Requirements modelling and evaluation for digital preservation: A COTS selection method based on controlled experimentation

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ABSTRACT

Most methods for the general problem of Commercial-off-the-shelf component selection use goal-oriented requirements modelling and multi-criteria decision making techniques and are applicable across a wide range of domains. This usually implies high levels of complexity. Recently a very specific selection problem emerged in the context of digital preservation. The selection of the most suitable tool to keep a type of digital object alive when the original technical environment ceases to exist is a highly complex domain-specific selection problem with several peculiarities: Highly homogeneous functionality across tools, complex evaluation of quality across settings, and a high need for automation, standardisation, and documentation. This paper describes an evidence-based empirical methodology for COTS component selection in digital preservation through controlled experimentation. We describe the specific selection problem, show how the process of utility analysis can be tailored to fit the problem space and describe the methodology, which is geared towards automated evaluation in an empirical setting. We outline existing tool support and discuss case studies and future directions.

Categories and Subject Descriptors

D.2.1 [**Software Engineering**]: Requirements/Specifications

General Terms

Design,Documentation,Measurement,Experimentation

Keywords

Requirements Engineering, COTS selection, empirical evaluation, Utility Analysis, Decision Support Tool

1. INTRODUCTION

Over the last years, a very specific and complex COTS component selection problem has arisen in a rather new field of computer science, which is generally called *digital preservation*. While analog objects such as photographs or books directly represent the content, digital objects are often useless without the technical environment they have been designed for. In contrast to a book, a Word document cannot be rendered without a suitable hardware and software environment. The constant changes in IT environments render objects inaccessible within years and thus challenge the longevity of digital information. Especially for born-digital material this often means that the contained information is lost completely. Digital preservation denotes the efforts to preserve digital objects for a given purpose over long periods of time. The two dominant types of *preservation actions* taken to keep digital content alive today are migration and emulation. While migration transforms the objects to more widely accessible representations, emulation creates a technical environment where the objects can be rendered.

A growing number of tools performing migration and emulation are available today; each tool has particular strengths and weaknesses, and most often, there is no optimal solution. On the other hand, requirements vary across institutions and domains, and for each setting, very specific constraints apply that need to be considered. The decision for a tool is further complicated by the variation in the digital content that has to be preserved. *Preservation planning* aids in the decision making process by selecting suitable action tools that operate on digital objects or their environments by evaluating available solutions against clearly defined and measurable criteria. This process is a domain-specific COTS selection problem which exhibits several peculiarities. Most notably, the *functionality of tools is very specific and limited* – usually it boils down to a function `convert(from,to)` or `render(object)`. This functional homogeneity implies that COTS selection in digital preservation has the option to empirically evaluate potential components in a realistic setting prior to the actual integration into a system. On the other hand, while functionality is very specific, a crucial aspect in the selection procedure is the question of how well the *significant properties* of digital objects are preserved.

A number of approaches for COTS selection have been proposed [4]. Most are designed to be applied across a wide range of different domains. However, their generality and complexity implies that they are not truly supportive in the particular decision making processes carried out by domain experts in digital preservation, who are in general not experts in Software Engineering. Moreover, the homogeneity of the evaluation problem in DP provides opportunities to leverage economies of scale in component selection method-

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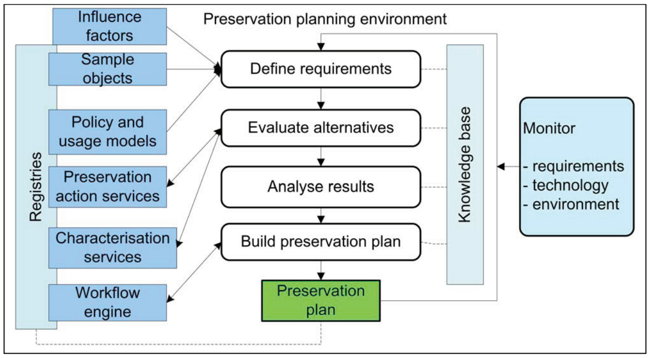

Figure 1: Preservation planning environment

ologies. Most specifically, it allows us to rely on empirical evaluation and automated measurements to support the evaluation. Ncube discusses limitations of multi-criteria decision making techniques such as WSM or AHP, which are often used in COTS selection [5]. While WSM has earned criticism for the necessity to determine criteria weights in advance without having seen alternative solutions, AHP is problematic because of the sheer complexity and effort that is introduced by the pairwise comparison of criteria.

In this paper, we present a domain-specific COTS selection methodology for digital preservation based on utility analysis. Components are evaluated in an empirical process by applying them on sample content in a controlled setting. The outcomes are evaluated in a quantitative, repeatable manner according to hierarchically defined criteria.

2. REQUIREMENTS ENGINEERING FOR DIGITAL PRESERVATION

Evaluating software components for digital preservation is a key component of the *preservation planning* activity in the OAIS model[3]. In the methodology described in [6], evaluation is carried out in an 11-step procedure in the classic three phases of identifying requirements, evaluating alternatives and analysing results to arrive at a recommendation for a specific component. Figure 1 abstracts the principal building blocks of the resulting planning environment, including a fourth phase of plan definition which basically creates an integration plan for the repository system.

Requirements definition relies on utility analysis [7], specifying goals and criteria in a hierarchical manner. Some of the factors considered may partially be modelled in a formal way, thus allowing automatic reasoning and derivation of environment constraints that can support the evaluation procedure. Others, such as object characteristics, can be semi-automatically constructed by analysing the properties of the digital objects and specifying which characteristics need to be preserved. This *characterisation* relies on formal languages such as the eXtensible Characterisation Languages [2]. The requirements trees are elicited in interactive group sessions, where software support aids in the definition process. A knowledge base provides best-practice criteria catalogues that can be applied and further refined, providing a feedback loop into the decision process. The software tool is publicly available. **Requirements evaluation** takes advantage of the homogeneity of the problem space and follows an empirical approach. Candidate tools are applied on the sample objects identified in phase 1 in a controlled environment, providing a thorough evaluation and evidence base in realistic experiments. A distributed web service infrastructure facilitates the discovery of potential tools and their invocation. The experiments can be highly automated because the principal functionality is extremely homogenous over the set of candidates, and comparison tools can automate the validation of tools [1].

In the final step, visual analysis of results allows a comparison of performance values not only on the root level, but on all levels of the tree hierarchy. Thus it supports an in-depth analysis of the specific strengths and weaknesses of each candidate component and an evidence-based decision for a specific component. Weighted multiplication is used to filter candidates where unacceptable performance values occur at the criterion level, while weighted addition is used for a direct comparison of alternatives. The definition of acceptance criteria provides a gap analysis which clearly points out both strengths and limitations of candidates.

The approach has been applied in a series of case studies conducted in collaboration with large institutions across Europe, ranging from electronic publications in a national library to the evaluation of tools for preserving computer video games. These case studies have led to recent refinements and extensions of the methodology. Current work is geared towards the automatic derivation of requirements from modelled constraints and environment factors; tracing and monitoring of influence factors and continuous impact assessment; recommender systems for eliciting key influence factors and suggesting sets of requirements from the knowledge base; integration of existing software quality models; and specifically, the automated evaluation of potential actions against requirements.

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3. REFERENCES

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