceptable performance in all cases.

Considering the dimensions of typical German underground hard coal mines (up to 5 km × 5 km × 1.5 km, represented by 30000 discrete geometric elements) it arises that a portable implementation (e. g. using Java applets or scripting languages) is not acceptable because of the outlined performance requirements. Also taking into account that it is sufficient that the visualization clients can support the Microsoft Windows operating system, this led to the decision to realize the visualization clients as ActiveX components using the C++ programming language. Utilizing the OpenGL library – a standard in graphical computing – allows for sufficient performance even on slower machines and impressive performance boosts on systems where high-performance graphics cards are available.

Last but not least, the ActiveX technology ensures convenient integration of the clients into external applications written in programming languages like Microsoft Visual Basic or Borland Delphi.

2.3.2 *Connecting the visualization clients and the ProNet server*

On figure 3 the visualization clients are on the left side. The central ProNet server deals with almost the whole information exchange of these components. This server both makes static files available for download operations and enables the clients to issue direct database requests or information uploads via CGI interface applications (see the next section for more details on this topic).

The only exception from this client-server communication principle is the direct access to the TAPI software interface ("Microsoft Telephony API") by the visualization clients. This is necessary for enabling the initiation of telephone calls out of the ProNet user interface.

2.3.3. *CGI programs and server processes*

Interactive database operations triggered by the ProNet visualization clients as well as information upload towards the central web server are implemented using CGI technology („Common Gateway Interface"). Almost every web server supports this standardized interface. Some web servers also provide alternatives to CGI. Such as ASP („Active Server Pages", Microsoft) or the open-source scripting interface PHP („PHP Hypertext Preprocessor"). However, alternative interfaces are not yet offered by all web servers. And – relating to PHP – it must be mentioned that a scripting language running on the server implies heavy performance losses.

An important disadvantage of CGI technology will also be mentioned. Using this interface the server needs to start (and stop) a program for every single client request. This would normally result in an equally high number of database connections (and disconnections) taking place, thus reducing the system performance to an unsatisfying low level.

Figure 3 illustrates the eventual solution that has been chosen for the implementation of the ProNet system. On the server a number of service processes are invoked only once. They remain permanently connected to the GTP database. Then, if some information is requested by a visualization client, the particular CGI program does not access the database directly, but establishes a socket connection to one of the server processes instead. This “diversion” allows the faster access of the database. It also maintains the option of using the portable and platform independent concept of CGI programming.

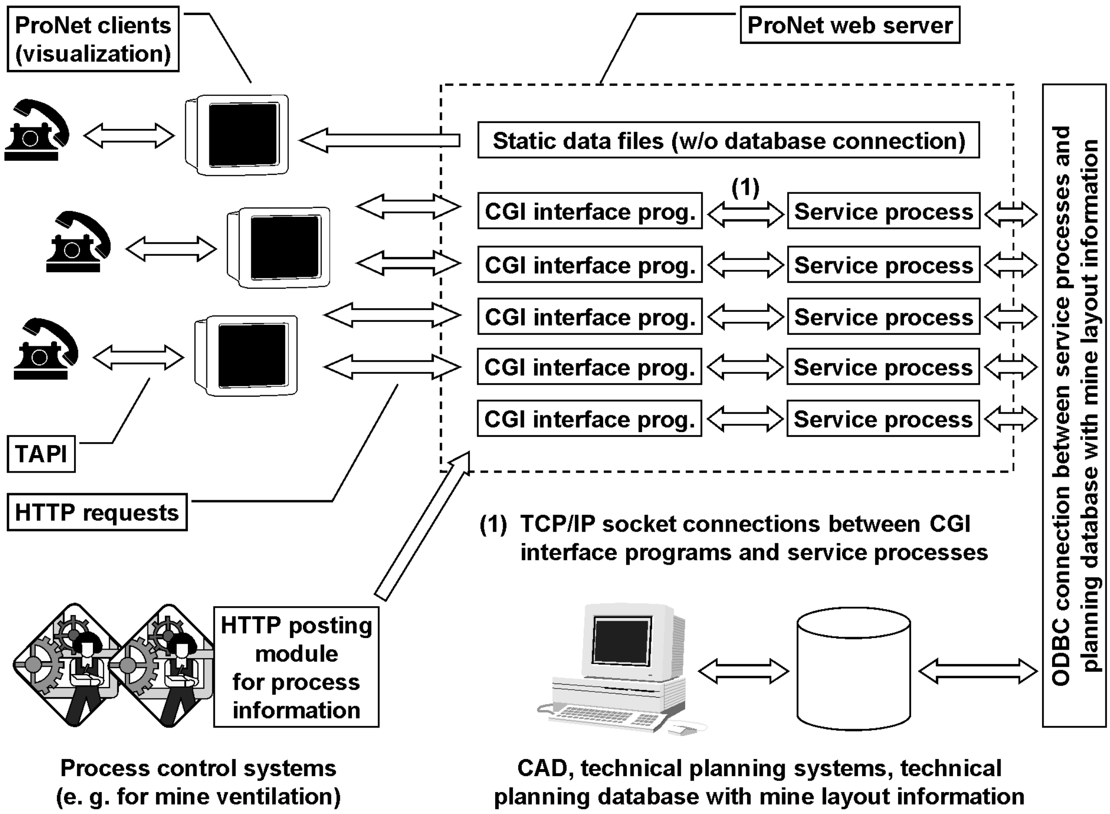

Figure 3. Internal structure and flow of information.

2.3.4. *Integrating process control information*

Finally, a description of how the information originating from process control systems is delivered to the ProNet web server is given. This has also been implemented by using the CGI interface, directly according to the method chosen to connect the visualization clients to the web server. Sensor names and measured values along with status codes are continuously routed to the ProNet server. Using the GTP database the ProNet server creates references between this sensor information and it’s desired graphical representation.

A specialized data-sending software module (“HTTP Posting Module”) has been developed to simplify the integration of further process control systems into the ProNet environment. This module can easily be attached to all common kinds of process control software systems by a well documented and convenient interface.

3 EXAMPLES OF USE

The screenshots supplied in this section present typical examples of use. They show the ProNet visualization as a web browser application within the mining company's intranet.

3.1 *Mine geometry analysis*

Figure 4 gives an initial impression of the three-dimensional mine geometry visualization. It is possible to freely move, rotate, zoom, save or load such views.

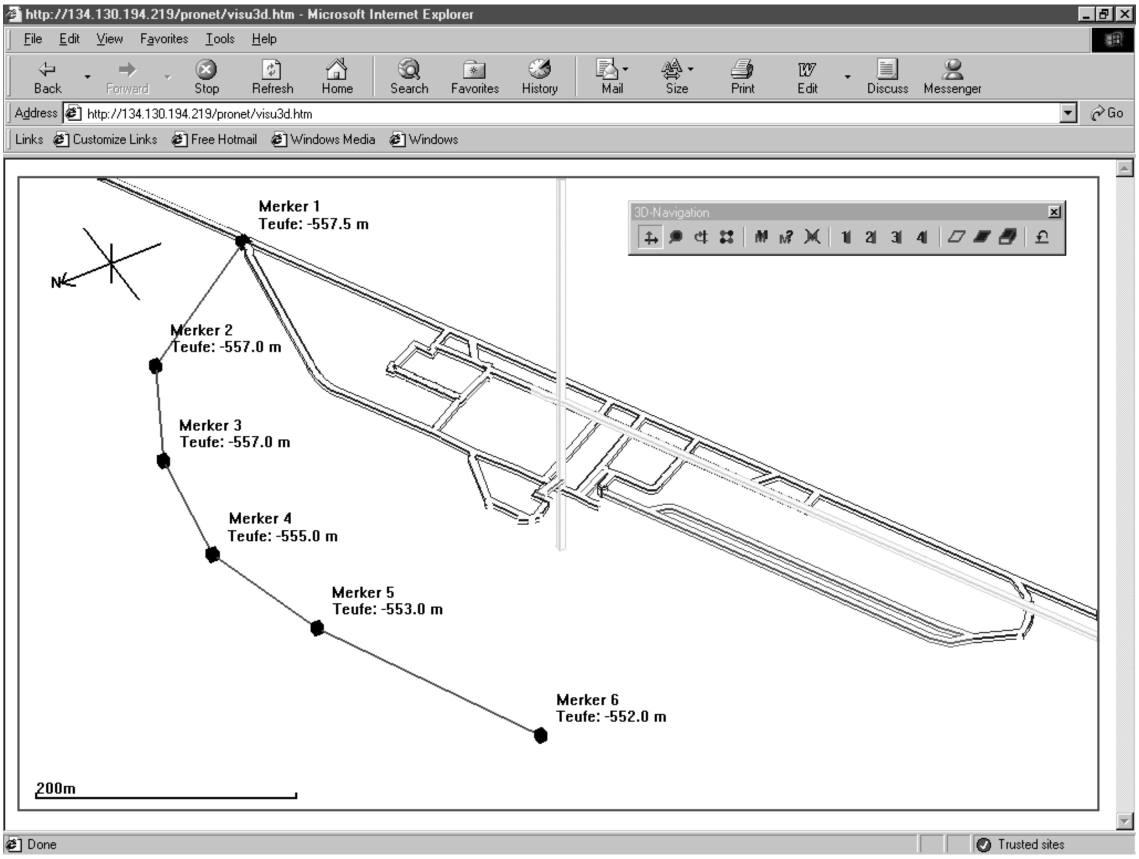

Figure 4. Mine geometry visualization, marker positions

So called "markers" can be applied to routes and even to arbitrary positions. Through those markers, detailed geometric information about any location within the mine may be retrieved. Several markers can also be combined forming "marker chains". Thus providing means for pacing off underground routes, boundary lines or any other sort of distances. Figure 4 includes an example of such a marker chain.

3.2 *Real-time data delivered by process control systems*

The integration of different data sources linked to the three-dimensional mine geometry visualization is one of ProNet's key features. Figure 5 shows some carbon monoxide measuring devices along with their current measured values. It should be pointed out that this sort of live visualization can currently only be provided by the ProNet information system:

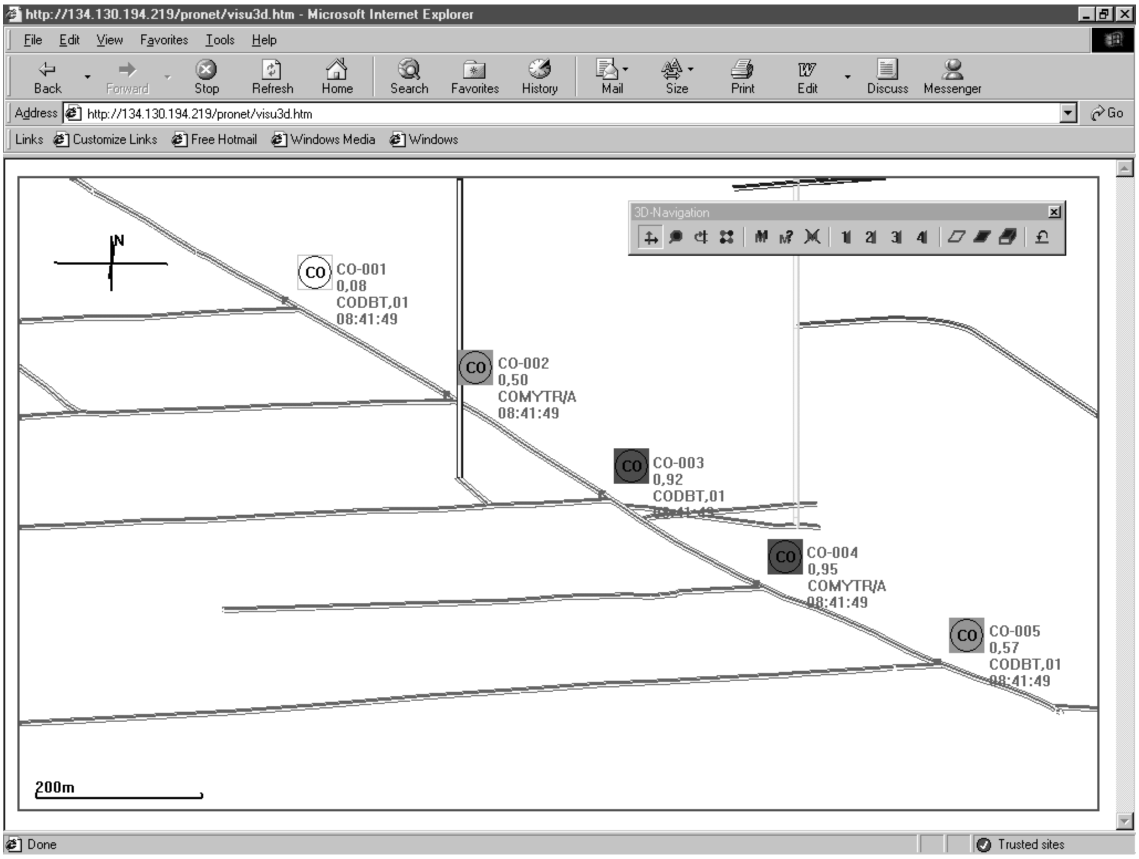

Figure 5. Visualization of carbon monoxide measuring devices.

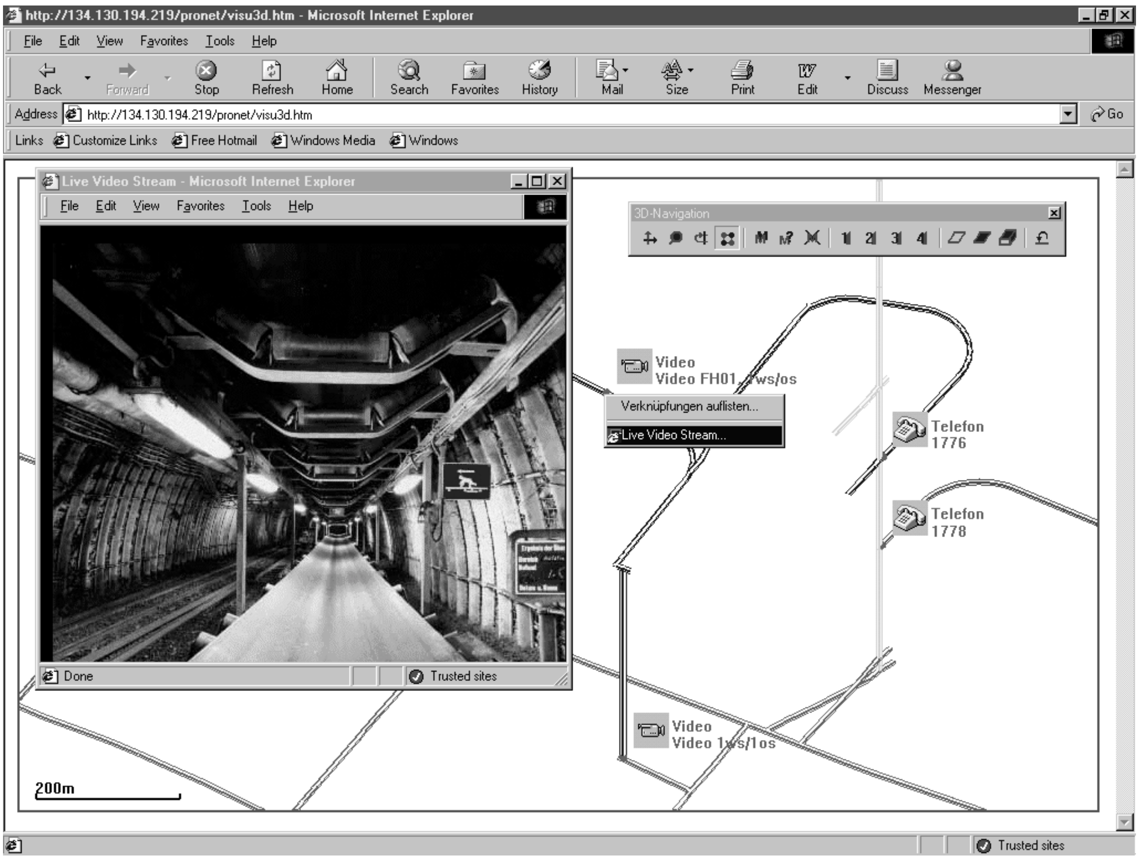

Figure 6. Hyperlinking to a video stream web server.

Although common mine ventilation planning systems are able to show the 3D locations of different measuring devices along with some technical specifications, references to currently measured values cannot be established. On the other hand, the safety department handles such process-oriented information and can even display it in different kinds of bar- and line-charts. However, it is not possible to display a three-dimensional view of the mine geometry.

Last but not least, the ProNet system also provides monitoring functions for an active observation of running processes. Administrators and users can define filter criteria on how the mining process has to be observed and integrate them into the visualization. ProNet will automatically display and hide the objects to be monitored together with their currently measured values according to the activated monitoring rules.

3.3 *External connections via hyperlinks*

Figure 6 demonstrates the connection to external information services using so called hyperlinks. All objects and symbols shown in a ProNet visualization can include hyperlinks that are similar to those commonly used in HTML documents. Video camera symbols may therefore be linked to web pages that are delivered by a video stream web server. Thus, the user may click on a camera icon in order to display a live video stream.

But there’s more to the hyperlink technology than just video streams. Some commercial process visualization software systems used in the mining industry already offer integrated web servers. Via hyperlinks, ProNet objects may be connected to these servers. Of course, linking to conventional CAD drawings and office documents is also possible.

4. CONCLUSION

The initial ProNet installations at several German hard coal mining locations showed very positive user responses. It’s system handling is easy to learn, and the 3D visualization is much more convenient than abstract tables and bar chart graphics offered by traditional process visualization environments.

Further development of the ProNet system is in progress. This includes the integration of additional sources of information as well as more specialized functional enhancements of the visualization clients. For example, the management of objects whose positions cannot be described by discrete points only, will shortly be supported. Besides dealing with pipe constructions, this permits the graphical representation of material supply chains and air ventilation structures.

5 LITERATURE

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