

COMPLEXITY ASSISTANT – APPLICATION OF THESAURUS TECHNOLOGY IN THE AUTOMOTIVE INDUSTRY

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Abstract

The following contribution points out the possibilities and chances through the application of the thesaurus technology within the complexity management in the automobile industry. It draws an overview of the present status of complexity management and presents the concept and implementation of the complexity assistant system developed by the Chair of Engineering Design, Friedrich-Alexander-University Erlangen-Nuremberg. The stated work resulted during the participation in the iViP-Project (Integrated Virtual Product Creation, sponsored by the BMBF Germany) [1]. The project management consisted of the Fraunhofer Institute for Production Systems and Design Technology IPK-Berlin (project coordination), Volkswagen AG (industrial consortium leader), and Siemens Business Services (SBS).

Keywords: complexity management, design information management

1. Introduction

The automotive industry is confronted with an increasing customer demand for non-standard products and services. This development tends to result in constantly growing version variety that shows a general tendency to greater product and process complexity. Complexity management in the machine and automotive manufacturing defines a discipline, dealing with the management of constantly increasing product and process variety in the enterprise. That is strategies and methods for estimation, control and reduction of complexity during the entire product life cycle. The main aim of complexity management is to achieve customer requirement with as few as possible component and a module versions. This leads to lean, competitive and cost-effective design-, manufacturing-, logistic-processes within the companies [2, 3, 6]. While dealing with and fulfilling customer demand complexity management increases. It has to differentiate between intended and necessary product variants and component or module versions which can be cut down without reducing the supply variety.

Due to combination of available optional equipment while building up a car configuration, the customer of Volkswagen A.G. can choose out of theoretically more than a billion variants of cars. This example as well as the trend to customized production circumstantiates the basic necessity for complexity management in the entire automotive industry. The quantity of sold vehicles is not nearing the number of possible configurations. Nevertheless the necessary

vehicle components must be developed and tested for all possible configurations. The assembly and functionality of rarely required product variants, the so called “exotic cars”, can not be tested sufficiently. As a result functional impairment and mounting faults lead to delays of production and extended delivery times i.e. increase of manufacturing-costs.

2. Motivation and requirements

The Complexity Management (CM) offers approaches for solving the depicted problem [3]. In the automotive industry CM Methods concern the dealing with or the reduction of variants. The application and the use of the different complexity management methods usually takes place with computer aid. However interoperability and user guidance are insufficiently implemented and supported. On this account it stands to reason to develop an assistant software system for hosting and aiding the usage of complexity management methods. According to the very large function range of the individual complexity management methods the efficient use is possible only with an extensive and specialized knowledge in diverse fields. This implies the development of separate software modules for each individual method and area of expertise. The meaningful application, use of existent separate software modules is enhanced by joining and combining them into an assistant system. This system can be understood as a complexity framework.

The system has to support the complexity manager while processing complexity questions and tasks, i.e. by proposing an appropriate software module for the handled task. The user has to be able to perform a search in the knowledge base by typing an explicit question or keyword or by browsing through the different knowledge presentations. Listings of keywords are a solution for restricted areas of expertise. If their number is small enough and their meaning clear without ambiguity a search mechanism build on keywords would be sufficient. But knowledge can not be always described, deposited and provided within formal descriptions. This implies various ways of informal representation. The search after a qualified tool to map the semantic network of words, definitions, laws, methods, experts, projects etc. lead to the thesaurus technology (Chapter 3). A thesaurus based tool can administrate, analyse and evaluate the multiple links between the complexity management terms within the system [4]. A database and the system functionality for saving and retrieving data, as a basic condition of every software system is not further specified. Connecting the knowledge chunks with experts within the company or expert networks could be a major improvement while using the system by ensuring a faster availability of know-how. Further on the system is not limited to the specialist area "complexity management" and is build to integrate different other knowledge fields.

3. Thesaurus technology

The knowledge-base, the main knowledge background of the developed system is based on the thesaurus technology. Umstätter [11] defines a thesaurus in the broadest sense as a thematically ordered system of signs. A narrower sense is the thematically ordered vocabulary which determines the meaning of entities (words) syntactically. Thesaurus organise the received character strings achieving the reconstruction of semantic networks. Umstätter specifies the following kinds of thesaurus:

- natural language
- professional terminology of a special application or field of activity

- standardised language of a knowledgebase
- organisation of material and immaterial objects (semantic) [7]

Examples of subject areas covered by thesauri are education, metallurgy, art, architecture etc.. For indexers and searchers the thesaurus is an information storage and retrieval tool. It consists of structured listings of words and phrases authorized for use in the indexing system. Also it offers aids to navigate through the thesaurus.

Simplified the main three rules governing the building of a thesaurus are:

- Use only a limited list of terms by linking all other term with USE and USE FOR (UF) relationships
- Structure the terms of the same kind into hierarchies by linking the terms through BROADER TERM (BT) and NARROWER TERM (NT) relationships
- Include all other semantic collocation between terms by RELATED TERM (RT) relationships.

Comprising, a thesaurus arranges the defined terms (descriptors) systematically by defining relations. Further information on building up a thesaurus and application fields are given in [7-12].

4. The assistant system

4.1 Architecture

One of the main architectural requirements to the system was the integration into different software systems. Within the scope of iViP the complexity assistant was integrated with the iViP-Client showing its appropriateness for distributed computing. The detailed iViP-architecture is shown in Fig. 1.

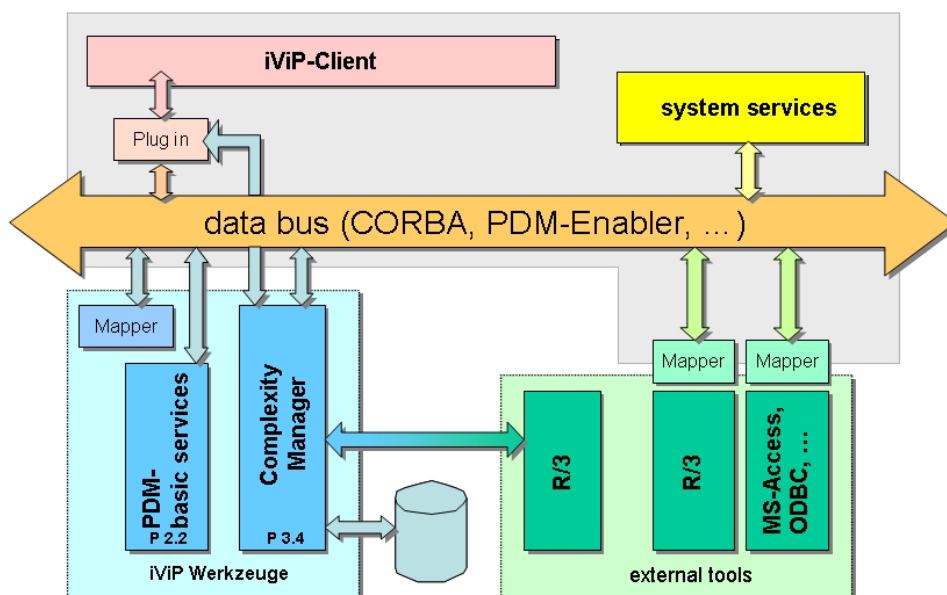


Fig. 1: iViP-platform-architecture

Figure 2 exemplifies the relation types implemented within the assistant system. The relations NARROW TERM (NT) and BROADER TERM (BT) express true specific/generic relationship between terms. Using NT and BT a hierarchy of term can be build up. The RELATED TERMS of terms provide a mechanism to draw attention to other items which the user should consider. An RT reference is used for non-hierarchical semantic relations in the knowledge base. RT relations build up the semantic network by linking terms which are some kind connected, not hierarchically related, but where someone searching ought also to consider looking to the other. The natural and scientific language use different expressions while describing similar facts. This kind of relation was implemented as SYNONYM TERM and is primarily used for narrowing the vocabulary. Terms can be linked with several kinds of file objects: descriptions, executables, experts etc. (see Data structure Fig. 5) . The descriptions for instance are defining the term by text, picture etc. in diverse formats *.doc, *.html etc. Executables are links to programs related to the term.

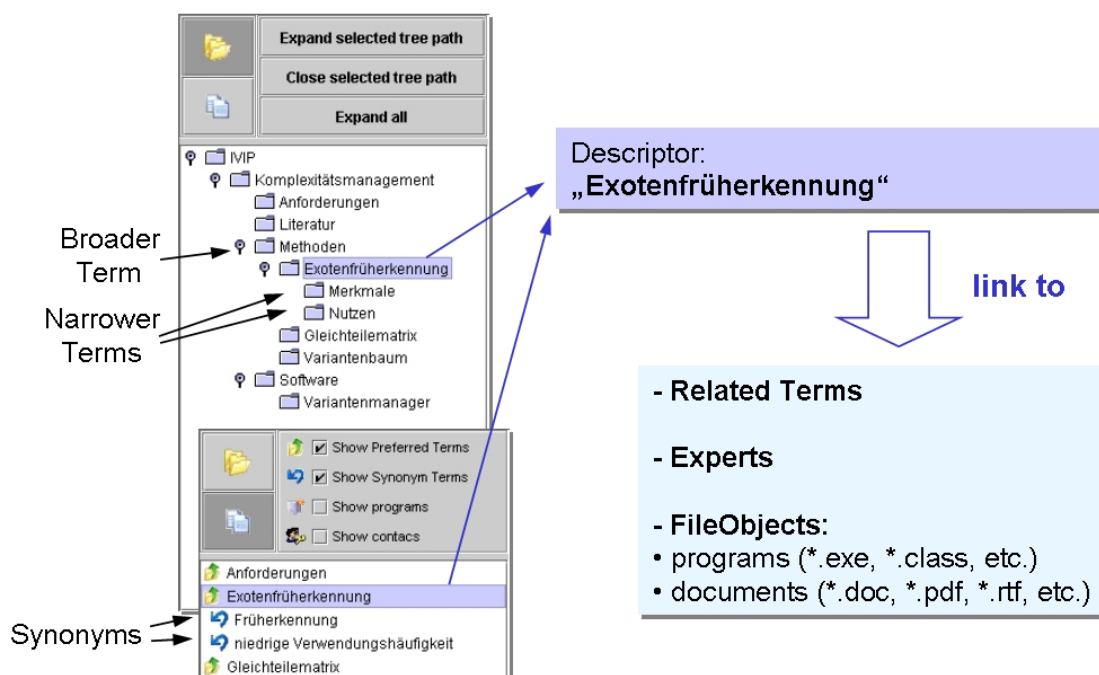


Fig. 2: All types of relations within the thesaurus

4.2 Use cases – Usage and indexing

The support functionality of the assistant system has been divided into two main categories: usage and administration of the thesaurus.

Search and surf through the data repository can be done by text search or manually using the graphical data representation. Fig. 3 shows the main window of the designed system and a presentation of the thesaurus data in the Complexity Assistant. Field A) displays the information as a tree or as a list. In the window on the left side the whole data repository is shown, possible in two different ways: In Fig. 3 a tree view is shown ordering the Preferred Terms in a generic/specific hierarchy (BT and NT relations). An alternate type of presentation is a alphabetically ordered list showing all entities of the thesaurus including synonyms.

The keyword search can be started with one or several terms. The user enters the term in the textbox at the top of the window. The search settings button on the right side of the text input box opens a dialog to edit the search options. If the “Start search”-button is clicked, all Preferred Terms found are shown in a list on the left bottom side of the main window B). If the user selects one term in this list, all data linked with this Preferred Term is displayed in the windows on the right side (C, D, E, F).

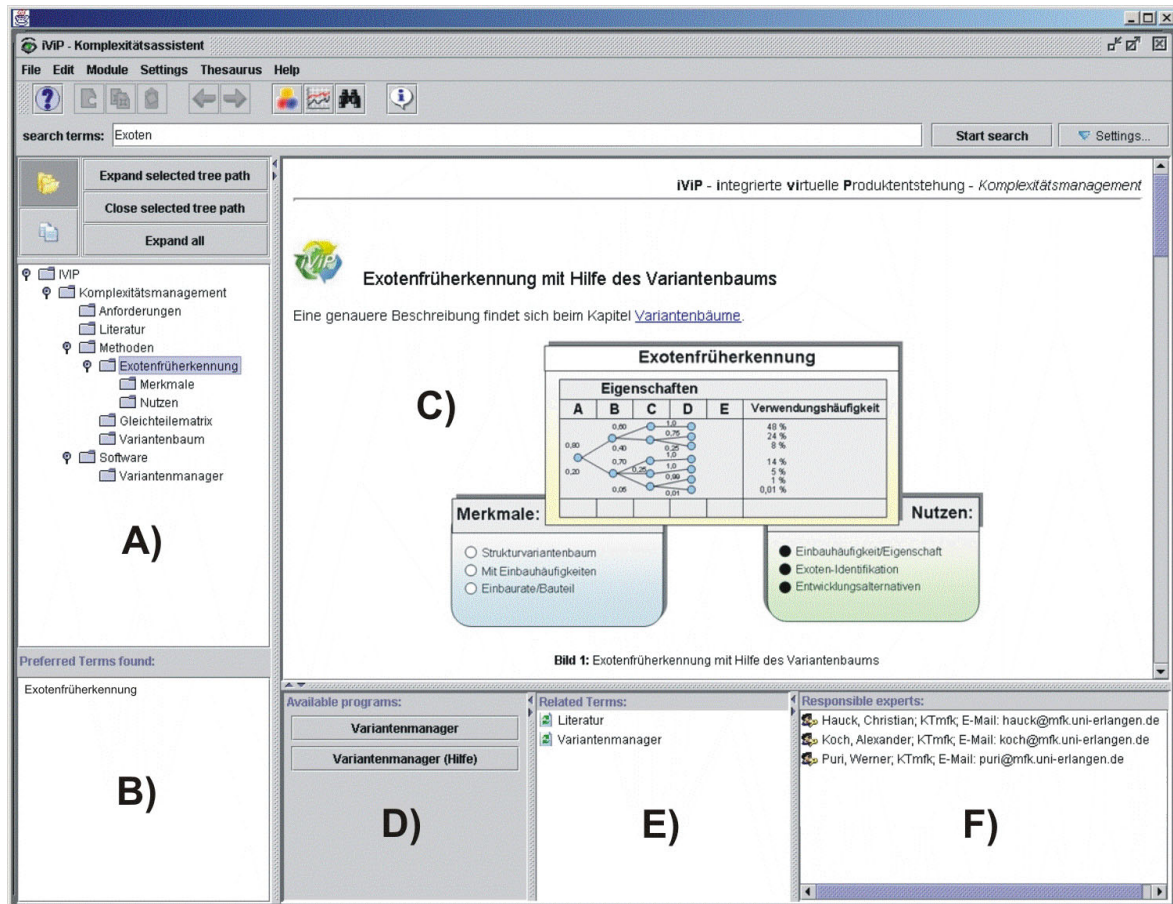


Fig. 3: The GUI of the developed assistant system

The middle panel C) retains a surface to display documents like Word-files, plain text-files, HTML-documents, PDF-documents etc. Software modules linked to the Preferred Term are shown in the window “Available programs” D) and can be started directly, either within the assistant or on the ivip-server-platform. It’s also possible to start only the helping system of a certain software module in a first step. Also shown in the lower part of the window are all Related Terms E) and responsible experts F) with context information, i.e. telephone numbers and e-mail-addresses.

Fig. 4 shows the indexing operation of the thesaurus. The building of the thesaurus follows four main steps: collection, evaluation, structure and update of terms. These imply functions for definition, change and deletion of term and relations in the system. Even so the indexing of a thesaurus is a challenging and expensive task. For this reason the administration is done with assistance of a wizard in the assistant system, one the one hand for easing use through guidance and on the other hand to ensure the consistency of all data.

Some stages of the creation are shown in Fig. 4. First of all the decision has to be made if the new descriptor is a synonym or a preferred term. After entering the name of the descriptor the user has to define, into which hierarchy level the term will be inserted. This is realized by selecting the corresponding generic term and the species in the tree structure. Further on a variety of administration-informations will be assigned like the last date of change, source of the information etc. In the following stages of the wizard there's the possibility to create different kinds of links to other descriptors or to a variety of different types of objects by a "FileObj"-relation (compare Fig. 5).

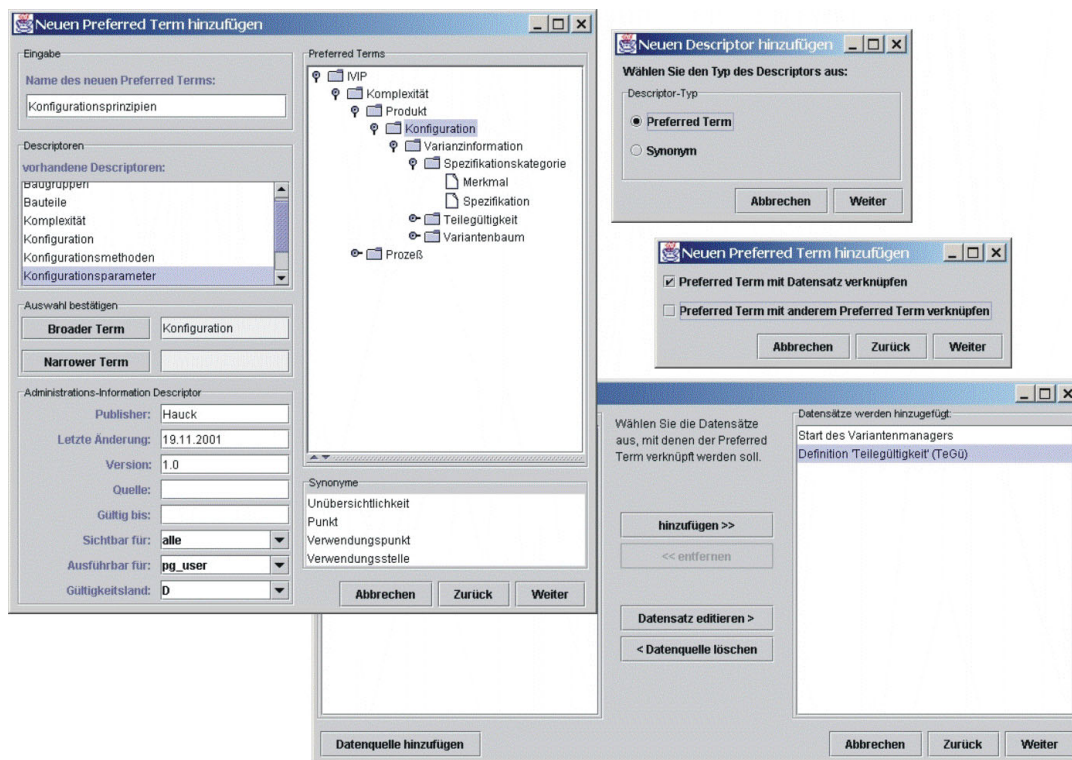


Fig. 4: Indexing the thesaurus by a wizard

The evaluation of the assistant system was carried out during different sessions of the iViP-sub-project "Complexity Management". The data consists mainly of methods of complexity prevention, complexity control and complexity reduction. The introduction and indexing the data within the thesaurus proved the necessity and advantage of using the wizard functionality. A high quality concerning the data consistency was achieved by usage of the wizard. At the same time the time needed for indexing could be minimized. The retrieval functionality was tested by users having different levels of knowledge in the field of complexity management. The cross-linking of thesaurus entities proved to be the most important property supporting the retrieval of information. The individual approach of individual users was studied. What way is the common user choose while searching for an answer to a specific complexity problem? Most users tried to find a solution by using the search functionality of the system, while skilled users favoured searching manually in the data repository.

The object oriented implementation data structure of the thesaurus is shown in Fig. 5. The main element of the data is the "Descriptor"-object. In the data representation the names of all

descriptors are shown in the tree in Fig. 2. To realize the generic term relationship and the species relationship mentioned above the two classes “CompTreeNode” and “CompTree” are used representing a tree structure.

On the one hand a “Descriptor”-object can be linked to another “Descriptor”-object via a “Relation”-object. This type of relation is called “Related-Term-relation”, if the second “Descriptor” itself is another Preferred Term. It is a “Synonym”-relation, if the second “Descriptor”-object is a Synonym, marked by a flag in the class object. On the other hand all “Descriptor”-objects are linked to a “FileObj”-object (i.e. definition document). This relation is called “File-Object-Relation” and is not a standard type of relation in a common thesaurus. Further on the “Related-Term-relation” can be assessed, which means that a search result can be more or less detailed, controlled by the search options. All relations are realized by a “Relation”-object, which retains also two other objects: The “Admin”-object and the “Experts”-object. The “Admin”-object controls all administration information for example user rights. Thus the creation of different views to the data repository was implemented. The “Expert”-object retains information of persons and facilities which are responsible for the corresponding “Relation”-object, so the user always has a contact person where he can get further information.

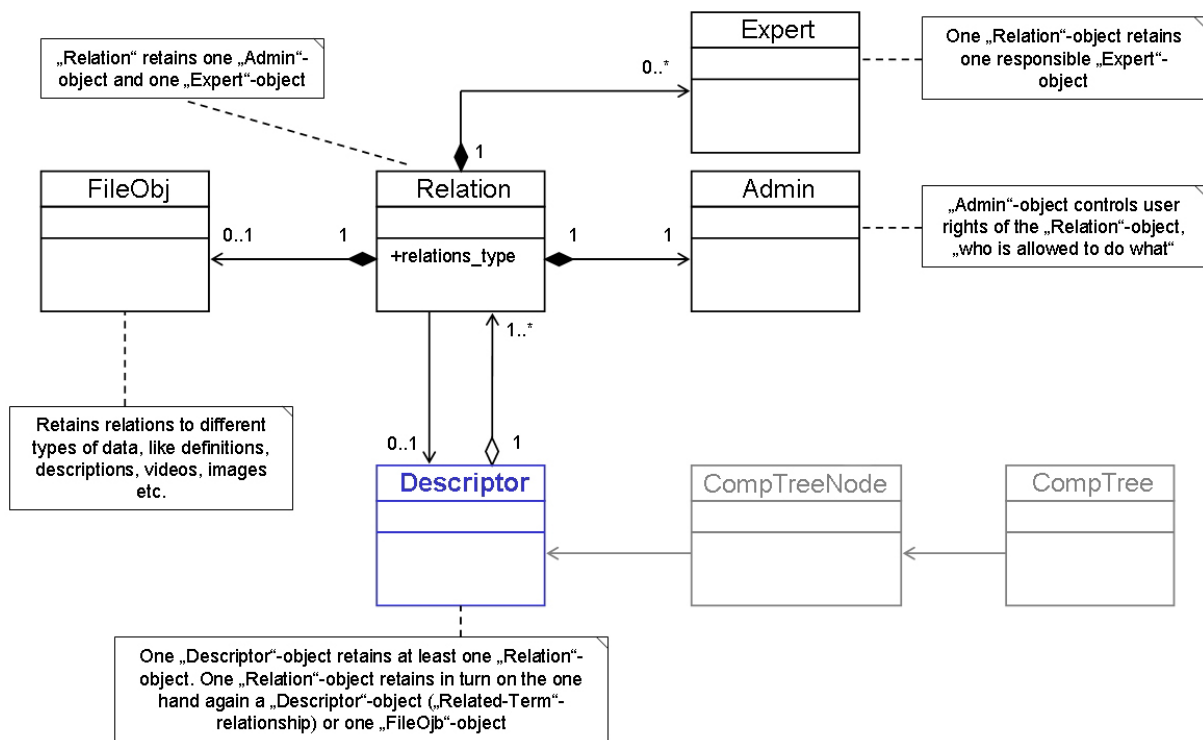


Fig. 5: The data structure of the assistant system expressed by a UML diagram

The “FileObj”-object retains all other possible information linked on a certain relation. It concerns the following data types: textual definitions, descriptions, links to the WWW, images or video clips etc.. The thesaurus is stored in an object oriented database.

5. Further functionalities

Further development of the assistant system should take into account and improve following functionalities:

- Logging all the users' queries. If the system detects that a user searches for terms other users searched before. The user can get a tip from the system concerning the query to contact other users or by displaying the former results. Benefits would emerge from the shortage of query time (getting the already found a solution for the problem) and better communication between experts.
- The integration of the assistant system with other knowledge based systems.
- The presentation of search results through new kinds of graphical displays, i.e. a 3D tree structure.
- Indexing the thesaurus half automated with existing data repositories.

6. Summary

The paper focuses on the factors that illustrate the need for and a possible, but yet pragmatic, approach to a better handling of complexity within large complex product development organizations. The computer supported assistance is given by the implemented system CompAss. The base technology for collection and storage of knowledge is the thesaurus technology. new relations had to be implemented due to specific information needed in the field of mechanical engineering respectively complexity management. The assistance functionality is realized with two main functions: search in and build up the knowledgebase. Primarily the system points out the methods of complexity management, software modules and other information that enables the user to solve questions in the field of complexity management.

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