



SALERO

Evaluation of the Economics of Multimedia Ontologies and Integrated Prototype

SALERO Deliverable 3.1.4



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1 Executive Summary

SALERO's overall goal is to define and develop 'intelligent content' with context-aware behaviours for self-adaptive use and delivery across different platforms, building on and extending research in media technologies, Web semantics to reverse the trend towards ever-increasing costs of creating media.

Work Package 03 "Media Semantics and Ontologies" aims to improve creation, management, retrieval and (re-) use of all types of multimedia objects through their augmentation with semantic information about their meaning. One important part of the work in WP03 is the development of ontologies for the annotation of multimedia objects.

This document takes a closer look at specific facets of these ontologies. It aims to tackle an identified gap in the field of ontology engineering which is of utmost relevance for their use in commercial settings: the assessment of the economics of ontologies.

Ontologies are intended to provide reusable pieces of declarative knowledge. They can, together with semantic technologies like reasoning, easily be assembled to become high-quality and cost effective systems. Although the benefit of ontologies in different application areas has already been shown, it is not clear for many people how to build ontologies or how to predict the economic value of the use of them in productive environments.

Therefore the purpose of this deliverable is to present a model for the evaluation of the economics of ontologies in terms of costs and benefits.

The model consists of two parts: For the cost estimation part, ONTOCOM, a model for cost estimation for ontology engineering processes, will be adapted for the use with multimedia ontologies. For the benefits part we propose to adopt a method called User Information Satisfaction. Here we propose a questionnaire design that can be used to assess the value and benefit of (multimedia) ontologies.

The deliverable is structured as follows:

Section 3 provides an introduction to the topic of cost and benefit analysis in the field of ontology engineering.

Section 4 introduces the ONTOCOM model for cost estimation of ontologies and section 5 illustrates the calibration of the model for the use with multimedia ontologies.

Section 6 introduces the topic of benefit estimation and examines it from the perspective of ontologies.

Section 7 presents the application of the "User Information Satisfaction" method for the assessment of (multimedia) ontologies: There, a taxonomy of user- and application-dimensions of ontologies is presented which might influence the benefits of the use of ontologies.

Section 8 explains the tools that we used for the survey and the calibration of the ONTOCOM model and section 9 concludes with an outlook.

2 Introduction

2.1 Purpose of this Document

The purpose of this document is to present a model for the estimation of costs and benefits of ontologies. Its purpose is to adapt an existing model for cost estimation to the special circumstances regarding multimedia ontologies and to present an approach for the estimation of benefits of ontologies in quantitative terms for the assessment of (multimedia) ontologies.

2.2 Scope of this Document

A calibrated version of an existing cost estimation model is developed for the estimation of the costs for engineering of ontologies. The model is calibrated with data from a user survey about the engineering of multimedia ontologies. In order to provide a complete evaluation model for the economics of ontologies, a benefit measurement approach is suggested based on methods from the field of information systems.

2.3 Status of this Document

This is the final version of D3.1.4.

2.4 Related Documents

Before reading this document it is recommended to be familiar with the following document:

- D3.1.1 Representation Techniques for Multimedia Objects

3 Cost / Benefit Analysis in Ontology Engineering

Nowadays ontologies are a popular tool to represent common knowledge about a domain. Ontologies can be amongst others used to integrate different systems or models, to present facts to users in knowledge management applications or to use them as a supportive tool in semantic search. Ontologies are intended to provide reusable pieces of declarative knowledge which can be, together with semantic technologies like reasoning, easily be assembled to become high-quality and cost effective systems [Fensel, 2001]. Although the benefit of ontologies in different application areas has already been shown ([Oberle, 2006], [Aitken and Reid, 2000], [Castells et. al, 2007]) it is not clear to many how to build ontologies or how to predict the economic value of the use of them in productive environments.

It is not feasible to introduce ontologies in companies without a means to predict the benefits and the costs of its development and utilization. Important factors regarding this respect are means for cost estimation and means to estimate the business value of ontologies. This has not been researched to a sufficient extent in the field of ontology engineering before.

It is the purpose of this deliverable to further analyse this field in the context of SALERO. In the subsequent section we first give a general introduction to ontology engineering and then introduce cost/benefit analysis in the context of ontologies.

3.1 Ontology Engineering

Ontology Engineering is formally defined as “the set of activities that concern the ontology development process, the ontology lifecycle, and the methodologies, tools and languages for building ontologies” [Gomez-Perez et al., 2003] A comprehensive overview of ontology engineering methodologies can be found in [Gomez-Perez et al., 2003].

The whole ontology engineering process is divided into different activities: Most methodologies differentiate between management, development-oriented and support activities for ontology engineering [Paslaru-Bontas-Simperl et al., 2006b]. The activities are visualized in Figure 1:

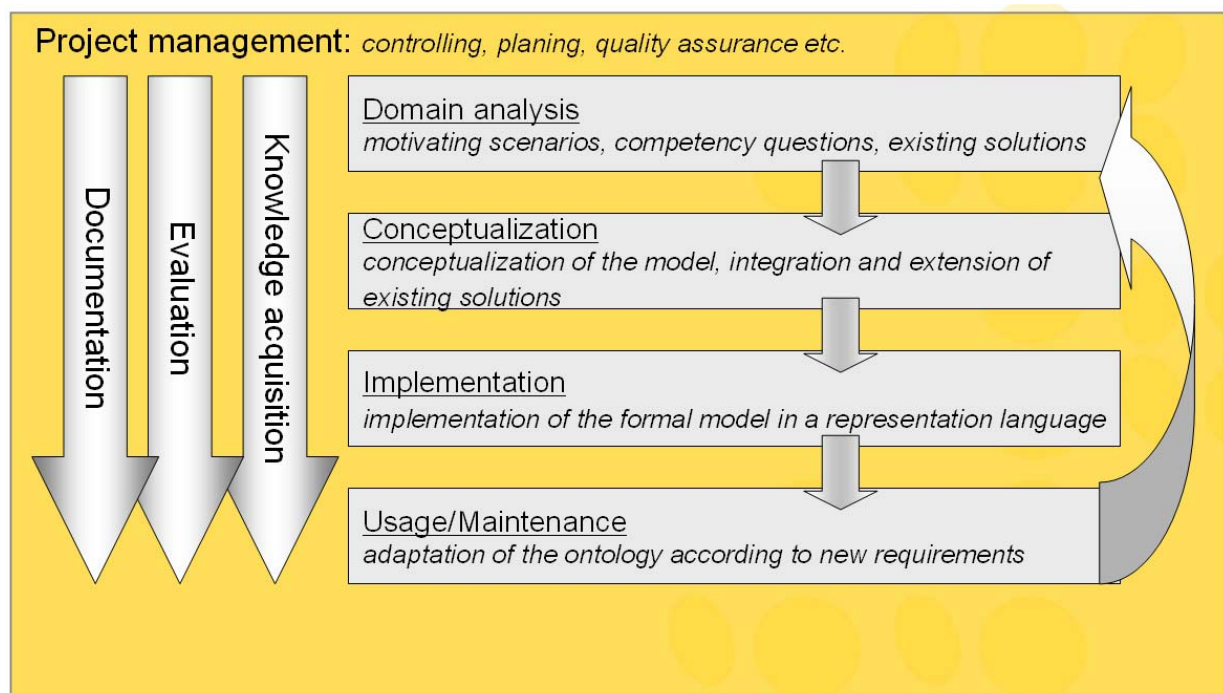


Figure 1 - Ontology Engineering Activities [Paslaru-Bontas-Simperl et al., 2006b]

(1) **Ontology Management activities:** These activities cover the overall process

(2) **Pre-Development Activities:**

- a. **Feasibility Study:** The intention of a feasibility study is to examine if an ontology is able to solve a set of given problems, outlines potential solutions and also sketches the economic feasibility of the ontology engineering process

(3) **Ontology Development Activities**

- a. **Domain analysis:** This task covers the analysis of the domain to be modelled including motivating scenarios, competency questions, important terms, and an analysis of existing solutions.
- b. **Conceptualization:** This task involves the conceptualization of the domain; this typically includes identifying concepts and properties, hierarchical relations between the concepts and rules/axioms holding between the concepts and in the domain in general. It also includes the integration and extension of existing models
- c. **Implementation:** This task involves the implementation of the model in a representation language that has the expressivity needed to cover the domain and conceptualization

(4) **Post Development Activities**

- a. **Maintenance** includes the adaptation of the ontology to new requirements. It also covers the extension or population of the ontology
- b. **Use** includes the application of the ontology (i.e. to use it for semantic search, integration of different systems or for negotiation between different models)

(5) **Ontology Support Activities**

- a. **Ontology Reuse** is about the reuse of the ontology in another ontology or setting
- b. **Knowledge Acquisition** is a constant process set out to acquire knowledge about the domain
- c. **Evaluation** deals mainly with the coverage check of the ontology according to the requirements defined.
- d. **Documentation**

Usually different persons are involved in an ontology engineering process including most notably domain experts and ontology builders.

3.2 Cost / Benefit Analysis

In this section the general intention of estimating the costs and benefits of ontologies is introduced and similarities with different fields are spotted.

Cost analysis

Although many ontology engineering methodologies exist, the time needed for the building of ontologies can not adequately be measured nor be estimated. Not many models for cost estimation in the field of ontology engineering exist. However, this particular field of estimation of the economics, shares similarities with the field of Software Engineering in which methods have been established to measure the costs needed to develop a piece of software.

Software Engineering provides systematic methods to manage tasks like designing, implementing and maintaining software systems. The typical software lifecycle that Software Engineering methodologies are able to deal with are user requirements, design, testing, documentation, deployment and maintenance. In the same sense, ontology engineering consists of methods to create, implement and maintain ontologies (as outlined in section 3.1). However compared to ontology engineering, software engineering is different in two main points as outlined in [Paslaru-Bontas-Simperl and Mochol, 2006]: The main difference is their outcome: software vs. ontologies. Additionally other differences exist at project setting (collaborative vs. single team effort, etc). This is why software engineering

methodologies can not be used in an equal manner in ontology engineering. But nonetheless, a cost model for ontology engineering should take into account results from the software engineering domain.

The costs of building ontologies are amongst others measured by the number of ontological primitives (e.g. concepts, properties, axioms) contained in the conceptual models and not by lines of code like in software systems. Important aspects for the cost estimation of ontologies furthermore include

1. the type of ontological primitives,
2. the population/instantiation of the ontologies which is producing significant effort,
3. the experience of the project team, or
4. the complexity of the domain to be modelled.

In contrast to software engineering in which it is generally assumed that every line of code needs similar effort, the effort generated mainly depends on the type of primitive to be modelled. Another great difference is the role of the domain expert who has a much greater influence on the effort needed to produce the outcome than in software engineering. This makes ontology engineering different to software engineering in general. However it can still be assumed that the effort associated with the engineering process depends on the complexity of the resulting product like in software engineering. Due to the intrinsic similarities between both engineering fields, a cost estimation method for the ontology engineering domain should build on the methods developed in the area of software engineering.

See [Paslaru-Bontas-Simperl and Mochol, 2006] for more details.

We will further detail the issue of cost analysis of ontologies in section 4 where we introduce the ONTOCOM model and in section 5 where we present the calibration of the model with data from multimedia ontologies.

Benefit analysis

Estimating the costs needed to develop ontologies is not enough to make a statement about the economics of them. Usually cost analysis comes in line with benefit analysis to measure the business performance of a system. In the field of ontology engineering this process is sometimes referred to Ontology Economics¹.

However, benefit analysis has not been approached in the field of ontology engineering before. But again, many approaches exist in adjacent fields: Many methods can be found in the field of information systems and IT that can be used to measure the business performance of systems in financial, quantitative or qualitative terms.

In the field of information systems / IT the benefits of a system are greatly depending on the type of system and the intention of the introduction of the system. In general there can be very distinct notions why information systems are introduced: e.g. to automate a previously manual task, to provide computational support for a manual task, to act as a source of information or to improve a certain task in terms of computational complexity. Due to this broad range of expected benefits there are many distinct methods for benefit measurement available: the amount of methods to measure IT benefits (and its associated costs) can be estimated to about 100. About 80 methods are reported in [Andresen, 2001] which the author grouped according to their output:

- (1) *Financial methods*, i.e. methods that have an output of financial character. These methods assess the IT investments financial value by analysing its cash in- and out-flow.
- (2) *Quantitative methods*, i.e. methods that provide an output with one of several non-financial and quantitative measures.

Qualitative methods, i.e. methods that provide qualitative output (e.g. diagrams or subjective statements).

In order to make a statement about the benefits of ontologies in economic terms, the general benefits and promises of ontologies have to be identified: The promises of what ontologies can solve, are broad,

¹ The term 'Ontology Economics' is derived from the term 'Information Economics' which is a method to estimate the economic value of information systems in terms of costs and benefits.

and as correctly stated in [Hepp, 2008] the development costs for ontologies sometimes outweigh its benefits in a particular task.

We will further detail the nature of benefits of ontologies in section 6.1.2. Furthermore different methods for benefit estimation are presented in section 6.3 and finally a suggested method for benefit estimation for ontologies is presented in section 6.4.

3.3 Related Work

Cost Analysis

In the course of this deliverable we present a particular cost estimation methodology for ontologies called ONTOCOM. This methodology is to our knowledge the only well elaborated approach in this area. Other approaches have been defined in the area of software engineering, industrial production or IT [Böhm, 1981] [Kemerer, 1987] [Stewart et al., 1995]. A similar approach has also been defined for the development of knowledge-based systems [Felfernig, 2004]. Furthermore in [Menzies, 1999] cost estimation for ontologies is discussed, but no model is provided. [Korotkiy, 2005] provides a model for cost estimation based on an estimation model for Web applications. However it is not tailored to the specific needs of ontology engineering.

Benefit Analysis

To the best of our knowledge benefit analysis/estimation for ontologies has not been researched broadly before. However, there are many models in the area of information systems ([Andersen, 2001], [Sassone and Schaffer, 1978], [Remenyi et al., 1995], [Parker and Benson, 1998], or [Carter et al., 1995]) to build upon.

[Ellman, 2004] provides arguments for the benefits of taxonomies for knowledge management and knowledge transfer in enterprise information systems. He provides some arguments for benefits that occur but no model to estimate the benefits. Also Menzies provides arguments for the benefits of ontologies, like interoperability, browsing/searching, reuse, or structuring [Menzies, 1999]. The author provides first estimates regarding cost/benefits and argues that especially automatic generation of code based on ontologies and rules can save significant development effort. Furthermore he argues that the costs for maintenance and adaptation of the ontology might outweigh the benefits that ontologies introduce to a system. Again, no model for general benefit estimation of ontologies is provided.

Some research has been undertaken to assess the technical functionality of an ontology based system: Maynard defined a set of criteria and properties that an ontology based annotation system has. Additionally a set of metrics for performance evaluation are defined [Maynard, 2005]. Aitken and Reid compare a traditional keyword based information retrieval system against an ontology based information retrieval system [Aitken and Reid, 2000]. Both papers do not provide a general methodology.

Also Wolff et al. [Wolff et al., 2005] account for the importance of benefit estimation in the field of ontologies. They present thoughts about the cost effectiveness of Semantic Web Services. While they mainly provide a first model for cost estimation, benefits are not considered to a large extent. They argue some benefits that are gained from automation. These benefits can be measured according to financial terms.

4 Cost Estimation: The ONTOCOM Model

In this section we first introduce the general ONTOCOM model and then report on how we adapt it for the use with multimedia ontologies.

ONTOCOM (Ontology Cost Model) is a model for predicting the costs related to ontology engineering processes. The model is generic with respect to the fact that it allows the generation of cost models suitable for any particular ontology development strategy which is shown in [Paslaru-Bontas-Simperl and Tempich, 2005b].

ONTOCOM is briefly introduced in the remainder of this section: we introduce the general model and illustrate how to calibrate and how to use it.

More information about ONTOCOM can e.g. be found in [Paslaru-Bontas and Mochol, 2005], [Paslaru-Bontas-Simperl et al., 2006b], or [Paslaru-Bontas-Simperl and Mochol, 2006].

4.1 Cost Estimation Methodologies

Cost estimation methods can be used to measure and predict costs related to ontology engineering activities. As many cost estimation methods exist ([Böhm, 1981] [Stewart et al., 1995]), appropriate cost estimation methods have to be selected in accordance with the particularities of the current project regarding product, personnel and process related aspects.

Different cost estimation methods that were seen as relevant for the application within ONTOCOM are explained in [Paslaru-Bontas and Mochol, 2005] and [Paslaru-Bontas-Simperl et al., 2006b].

These methods include:

- (1) *The Analogy Method*: This method uses available data from similar projects to estimate the costs of the proposed project. This method depends on the availability of data and the similarity of the projects from which this data was gathered to the proposed project.
- (2) *The Bottom-up Method*: This method first identifies individual project outcomes and makes cost estimates for these outcomes. The separate estimates are finally combined to produce a single estimation for the overall project.
- (3) *The Top-Down Method*: This method acts in the opposite way to the bottom-up method: First global parameters are identified and the project is partitioned into lower-level components. This method is appropriate for an early cost estimate when only global properties are known.
- (4) *Expert Judgement / Delphi Method*: The idea of this approach is to distil knowledge from a group of experts for surveying experiences from past projects using questionnaires. One drawback is the subjectivity of this approach.

Parametric / Algorithmic Method: This method analyses main cost drivers of a specific class of projects and their dependencies and uses statistical techniques to adjust the corresponding formulas.

Based on the current state of the art in ontology engineering the following methods were selected for the development of cost estimation methods for ontology engineering: The top-down, parametric and expert-based method. It is argued in [Paslaru-Bontas and Mochol, 2005] and [Paslaru-Bontas-Simperl et al., 2006b] why these act viable basis for that purpose.

4.2 The ONTOCOM Model

ONTOCOM is realized in three distinct phases which are based on the cost estimation methods outlined in section 4.1:

- (1) First, a **top-down breakdown** is made in order to reduce the complexity of the overall estimation: The whole ontology engineering process is split into multiple sub-processes based on the ontology engineering methodology applied.

- (2) The associated costs are then elaborated using the **parametric method** which results in a statistical prediction model
- (3) In order to calibrate the model based on previous project data, **expert evaluations** are used to evaluate and revise the predictions of the initial model (a-priori-model). Together with the combination of empirical data this results in an **a-posteriori-model**.

4.2.1 The Work Breakdown Structure

According to the general structure of available ontology engineering methodologies, the overall process is split into multiple sub-processes (see section 3.1 for an explanation):

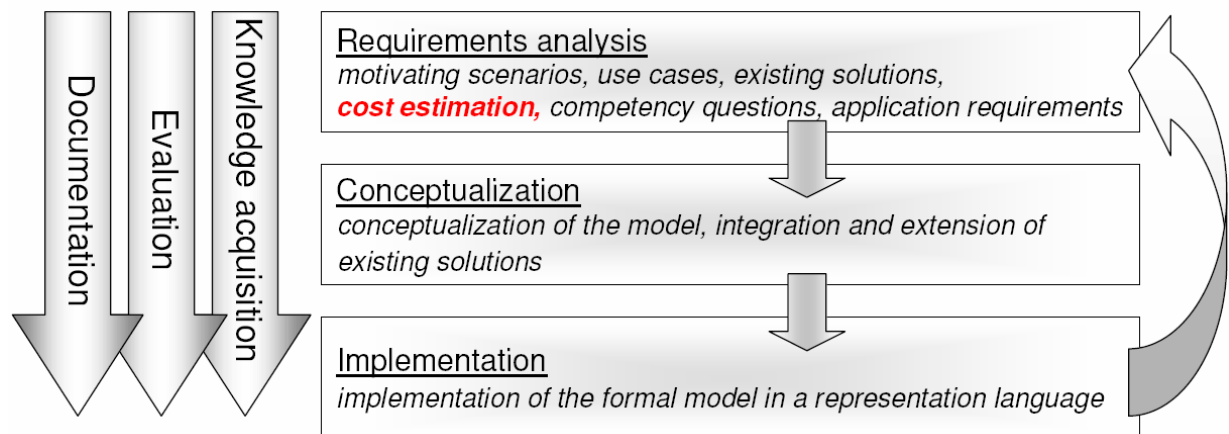


Figure 2 - A typical ontology engineering process [Paslaru-Bontas-Simperl et al., 2006b]

1. Requirements Analysis
2. Conceptualisation
3. Implementation
4. Evaluation

Depending on the ontology lifecycle of the underlying methodology, these process steps are seen in a sequential order or occur in parallel. In some ontology engineering methodologies the activities “documentation”, “evaluation” or “knowledge acquisition” are seen as so-called support actions that occur in parallel to the main activities.

The work breakdown structure is further detailed in [Paslaru-Bontas-Simperl et al., 2006a].

4.2.2 The Parametric Equation

The parametric method now integrates the efforts associated with each component of the work breakdown structure into an overall equation.

The necessary person months are calculated by the following equation:

$$PM = A * Size^{\alpha} * \prod CD_i \quad \text{Eq. 0}$$

In this formula **PM** identifies the calculated person-months. **A** is a baseline multiplicative calibration constant in person-months. **Size** is the size of the ontology, and α is a parameter for handling a possible non-linear behaviour of the estimated effort contingent on the ontology size. The cost drivers are represented by **CD_i** and have five rating levels from very low to very high, depending on their relevance in the ontology engineering process.

4.2.3 The Cost Drivers

The ONTOCOM cost drivers were carefully selected based on a literature survey regarding the state of the art in ontology engineering and based on expert interviews.

During the course of the definition of the model, three groups of cost drivers that have direct impact on the predication of the estimation were identified: Product-related-, personnel-related-, and project-related-cost drivers. The cost drivers are listed in the remainder of this section. A detailed overview of the cost drivers can be found on the ONTOCOM website².

Product-related cost drivers

The product cost drivers account for the influence of product properties on the overall costs. These include:

- (1) Cost drivers for ontology building
 - a. Complexity of the Domain Analysis (DCPLX)
 - b. Complexity of the Conceptualization (CCPLX)
 - c. Complexity of the Implementation (ICPLX)
 - d. Complexity of the Instantiation (DATA)
 - e. Required Reusability (REUSE)
 - f. Documentation Needs (DOCU)
 - g. Complexity of the Ontology Integration (OI)
 - h. Complexity of the Ontology Evaluation (OE)
- (2) Cost drivers for reuse and maintenance
 - a. Complexity of the Ontology Evaluation (OE)
 - b. Complexity of the Ontology Modifications (OM)
 - c. Ontology Translation (OT)
 - d. Ontology Understanding (OU)
 - e. Ontologist / Domain Expert Unfamiliarity (UNFM)

Personnel-related cost drivers

The personnel cost drivers emphasize the role of team experience or ability in the process. These include:

- (1) Cost drivers for building, reuse and maintenance
 - a. Ontologist / Domain Expert Capability (OCAP/DECAP)
 - b. Ontologist / Domain Expert Experience (OEXP / DEEXP)
 - c. Personnel Continuity (PCON)
 - d. Language and Tool Experience (LEXP / TEXP)

Project related cost drivers

These cost drivers take into account the overall setting of the engineering process, like tool support, etc.

- (1) Cost drivers for building, reuse and maintenance
 - a. Tool Support (TOOL)
 - b. Multi-site Development (SITE)
 - c. Required Development Schedule (SCED)

² <http://ontocom.ag-nbi.de/>

4.3 Calibration of the ONTOCOM Model

The general ONTOCOM model provides a parametric equation for the estimation of ontology engineering costs based on predefined effort multipliers associated to the cost drivers. However, in order to achieve a prediction that is as precise as possible a calibration of the model should be performed by adjusting the values of the cost drivers to better fit to a specific context. We detail this process for the domain of multimedia ontologies in section 5.3.

The approach selected by ONTOCOM for the adaptation of the non-calibrated effort multipliers is a combination of expert estimations of the values associated to the cost drivers and empirical data. For the expert estimations the Delphi method was used. For the collection of the empirical data a survey, which is divided into four groups of questions related to the different cost drivers, is used. A more detailed description of the survey is provided in [Paslaru-Bontas-Simperl and Tempich, 2005].

In the following we present the process of adaptation of the model used in ONTOCOM once the expert estimations and the empirical data are available. Starting point was the COCOMO II Bayesian calibration approach described in [Devnani-Chulani, 1999] and an adaptation of it to ontologies. In the following a short overview of this calibration technique is provided. The calibration is also explained in [Paslaru-Bontas-Simperl and Tempich, 2005b] and [Paslaru-Bontas-Simperl et al., 2006b].

First, an adaptation of equation Eq. 0 has to be performed. This is done by the introduction of the parameters β_i that represent the scaling factors for the adaptation of the values of the respective cost driver.

$$PM = A * Size^\alpha * \prod CD_i^{\beta_i} \quad \text{Eq. 1}$$

The calculation of these scaling factors can be performed by applying the logarithm function on both sides of Eq. 1: The result of the application is Eq. 2. The parameters are then determined using the multiple linear regression approach.

$$\ln(PM) = \ln(A) + \alpha * \ln(Size) + \sum \beta_i * \ln(CD_i) \quad \text{Eq. 2}$$

The resulting effort multipliers represent an adaptation that best fits to the empirical data.

To provide accurate results, a huge amount of empirical data has to be available in order to achieve a meaningful result. Furthermore, results of the calculation can also be influenced negatively by particular compositions of the empirical information such as the presence of outliers. In order to avoid a calibration that results in less precise predictions the scaling factors calculated by the linear regression are combined with expert estimations. So for example the resulting scaling factor can be a combination of 10% of the values calculated with linear regression and 90% of the ratings estimated by expert. However, this weighting can fit well to some situations and not for others. In order to provide a weighting adapted to the available data, a Bayesian approach of linear regression is used in ONTOCOM.

Equation Eq. 3 presents a formula for the calculation of the scaling factors β^{**} following the Bayesian approach that considers empirical data and expert estimations. Thereby, s^2 represents the variance of the residual of the linear regression, X is a matrix containing the collected data, H^* is the inverse of the matrix containing the variance of the expert estimations, and b^* is the matrix containing the means of the expert ratings.

$$\beta^{**} = \left[\frac{1}{s^2} X'X + H^* \right]^{-1} x \left[\frac{1}{s^2} X'X\beta + H^*b^* \right] \quad \text{Eq. 3}$$

Based on this formula adapted effort multipliers for the used cost drivers can be calculated. Once the new values are available, a check of the quality of the prediction can be performed by comparing the predictions with the observed data. Moreover, the significance of the new cost drivers can be calculated by the help of Eq. 4. A low value indicates a better estimation of the cost driver and vice versa.

$$\text{Var}(\beta^{**}) = \left[\frac{1}{s^2} X'X + H^* \right]^{-1} \quad \text{Eq. 4}$$

A detailed explanation of the application of Bayesian analysis for the calibration of cost estimation models can be found in [Devnani-Buchnani, 1999]. Additional information about the calibration of ONTOCOM is available in [Paslaru-Bontas-Simperl et al., 2006b].

4.4 Using the ONTOCOM Model

In this section we present a brief example showing the application of ONTOCOM.

First, the size of the ontology to be built has to be specified. The estimation is given in thousands of ontological primitives (concepts, relations, axioms and instances). For our example we consider an ontology with 600 concepts, 100 relations and 50 axioms. Based on this information we can calculate the size parameter as follows:

$$\text{Size} = \frac{600 + 100 + 50}{1000} = 0.75 \quad \text{Ex. 1}$$

Once the size parameter of the equation is calculated, the ratings of the cost drivers, have to be specified. Only cost drivers whose influence can be estimated at this point are considered here. Depending on the influence of the cost drivers on the final effort they are rated either *very low*, *low*, *nominal*, *high*, and *very high*. Cost drivers with a high impact on the effort should be rated with high or very high, cost drivers with a low impact with low or very low and cost drivers that do not influence the final effort with nominal. In the calculation the ratings are replaced by its values. For our example we already use the values which result from the calibration presented in section 5.3 (see Table 2 - New effort multipliers).

Considering an ontology where the domain analysis complexity (DCPLX) and the evaluation of the results (OE) has a high influence on the effort, whereas, the instantiation complexity (ICPLX) has a low impact on the effort. The effort multipliers are listed in Table 1.

| Cost driver | Rating |
|-------------|-------------|
| DCPLX | 1.26 (high) |
| OE | 1.09 (high) |
| ICPLX | 1.05 (low) |

Table 1 - Cost driver ratings

For the remaining cost drivers the nominal values are used. For the constant A and for α we use the values 2.58 and 0.15 as resulting from the calibration (see section 5.3). The effort prediction for our example results in the following number:

$$PM = 2.58 * 0.75^{0.15} * (1.26 * 1.09 * 1.05) = 3.56 \quad \text{Ex. 2}$$

5 Using ONTOCOM for Multimedia Ontologies

In this section we first outline how we approach the calibration of the model and the adaptation to the domain of multimedia ontologies.

5.1 Approach

It is typically suggested to calibrate cost estimation models based on data from projects undertaken in the own company or in a particular domain in which the model should be applied [Devnani-Chulani, 1999]. Therefore the aim of this task in SALERO is to provide a calibrated version of the ONTOCOM model that can be applied to multimedia ontologies. Therefore a survey was conducted: Developers of ontologies in the multimedia domain were asked to fill out questionnaires whereas the results gathered are used to calibrate the model in order to reach sufficient predictions for future multimedia related ontology developments. The result of this survey is additionally combined with expert evaluation of ONTOCOM to provide more accurate results.

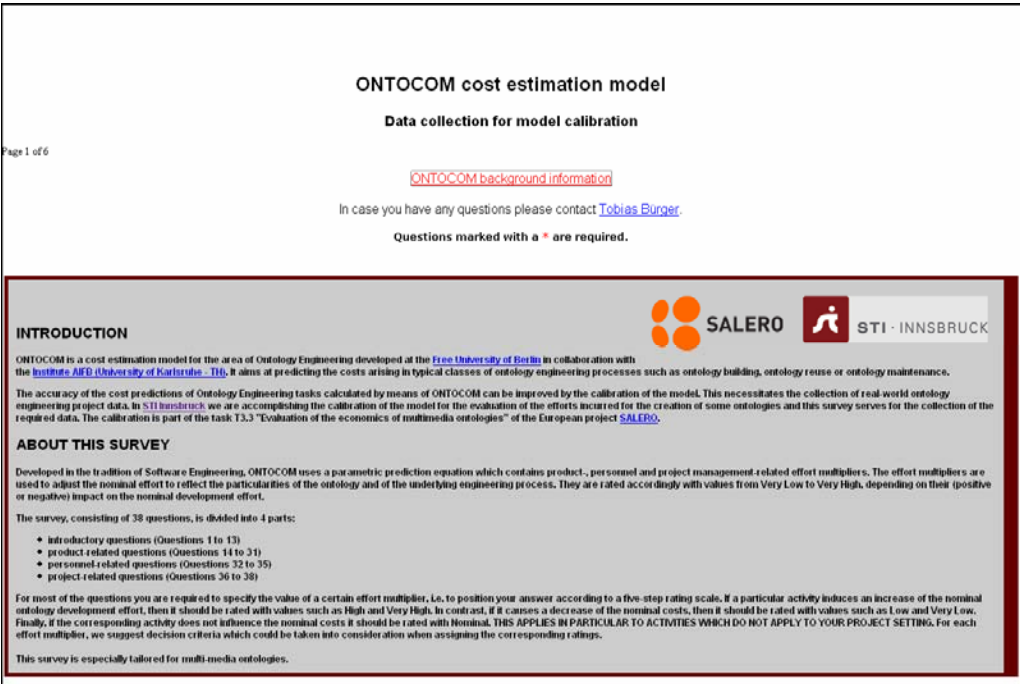
For the expert estimations we used the expert data provided by ONTOCOM directly, therefore, we did not have to do interviews in order to gather this data.

In the following sections a more detailed presentation of the collected empirical data and the calibration is provided.

5.2 Empirical Results – Data Collection and Analysis

For the calibration of the model expert data and empirical data are needed. The empirical data are collected by the use of a survey composed of questions related to the different cost drivers of the model. A detailed presentation of the structure of the ONTOCOM survey can be found in [Paslaru-Bontas-Simperl and Tempich, 2006c].

Within the SALERO project we used this survey and adapted it to better fit to the needs of multimedia ontologies. However, the added questions are not directly associated to some cost drivers and are therefore not relevant for the calibration.



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ONTOCOM cost estimation model

Data collection for model calibration

[ONTOCOM background information](#)

In case you have any questions please contact [Tobias Burger](#).

Questions marked with a * are required.

INTRODUCTION

ONTOCOM is a cost estimation model for the area of Ontology Engineering developed at the [TU no University of Berlin](#) in collaboration with the [Institute AIFB \(University of Karlsruhe - TH\)](#). It aims at predicting the costs arising in typical classes of ontology engineering processes such as ontology building, ontology reuse or ontology maintenance.

The accuracy of the cost predictions of Ontology Engineering tasks calculated by means of ONTOCOM can be improved by the calibration of the model. This necessitates the collection of real-world ontology engineering project data. In [STI Innsbruck](#), we are accomplishing the calibration of the model for the evaluation of the efforts incurred for the creation of some ontologies and this survey serves for the collection of the required data. The calibration is part of the task T3.3 "Evaluation of the economics of multimedia ontologies" of the European project [SALERO](#).

ABOUT THIS SURVEY

Developed in the tradition of Software Engineering, ONTOCOM uses a parametric prediction equation which contains product-, personnel and project management-related effort multipliers. The effort multipliers are used to adjust the nominal effort to reflect the particularities of the ontology and of the underlying engineering process. They are rated according with values from Very Low to Very High, depending on their (positive or negative) impact on the nominal development effort.

The survey, consisting of 38 questions, is divided into 4 parts:

- introductory questions (Questions 1 to 13)
- product related questions (Questions 14 to 31)
- personnel related questions (Questions 32 to 35)
- project related questions (Questions 36 to 38)

For most of the questions you are required to specify the value of a certain effort multiplier, i.e. to position your answer according to a five-step rating scale. If a particular activity induces an increase of the nominal ontology development effort, then it should be rated with values such as High and Very High. In contrast, if it causes a decrease of the nominal costs, then it should be rated with values such as Low and Very Low. Finally, if the corresponding activity does not influence the nominal costs it should be rated with Nominal. THIS APPLIES IN PARTICULAR TO ACTIVITIES WHICH DO NOT APPLY TO YOUR PROJECT SETTING. For each effort multiplier, we suggest decision criteria which could be taken into consideration when assigning the corresponding ratings.

This survey is especially tailored for multi-media ontologies.

Figure 3 - ONTOCOM / SALERO Data Collection Survey - Start Screen

The start screen for the survey is shown in Figure 3. The survey is available online: <http://survey.der1.at/public/survey.php?name=OntocomSaleroMultiMedia>

We used the survey to gather data about ontology engineering projects done in the field of multimedia ontologies. Based on a literature survey we identified 55 multimedia ontologies that were built in the last 5 years. We sent out the survey to the main developers of 51 of these ontologies and asked them to fill out the survey. The main authors of the remaining ontologies could not be reached because their email addresses no longer exist. We got 15 replies which results in a response rate of 30%.

We asked one particular question about the **main application of the reported multimedia ontology**.

The question was a single-choice question, thus the participants could only pick one possible choice. The main application of multimedia ontologies based on the data is annotation (46.7%) or retrieval (20%) (see Figure 4). In most cases it is however difficult to draw a clear border between the application scenarios and sometimes more options are valid.

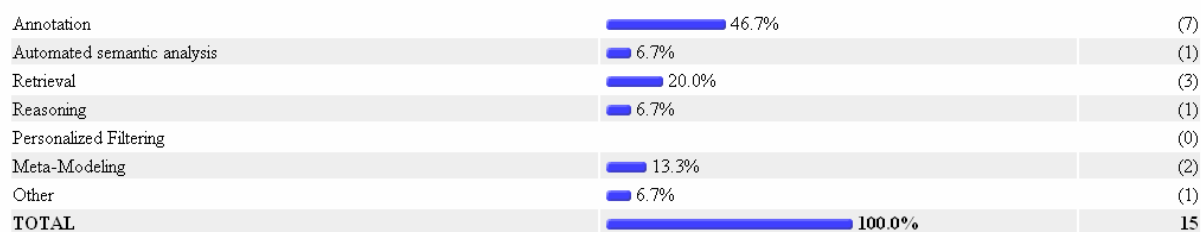


Figure 4 - Main application of multimedia ontologies

The reported **total size** (including concepts, properties, relations, axioms, etc.) of the ontologies varied between 36 and 100000.

Only one ontology was developed by following an **existing engineering methodology** (OntoKnowledge) and the majority of ontologies were **implemented** in OWL-DL (see Figure 5). The reason for that might be that most ontologies were single-person efforts. Perhaps this is the reason why no engineering methodology was followed in the most cases. The reason for OWL / RDF-S is of course because of its popularity.

10. What language did you use for the implementation of the ontology?

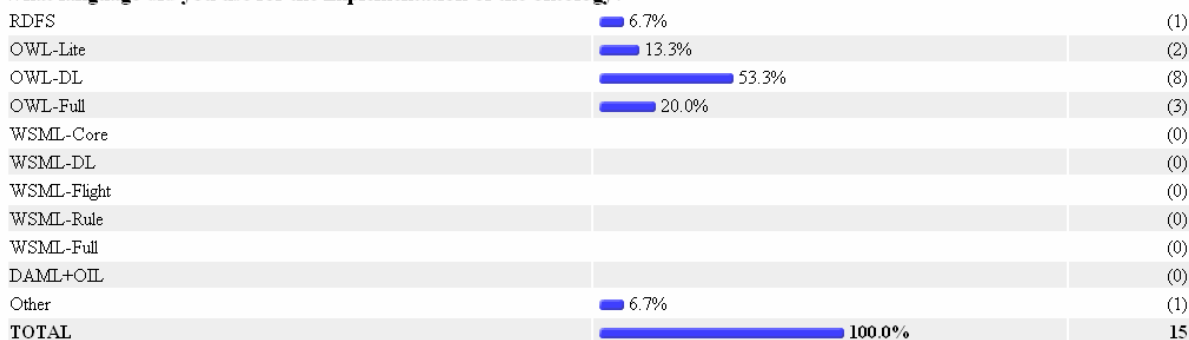


Figure 5 - Ontology implementation language

The reported **development time** of the ontologies varied between 0.5 person months and 130 person months while most ontologies were totally developed from scratch (45%).

The whole summary of the data collection can be found in Appendix I.

5.3 Calibration of the ONTOCOM Model

In this section we present the steps and the results of the calibration of the ONTOCOM model we performed. First of all, empirical data and expert data necessary for the further calculations have to be gathered. As aforementioned for the expert estimations we used the data provided by ONTOCOM and for the collection of the empirical data we used the data as described in section 5.2.

To further improve the results of the calibration we additionally used data about ontologies done at STI Innsbruck which were gathered in a separate survey. Thus, we collected a set of 19 data points which, added to the 47 data points already available in ONTOCOM, resulted in a set of 66 data points.

At the beginning of the calibration process the empirical data has to be prepared. This includes analysing which values to use for the further calculations in order to have a qualitative data set. Furthermore data about cost drivers with to less data points have to be eliminated or highly correlated cost drivers have to be merged by the help of a correlation matrix (see Figure 6). Cost drivers with a low influence on the final effort PM are not included in calibration and cost drivers with a high correlation are merged. As result of this analysis the following list of cost drivers was selected to be included in the calibration: DCPLX, CCPLX, ICPLX, OE, REUSE, DOCU, OCAP/DECAP, OEXP/DEEXP, and SITE. A new effort multiplier for DATA could also not being calculated because of the lack of expert data.

| | SIZE | PM | DCPLX | CCPLX | ICPLX | DATA | OE | REUSE | DOCU | OCAP_DECAP | OEXP_DEEXP | LEXP_TEXP | PCON | SITE |
|------------|---------|---------|---------|---------|---------|---------|---------|---------|---------|------------|------------|-----------|--------|------|
| SIZE | 1 | | | | | | | | | | | | | |
| PM | 0,2093 | 1 | | | | | | | | | | | | |
| DCPLX | 0,2340 | 0,4285 | 1 | | | | | | | | | | | |
| CCPLX | -0,0100 | 0,3521 | 0,3628 | 1 | | | | | | | | | | |
| ICPLX | 0,1379 | 0,1647 | 0,2601 | 0,2325 | 1 | | | | | | | | | |
| DATA | 0,1081 | 0,2843 | 0,2717 | 0,3246 | 0,3194 | 1 | | | | | | | | |
| OE | 0,0444 | 0,3249 | 0,1425 | 0,2988 | -0,0738 | 0,0774 | 1 | | | | | | | |
| REUSE | 0,1678 | 0,2801 | 0,2810 | 0,0933 | 0,3323 | 0,2605 | 0,0797 | 1 | | | | | | |
| DOCU | 0,0018 | 0,3210 | 0,3170 | 0,3636 | 0,2421 | 0,1965 | 0,3499 | 0,2336 | 1 | | | | | |
| OCAP_DECAP | 0,1290 | -0,1895 | 0,0264 | 0,0183 | -0,0732 | 0,0637 | -0,1491 | -0,1186 | -0,2784 | 1 | | | | |
| OEXP_DEEXP | 0,2064 | -0,1919 | 0,0600 | -0,0457 | -0,0958 | -0,0133 | -0,1929 | -0,1105 | -0,2111 | 0,6099 | 1 | | | |
| LEXP_TEXP | 0,1205 | 0,0510 | 0,2459 | -0,0042 | 0,1286 | 0,1388 | -0,0731 | -0,1729 | -0,1027 | 0,2820 | 0,4382 | 1 | | |
| PCON | -0,0075 | 0,0350 | -0,0539 | -0,1079 | -0,0484 | 0,0533 | 0,2487 | 0,2359 | 0,1362 | 0,0395 | -0,0512 | -0,0756 | 1 | |
| SITE | 0,0183 | 0,2395 | 0,2723 | 0,1163 | 0,1299 | 0,1184 | 0,0698 | 0,0498 | -0,0195 | -0,0214 | 0,0742 | 0,2681 | 0,1086 | 1 |

The cost driver LEXP_DEXP and PCON will be eliminated because they have a low influence on the effort PM.

| | |
|--|-----------------------------------|
| | highly correlated (value >= 0.65) |
| | low influence to effort (PM) |

Figure 6 - Correlation matrix

Once, the data set for the calibration is prepared, linear regression and Bayesian analysis are performed as described in section 4.3. Based on the results of these calculations the new effort multipliers can be calculated. Table 2 lists the values of the calibrated ratings of the aforementioned cost drivers³. The different ratings identify the impact of the cost driver on the final effort for building the ontology. For the constant A and for α the calibration calculated the values 2.58 and 0.15 respectively.

| | VL | L | N | H | VH |
|----------------|------|------|---|------|------|
| DCPLX | 0.49 | 0.74 | 1 | 1.26 | 1.51 |
| CCPLX | 0.25 | 0.75 | 1 | 1.26 | 1.79 |
| ICPLX | 1.13 | 1.05 | 1 | 0.96 | 0.94 |
| REUSE | 0.46 | 0.85 | 1 | 1.15 | 1.46 |
| DOCU | 0.60 | 0.82 | 1 | 1.16 | 1.31 |
| OE | 0.61 | 0.90 | 1 | 1.09 | 1.25 |
| OCAP/DECA P | 0.80 | 0.88 | 1 | 1.21 | 1.74 |
| OEXP/DEEXP | 1.03 | 1.02 | 1 | 0.98 | 0.93 |
| SITE | 0.56 | 0.80 | 1 | 1.17 | 1.32 |

Table 2 - New effort multipliers

Discussion of the calibration: For the cost driver OCAP/DECAP the data analysis suggests that an experienced project team needs longer to build an ontology. This is counter-intuitively. This effect is also reported in [Paslaru-Bontas-Simperl et al., 2006b]. The main reason – as reported there – might be that ontology engineers from academia were more experienced. For the expert data this value distribution is reversed. However based on a high variance among the expert data for OCAP/DECAP the survey data has a greater impact on the final result. The observations reported in [Paslaru-Bontas-Simperl et al., 2006b] were mainly confirmed. However we identified another cost driver that leaves room for improvement: The SITE parameter. Here the data analysis counter-intuitively suggests that

³ VL stands for very low, L for low, N for nominal, H for high, and VH for very high

mail communication lowers the effort needed to build ontologies while frequent face-to-face meeting increase the effort significantly. This could be based on the assumption that face-to-face meetings produce more different views on the ontology and originate in more discussions which of course raises the effort needed to build ontologies.

5.4 Calibration Evaluation

In the previous section the process of calibration in SALERO is described. In Table 2 the results of the calibration are presented. Based on these values the prediction quality of the calibrated model can be determined.

| Prediction Accuracy | Range of 30% | Range of 75% |
|--|--------------|--------------|
| Calibration with 47 data points | 15.79% | 36.84% |
| Calibration with 66 data points | 21.05% | 42.11% |

Table 3 - Prediction quality

Table 3 presents the prediction accuracy before and after the calibration with the new data. The percentages are calculated based on the data of the 19 ontologies collected through our survey. The accuracy is calculated by defining a range of 30% and 75% around the prediction adding and subtracting 30% or 75% of the estimated value. If the value of the actual effort is within these ranges the prediction is considered to be correct. The calibration of the model by 47 data points produced a correct prediction for 15.79% of our 19 data points for a range of 30% and of 36.84% for a range of 75%. After calibrating the model with the 66 data points 21.05% of the prediction within a range of 30% and 42.11% of the predictions within a range of 75% were correct.

This result demonstrates that the prediction quality can be improved through a calibration with a greater amount of data points. This observation is in line with a rule postulated by Devnani-Chulani in [Devnani-Chulani, 1999]: This rule states that the amount of data sets should be five times higher than the amount of cost drivers. This is based on the rule of thumb that every parameter that is calibrated should have at least 5 data points.

5.5 Estimation for the SALERO Virtual Character Ontology

In this section we provide a relevant example for SALERO by estimating the person months needed for the development of the SALERO Virtual Character Ontology.

The estimation makes use of the new effort multipliers as reported in section 5.3.

In order to estimate the effort, we interviewed Philip Hofmair from JOANNEUM RESEARCH.

The size of the ontology can be calculated according to Ex. 3: The ontology contains around 165 classes, 300 properties, 285 individuals and 500 axioms/functional properties.

$$Size = \frac{165 + 300 + 285 + 500}{1000} = 1.25 \quad \text{Ex. 3}$$

The interview resulted in the cost driver ratings in Table 4. We included the information available at this point of development.

The value of the DCPLX cost driver was computed as an equally weighted, averaged sum of a high-valued rating for the domain complexity (1,26) , a high rating for the Requirements complexity (1,26) and a high effort multiplier for the information sources complexity (1,26):

$$DCPLX = \frac{1*1,26 + 1*1,26 + 1*1,26}{1+1+1} = 1,26$$

Ex. 4

| Cost Driver | Effort | Value | Cost Driver | Effort | Value |
|------------------------|----------------|-------|--------------------------|-----------|-------|
| Product factors | | | Personnel factors | | |
| DCPLX | High | 1,26 | OCAP/DECAP | High | 1,06 |
| CCPLX | Nominal | 1 | OEXP/DEEXP | Nominal | 1,01 |
| ICPLX | Very Low | 1,13 | PCON | Very High | 0,70 |
| DATA | Nominal | 1 | LEXP | Nominal | 1 |
| REUSE | Nominal | 1 | TEXP | High | 0,90 |
| DOCU | Very Low | 0,60 | | | |
| OM | Nominal | 1 | Project factors | | |
| OT | not applicable | | TOOL | Very Low | 1,42 |
| OU | Nominal | 1 | SITE | High | 1,17 |
| OE | Very Low | 0,61 | SCED | not asked | |

Table 4 - Cost driver ratings for the SALERO Virtual Character Ontology

The values of the combined cost drivers (DATA, OU, OCAP/DECAP, OEXP/DEEXP) were computed like DCPLX in Ex. 4 accordingly.

For the constant A and for α we use the values 2.58 and 0.15 as resulting from the calibration (see section 5.3).

We use the adapted ONTOCOM general equation for the centralized building phase (including PM estimations for the newly built part and the reused part) as introduced in [Paslaru-Bontas-Simperl and Tempich, 2005b] which contains a simplified reuse function as compared to [Paslaru-Bontas and Mochol, 2005]:

$$PM_{CB} = Size_{CBB} * \prod PROD_{CBB} * \prod PERS * TOOL +$$

$$Size_{CBR} * \prod PROD_{CBR} * \prod PERS * TOOL \quad \text{Eq. 5}$$

$$\prod PROD_{CBB} = DCPLX * CCPLX * ICPLX * REUSE * DOCU * OE * OI \quad \text{Eq. 6}$$

$$\prod PROD_{CBR} = OU * OE * OI * OT * OM * DOCU \quad \text{Eq. 7}$$

$$\prod PERS = OCAP * DECAP * OEXP * DEEXP * PCON * LEXP * TEXP \quad \text{Eq. 8}$$

$$\prod TOOL = SITE * SCED * TOOL \quad \text{Eq. 9}$$

The effort prediction for our SALERO example results in the following number (while assuming that around 5% of the ontology was built from scratch⁴):

⁴ Probably this number is even less

$$PM = 2.58 * 0.0625^{0.15} * (1.26 * 1.13 * 0.6 * 0.61 * 1.06 * 1.01 * 0.70 * 0.9 * 1.42 * 1.17) + \\ 2.58 * 1.1875^{0.15} * (0.61 * 0.60) = 1,96$$

Ex. 5

The effort for developing the ontology was estimated by Philip Hofmair between one and two person months. The estimation is very close to this prediction with 1.96.

6 Benefit Estimation for Ontologies

In this section we will provide first ideas about benefit measurement for ontologies.

The possibility of making statements about the costs for building an artefact is generally not enough to make a statement about its economic value. The economic value of an artefact in the fields of information systems, production or IT is generally measured in terms of ROI ("Return on Investment"): What is the benefit that is gained by the introduction of the artefact into a productive system? Thus, in order to determine the economic value of ontologies a method for analysing benefits has to be developed that can be used to compare the estimated costs to quantitative or financial figures.

It is particularly not easy to quantify the benefits that occur with the introduction of ontologies to a system: It is generally agreed that an information system only acquires value when used in collaboration with other resources as part of a business process that will result in the enhancement of the effectiveness. This statement can almost directly be mapped to the field of ontology engineering. However it should not be neglected that an ontology itself can have value as it is e.g. capable of communicating valid assumptions, interrelations or rules in a domain: Even the structuring of the domain, i.e. the building of the underlying model for an ontology can cause a learning effect and better help to capture the coherences in a domain [Schaffert et al., 2006]. The different type of benefits that may occur through the application of ontologies makes it difficult to provide a generic model for benefit estimation.

In the remainder of this section we first will introduce the nature of benefits and the difference between tangible and intangible benefits. Second we will introduce methods to quantify benefits in general. Section 6.3 will introduce possible benefit estimation methods that could be applied to ontologies and finally in section 6.4 we suggest methods for benefit estimation for ontologies in particular.

6.1 Nature of Benefits

6.1.1 *Tangible and intangible benefits*

Benefits may occur in different manners and are distinguished based on their influence on the performance of the overall company or system.

Tangible benefits directly influence the performance of the firm and as such potentially reduce costs directly.

Intangible benefits influence the overall behaviour and circumstances of a system indirectly: e.g. they lead to better information communication. Intangible benefits typically can not easily be measured in financial terms. They are therefore often quantified using questionnaires.

6.1.2 *The nature of benefits of ontologies*

In [Gruninger and Lee, 2002] the **uses of ontologies** have been summarised as follows:

(1) For communication:

Between implemented and computational system

Between humans

Between humans and implemented computational systems

(2) For computational inference

For internally representing plans and manipulating plans and planning information

For analyzing the internal structures, algorithms, inputs and outputs of implemented systems in theoretical and conceptual terms

(3) For reuse (and organization) of knowledge: For structuring or organizing libraries or repositories of plans and planning and domain information

Furthermore, Hepp provides **six distinct technical effects** that come along with ontologies [Hepp, 2008]:

- (1) Using philosophical notions as guidance for identifying stable and reusable conceptual elements
- (2) Unique identifiers for conceptual elements
- (3) Excluding unwanted interpretations by means of informal semantics
- (4) Excluding unwanted interpretations by means of formal semantics
- (5) Inferring implicit facts automatically
- (6) Spotting logical inconsistencies

Communication and reuse of knowledge is the main reason for the use of ontologies as the results of a recent survey done at the University of Madeira showed ([Cardoso, 2007]). The study reported that ontologies are mostly used to make domain assumptions explicit (70%), to enable reuse of domain knowledge (56%), or to share a common understanding of the structure of information among people or software agents (37%). Other uses were only reported by 12% of the people that filled out the questionnaires.

We want to summarize the observed benefits in the following listing: **Benefits can occur if ontologies are used for the following purposes:**

- (1) Interoperability
- (2) Browsing / searching (automatic inferring of implicit facts)
- (3) Reuse
- (4) Structuring
- (5) Automation / code generation
- (6) Disambiguation (unique identification)
- (7) Knowledge transfer (by excluding unwanted interpretations through informal semantics)
- (8) Spotting logical inconsistencies

Despite of (5), **all possible benefits are more or less intangible** and thus cannot easily be measured.

The expected benefits of the use of ontologies are very distinct in itself and for sure demand for the application of different benefits measurement approaches. Thus the assessment of ontology benefits demands for the use of different methods according to the actual use of the ontologies. This observation comes in line with the observations in [Andresen, 2001] where the use of different methods is suggested according to different circumstances.

Finally, benefits of ontologies will differ due to the quality of the ontology provided. The measurement of the quality of ontologies is however a complex topic.

6.2 Quantifying Benefits of IT Systems

There are several methods to quantify benefits in information systems in general. These methods can be used to deduce comparable figures from tangible (i.e. directly measurable benefits) and intangible (i.e. hidden, not obvious) benefits.

In order to select a method, the purpose of the introduction of the system has to be clearly identified. To identify the purpose we can refer to the IT investment matrix introduced in [Remenyi et al., 1995] which provides classifiers for projects according to the dimensions risk/visibility and profitability.

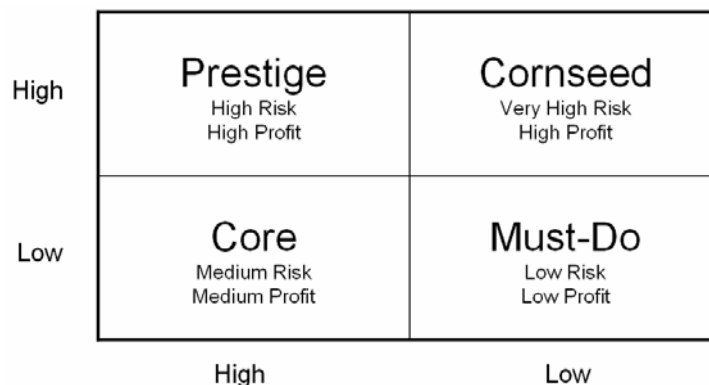


Figure 7 - Business investment types (according to [Remenyi et al., 1995])

This matrix has a strong resemblance to the McFarlan taxonomy which allows classifying systems according to the degree of competitive advantage that is gained and the degree of which the system or company is dependent on the function of the system.

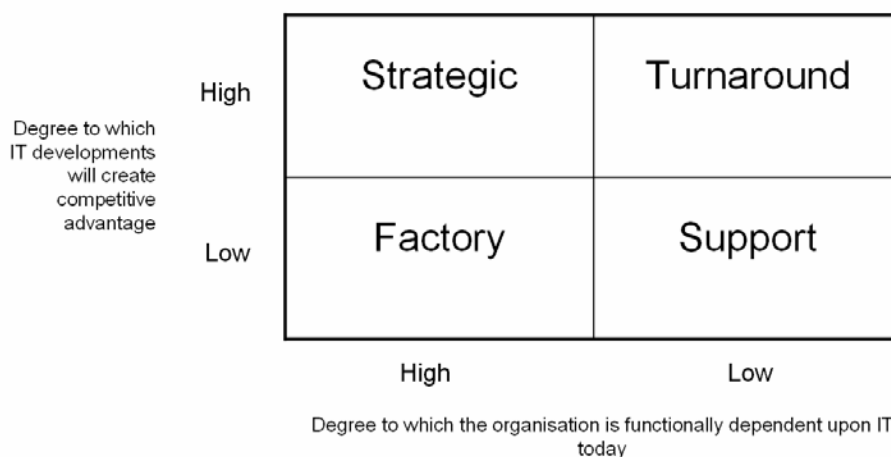


Figure 8 - The McFarlan Grid Matrix (according to [Remenyi et al., 1995])

We can easily see that ontologies are most often introduced in support systems or in factory systems and sometimes as prestigious/strategic investments. Based on our previous experience, in most cases the function of a system is not dependent on the introduction of ontologies. However examples exist in which ontologies fulfil a core role in a central system.

As we already said, the value of the system is greatly determined by its purpose. Additionally the real business value of a system is strongly dependent on the context and the perception, i.e. where and how it is used and the person who is to assessing the value of a system. That is why Remenyi et al. suggest to evaluate different investment types in a different way as can be seen in Table 5.

| Investment purpose | Investment type | Evaluate/measure |
|-------------------------|--------------------------------|-------------------------------|
| Business survival | Must do | Continue/Discontinue business |
| Improving efficiency | Vital/core | Cost benefit |
| Improving effectiveness | Critical/core | Business analysis |
| Competitive leap | Strategic/prestige | Strategic analysis |
| Infrastructure | Architecture/must do/corn seed | Very broad terms |

Table 5 - Investment purposes, types and evaluation techniques [Remenyi et al., 1995]

In general there are **two different generic approaches to measurement**, which are common to all measurements:

- (1) Physical counting
- (2) Assessment by ordering, ranking or scoring

In most cases it is hard to directly observe the effect of the IT system and counting is not always possible. This is especially true for the measurement of intangible benefits. Therefore Remenyi et al. suggest following a particular **approach to measure the intangible benefits of a system** [Remenyi et al., 1995]:

- (1) Conceptualise the chain of cause-and-effect events that may result from the introduction of the system
- (2) Identify how it will be possible to establish the changes that are likely to occur as a result of the introduction of the information system. Here the focus is on the direction of the changes, i.e. will the inventories rise or fall?
- (3) Consider how the size of the change may be measured
- (4) Where the effect of the system is clear, the analyst may proceed with the next three steps
- (5) Measure the size of the change
- (6) Put a monetary value on the changes that have been observed. Use techniques such as payback, Return-Of-Investment Net Present Value, etc. to assess whether the information system investment will produce an adequate return to justify proceeding

6.3 Methodologies to Assess the Performance of IT Systems

As already introduced in section 3.2, methods to assess the benefits of an IT system can be grouped according to their output:

- (1) **Financial methods**
- (2) **Quantitative methods**
- (3) **Qualitative methods**

It is generally agreed that methods to assess the performance of an IT systems or the benefits it creates should be selected based on the use case to which they are applied.

The history of IT benefit analysis dates back to the 50s where IT based systems were introduced **to automate specific tasks and processes**. In the 70s decision support systems were introduced **to support the users**. Thus benefit through improved information has been observed. In the 1980s finally applications appeared that were able **to create new business processes through transformation of existing ones** (see e.g. EDI).

Each of the major impacts (i.e. to automate, inform or to translate) requires different approaches when assessing the investments in them ([Andresen, 2001]): For example, IT investments whose major impact is automation should be evaluated using financial evaluation methods, whereas all other cases require more complex methods or even combinations of different methods.

Remenyi et al. suggest the use of the following **methodologies**. These suggestions are based on their popularity and widespread use⁵:

- (1) **Strategic match analysis and evaluation** (Quantitative method, fully subjective): This method is about to test whether an IT system supports the overall company strategy.
- (2) **Value chain assessment** (Qualitative method, fully subjective): This is a scoring and ranking system which should be used in conjunction with value chain analysis [Porter, 1985]. The method may be applied to internal value activities as well as overall industry value activities. For the application of these methods weights may be associated with more important systems and scores may be given.

⁵ We additionally classified the methodologies according to the classification system proposed by Andresen in [Andresen, 2001]. Additionally they are categorised in terms of their relative subjectivity/objectivity as done in [Remenyi et. al, 2000]

- (3) **Relative competitive performance** (Financial method, partially objective): This method assesses performance of a company/system by comparing themselves to their competing partners/systems.
- (4) **Proportion of management vision achieved** (Qualitative method, fully subjective): This is a scoring and ranking technique with a high degree of subjectivity. The method is usually applied by doing surveys or questionnaires. The idea of this method is to assess whether the systems performance matches the initial plans.
- (5) **Work study assessment** (Qualitative method, partially objective): This method continuously reviews the work performed and thus requires regular reviews. The output of this method may be highly subjective but it may be used as input to subsequent cost benefit analysis methods.
- (6) **Economic assessment – I/O analysis** (Financial method, partially objective): This is a very theoretical approach to cost/benefit analysis. The method requires a mathematical model that expresses relationships between in- and output of a system. Despite its formal and mathematical foundation this method relies on subjective views of the nature of the relationship between input/output.
- (7) **Financial cost benefit analysis** (Financial method, partially objective): This is a family of methods that involve the calculation of financial ratios.
- (8) **User attitudes** (Qualitative method, fully subjective): This method is a survey-based method which may be used to extract attitudes towards the importance of a particular system or the overall IT function.
- (9) **User utility assessment** (Quantitative method, partially objective): This method measures the value of a system according to its usage frequency. This is done by counting the amount of activity in the system which is measured in terms of its input, processing, and output.
- (10) **Value added analysis (Quantitative method)**: This method first assesses the value of a system to derive its benefits. Secondly an assessment is made to decide whether the benefits derived have justified the costs.
- (11) **Return on management** (Financial method): This is a value-added approach that puts the management added value (MAV) in the centre. MAV is derived by dividing the Return on Management factor by the management costs. The approach is based on the philosophical notion that good management is the key factor for successful projects and companies.
- (12) **Multi-objective, multi-criteria methods** (Quantitative method): These methods measure business value not in terms of money but in terms of preferences of the stakeholder.

Remenyi et al. suggest to combine at least 2-3 methodologies as in most cases a single measure is not sufficient to make an evaluation. Important questions to consider are: What assumptions underlie the cost and benefit calculations? What goes into the investment? What costs should be directly attributed to a system? What benefit streams have been identified? What is the nature of the streams?

Remenyi et al. and Andresen both agree on the critical skills to be able to select the methodology most appropriate for the organisation's particular circumstances. This is why Anderson introduced a framework to guide a decision maker through the process of selecting an appropriate method in the field of production.

Andersen suggests to use the following methods for benefit assessment in the context of construction, based on the following criteria (a) the method should represent the characteristics of the method in either the financial/quantitative/qualitative group, (b) the methods should be documented and the documentation should be accessible, (c) the methods should be well structured and (d) the methods should often be cited in literature. Based on these criteria he has chosen the following methods which we take into consideration because they were not suggested by Remenyi et al.:

- (13) **Net Present Value** (Financial method, partially objective): This is a financial method that can be used to evaluate capital investments. The output of this method is an economic measure illustrating the return of the investment in financial terms.
- (14) **Information Economics** (Quantitative method): This method is a combination of multiple methods into a bigger framework. The framework assesses the enhanced Return on Investment (ROI), the business domain, and the technology domain using a combination of

different methods. Marks and weights are assigned to the multiple outputs. The results are two numerical numbers: The first one showing the total value of the IT investment and the second illustrates the risk of failure of implementing the IT investment.

(15) Critical Success Factors (Qualitative method, highly subjective): This evaluation method can be used to identify the key requirements to ensure success for an IT investment. Critical success factors have an influence on the success of an IT investment. The output of this method is a list of ranked critical success factors for the implementation of the analysed investment.

(16) Measuring the Benefits of IT Innovation (Quantitative method): This method is actually a combination of multiple atomic methods. It consists of two parts: an economic part and a strategic part. The strategic part is composed of questions about the background and the strategic aspects of the IT investment. The benefit part consists of three tables focusing on: the efficiency benefits (the economically measurable benefits), the effectiveness benefits (the other measurable benefits) and the performance benefits (non-measurable benefits). The output of this method illustrates an estimate of the cost savings, the relative increase of the effectiveness benefits and displays the importance/influence of the non-measurable benefits.

6.4 Towards a Method for Benefit Estimation of Ontologies

To provide a generic method for benefit estimation of ontologies is beyond the focus of our preliminary work. What we intend to do is to select a method from the introduced methods in section 6.3 and apply it for the estimation of the benefits of ontologies.

As we observed in section 6.1.2, the major impact of ontologies chosen from the impact taxonomy of IT systems ([Remenyi et al., 1995]) is to improve information communication. This follows from the observations presented in [Cardoso, 2007] and the results of our ontology survey in question 4 "What is the main application of your (multi-media) ontology" which are presented in Annex I.

6.4.1 Requirements

Based on our observations and on our experiences with ontology based systems we postulate the following requirements which a methodology for the measurement of ontology benefits to estimate improved information communication and knowledge transfer shall fulfil:

- (1) The method should allow the **measurement of intangible benefits**. This is based on our observation that most benefits have an intangible nature (see section 6.1.2).
- (2) As the main impact of the use of ontologies is to improve information communication (according to the impact taxonomy), the method should not have a financial output. Furthermore in order to compare the results to the cost estimation results of ONTOCOM the method should have a **quantitative output**.
- (3) The method should be **domain-independent** (as e. g. some methods reported in [Andresen, 2002] were particularly designed for specific domains).

6.4.2 Method selection

The selection of the method is based on the suggestions in [Remenyi et al., 1995] and [Andresen, 2001] which are presented in section 6.3.

We first took into account the framework that Andresen developed in order to provide a means to select an IT evaluation method based on the particular context of a company. The proposed framework for the selection of a relevant IT evaluation method which was proposed by Andresen in [Andresen, 2001] is not exactly usable for our purpose. The reason for that is because its intention is to evaluate the overall IT performance in a company. However it partially gives hints on which method could be appropriate for our purpose.

Andresen defined a framework that can be used to select an appropriate IT evaluation method based on specific parameters. He defined a set of attributes that are grouped into company related, methods in IT investment related and methods in evaluation related attributes. Based on a weighting of these attributes a usability score can be computed that determines the method that should be applied.

We consider the first set of attributes (company related) as irrelevant for our case and therefore omit them. The calculation to determine the best method for the use for the benefit estimation of ontologies can be found in Appendix II. Based on that calculation, both the methods MBITI “Measuring the benefits of IT Innovation” and IE “Information Economics” were selected as being appropriate candidates out of Andresen’s selection of methods. As MBITI is however domain-dependent as it was especially developed for the usage in the construction industry, it is excluded from our observation.

As IE is considered as a framework for evaluating alternatives for IT investments in a company it is not necessarily appropriate for the evaluation, too. IE consists of costs and values, tools and measurements, coupled with risk evaluation and other investment issues in a decision-making process. Furthermore IE again is focused on the assessment of an IT investment in the context of a whole company which is not appropriate in our case.

As the suggestion of Andresen derived from an application of his framework seem not appropriate for our case or are too heavy-weight, the guidelines from Remenyi et al. as presented in [Remenyi et al., 1995] are followed. The traditional approaches are generally regarded as inadequate for measuring intangible benefits. Thus we based our suggested method on most recent approaches which - as pointed out in Remenyi et al - incorporate user perceptions into an overall measure of satisfaction with it.

6.4.3 User Information Satisfaction

One method that can be applied for benefit estimation of ontologies is **User information satisfaction (UIS)**: User satisfaction can be measured through a comparison of user expectations of the IS with the perceived performance of the system on a number of different facets. Remenyi et al. discuss two models for UIS measurement: the Kim model and the Miller and Doyle model. Both models follow a similar spirit.

In the **Kim approach**, UIS is measured by the discrepancy between the user’s perception score of the IS performance and the user’s expectation score of the IS. The Kim approach considers multiple-gaps and organisational factors. UIS is then a function over these gaps and functions. The gaps should be measured according to factor analysis.

The second approach that is described in [Remenyi et al., 1995] is the **Miller-Doyle approach** which showed convincing results in different sectors and domains. The perceived effectiveness of the IS function is measured using a questionnaire. The original questionnaire consisted out of 5 parts: A to E:

- Part A consists of questions that measure the extent to which certain facets are perceived to be important in ensuring the organisation’s IS will be effective and successful.
- Part B consists of questions for the future needs for IS.
- Part C contains the same questions as part A, but now the participant is asked to rate the questions with respect to the actual performance achieved.
- Part D consists of questions relating to the organisation’s performance in developing new systems.
- Part E captures demographic data.
- An additional question asks for a rating of the organisations’ overall IS performance.

Part A and B include importance ratings that capture the perceptions on the business needs. Part C and D include performance ratings that capture perceptions of the organisation’s capabilities.

The interpretation of the results as described in [Miller and Doyle, 1987] results in a measure of the perceived performance and the importance of a IS function. The correlations between mean performance and mean importance can be used to assess the overall effectiveness of an IS function

7 User Information Satisfaction Analysis for Ontologies

In this section we present the design of a questionnaire that can be used to perform a User Information Satisfaction (UIS) analysis for ontologies in information systems. This UIS analysis results in a quantitative figure representing the overall function of the system.

This part presents initial work done in this area.

7.1 Single vs. Multiple-Gap Analysis

As introduced in section 6.4.3, there are two different UIS model types: There are models following a single-gap approach and models that follow a multiple-gap approach:

- (1) **Single-gap models** compare the perceived importance and the actual performance of the system. This is done by issuing questionnaires to one user group asking them to answer questions about the importance and the performance. The questionnaires might be handed to different groups: For example it is recommended to issue questionnaires to the end user group and the application designers/developers. One example for a single-gap model was suggested by Miller and Doyle [Miller and Doyle, 1987].
- (2) **Multiple-gap models** assume that the UIS is influenced by the post-implementation expectations and by the pre-implementation expectations. Typically these models also consider the requirements, design, and installation phase of the system. Here different gaps may occur: i.e. the gap between the user's expectations and the system designer's interpretations of these expectations or the quality of the installed system and the user experience. Multiple-gap models are particularly useful for assessing how systems are viewed at various stages of their production, implementation and use and how these impact UIS. One example is the model by Kim [Kim, 1990].

We propose to approach the measurement of benefits of ontologies in **two stages**:

- (1) First a **single-gap model** shall be applied that issues questions to the end user of the system. This can be done using the questionnaire explained in section 7.2 and using the questions in section 7.3. The analysis of the results can be done by following the steps explained in section 7.4.
- (2) A **second stage** should investigate the use of a multiple-gap model which is visualized in Figure 9. This multiple-gap model seems appropriate for the benefit measurement of ontologies as the gaps between the different user groups (i.e. domain experts, ontology engineers, application end user) are explicitly taken into account. However this approach – as also highlighted in [Remenyi et al., 1995] – is longitudinal in nature. As it has to accompany the whole engineering process, it is beyond the scope of this deliverable.

Our suggested model for ontology benefit measurement is visualized in Figure 9. For this approach the gaps might be investigated using different questionnaires as some questions do not affect all the different users involved in the process (domain expert vs. application designer). The set of questions for the different questionnaires might however be distilled from the set of attributes/facets of ontology based systems which are proposed in section 7.3.

The UIS can then be explained by the following formula⁶:

$$UIS = f(Gap_1, \dots, Gap_n, Influential_Factors), n \in \mathbb{N} \quad \text{Eq. 10}$$

To operationalise this model, it will be necessary to develop tools to measure the gaps. Here factor analysis, correlation and regression analysis is suggested to either measure the influential factors but also the extent of these gaps.

⁶ The formula is adapted from [Remenyi et al., 2000]

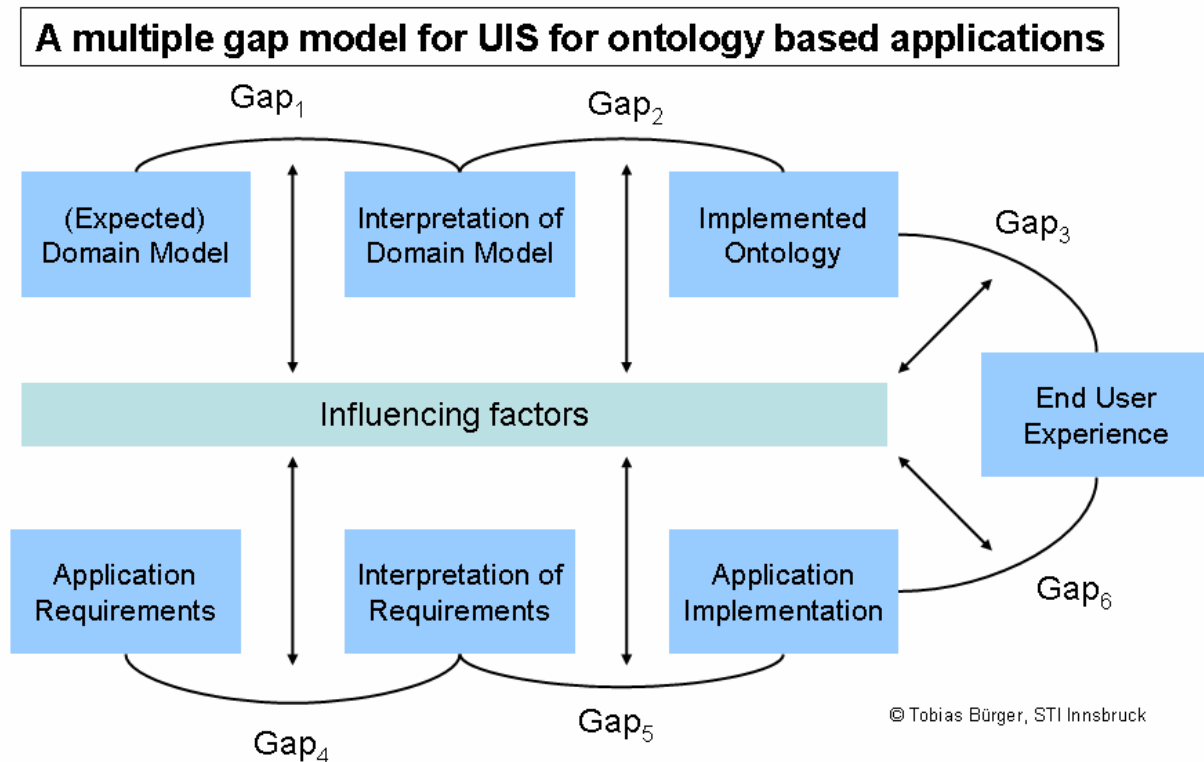


Figure 9 - A multiple-gap model for UIS for ontology based applications

Gaps 1-3 consider the ontology perspective of an ontology based application and gaps 4-5 the application perspective.

Interpretation of the gaps

- **Gap₁**: This is the discrepancy between the expectations of the domain experts (i.e. his view of the particular aspects that should be modelled) and the ontology engineers' interpretations of the model.
- **Gap₂**: This is the discrepancy between the ontology engineers' interpretation of the "world" to be modelled and the actual implementation of the ontology. This gap is typically tested using ontology evaluation methods.
- **Gap₃**: This is the discrepancy between the quality of the implemented ontology and what the user experiences when interacting with it.
- **Gap₄**: This is the discrepancy between the expectations of the user on the functionality of the application and the interpretation of the developer.
- **Gap₅**: This is the discrepancy between the interpretation of the requirements and the actual implementation.
- **Gap₆**: This is the discrepancy between the quality of the implemented application and the end user experience.

7.2 Questionnaire Design

According to the approach proposed in [Miller and Doyle, 1987] the questionnaire is divided into three parts: the first part measures the perceived **importance** of facets for the effectiveness of an ontology based information system. The second part measures the **performance** of the system. The third part involves questions about the overall satisfaction with the system.

Based on the usage of the ontology a different set of questions should be used in these questionnaires. The set of questions that were identified are tailored towards the assessment of multimedia ontologies

or applications based on multimedia ontologies respectively. An ontology only acquires value when it is used in collaboration with other resources. Based on that commonly agreed fact, we take into account the application dimension in the questionnaire design.

A set of basic questions is used in the first and second part of the questionnaire.

In the first part – as already said above – the participant is asked to provide his/her opinion about the importance of the attribute in ensuring the effectiveness of the ontology.

As the purpose of multimedia ontologies in general is either annotation, reasoning, retrieval, personalization or high level summarization we take into account these specific application cases.

The attributes were partially derived from [Benyani et al., 1999] and from personal experiences in the field of multimedia ontologies and their application.

The users are confronted with the following question in part A of the survey: “Please respond by ticking the option which corresponds to your opinion of the **importance** of the following X attributes in ensuring the effectiveness of your ontology.”⁷

In part B of the survey the following question is posed: “Please respond by ticking the option which corresponds to your opinion of the actual **performance** of the ontology in terms of the following X attributes”⁸

Part C contains only one question: “Please rate your overall opinion about the ontology”. Furthermore the user is asked to supply further comments concerning the ontology.

The whole questionnaire can be found in Appendix III.

7.3 Facets of Ontology-Based Systems

This section details a first set of facets or attributes of ontology based system. These facets will be subject of a questionnaire for the User Information Satisfaction analysis of multimedia ontologies. This set is a starting point and is subject to future discussions. Please note that we didn't take into account benefits occurring from automation of processes, like automatic code generation, etc. The attributes are especially targeted at multimedia ontology based applications containing attributes for the most frequent uses of multimedia ontologies.

The participants in the survey which can be based on these attributes will be confronted with questions to rate the importance and actual performance of each facet.

Common attributes of ontologies

1. Easy access to the ontology
2. Up-to-dateness of the ontology
3. User confidence in the ontology
4. Degree of personal control over the ontology
5. Ontology responsiveness to changing users needs
6. Participation in the planning of requirements or competency questions
7. Extent of user training
8. Documentation of the ontology
9. A high degree of technical competence from ontology administrators

Comprehensiveness of the ontology

10. User's understanding of the ontology
11. Match of users' perception of phenomena with the ontology

⁷ The question was adapted based on a questionnaire in [Benyani et al., 1999]

⁸ Dito.

12. Understand ability of the categorization of concepts in the ontology
13. Size of gap between the ontology concepts and the preferred concepts of the user

Attributes accounting applications using the ontology

14. Ability of the system to improve one's personal productivity
15. Standardization of interfaces
16. A low percentage of downtime of the application
17. Improved interoperability
18. Fast response time from support staff to remedy problems

Browsing / exploration

19. Configuration of the visualization options
20. Dynamic views
21. Comprehensiveness of the visualization
22. Navigation facilities
23. Single point of access
24. Reduced time and cost of localization

Application 1: Semantic search / retrieval

25. Coverage of labels in the document collection by properties of classes
26. Short user queries
27. Specialized or more terms added to refine search
28. Free text input
29. Query operators
30. Controlled terms
31. User feedback
32. Ordered / organized results
33. Data selection methods
34. Query refinement facilities
35. Semantic auto completion
36. Response time

Application 2: Annotation

37. Visual annotation
38. (Semi-) automatic annotation
39. Concept matching user perception
40. Extensibility of the ontology with new concepts
41. Reflection about knowledge

Application 3: Reasoning

42. Result explanation
43. Improved concept detection
44. Query expansion
45. Additional insights

Application 4: Personalization

- 46. Adapted interface
- 47. Personalized results
- 48. Configurability of personalization features

Application 5: High level summarization

- 49. Faster information communication
- 50. Improved learning of facts
- 51. Typed relationships

Application 6: Information communication

- 52. Sharing of perspectives
- 53. Common terminology
- 54. Agreed facts
- 55. Assistance in validating a description
- 56. Reduced information overload
- 57. Ease of name changes

It is expected that, based on first survey results, these attributes can be narrowed down or extended. Factor analysis can then also reveal underlying dimensions that most influence the results.

A questionnaire based on these facets/attributes is provided in Appendix III.

7.4 Result Analysis

The results of the UIS survey may be interpreted by different measures. Both the influential factors as well as the areas where effort is still required to improve the success, can be measured. As we didn't collect data so far, no example will be presented at this stage. However, we give some pointers to statistical methods that can be applied for the analysis of the results.

1. The **overall user attitude** may be computed as the composite score of the mean values of the performance.
2. The **fit between the importance and performance ratings** can be measured using a correlation analysis. A high positive correlation between the ratings is a signal for consensus.
3. **Gap analysis** can be done using snake diagrams to visualize the gap between expectations and performance. A correlation between the gap scores and overall satisfaction show where effort is required and which gap influences the overall satisfaction.
4. A **performance analysis** including standard error calculations is an indicator for poor or good performance in each attributes.
5. A **regression analysis** can be applied to explain the overall satisfaction scores.
6. **Factor analysis** can be applied to determine the number and the nature of the underlying dimensions, i.e. those factors that determine the current situation most. The idea is to locate and identify fundamental properties underlying the results. This technique is sometimes used in marketing to identify those attributes that should be used to advertise products. It is basically a regression analysis which establishes a view on which variables are important. In our case it can be used to determine those factors that mostly influence a positive end user experience.

A result analysis example of an UIS questionnaire data analysis can be found in [Remenyi et al., 1995].

8 Tool Support

For the estimation of the economics of the ontologies in SALERO we mainly used two tools, namely phpESP⁹ and Excel.

PhpESP is a Web application for the creation and execution of surveys written in PHP. It provides an administration area, accessible only with a user login, where surveys can be created and tested. Once a survey is ready it can be activated what enables it to be accessed and filled without the need of login data. For the visualization of the collected data phpESP provides several views that allow an analysis of the gathered information. Moreover, there is the possibility to export the data to a comma separated value file what enables the reuse of the information within other tools.

For the calculation and evaluation of the calibration we used an Excel document. This choice enabled the direct use of the data exported by phpESP without the need of changes or adaptation.

The Excel document consists of multiple sheets to allow the calibration of the ONTOCOM model and the assessment of the prediction quality.

⁹ <http://phpesp.sourceforge.net/> (last accessed: 01.02.2008)

9 Conclusion

The intention of this document is the presentation of an approach for the assessment of the value of ontologies in terms of costs and benefits.

To reach that goal we presented a calibrated version of the ONTOCOM model for cost estimation of (multimedia) ontologies. Despite the fact that the prediction results improved compared to the results reported in [Paslaru-Bontas-Simperl et al., 2006b], there is still room for further refinement of the factors used for the estimation. We derive this hypothesis based on an observation in [Andresen, 2001] that says that each cost driver which influences the overall estimation should at least be represented with 5 data points in a survey. Therefore at least 100 datasets for the calibration would be needed in order to provide more accurate results.

We provided the first available method for the benefit assessment of ontologies. However, the benefit measurement also leaves room for improvement as it only contains a first suggestion for a method and a possible application to multimedia ontologies. A combined method of multiple atomic models might be more appropriate. But this is subject to further research. Additionally a survey will be conducted in the future to get data about the overall satisfaction and performance of ontology based systems.

The results of the data analysis from the survey confirmed the observations from an earlier survey of Paslaru-Bontas-Simperl et al. in [Paslaru-Bontas-Simperl and Tempich, 2006c]: In [Paslaru-Bontas-Simperl and Tempich, 2006c] the authors present an analysis of the state-of-practice in ontology engineering done in the year 2006. Most notably they experienced, that most ontologies are created from scratch and that the engineers did not follow a decent ontology engineering methodology. This is also true for the data we collected, where 45% of the ontologies were totally built from scratch. In two additional cases almost 100% of existing ontologies was directly reused after a translation from XML to OWL. Regarding the reuse of ontologies, the data indicates that sometimes the effort needed to analyse ontologies that could be reused and the effort to integrate / translate them is higher than the effort needed to create ontologies from scratch. However it should not be neglected that ontology reuse typically increases interoperability with other systems and has the effect to increase the quality of the ontologies concerned [Paslaru-Bontas 2007]. Therefore, ontology reuse is an important issue. Due to the lack of data about reuse no clear statement can be made regarding this respect. The primarily reason for most people not to reuse existing ontologies in the multimedia domain could be the lack of ontologies available that are widely recognized. A further reason might be that people are not aware of ontology reuse methodologies. A context based methodology for ontology reuse is e.g. presented in [Paslaru-Bontas 2005], [Paslaru-Bontas et al. 2005] or [Paslaru-Bontas 2007]. Regarding the ontology building steps it again is shown that the analysis of a domain and the conceptualization is a time-consuming process. As also mentioned in [Paslaru-Bontas-Simperl and Tempich, 2006c], tool support for requirements elicitation and conceptualization could improve this aspect of ontology engineering. The analysis of the person-related questions turned out that most people involved are advanced domain and ontology engineering experts with long experience in ontology building or engineering. Notably, almost 100% of the people that filled out the survey have an academic background. Therefore it would also be interesting to interview engineers of ontologies that were built in an industrial or commercial context in the field of multimedia.

Finally, it can be noted that in order to further enhance the results of the cost estimation, more data about existing ontologies has to be collected.

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11 Glossary

Terms used within this deliverable project sorted alphabetically.

| | |
|---------|---|
| IE | Information Economics |
| IS | Information System |
| IT | Information Technology |
| MBITI | Measuring the Benefits of IT Innovation |
| NPV | Net Present Value |
| ONTOCOM | Ontology Cost Model – A model to estimate the costs needed for engineering ontologies |
| UIS | User Information Satisfaction |

Partner Acronyms

| | |
|---------|--|
| AM | Activa Multimedia, ES |
| BLITZ | Blitz Games, UK |
| DIT | Dublin Institute of Technology, IE |
| DTS | Digital Theatre Systems, UK |
| FBM-UPF | Fundació Universitat Pompeu Fabra, ES |
| GVG | Grass Valley Germany, DE |
| JRS | JOANNEUM RESEARCH Forschungsgesellschaft mbH, AT |
| LFUI | STI, Leopold-Franzenzs Universtät Innsbruck, AT |
| PGP | Pepper's Ghost Productions Ltd., UK |
| TAIK | Taideteollinen Korkeakoulu, FI |
| UG | University of Glasgow, UK |
| UPF | Universitat Pompeu Fabra, ES |
| URL | Universitat Ramon Llull, ES |

12 Annex I – Data Collection Summary

The results of the data collection are being anonymized as some of the participants provided their email addresses to get informed about the results or provided personal comments.

Additionally the explanations of the ratings and rating criteria are omitted. These can be found online: <http://ontocom.ag-nbi.de/ontocom.html>. Additionally we removed the examples from some of the questions.

Data collection for model calibration

INTRODUCTION

ONTOCOM is a cost estimation model for the area of Ontology Engineering developed at the Free University of Berlin in collaboration with the Institute AIFB (University of Karlsruhe - TH). It aims at predicting the costs arising in typical classes of ontology engineering processes such as ontology building, ontology reuse or ontology maintenance.

The accuracy of the cost predictions of Ontology Engineering tasks calculated by means of ONTOCOM can be improved by the calibration of the model. This necessitates the collection of real-world ontology engineering project data. In STI Innsbruck we are accomplishing the calibration of the model for the evaluation of the efforts incurred for the creation of some ontologies and this survey serves for the collection of the required data. The calibration is part of the task T3.3 "Evaluation of the economics of multimedia ontologies" of the European project SALERO.

ABOUT THIS SURVEY

Developed in the tradition of Software Engineering, ONTOCOM uses a parametric prediction equation which contains product-, personnel and project management-related effort multipliers. The effort multipliers are used to adjust the nominal effort to reflect the particularities of the ontology and of the underlying engineering process. They are rated accordingly with values from Very Low to Very High, depending on their (positive or negative) impact on the nominal development effort.

The survey, consisting of 38 questions, is divided into 4 parts:

introductory questions (Questions 1 to 13)

product-related questions (Questions 14 to 31)

personnel-related questions (Questions 32 to 35)

project-related questions (Questions 36 to 38)

For most of the questions you are required to specify the value of a certain effort multiplier, i.e. to position your answer according to a five-step rating scale. If a particular activity induces an increase of the nominal ontology development effort, then it should be rated with values such as High and Very High. In contrast, if it causes a decrease of the nominal costs, then it should be rated with values such as Low and Very Low. Finally, if the corresponding activity does not influence the nominal costs it should be rated with Nominal. THIS APPLIES IN PARTICULAR TO ACTIVITIES WHICH DO NOT APPLY TO YOUR PROJECT SETTING. For each effort multiplier, we suggest decision criteria which could be taken into consideration when assigning the corresponding ratings.

This survey is especially tailored for multi-media ontologies.

1. Provide the name of the ontology:

<anonymized>

2. Provide the namespace of the ontology (if available):

<anonymized>

3. Please provide a short description of the domain and purpose of the ontology:

<anonymized>

4. What is the main application of your (multi-media) ontology?

Multimedia ontologies are mostly designed to serve one or more of the following purposes:

Annotation, which is in most cases motivated by the need to have high-level summarizations of the content of multimedia items, using commonly accepted concepts and terms.

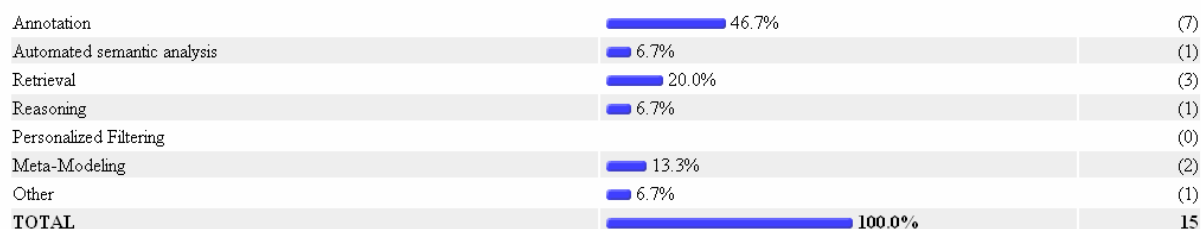
Automated semantic analysis, i.e. to support the analysis of the semantics and syntax of the structure and content of multimedia items.

Retrieval, i.e. to use rich formal descriptions to enable context-based retrieval and recommendations to users. The use of semantics enables automatic matching of content properties with user properties.

Reasoning, i.e. the application of reasoning techniques to discover previously unknown facts of multimedia content or to enable question answering about properties of the content.

Personalized Filtering, i.e. the delivery of multimedia content according to user-, network- or device-preferences.

Meta-Modelling, i.e. to use ontologies or rules to model multimedia items and associated processes.



5. How many entities does the ontology (approximately) contain?

Please sum the number of concepts, properties, relations, axioms and fixed instances

NOTE: Include also the number of entities of the reused ontologies

Aggregated data:

| Range (Number of entities) | Answers |
|-------------------------------|---------|
| 0-100 | 2 |
| 101-500 | 6 |
| 501-1000 | 1 |
| More than 1000 | 5 |
| other¹⁰ | 1 |

Table 6 - Number of entities in the ontology

Original answers:

¹⁰ The resp. person answered "more than 600"

| # | Response |
|---|---------------|
| 1 | 100000 (?) |
| 1 | 1100 |
| 1 | 1319 |
| 1 | 1500 |
| 1 | 200 |
| 1 | 220 |
| 1 | 250 |
| 1 | 300 |
| 1 | 36 |
| 1 | 450 |
| 1 | 47 |
| 1 | 4750 |
| 1 | 500 |
| 1 | 900 |
| 1 | more than 600 |

6. How many concepts does the ontology (approximately) contain?

Aggregated data:

| Range (Number of concepts) | Answers |
|-------------------------------|---------|
| 0-100 | 7 |
| 101-500 | 5 |
| 501-1000 | 2 |
| More than 1000 | 1 |

Table 7 - Number of concepts in the ontology

Original answers:

| # | Response |
|---|------------|
| 1 | 100 |
| 1 | 100000 (?) |
| 1 | 11 |
| 1 | 120 |
| 1 | 14 |
| 1 | 153 |
| 1 | 310 |
| 1 | 465 |
| 1 | 500 |
| 1 | 54 |
| 1 | 60 |
| 1 | 628 |
| 1 | 7 |
| 1 | 700 |
| 1 | 90 |

7. How many properties does the ontology (approximately) contain?

Aggregated data:

| Range (Number of properties) | Answers |
|---------------------------------|---------|
| 0-100 | 8 |
| 101-500 | 5 |
| 501-1000 | 0 |
| More than 1000 | 2 |

Table 8 - Number of properties in the ontology

Original answers:

| # | Response |
|---|----------|
| 1 | 100 |
| 1 | 1000 |
| 1 | 13 |
| 1 | 1310 |
| 1 | 17 |
| 1 | 180 |
| 2 | 250 |
| 1 | 273 |
| 2 | 30 |
| 1 | 40 |
| 1 | 465 |
| 1 | 49 |
| 1 | 50 |

8. How many axioms does the ontology (approximately) contain?

As a guideline:

RDF(S) ontologies do not contain axioms.

OWL Restrictions or equivalence expressions count as one axiom.

The same applies for rules.

Aggregated data:

| Range (Number of axioms) | Answers |
|-----------------------------|---------|
| 0-100 | 7 |
| 101-500 | 3 |
| 501-1000 | 1 |
| More than 1000 | 1 |
| Other¹¹ | 1 |

Table 9 - Number of axioms in the ontology

Original answers:

¹¹ The person answered „more than 1000“

| # | Response |
|---|----------------|
| 1 | 12 |
| 1 | 150 |
| 1 | 1700 |
| 2 | 2 |
| 2 | 200 |
| 1 | 23 |
| 1 | 30 |
| 2 | 50 |
| 1 | 952 |
| 1 | more than 1000 |

9. How many fixed instances does the ontology (approximately) contain?

Fixed instances in our understanding are completed concept instantiations which never or rarely change in the ontology life time, such as country lists or continent lists.

Aggregated data:

| Range (Number of fixed instances) | Answers |
|---|---------|
| 0-100 | 5 |
| 101-500 | 4 |
| 501-1000 | 0 |
| More than 1000 | 2 |
| Other¹² | 1 |

Table 10 - Number of fixed instances in the ontology

Original answers:

| # | Response |
|---|---------------|
| 1 | 100 |
| 1 | 1319 |
| 1 | 150 |
| 1 | 170 |
| 1 | 175 |
| 1 | 1855 |
| 1 | 20 |
| 1 | 250 |
| 1 | 3 |
| 1 | 50 |
| 1 | 70 |
| 1 | more than 200 |

10. What language did you use for the implementation of the ontology?

| | | |
|--------------|---------------|-----------|
| RDFS | 6.7% | (1) |
| OWL-Lite | 13.3% | (2) |
| OWL-DL | 53.3% | (8) |
| OWL-Full | 20.0% | (3) |
| WSML-Core | | (0) |
| WSML-DL | | (0) |
| WSML-Flight | | (0) |
| WSML-Rule | | (0) |
| WSML-Full | | (0) |
| DAML+OIL | | (0) |
| Other | 6.7% | (1) |
| TOTAL | 100.0% | 15 |

¹² The person answered „more than 200“

11. What ontology engineering methodology did you use (if any)?

- # Response
- 1 Community-based development on top of an ontological "core" (defined by the event, the timeline and the FRBR ontologies).
- 1 Competency questions
- 1 Manual alignment
- 1 OntoKnowledge
- 1 Since the ontology captures the semantics of the MPEG-7 XML Schemas, it was based on a model for mapping XML constructs with OWL constructs, the XS2OWL mapping model.
- 1 The "XML Semantics Reuse Methodology"
- 1 Based on the MPEG-7 standard and the DOLCE foundational ontology

12. How many person months did you spend in building the ontology?

Please sum the time spent by each participant involved in building the ontology (not to be confused with the duration of the application building process)

Please consider the time to collect initial requirements, the time to build the ontology, the time to test and refine the ontology, and the time to document the process

Aggregated data:

| Range (Number of person months) | Answers |
|---------------------------------------|---------|
| 0-1 | 4 |
| 2-5 | 4 |
| 6-10 | 3 |
| 11-50 | 2 |
| More than 50 | 2 |

Table 11 - Number of person months spent building the ontology

Original answers:

Response

- 1 0.5
- 1 1
- 1 1 (not counting the XSD2OWL development which is independent and generic, i.e. for any XSD)
- 1 1/2
- 1 15
- 1 150
- 1 18
- 1 2
- 1 3 person-months (not sure)
- 1 4 person-months
- 1 5
- 2 6
- 1 8 months
- 1 Raw estimation: 130

13. If you would like further information about the results of the survey please provide your email address below:

<anonymized>

Part 1: ONTOLOGY BUILDING

Questions 11 to 15 refer to particular properties of the ontology as well as to the characteristics of certain phases of the ontology building process.

In order to facilitate your estimation of the rating value applicable in your case we provide some examples from our own experience. However, these examples can only be a guideline and your experiences may very well differ from ours.

14. Which percentage of the total ontology was built from scratch?

Aggregated data:

| Range (Percentage built from scratch) | Answers |
|---|---------|
| 0-20% | 2 |
| 21-40% | 1 |
| 41-60% | 1 |
| 61-80% | 2 |
| 81-99% | 2 |
| 100% | 7 |

Table 12 – Percentage of the ontology that was built from scratch




Original answers:

| # | Response |
|---|----------|
| 1 | 0% |
| 1 | 1% |
| 3 | 100 |
| 4 | 100% |
| 1 | 30 |
| 1 | 50 |
| 1 | 70 |
| 1 | 80 |
| 1 | 90 |
| 1 | 95 |

15. How extensive was the analysis of the domain in your case?

The effort invested in the domain analysis is assumed to depend on the following aspects, which are to be evaluated separately:

1. Was the domain to be modelled complex in its nature?
2. Were the application requirements difficult to handle?
3. Did you have any additional information sources to support the domain analysis?

| | Average rank | | | | | |
|--|---|---|---|---|---|-------|
| | 1 | 2 | 3 | 4 | 5 | |
| Rating for the complexity of the domain (1 very low ... 5 very high) |  | | | | | (3.6) |
| Rating for the complexity of the requirements (1 very low ... 5 very high) |  | | | | | (3.5) |
| Rating for the availability of additional sources (1 very low ... 5 very high) |  | | | | | (3.1) |

16. How complex was the conceptualization of the ontology provided the specification of its requirements?

Factors influencing the complexity of this process step are the structure of the conceptual model, the availability of modelling patterns etc.

| | Average rank | | | | | |
|--|---|---|---|---|---|-------|
| | 1 | 2 | 3 | 4 | 5 | |
| Rating for the conceptualization complexity (1 very low ... 5 very high) |  | | | | | (3.7) |

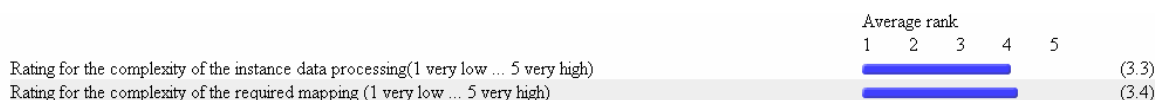
17. Provided the conceptual model, how difficult was it to implement in a specific representation language?

Example: In case you used an ontology editor to conceptualize the domain and you could export the result directly in the desired representation language, e.g., OWL the rating should be "Low".



18. Which kind of data was used to instantiate the ontology?

The form of the instance data and the method used for the extraction of ontology instances and their integration into the ontology are assumed to influence the effort required by the ontology population phase.



Part2: ONTOLOGY REUSE

In case the engineering process was augmented by the reuse of existing ontologies, please provide the information required in questions 16 to 25. If more than one ontology was re-used during your project, the questions assume average values.

If you did not reuse any external ontologies, just skip to the next page (question 22).

This survey distinguishes between ontologies and other knowledge sources: database schemas, XML schemas, UML diagrams, text documents etc., used as input to build your ontology, are considered information sources. If ontologies, available in an ontology representation language were used as input to build the ontology, these are considered reused ontologies.

19. What was the total size of the ontologies you reused?

| # | Response |
|---|-----------|
| 1 | 100 |
| 1 | 300 |
| 1 | 99% |
| 1 | 99599 (?) |

20. What percentage of the reused ontologies has been directly integrated to the final ontology?

| # | Response |
|---|----------|
| 1 | 0% |
| 1 | 100% |
| 1 | 33 |
| 1 | 40 |
| 1 | 99% |

21. What percentage of the reused ontologies has been reused after being translated into a new representation language?

| # | Response |
|---|----------|
| 1 | 1 |
| 1 | 20 |
| 1 | 30% |
| 2 | 99% |

22. What percentage of the reused ontologies has been reused in a modified form?

Note that modifications exclude translations to other representation languages.

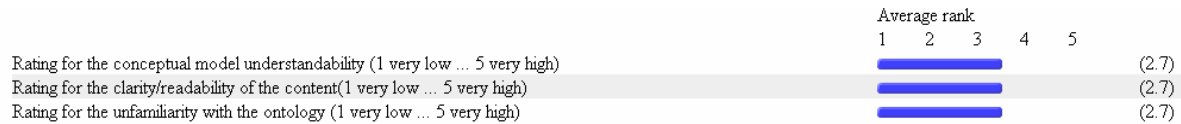
| # | Response |
|---|----------|
| 2 | 0% |
| 1 | 2 |
| 1 | 5 |
| 1 | 99% |

23. What percentage of the reused ontologies has been reused in a translated and modified form in the final ontology?

| # | Response |
|---|----------|
| 2 | 0% |
| 1 | 1 |
| 1 | 2 |
| 1 | 99% |

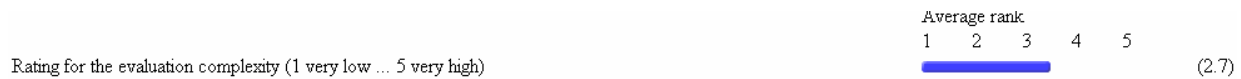
24. How difficult was it for you to understand the ontologies to be reused?

Aspects such as the complexity of the conceptual model and the clarity of the implemented ontology, as well the familiarity of the engineering team w.r.t. the ontology are assumed to influence this factor.



25. Provided a satisfactory understanding of the ontologies to be reused, how difficult was their evaluation w.r.t. the application requirements?

Note: Evaluation includes the generation of machine process able test cases as well as the manual examination of the ontology.



26. How difficult was it to translate the ontologies to be reused into the target representation language?



27. How laborious was it to modify the ontologies that were to be reused?



28. In case you needed to integrate several ontologies, how complex did this step prove to be for you?



29. How difficult was the evaluation of the final ontology w.r.t. the application requirements?

Note: Evaluation includes the generation of machine process able test cases as well as careful manual examination of the ontology.



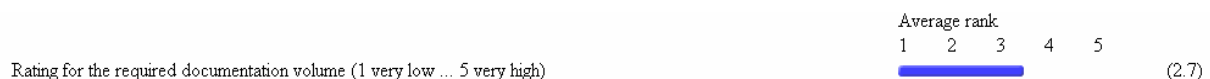
30. Shall the ontology be reusable in other applications?

This question attempts to capture the additional effort associated with the development of a reusable ontology.



31. How extensive was the documentation of the whole process?

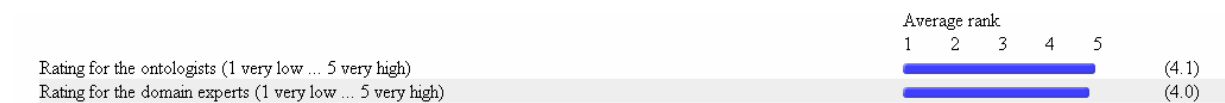
Note:The documentation process includes the description of the ontology building process, the description of the ontology entities, the description of ontology use, etc.



Part3: PERSONNEL

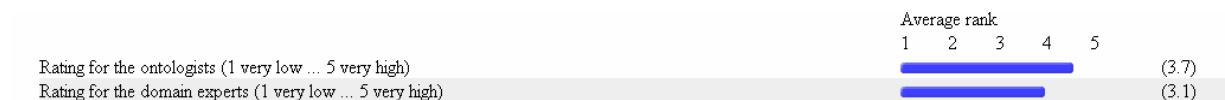
32. How capable were the ontologists and domain experts (on average)?

This question is related to the average level of technical knowledge of the ontology engineer (ontologist) and the average level of domain knowledge of the domain expert.



33. How much experience had your project team (ontology engineers and domain experts) w.r.t. their tasks during the ontology engineering process?

Please specify the level of experience of the domain experts w.r.t. the domain knowledge and the level of experience of the ontology engineers w.r.t. building ontologies.



34. How much experience had the project team w.r.t. representation languages and tools?

This aim of this question is to estimate the level experience of the project team constructing the ontology w.r.t. the ontology representation language and w.r.t ontology management tools (e.g. editors, validators, APIs).



35. How high was the personnel turnover during the project?

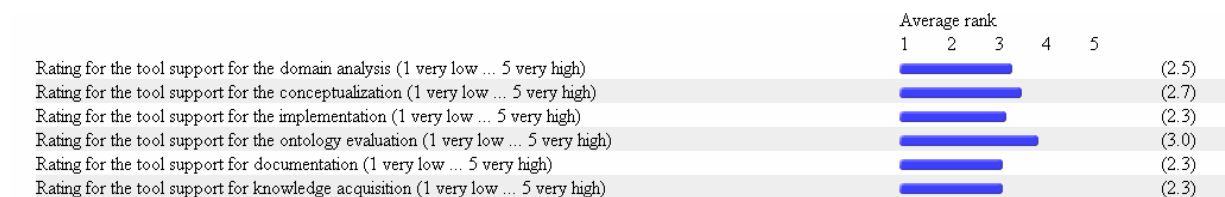
This question is related to additional costs caused by frequent changes in the project team.



Part4: PROJECT

36. How high was the available tool support in each process stage?

This question takes into account cost savings achievable through the usage of ontology management tools.



37. Given a multisite development environment, what were the preferred means of communication among project participants?



38. Comments:

If you have any comments, question or other issues related to the survey please let us know. We appreciate any input to improve this survey and the related research.

<anonymized>

13 Appendix II – Usability Score Computation Using the Andresen Framework

The approach suggested by Andresen in [Andresen, 2001] is followed to select a first method that could be used for benefit estimation of ontologies. The guidelines were followed in order to determine a usability score for the methods that can be selected based on the framework.

| Selected attribute | | Ref. | NPV | MBITI | IE | CSF | Weight |
|--------------------|---|-------|-----|-------|-----|-----|--------|
| Multiple | Purpose of IT Evaluation | | | | | | |
| | Identify the best IT investment | 9.2.1 | X | (X) | X | (X) | * |
| | Evaluate impact from IT investment | | X | X | X | | |
| | Manage IT investment | | | X | (X) | X | |
| | Increase knowledge and skill | | X | X | X | X | |
| Multiple | IT Evaluation Criteria | | | | | | |
| | Financial | 9.2.2 | X | X | X | | 3 |
| | Strategic | | | X | X | | |
| | Competitive | | | | X | | |
| X | Effectiveness of use | | | X | | | |
| X | Quality improvements | | | | | | |
| | Requirements | | | | | X | |
| X | End-user satisfaction | | | | | (X) | |
| | External satisfaction | | | | | | |
| | Technology | | | | X | | |
| | Risk | | | X | | | |
| Multiple | Format of Output | | | | | | |
| | Financial | 9.2.3 | X | X | X | | 3 |
| X | Ratio | | | X | X | | |
| | Qualitative | | | X | X | X | |
| | Requirements | | | | | X | |
| Single | | | | | | | |
| X | Single | | X | | (X) | | |
| | Multiple | | | X | X | X | |
| Single | IT Evaluation Champion(s) | | | | | | |
| | Operational | 9.2.4 | (X) | | | (X) | 0 |
| | Tactical | | X | X | X | X | |
| | Strategic | | X | | X | X | |
| Single | User of IT Evaluation | | | | | | |
| | Operational | 9.2.5 | | X | | X | 0 |
| | Tactical | | X | X | X | X | |
| | Strategic | | X | | X | | |
| Single | Cost of IT Evaluation | | | | | | |
| | Inexpensive | 9.2.6 | (X) | | | X | 0 |
| | Moderate | | X | (X) | (X) | X | |
| | Expensive | | | X | X | | |
| | Very expensive | | | X | X | | |
| Single | Difficulty of IT Evaluation Method | | | | | | |
| X | Low | 9.2.7 | (X) | | | X | 1 |
| | Moderate | | X | X | | X | |
| | High | | (X) | X | X | | |
| | Very high | | | | X | | |
| Subtotal | | | | | | | |
| | X | | 1 | 6 | 3 | 1 | |
| | (X) | | 0 | 1 | 1 | 3 | |
| | No Cross | | 12 | 6 | 9 | 9 | |
| | * | | + | + | + | - | |

Figure 10 - Computation sheet for IT evaluation related parameter [Andresen, 2001]

The usability score is computed by assigning weights and scores to specific parameters, i.e. company related, IT evaluation methods related and IT investment related. The company related attributes were omitted because they are not suitable for our case. The computation sheet for the IT evaluation method related parameter is shown in Figure 10.

| Selected attribute | | Ref. | NPV | MBITI | IE | CSF | Weight |
|---|------------------------------|-------|-----|-------|-----|-----|--------|
| Single Type of IT Investment | | | | | | | |
| | Mandatory changes | 9.3.1 | X | X | X | X | 1 |
| | Automation | | X | X | | | |
| X | Direct value added | | X | X | (X) | | |
| | MIS and DSS systems | | | X | X | (X) | |
| | Infrastructure | | | X | X | X | |
| | Inter-organisational | | | (X) | (X) | X | |
| | Strategic systems | | | (X) | X | X | |
| | Business transformation | | | | X | X | |
| Single Size of IT Investment | | | | | | | |
| X | Small | 9.3.2 | X | | | X | 1 |
| | Medium | | X | X | X | X | |
| | Large | | (X) | X | X | X | |
| | Very large | | | X | X | X | |
| Single Purpose with IT Investment | | | | | | | |
| | Automate | 9.3.3 | X | X | (X) | | 3 |
| X | Informate | | | X | X | (X) | |
| | Transformate | | | (X) | X | X | |
| Single IT Investment's Domain | | | | | | | |
| | Person | 9.3.4 | X | | | X | 0 |
| | SBU/Department | | X | X | X | X | |
| | Company | | X | X | X | X | |
| X | Building project | | (X) | (X) | | X | |
| Single Stage of IT Evaluation | | | | | | | |
| | Consider new IT investment | 9.3.5 | X | (X) | X | X | 1 |
| X | Decide IT system | | X | X | X | | |
| | Develop IT system | | | (X) | | (X) | |
| | Implement IT system | | | (X) | | (X) | |
| | Use of IT system | | | X | | | |
| | Upgrade or abandon IT system | | (X) | X | X | | |
| Single Importance of IT Investment | | | | | | | |
| | Low | 9.3.6 | X | (X) | | X | 1 |
| X | Moderate | | X | X | (X) | X | |
| | High | | | X | X | (X) | |
| | Very high | | | (X) | X | (X) | |
| Subtotal | | | | | | | |
| | X | | 4 | 6 | 4 | 2 | |
| | (X) | | 0 | 0 | 2 | 3 | |
| | No Cross | | 3 | 1 | 1 | 1 | |
| | * | | | | | | |

Figure 11 - Computation sheet for methods in IT investment related parameter [Andresen, 2001]

The computation sheet for the methods in IT investment related parameters is shown in Figure 11.

| | NPV | MBITI | IE | CSF |
|----------------|-----|-------|----|-----|
| COMPANY | | | | |
| X | 0 | 0 | 0 | 0 |
| (X) | 0 | 0 | 0 | 0 |
| No cross | 0 | | 0 | 0 |
| * | | | | |

| IT EVALUATION | | | | |
|---------------|----|----|----|----|
| X | 1 | 6 | 3 | 1 |
| (X) | 0 | 1 | 1 | 3 |
| No cross | 12 | 6 | 9 | 9 |
| * | + | + | + | - |
| IT INVESTMENT | | | | |
| X | 4 | 6 | 4 | 2 |
| (X) | 0 | 0 | 2 | 3 |
| No cross | 3 | 1 | 1 | 1 |
| * | | | | |
| TOTAL | | | | |
| X | 5 | 12 | 7 | 3 |
| (X) | 0 | 1 | 3 | 6 |
| No cross | 15 | 7 | 10 | 10 |
| * | + | + | + | - |

Table 13 - Computation of the usability scores (based on [Andresen, 2001])

The usability scores of the methods are computed according to the results in Table 13. Based on that results, CSF is excluded and NPV, MBITI and IE are considered as they fulfil the necessary requirement. MBITI has the highest usability score, followed by IE. Both are quantitative methods and therefore considered for the application with ontologies.

14 Appendix III - UIS Questionnaire Design for (Multimedia) Ontologies

In this section we will present a questionnaire for User Information Satisfaction analysis of multimedia ontologies. The questionnaire is based on the original questionnaire from Miller and Doyle [Miller and Doyle, 1987]. It contains three parts. Part A contains questions which measure the extent to which certain facets of the ontology (or the ontology based application) are perceived to be important in ensuring the effectiveness of the application / ontology.

Part B contains questions about future requirements.

Part C consists of the same questions as Part A but now the actual performance should be rated.

Part D contains a question on the overall performance.

The attributes questioned in Part A and C are the one that are listed in section 7.3 "Facets of Ontology-Based Systems".

Data collection for benefit estimation of (multimedia) ontologies

INTRODUCTION

MOBEFIT (Multimedia Ontology BEneFIT) - a model for the benefit estimation of (multimedia) ontologies - is currently being developed at the University of Innsbruck. It aims at predicting the economic value of ontologies together with the application of a cost estimation model for ontologies called ONTOCOM.

The overall user satisfaction is a measurement for the effectiveness of a system. To make a statement about the user satisfaction the collection of real-world ontology engineering project data is necessary. The design of the model is part of the task T3.3 "Evaluation of the economics of multimedia ontologies" of the European project SALERO.

ABOUT THIS SURVEY

The MOBEFIT method is based on User Information Satisfaction analysis whose idea is to measure the gap between the perceived importance of particular system attributes and their actual performance.

The survey consists of 4 parts:

- Part A contains questions which measure the extent to which certain facets of the ontology (or the ontology based application) are perceived to be important in ensuring the effectiveness of the application / ontology
- Part B contains questions about future requirements
- Part C consists of the same questions as Part A but now the actual performance should be rated.

Part D contains a question on the overall performance.

For the questions in part A you are required to specify the importance of a specific system attribute on a four point scale, i.e. to position your answer according to a four-step rating scale: Irrelevant, Not important, Important, Critical. You additionally might tick "Don't Know".

For the questions in part B you are requested to provide your personal wish list for future attributes of the system.

For the questions in part C you are required to rate the perceived performance of the same system attributes that were asked for in Part A. Again the rating is can be done on a four-point scale: Very poor, poor, good, excellent.

Part D finally contains questions about your overall opinion of the application / ontology.

Part A – Importance

Please respond by ticking the option which reflects your opinion about the importance of the following listed attributes of ontologies and ontology based systems in ensuring their effectiveness.

| A.1 Common attributes of ontologies | |
|--|--|
| 1 | Easy access to the ontology Irrelevant _____ Not important _____ Important _____ Critical _____ Don't Know _____ |
| 2 | Up-to-date ness of the ontology Irrelevant _____ Not important _____ Important _____ Critical _____ Don't Know _____ |
| 3 | User confidence in the ontology Irrelevant _____ Not important _____ Important _____ Critical _____ Don't Know _____ |
| 4 | Degree of personal control over the ontology Irrelevant _____ Not important _____ Important _____ Critical _____ Don't Know _____ |
| 5 | Ontology responsiveness to changing users needs Irrelevant _____ Not important _____ Important _____ Critical _____ Don't Know _____ |
| 6 | Participation in the planning of requirements or competency questions Irrelevant _____ Not important _____ Important _____ Critical _____ Don't Know _____ |
| 7 | Extent of user training Irrelevant _____ Not important _____ Important _____ Critical _____ Don't Know _____ |
| 8 | Documentation of the ontology Irrelevant _____ Not important _____ Important _____ Critical _____ Don't Know _____ |
| 9 | A high degree of technical competence from ontology administrators Irrelevant _____ Not important _____ Important _____ Critical _____ Don't Know _____ |
| A.2 Comprehensiveness of the ontology | |
| 10 | User's understanding of the ontology Irrelevant _____ Not important _____ Important _____ Critical _____ Don't Know _____ |
| 11 | Match of users' perception of phenomena with the ontology Irrelevant _____ Not important _____ Important _____ Critical _____ Don't Know _____ |
| 12 | Understand ability of the categorization of concepts in the ontology Irrelevant _____ Not important _____ Important _____ Critical _____ Don't Know _____ |
| 13 | Size of gap between the ontology concepts and the preferred concepts of the user Irrelevant _____ Not important _____ Important _____ Critical _____ Don't Know _____ |
| A.3 Attributes accounting applications using the ontology | |
| [14-18] | |
| A.4 Browsing / exploration | |

| |
|---|
| [19-24] |
| A5. Application 1: Semantic search / retrieval |
| [25-36] |
| A6. Application 2: Annotation |
| [37-41] |
| A7. Application 3: Reasoning |
| [42-45] |
| A8. Application 4: Personalization |
| [46-48] |
| A9. Application 5: High level summarization |
| [49-51] |
| A10. Application 6: Information communication |
| [52-57] |

Part B – Future Requirements

Please list any abilities that you think an ontology based system should be able to have.

Part C – Actual performance

Please respond by ticking the option which reflects your opinion about the actual performance of the following listed attributes of ontologies and ontology based systems in terms of the following attributes.

| C.1 Common attributes of ontologies | |
|--|---|
| 1 | Easy access to the ontology Very _____ poor _____ Poor _____ Good _____ Excellent _____ Don't Know _____ |
| 2 | Up-to-date ness of the ontology Very _____ poor _____ Poor _____ Good _____ Excellent _____ Don't Know _____ |
| 3 | User confidence in the ontology |

| | | | | | | |
|---|--|------|------------|------------|-----------------|------------------|
| | Very _____ | poor | Poor _____ | Good _____ | Excellent _____ | Don't Know _____ |
| 4 | Degree of personal control over the ontology | | | | | |
| | Very _____ | poor | Poor _____ | Good _____ | Excellent _____ | Don't Know _____ |
| 5 | Ontology responsiveness to changing users needs | | | | | |
| | Very _____ | poor | Poor _____ | Good _____ | Excellent _____ | Don't Know _____ |
| 6 | Participation in the planning of requirements or competency questions | | | | | |
| | Very _____ | poor | Poor _____ | Good _____ | Excellent _____ | Don't Know _____ |
| 7 | Extent of user training | | | | | |
| | Very _____ | poor | Poor _____ | Good _____ | Excellent _____ | Don't Know _____ |
| 8 | Documentation of the ontology | | | | | |
| | Very _____ | poor | Poor _____ | Good _____ | Excellent _____ | Don't Know _____ |
| 9 | A high degree of technical competence from ontology administrators | | | | | |
| | Very _____ | poor | Poor _____ | Good _____ | Excellent _____ | Don't Know _____ |
| C.2 Comprehensiveness of the ontology | | | | | | |
| 10 | User's understanding of the ontology | | | | | |
| | Very _____ | poor | Poor _____ | Good _____ | Excellent _____ | Don't Know _____ |
| 11 | Match of users' perception of phenomena with the ontology | | | | | |
| | Very _____ | poor | Poor _____ | Good _____ | Excellent _____ | Don't Know _____ |
| 12 | Understand ability of the categorization of concepts in the ontology | | | | | |
| | Very _____ | poor | Poor _____ | Good _____ | Excellent _____ | Don't Know _____ |
| 13 | Size of gap between the ontology concepts and the preferred concepts of the user | | | | | |
| | Very _____ | poor | Poor _____ | Good _____ | Excellent _____ | Don't Know _____ |
| C.3 Attributes accounting applications using the ontology [14-18] | | | | | | |
| C.4 Browsing / exploration [19-24] | | | | | | |
| C.5 Application 1: Semantic search / retrieval [25-36] | | | | | | |
| C.6 Application 2: Annotation [37-41] | | | | | | |
| C.7 Application 3: Reasoning | | | | | | |

[42-45]

C.8 Application 4: Personalization

[46-48]

C.9 Application 5: High level summarization

[49-51]

C.10 Application 6: Information communication

[52-57]

Part D – Overall opinion

Please rate your overall opinion about the ontology and the ontology based system.

Very poor _____

Poor _____

Good _____

Excellent _____

Please supply any further comments about the performance of the ontology and the ontology based system.
