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SUPPORT FOR PLANT DESIGN WITH A MODULAR CONCEPT

MODUŁOWE WSPOMAGANIE PROJEKTOWANIA INSTALACJI PRZEMYSŁOWYCH

A b s t r a c t

Cost estimation of various project variants (process-synthesis) and the subsequent quotation demands accurate, rapid and inexpensive estimating. Modularization and the use of parametric models correspond to these requirements. Kept together by a knowledge management system a framework with following characteristics is provided: estimating relies on historical data (accessible through mapping technology) and it is consistent and repeatable.

Keywords: modular cost estimation, ontology, parametric model

S t r e s z c z e n i e

Szacowanie kosztów dla alternatywnych rozwiązań projektowych (synteza procesu) oraz przygotowanie oferty wymagają dokładnej, szybkiej oraz niedrogiej kalkulacji wstępnej. Tym wymogom odpowiadają modularyzacja i zastosowanie parametrycznych modeli. Wraz z systemem zarządzania wiedzą przygotowano strukturę o odpowiedniej charakterystyce, a szacowanie oparte na danych historycznych (dostępne poprzez technologię mapowania) jest spójne i powtarzalne.

Słowa kluczowe: modułowe szacowanie kosztów, ontologia, model parametryczny

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1. Introduction

The path of a project from requirement specifications to ordering goes through the quotation procedure. Naturally in a company less capacity is used for job creation than for order processing. Knowledge transfer from order processing to offer placement leads to greater safety in offers.

Research goal of this work is an application framework for the variant comparison (process-synthesis) and the subsequent quotation. The work is supported by the Society for Chemical Engineering and Biotechnology – Gesellschaft für Chemische Technik und Biotechnologie (DECHEMA) and the German Federation of Industrial Research Associations for the promotion of R&D for small and medium-sized enterprises – Arbeitsgemeinschaft industrieller Forschungsvereinigungen „Otto von Guericke" e.V. (AiF). We have the unique chance to share the experience of 10 involved industrial companies and 2 universities.

Due to the modular nature there will be no capacity in the order processing deducted, but only the experience of the job creation provided. The framework is supported by a knowledge management system.

2. Modularization

2.1. Consideration

Modularization is performed to gain profit from knowledge reutilization. Thereby we are confronted with two complementary targets: First we want to minimize the interfaces. Every entered value on module boundary has to be known or able to be estimated and is a possible source for errors. But also reusability has to be considered. Standard universal modules with sometimes too many parameters are weighted contra special modules rarely used and therefore unprofitable.

2.2. Conclusion

This in mind we provide miscellaneous module versions:

1. Modules, representing whole plants.
2. Modules, describing Unit Operations.
3. Modules, representing devices.
4. Modules, representing individual machines.

Limitation to one module version only restricts framework usability unacceptable. Providing only individual machine modules lowers earnings from standardized devices. Many interfaces would have to be declared. On the other hand constriction to groups of devices leads to unmanageable diversity.

3. Knowledge management

3.1. Objectives

First target is support for the user as an expert system for the modularization of the plant. Furthermore we have to access different data sources. Ontology is used to perform both objectives.

3.2. Data model

According to the Conceptual Lifecycle Process Model – CliP [5] a data model is developed, which preferably covers the entire parts of a chemical plant.

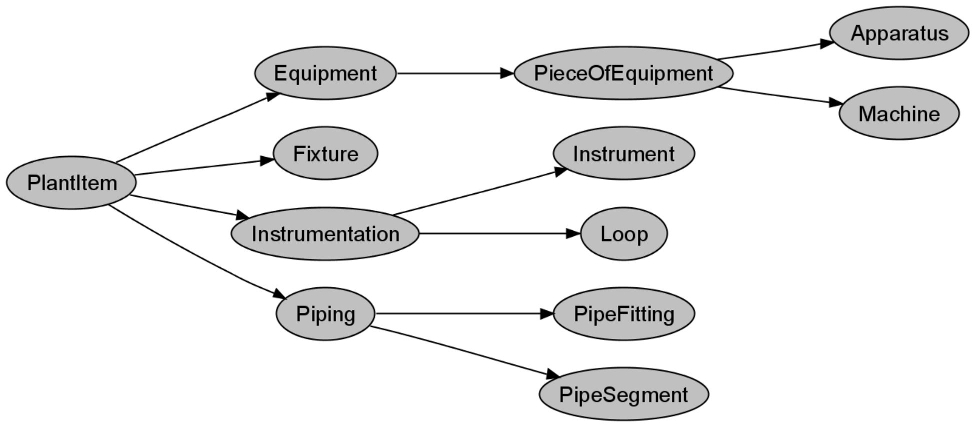

Fig. 1. Plant items according to CliP

Rys. 1. Elementy instalacji zgodne z modelem CLiP

3.3. Mapping

To gain access to different data sources we want to use the Ontology as a mapping service. Same mapping service, together with our data model, is used to transport data in our framework from one application to another.

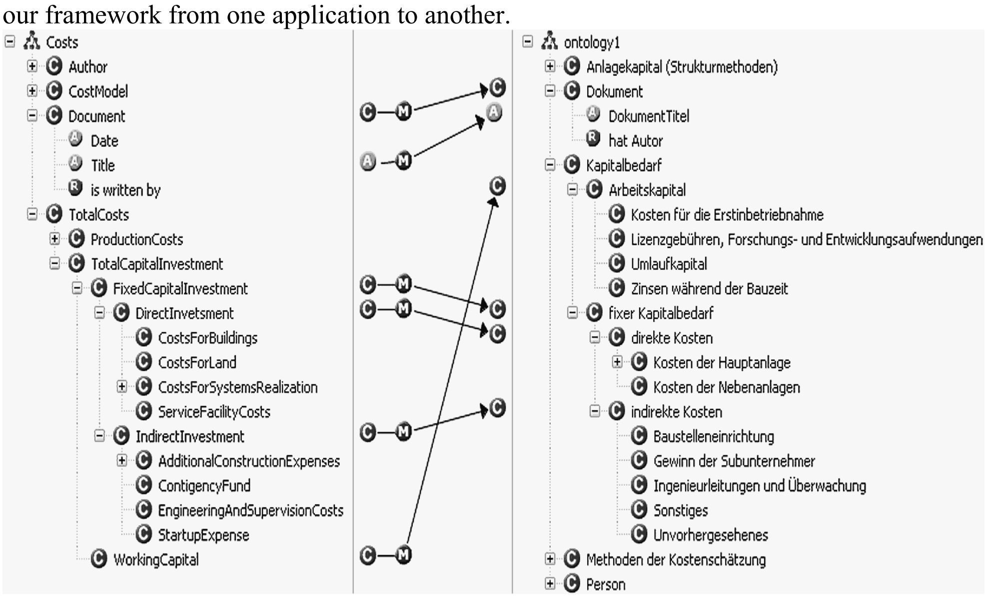

Fig. 2. »OntoMap« Plugin, an extension of OntoStudio

Rys. 2. »OntoMap« jako rozszerzenie programu OntoStudio

Figure 2 shows mapping between source ontology on the left side and target ontology on the right side [2]. Layout of source ontology is predefined; target ontology is our own data base, covering not only books and authors but also price indices, plant items, costs and methods.

4. Estimating models

While analogy estimates can sometimes be produced in minutes, they need similar projects for their accuracy. Expert Judgement is a choice if little is known about the process. Short-sighted experts can lose sight of major project parts. Bottoms-up estimates are inaccurate very early in project planning because of poor understanding of project scope, but typically improve as time goes on, and a bill of materials is built. They are usually time consuming and expensive. A parametric model offers rapid, inexpensive estimating at any stage of project life, and is generally the more accurate method in the early days of a project (ISPA/SCEA 2007).

Table 1

Estimating models

Model Category	Description	Advantages	Limitations
Analogy	Compare project with past similar projects	Estimates are based on actual experience	Truly similar projects must exist
Expert Judgment	Consult with one or more experts	Little or no historical data is needed; good for new or unique projects	Experts tend to be biased; knowledge level is sometimes questionable
Bottoms-Up	Individuals assess each component and then component estimates are summed to calculate the total estimate	Accurate estimates are possible because of detailed basis of estimate; promotes individual responsibility	Methods are time consuming; detailed data may not be available, especially early in a program; integration costs are sometimes disregarded
Parametric Models	Perform overall estimate using design parameters and mathematical algorithms	Models are usually fast and easy to use, and useful early in a program; they are also objective and repeatable	Models can be inaccurate if not properly calibrated and validated; it is possible that historical data used for calibration may not be relevant to new programs

Keeping support for plant design at early stage in mind we have chosen parametric models for our framework. Nevertheless we validate our models as much as possible – also against the other estimating models.

5. Parametric estimating

5.1. About

Parametric cost estimates are based upon the relationship between so-called cost drivers and the costs themselves. The costs can occur as currency units or time consumption. Parametric models can be classified as simple (with only one cost driver) or complex (consisting of multiple cost estimating relationships). The simplest model depends only on equipment mass and material. Under certain circumstances, this simple relationship is not satisfying: A small but powerful engine cost per kilogram more than usual one!

5.2. Database development

Parametric cost estimates are based on three major components: database development, model development, and model use. Commonly used data sources are engineering design records, program reviews, manufacturing records, departmental records, purchase orders, cost reports to customers and others, special cost studies, industry surveys, government reports and cost proposals. Cost proposals should only be used as last alternative. Data context is important – all attributes describing the circumstances the data where collected help to decide whether a future project to be estimated is similar to the historical project or not. All historical data need to be normalized, because we collect data from different organizations, which all are advancing, and we collect data from different projects from different years, perhaps from different countries. Some normalization require expert knowledge, others are mechanical. The two that are most nearly mechanical are adjustments for inflation and production quantity.

5.3. Model development

Model development can be described as a search for functions to fit the historical data. A purely cost or duration estimating model will provide what is called a „point estimate" of cost or duration. A point estimate is a single number that will always be in error to a greater or lesser extent. We wish to provide a model that deals with uncertainty and risk, a model which will provide a „range estimate" (probability distribution, giving some idea of the possible range of cost or schedule outcomes, and of the relative likelihood of particular outcomes).

Before using the parametric model a validation process is applied. Validation is the demonstration of a model's ability to reliably predict costs. With sufficient historical data, some points can be withheld from model building process and used as test points. With less historical data you loose accuracy for testability. Therefore comparison could perform against other estimating techniques. Projects final costs can also be compared with estimated costs. It may take a while before this approach can be applied. But by then, if we had a weak or inaccurate estimating model, it would be pretty late to find that out.

Because we consider historical data as a rare estate, we decided to use all of them for model building to advance accuracy of our models. Therefore validation mainly is a contest against other estimating techniques [3] and partly a contest against final project costs.

To be able to relate to something all assumptions, conditions and model changes have to be recorded when they occur.

5.4. Model use

If a model has global settings (year of inflation, inflation table to be used, method and slope of learning, average labour rates, average overhead rates, project start dates), they must all be checked and properly set before estimating activities begin.

The model may enter some default parameter values for the user, based on user selection from among a few basic estimating categories. The presence of such default „presets" in complex models is a labour saving device for users. The user can either accept or reject the preset defaults.

Development of a model is an iterative process. Therefore using a model sometimes means updating that model. While doing this, we document all changes to keep a trail.

6. Evaluation

An example of the first test of our framework is UniCat – the acronym for a new initiative on the area of catalysis research in the Berlin-Brandenburg area (Germany). UniCat is a Cluster of Excellence. Clusters of excellence will enable German university locations to establish internationally visible, competitive research and training facilities, thereby enhancing scientific networking and cooperation among the participating institutions.

7. Conclusion

To evaluate the cost-effectiveness of a process not only the investment costs are involved, but also production costs. Due to tax relief through depreciation allowance for a comparison of process variations a period of 10 years is specified. As already from the synthesis process a lot of information for production costs is to gather we will focus on estimating investment costs. To estimate those costs we decided to use parametric models. The pros outbalance the cons of this model category. The backbone of the framework is a knowledge base providing hints to support the user, give access to historical data and share all the data between the other applications.

Outstanding points of this work are: usability and uniqueness. Our solution is usable to support the entire workflow of engineering and also the single task of cost estimating. Unique is the complexity of the cost models. A unique feature is also the presentation of results – charts showing original data points and resulting estimation ranges simultaneously.

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