Knowledge creation and virtual enterprises in power plant construction

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Abstract

This article describes a procedure for knowledge creation in power plant engineering. Power plant construction typically involves virtual enterprises (VE), which are gathered from company specific virtual networks (VN). Having the focus on the inception phase of the construction project, the paper presents the principles that can be applied in collecting, creating and using standardised information. In Globemen Fortum Engineering (FE) has started the development of a knowledge creation environment (KCE) to support its VE concept. Tools available for collecting and classifying tacit knowledge are also presented. KCE is developing step by step through implementation of advanced commercial tools in phase with the generation of document and data templates. The paper concentrates on the process of knowledge evolution from the tacit information to explicit data, which can even be coded. The management of the total life cycle information of the power plant is also introduced. The paper includes the data model by which the functionality of VE can be tested during its establishment. In practice the testing may mean, for example, the optimisation of delivery boundaries within VE. This information is classified and stored using the hierarchical systematic common for product models making possible an organised collection of feedback information form finished VEs. The hierarchical structures also support product development and internet-based data exchange between partners. The paper includes a description of a case study concentrating on the collection and use of product life cycle data in VE. In the case KCE is tested as an environment to offer modularly implemented support for VE.

1. Introduction

A corner stone in knowledge creation is to collect information that is substantial for future activities. The quality, i.e. reusability, of the data available is often difficult to recognise when the connections between different pieces of information are not obvious. A lot of tacit knowledge may be lost, if the right context is not discerned. The knowledge creation environment (KCE) has been developed for collecting and
The different model used to define product and workflow are also introduced. In the paper describes the main features of KCE and possibilities for its utilisation in VE or VN. The different model used to define product and workflow are also introduced. In

Managing power plant information is a complex activity covering the total life cycle of the plant. Figure 1 shows the main phase in generating power plant specific information during its life cycle. In FE the target is to increase profitability by using experiments and product life cycle knowledge in inception or tender phase of the project. A tender specific concept will be received by modifying the general concept to meet the requirements presented in the client’s inception information. Optional O&M packages from operator party may be included in some power plant tenders. KCE platform is partly to speed up this modification process and also to improve the quality. Specific concepts are stored into the same scope library where the general concepts lie. The scope library also includes description of partners’ role in the delivery offering the basic data to define tender specific VE environments. Anticipated costs for entities of the information model are gathered from the resource library and used for cost estimation and pricing. The costs of the projects finalised will be stored as well as preliminary project budgets. The cost libraries are further used in cost control during the project delivery.

![Diagram](image)

*Figure 1: Managing product life cycle information of power plant*

The paper describes the main features of KCE and possibilities for its utilisation in VE or VN. The different model used to define product and workflow are also introduced. In
VN one of the challenges is the communication and data exchange among organisations whose partnership may last only a single project. This topic has also been discussed in Chapter 4, which expands on the testing of KCE in Globemen project.

2. Product and activity models

Figure 1 outlines the evolution of project information during tender phase (A21 and A22). The search of optimal scope and network for project delivery is an iterative process. Different combinations of delivery packages and partnerships have to be analysed. The convergent iteration requires that the product and activities are modelled systematically. In FE the main models used are a product, business and project models. Project simulation will be done in order to search and optimise the coherence of partners, limits of deliveries, labour resources and timetables. The models and their role in the VE simulation have been described in the Figure 2.

Common product model describes the parts (systems and equipment) of a standardised power plant from which a project specific model is formed to meet the client’s requirements. The product model includes documents and activities related to the parts or entities. Documents describe non-physical actions, for example, system descriptions, P&I diagrams and layout drawings. Operations describe, for example, phases, where the parts are manufactured, constructed or transferred during the project.

Private business models consist of company specific models and activities of operations and documents. The VE concept should be described in the business model. The company model contains facilities of the company, resources of the facilities and costs of
the resources. Operations and documents are divided into activities. The activities describe more accurately the method to execute operations or drafting of documents. The duration, resource (employee, machinery) and the method to use the resource will be given for each activity.

**Common project models** define project scope, timetable, delivery packages and other project specific issues. VE concept should be incorporated into the project level by a specific VE business model. The operations of VE are based on the product and business models. VE modelling often starts by selecting the principal contractors and main subcontractors. In turnkey projects the scope of the project is defined by pre-contracts among main contractors. When the VE has signed the contract with the client the project schedule is confirmed. Companies allocate their resources to operations and adjust their internal schedule to meet the deadlines fixed in the contracts.

**Simulation and optimisation of the delivery** - Delivery packages are optimised by investigating different possibilities to allocate responsibilities within VE. A particular simulation tool can be used in the optimisation. The parameters used in the simulation are usually prices, delivery times and scopes of delivery. In FE the results of simulations are examined with project planning and spreadsheet applications.

### 3. Knowledge Creation Environment

The basic role of KCE is connecting the product data of construction and operation to support the inception of new projects. The scope of the platform is to classify experiential information into a standardised information model. The input of tacit knowledge in the form received from practitioners shall be combined to pieces of data entries, thus assisting the creation of rules for decision making. Therefore the KCE platform is required as a tool for transferring the collected tacit information into explicit form. Pekka Välikangas et. al. have described the principal idea of the KCE in article [1]. More useful information about basic needs and correspondent enablers of organisational knowledge and networked business can be found from references [2]-[6].

Sequences between tacit knowledge and clear code for expert systems are described below. **Interviews** are discussions between experts of power plant techniques and knowledge engineers, where the reasoning between product/project thinking and correspondent documents is defined. **Documents** can be common textual, spreadsheet and CAD files in document management system. **Forms** are graphical user interfaces (GUI) for formatted data presented in dialogues and databases. **Informal mapping** is a mind mapping to evaluate tacit knowledge to logical structures of power plant techniques and to collect correspondent definitions in projects. **Structured mapping** is
formal use of LexiCon [7], XML and Unified Modelling Language (UML) for linking logical structures of power plant techniques and product model of expert system. Model solutions are presented with CAD-files and Databases, which are connected to product model of expert systems and they are also presented in design guides. Constraint of solution is code (of Lisp, JAVA, etc.) and formulas of checkpoints in expert systems. Rule for specification is a code in expert systems for design, operation and maintenance rules. New tacit knowledge arises during the process of knowledge evolution as new data in databases, new documents and new descriptions for products.

3.1 Information collection process

![Diagram]

Figure 3: KCE in Virtual Enterprise

Figure 3 illustrates the process of knowledge creation inside the network and the role of different players in this process. Co-operation in the network is in three different layers formed by marketing & sales personnel, technical personnel and knowledge engineer. FE’s company specific part in the VE is the simulation of VE and design work carried out by expert applications.

The process of collecting knowledge is organised by a knowledge engineer, who deals with marketing and sales people. Support from technical personnel in the network is
received in ordinary meetings or NetMeeting so, that engineering, procurement and construction (EPC) and O&M duties are properly defined. The iteration in steps 1 and 2 in Fig. 3 presents the capture of knowledge from potential VE structures and technical scopes. Iteration in steps 3 and 4 is concentrated on getting partner specific design documentation connected with VE and project delivery descriptions. Step 5 is for publishing this information in the network and participating companies.

Based on customer's inquiry in step 6, steps 1 - 5 are checked and VE data will be simulated from project management and cost estimation point of view in steps 7 and 8. Step 9 is a company specific action for getting this information into design tools and expert systems for tender phase design.

### 3.2 Collection of tacit knowledge

*Figure 4: Informal mapping of knowledge by Mind Mapping*

Mind mapping is a method for collecting and structuring information into informal knowledge. Example of how the design knowledge of equipment may be mapped is illustrated in Figure 4. Technical personnel and knowledge engineers are mining knowledge so that they can describe the logical knowledge structures of product, design
and project delivery. Knowledge engineers can also define the correspondent structure of the data warehouse and component structure in the expert system. “Active comments and questions” under Knowledge Creation are also structured.

It is possible to work concurrently with different experts and at the same time to have joint evaluations in meetings. Furthermore, the mind mapping applications may be used as a case-tool for WEB application development. This may then be used for browsing, proposing, entering, modifying, verifying and validating of knowledge within larger amount of participants.

### 3.3 Distribution of information in VE

Information will be distributed into Intranet and document management systems by creating dynamically WEB pages from mind maps and XML exports from structured documents. Mind mapping software is available for key persons, like knowledge engineers, technical personnel and sales managers. Feedback will be received through the user interface of the applications and Internet browser.

![Figure 5: Dynamically created WEB pages from the informal mapping of knowledge](image)
3.4 Use of product and activity models in KCE

In structured mapping, the collected and created rules and associated structures are stored in a knowledge repository. Work between informal and structured mapping is manually defined using LexiCon, software from STABU [7]. The knowledge is connected with the same semantics as that of the informal mapping (Figure 5). Example about the support of formal mapping is shown in Figure 6. **The pane on left-hand side** of the dialog is at same time for subject, activity, property, unit and reference trees of components. **Right pane** is for showing detailed information of the selected component at the left pane as well as showing how the selected component is associated with other items.

Following mechanism are available for making the network of associations: **component mechanism** for defining structures of equipment, systems and activities; **property mechanism** for defining the measurement of subjects and activities; **reference mechanism** for pointing out rules, which are related to described subjects and activities; **usage mechanism** is an automatically created summary on how the component is used by other components.

![User interface of LexiCon to formal mapping of knowledge](image)

**Figure 6: User interface of LexiCon to formal mapping of knowledge**
4. Use of KCE in power plant project

The system of initiating VE from VN in order to deliver a subsystem of a power plant is illustrated in Figure 7. The first step in establishing VE is to define optimal combination of partners for the delivery. KCE make it possible to gather information by simulating the function of VE in advance. The system assists in defining the shares of parties, costs of shares and timetables of the total delivery. Sub-chapters present methods on using KCE for defining projects with the scope of delivery and service requirements in order to establish a tender in VE.

**Figure 7: Tested generation of VE in GLOBE MEN project**

4.1 Description of VE

Figure 8 illustrates a way to collect information during the formulation of VE. Partners’ business goals are studied so that co-operation and information exchange are defined related to the scope of delivery and data requested for simulating the project delivery. Figure 9 is showing how data and example material is collected and structured in order to understand partners’ responsibilities and requested material in VE.
Figure 8: Combining mind maps of VE knowledge
The data exchange within VE is illustrated in Figure 10. The data exchange is concerning the defined informal and structured information of the product, delivery and O&M. Parties are using VE platform in order to exchange and store the collected knowledge for cost estimation and time scheduling. VE platform has been developed in GLOBEMEN project and it is based on the Product Model Server of EPM Technology. The information exchange is sequential, where the VE relevant knowledge is defined together in three phases - numbered in Figure 10.

The leader partner (FE) has collected information about balance of plant to define power plant process and correspondent equipment. Space and site layout definitions have been gathered for describing requirements for construction i.e. fire zone, noise level and structural requirements. Operator of the power plant (Fortum Service) has collected O&M definitions to build a suitable operation and maintenance option for tender. Constructor partner (YIT Construction) has defined layout, BOQ and working plan for construction so that i.e. technical solutions of facade and machine foundations are optimal for the constructor. The 4D simulation, which is a time schedule of construction process presented in 3D product model, is based on the product information collected from different partners.
Finally, with all the collected data from different partners, it is possible to simulate VE in order to establish the initiation of VE. The KCE has been used for gathering and structuring knowledge as fully explained and distributed data packages together with design tools, which were needed in the classic data creation and data exchange within VE. Correspondent CAD-applications and cost libraries have been tested with XML/IFC based advanced interoperability between different parties in VE. Correspondent CAD-applications and cost libraries have been tested with XML/IFC based advanced interoperability between different parties in VE.

5. Conclusions

Based on the case tests, the KCE is a promising concept for defining VE and establishing advanced support for information exchange between different parties in VE. It is obvious that the XML/IFC based exchange of product model was not sufficient alone, because there are different possibilities to define business and products in VE. Therefore, further structured explanatory publishable descriptions were needed beside the actual data in order to understand the essence of products and projects in VE. The KCE is seen as an enabler of VE, where the major role is to harmonise data exchange between different parties in VE.
References


