# HANNAH – An Intelligent Process Visualization and Diagnosis System using an Ontology as Knowledge management Tool

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## Abstract
The 3-year joint BMBF (German Federal Ministry of Education and Research) project called "KOMPLETT - Development and combination of innovative system components from process engineering, information technology and ceramics to create a sustainable key technology for water and nutrient cycles" aims at creating synergies of the latest developments from different research fields which at present have little contact with each other having as final goal the creation of an innovative key technology in the field of DeSaR (Decentralized Sanitation and Reuse).
Within the project one main objective was the development of an Intelligent Process Visualization and Diagnosis System (called HANNAH) for the high-tech KOMPLETT plant. In a first step knowledge and vocabulary from the different research fields mentioned above had to be brought together in a machine readable form. A well-engineered ontology soon emerged as the tool of choice. In a second step the visualization and diagnosis sub-systems were build around the ontology using the information and expert knowledge stored there.
The paper describes the development and the integration of this ontology as a core part of as well the visualization and the diagnosis subsystems.

**Keywords** Decision support system; Information Management; Ontology; Reasoning

## Introduction
The idea of the KOMPLETT-project is to separate the different factions of domestic wastewater and to recycle them in decentralized high-tech plants. These plants purify the wastewater just up to a quality needed or necessary for a specific application (e.g. for irrigation purposes a nutrient rich water would be produced).
To operate such systems experts supervising from a distant control center and non-experts like e.g. the janitor of a hotel doing the day-to-day maintenance must get all the information they need to do their work efficiently and securely. Furthermore experts and non-experts have to be enabled to exchange information, experiences and instructions to work together.
One approach is the development of an Intelligent Information System which is context sensitive, i.e. it proactively adapts the provided information depending on user-context (expert, learning employee, interested guest), task-context (observation, maintenance, optimization) and device-context (mobile, desktop). A short description of the development of such a system by using an ontology as a core component is given in this paper.

## Requirements
The following requirements for an Intelligent Process Visualisation and Decision Support System can be recapitulated from the conceptual formulation in the introduction:

- the system has to be able to organise and to evaluate large amounts of heterogeneous data, like online and offline process data, external expert knowledge or maintenance instructions of the plant;
- semantic relations between qualitative data, e.g. data about the technical processes or the physical layout of the plant and textual data like the documentation of the plant and its components have to be visualized;
- the system has to be user-, task- and device-context sensitive, i.e. diverse users working on different tasks with various devices have to get all the information they need in the right presentation to be able to do their jobs effectively and securely.

Ontologies are very well suited tool to meet these requirements.

## Concepts

### *Information Management and Intelligent Visualization*

A first step in the development of HANNAH was the organization of information and knowledge from the various research fields associated with the KOMPLETT project. By using a customized ontology the result was a common vocabulary to work with and machine-readable representation of the combined expert knowledge.

As the ontology amongst others contained all the technical and procedural information the whole plant and the relevant processes were modelled by interconnecting instances with appropriate relationships (i.g. “is-previous-component” or “is-next-component” for all hardware components following the water-flows through the plant or “is-information-about” for operation manuals and pictures connected with hardware components).

The visualization sub-system was able the read the data in the ontology and to generate a user-defined 3D-interface of almost any level of detail focused on any point of interest (see Figures 1 and 2).

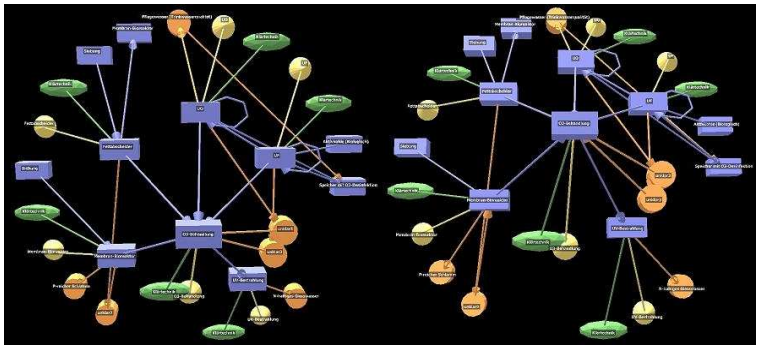

**Figure 1:** Visualization of an Ontology for the KOMPLETT-System

### *Diagnosis and Decision Support*

For such decentral high-tech facilities with a wide range of process steps like the KOMPLETT-plant it is not only important to identify a malfunction but also to isolate its cause and to propose a problem solving strategy.

By creating different classes of “plant-conditions” in the ontology and by interlinking the appropriate condition-instances with specific “cause” and “effect” relationships it is possible to evaluate e.g. online measured process data and to identify critical conditions in advance.

“Proposed-action”-instances guide the personnel through critical situations or even help to avoid them. As the physical layout of the plant and the function of its hardware components “is known” to the system it is possible to visualize the location of a technical problem (see Figure 2) and by this way helping the staff to solve it.

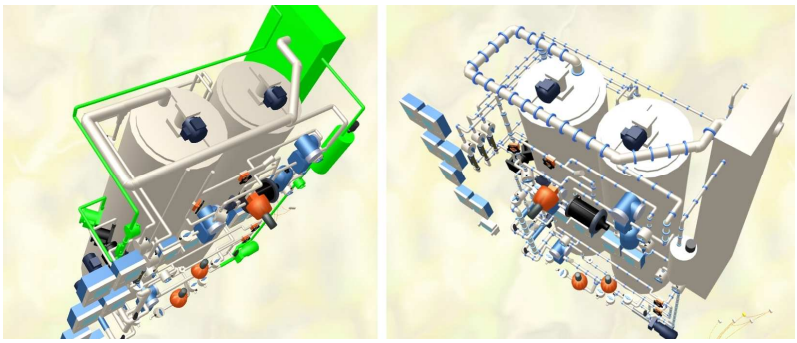

**Figure 2:** Highlighting of a specific line section of the KOMPLETT-plant


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