A Service-Oriented Approach to Assess the Value of Digital Preservation

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Abstract. Assessing the economic value of a preservation system that preserves increasing amounts of digital data produced and collected by public and private organizations is a challenging task. The financial sector, in particular the investment business, is characterized by constantly increasing volumes of high frequency market and transaction data which need to be kept for long periods of time (e.g., due to regulatory compliance). Designing and developing appropriate metrics and tools to support the economic performance assessment in the context of long term digital preservation is a complex and difficult process. This article has three main objectives: (1) to present the work pursued towards the elaboration of a set of metrics to support economic performance assessment in the context of long term digital preservation, (2) to exhibit the architecture of the economic performance assessment engine supporting this analysis, (3) to discuss preliminary results of the value assessment of digital preservation for the financial sector obtained by applying the proposed model. This work reflects the R&D activities pursued within the scope of the on-going R&D FP7 project ENSURE – *Enabling kNowledge Sustainability Usability and Recovery for Economic value* (http://ensure-fp7.eu).

Keywords: Service computing, performance assessment, digital preservation, financial sector.

1 Introduction

Assessing the economic value of a preservation system (or preservation solution) that ensures the preservation of increasing amounts of digital data produced and collected by public and private organizations is a complex and difficult task, e.g., due to the lack of awareness for data preservation from industry and the associated added-value. For example, the financial sector, in particular the investment business, produces and collects a big volume of digital data (e.g., market data, transactions data) that needs to be preserved for long term (e.g., for regulatory compliance, research purposes).

Enterprise's decision to adopt a preservation system is a complex process and economic factors (e.g., costs, expected payoffs) influence such a decision. Research on the economics of digital preservation is scarce and is focusing mainly on cost

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modeling (e.g.,[1-4]) and currently there are no metrics or tools to support an economic performance assessment analysis in the context of long term digital preservation (LTDP).

Although several advantages of LTDP are claimed (e.g., faster and secure access to preserved e-data compared to manual/traditional preservation or no e-data preservation), formal models, metrics, frameworks or tools to support the quantification of its (expected) economic benefits (e.g., cost-benefit analysis, return on investment in the context of LTDP) are not yet available. Several questions are still unanswered, e.g., What are the specific benefits a particular organization would gain by adopting a preservation system/ preservation solution? How can expected benefits be assessed in the context of LTDP, from an economic perspective? How to predict the economic performance of a preservation system? How to predict the future value of the preserved digital data? These issues are tackled in this article, which reflects the research work pursued within the scope of the on-going R&D FP7 project ENSURE – *Enabling kNowledge Sustainability Usability and Recovery for Economic value*[1].

This article has three main objectives: (1) to present the work pursued towards the elaboration of a set of metrics to support economic performance assessment in the context of LTDP, (2) to exhibit the architecture of the economic performance assessment engine supporting this analysis, developed within the scope of the ENSURE FP7 project, (3) to discuss preliminary results of the value assessment of digital preservation for the financial sector obtained by applying the proposed model.

The rest of this article is organized as follows. The next section briefly introduces the concepts of LTDP and service oriented computing. Section three refers to ways for value assessment in the context of LTDP. Advances towards the development of the Economic Performance Assessment engine are then presented. A case example from the financial sector is discussed in Section five. The article concludes with a section addressing the needs for further research.

2 Digital Preservation and Service Computing: A Brief Overview

2.1 Long Term Digital Preservation: Concept and Challenges

LTDP concerns, in a broad way, the activities related to preserving digital data over long periods of time, ensuring its accessibility and usability [5], allowing the retention of digital data (or digital objects) and its meaning [6]. The Consultative Committee for Space Data Systems [7] defines LTDP as the act of maintaining information, independently understandable by a specific community, supporting its authenticity over the long term.

Technical recommendations establishing a common framework of terms and concepts which make up an Open Archive Information System (OAIS) are presented in the OAIS Reference Model [7-8], which consists of six functional entities (and

[1] http://ensure-fp7.eu

related interfaces). Challenges in ensuring long term preservation of digital objects refer to (e.g., [9]): digital (technology) obsolescence, lack of standards and generally accepted methods for preserving information, deterioration (e.g., of digital data recording media), and high data heterogeneity.

Research in this area focused mainly on technical aspects and quality of preserved data. Research on the economics of LTDP is scarce and existing studies concern mainly cost modeling. The work presented in this article aims at advancing research in this area, focusing on economic performance analysis.

2.2 Services and Service Oriented Architecture

Services represent autonomous and platform-independent computational entities, which can be described, published, discovered, and dynamically assembled to deploy distributed interoperable systems (e.g., [10,11]). As emphasized in [12], service-oriented computing promotes the idea of assembling application components in a network of services to create agile applications that cross different geographically distributed computing platforms and organizations. The Service Oriented Architecture (SOA) allows services to communicate and exchange information between distributed systems; it provides means for service providers to offer services, and service users to discover services.

Web services are services that make use of the Internet as communication platform, and open Internet-based standards, such as: Simple Object Access Protocol (SOAP[2]) to exchange data; Web Service Description Language (WSDL[3]) to describe services; Business Process Execution Language for Web Services (BPEL4WS[4]) to specify business processes and interaction protocols [10][13]. Service providers can register their services in a public service registry using the Universal Description Discovery and Integration (UDDI[5]). Web services are currently regarded as the most promising service-oriented computing technology [14]. Web services offer standard-based mechanisms to connect electronically business partners [15].

2.3 Preservation Architecture Approaches

Architectures for data preservation systems need to be designed and specified to support preservation processes. Although there is no generally accepted definition of the data preservation system architecture, several aspects are usually considered as relevant, such as: the fundamental organization of a system, reflected in its components and their relationships to each other and the environment, as well as the principles guiding its design and evolution; the composite of the design architectures for products and their life-cycle processes [16]. Below are referred two examples of preservation architectures:

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[2] SOAP, `http://www.w3.org/TR/soap/`

[3] WSDL, `http://www.w3.org/TR/wsdl`

[4] BPEL4WS, `http://www.ibm.com/developerworks/library/specificaion/ws-bpel/`

[5] UDDI, `http://www.uddi.org` and `http://www.oasis-open.org/committees/uddi-spec`

- CASPAR[6] architecture was designed on the following principles: OAIS-compliance, technology-neutrality, loosely-coupled architecture, domain independence, preservation of intelligibility and knowledge dependencies, preservation of authenticity and digital rights.
- SHAMAN[7] reference architecture follows OAIS SOA Reference Model, comprising layered information package, refinement of the information package, pre-Ingest and post-Access activities.

2.4 ENSURE FP7 Project

The on-going R&D ENSURE FP7 project aims at extending the state-of-the art of digital preservation by building a self-configurating software stack addressing the configuration and preservation life-cycle processes in order to create a financially viable solution for specific user requirements [17]. It analyzes the tradeoff between the costs of preservation against the value of the preserved data, tackling quality aspects, focusing on use cases from the health care, clinical trials and financial sector. The ENSURE Reference Architecture[8] for digital preservation follows a SOA approach and was designed to support the OAIS Reference Model.

3 Assessing Value in the Context of LTDP

3.1 Background and Challenges

Few studies on the economics of LTDP exist, referring mainly to cost modeling. A first study on the costs of digital preservation aside storage cost issues is presented in [18], where different data types are identified and a decision model for appropriate preservation methods for the data types is advanced. Although the proposed cost model relies on the cost items identified for seven modules (creation, selection/evaluation, data management, resource disclosure, data use, data preservation and data use/rights), no quantification of these items is provided. Costs involved in digital preservation were also presented in [19]. A study reflecting the cost of digital preservation and the OAIS Reference Model is presented in [20], where three main aspects determining costs of an archive are identified: content data types and formats, access, and authority and control. A cost model for small scale automated digital preservation archives is presented in [1]. Cost aspects of ingest and normalization compliant to OAIS Reference Model is described in [2]. Challenges on LTDP cost modeling are discussed in [4].

The issue of economic performance assessment in the context of LTDP is of utmost importance for public and private organizations. The Blue Ribbon Task Force [21] concentrated on materials that are of long-term public interest, such as research data, scholarly disclosure, commercially owned cultural content, collectively

6 `http://www.casparpreserves.eu`
7 `http://shaman-ip.eu/shaman`
8 `http://ensure-fp7.eu`

produced Web content. As a result, they identified important structural challenges for the economic analysis, i.e., long term horizons, diffused stakeholders, misaligned or weak incentives, and lack of clarity about roles and responsibilities among stakeholders.

Examples of challenges for economic performance assessment analysis are: difficulty to estimate expected value of preserved data, future value of preserved data may increase or decrease in time (e.g., value of market data), change in costs (e.g., cost of information, cost of technology), technology changes (e.g., ICT advances, technology obsolescence), uncertainties related to future policy/ regulations and their impact on the value of preserved data, difficulty of quantify the added value attained by transferring data in paper format to digital format, quantification of the impact of risks on preservation. Private institutions face additional challenges on the economics of LTDP concern, mainly related to data heterogeneity, sector-specific regulations and policies.

An extensive literature survey has been conducted. The most important theories and approaches which can be relevant for the economic performance assessment in the context of LTDP were identified. Game theory and decision theory are only two examples of applicable theories for this analysis, and are briefly described below.

Game Theory. is a branch of applied mathematics that analyzes players who choose different actions in an attempt to maximize their payoffs [22]. A cooperative game allows the formation of coalitions: players join forces based on a binding agreement [23]. Main fields of application are: economic systems [24], biology, philosophy, and computer systems. The modeling approach of game theory is relevant to service computing and LTDP analysis to determine the gains (e.g., ROI) an organization may have by selecting a specific strategy (e.g., adoption of a certain preservation solution/ preservation configuration).

Decision Theory. Given a decision problem, decision theory makes use of probability theory to recommend optimal decisions, or an option that maximizes (expected) utility. Fields of application include economics, economic systems, and artificial intelligence. According to [25], a decision problem presumes: an association of a set of outcomes with each action; a measure U of outcome value which assigns a utility $U(\omega)$ to each outcome $\omega \in \Omega$; a measure of the probability of outcomes conditional on actions $Pr(\omega/a)$ denoting the probability that outcome ω is obtained after action $a \in A$. Based on these elements, the expected utility $EU(a)$ is defined in [25] as the average utility of the outcomes associated with an alternative, weighting the utility of each outcome by the probability that the outcome results from the alternative: EU(a) = $\int_{\Omega} U(\omega)\Pr(\omega/a)d\omega$. Decision theory is relevant for organizations analyzing the possibility to adopt a preservation system or new preservation solution/ configuration, especially when decision makers need to make forecasts of the expected gains and determine the payback period, for example.

In Table 1 are emphasized the strengths and weaknesses of game theory and decision theory towards economic performance assessment in the context of LTDP. The Expected Utility, for example, could be relevant to estimate the future value of preserved data and added value of a certain preservation solution that will be reflected, for example, in the ROI. Game theory, for example, is relevant to support the estimation of benefits related to the adoption of a preservation solution that is relevant for ROI and payback estimation.

Table 1. Relevant theories

Theory	**Definition and basic elements**	**Pros LTDP**	**Cons LTDP**
Decision Theory[24]	EU(a)= $\int_{\Omega} U(\omega)\Pr(\omega / a)d\omega$	Relevant for forecasting, ROI and payback period modeling.	Often difficult to elaborate reasonable estimates.
Game theory	A game function: v: $2^N \rightarrow R$ Players, moves or strategies, specifications of benefits for a strategy.	Relevant to model gains and ROI for a specific strategy (e.g., adoption of a preservation solution).	Lack of formal models/metrics to assess or monitor economic parameters.

A precondition for an adequate assessment of preservation systems and preservation solutions is the availability of metrics relevant in the context of LTDP. We can distinguish between measures describing system performance (e.g., preservation system availability, throughput, downtime, response time, and other quality-related attributes), and metrics for assessing the economic performance of a storage solution (e.g., payoffs, ROI, NPV, payback period). Models, metrics, methodologies, frameworks and tools for supporting an economic analysis and assessment in a digital preservation environment are not yet available. However, they would be of utmost importance for managers' decision whether to adopt or not a certain preservation system/ preservation solution.

4 Assessment Approach: Main Activities and Basic Architecture

To support the economic performance analysis in the context of LTDP, research is being pursued towards the development of specific metrics (e.g., return on investment-ROI, return of information, net present value-NPV, payback period). An Economic Performance Assessment (EPA) engine was designed to support the developed metrics. Figure 1 illustrates the main activities of the EPA engine.

The input information for the EPA engine refers to: *user requirements and preferences* (e.g., preservation solution lifetime, initial investment, number of copies, number of storage sites, not accomplish law fee), *results of the Cost Engine* (e.g., annual running cost, total cost associated with a preservation solution/ configuration), and the *global preservation plan* (which is an XML file with relevant information for the EPA analysis, e.g., configuration creation and expiration date) [16][26]. The outputs of the EPA engine will be the values of the metrics supporting economic

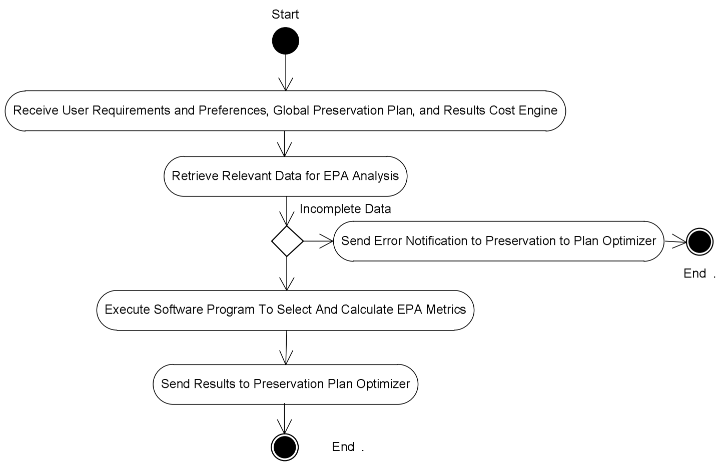

Fig. 1. Simplified flow diagram for the EPA engine

performance assessment, such as: estimated ROI associated to a preservation solution, estimated annual ROI, estimated payback period, estimated NPV.

The basic architecture for the EPA engine (and the environment in which it operates) is portrayed in Figure 2. The EPA Engine is part of the Preservation Plan Optimizer (PPO) component, which is responsible for driving the evaluation and optimization process [16][26]. The Configurator sends parameterized proposed preservation configurations to the PPO, which provides the EPA engine with the following information as input: the ENSURE global preservation plan, user requirements, and results of the Cost Engine [16][26].

A first version of the EPA engine was already implemented at the University of Porto, using Java. A second prototype will be developed. Part of the functionality of the EPA engine is already integrated into the ENSURE preservation stack. Web services are used to transmit the EPA engine results.

5 Case Example from the Financial Sector

5.1 Main Characteristics and Challenges for LTDP

The financial domain, in particular the investment business, is characterized by permanently incoming streams of high frequency market data. The digital data produced and collected by financial institutions (e.g., market data, transactions data) needs to be preserved for long term (e.g., for regulatory compliance, research purposes). In the past, the main focus of R&D was on performance improvement of the IT infrastructure in an attempt to deal with the constantly increasing volumes of data. Today the need of financial institutions for support in compliance to regulations and legal standards takes an increasingly important role [9][27][28].

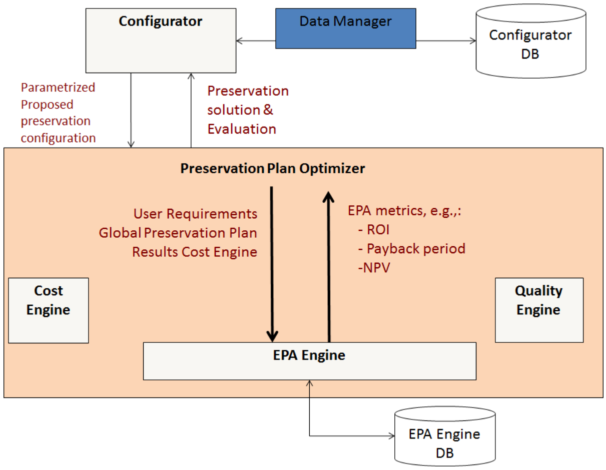

Fig. 2. Basic EPA Engine Architecture

The goals of financial institutions with respect to LTDP are threefold: **1.** to comply with legal and regulatory requirements to fulfill record retention obligations. The period for retention is five years after the termination of the business relationship. The type of documents comprises not only contractual papers and account statements concerning trading activities on behalf of the client, but, in general, every information ever given to the client, including marketing material, e-mails, telephone-protocols, etc. **2.** to protect the commercial value of market data for research purposes. Developing automated trading models requires a rich data base of financial market data, covering a large variety of trading instruments and reaching back over many years, eventually up to ten or twenty years. Tick data, covering every single price change, is expensive to buy and therefore, once purchased, represents a significant business value that has to be preserved. **3.** to ensure traceability of trading decisions even after years. For their own purposes and in order to anticipate eventual future regulatory requirements of transparency, this third goal is to ensure that the actual performance of trading models on historical data can be reconstructed for many years in the past. This requires the interaction of three components: the model, implemented in a proprietary programming language, the execution environment for the model, consisting of a particular version of the used charting and analysis software, and the data, stemming from a particular data source. Any variance in one of these components may lead to significantly large deviations in model performance.

A detailed description of stakeholders for the financial institutions, flows of data between different departments of a typical investment bank and data types that need to be preserved is available in [9]: ***Market data*** is received from the real time feed and forwarded to the historical database from where it is accessed by the financial engineers located in the R&D department. It is also displayed on the charts on the traders' desktop in the front office as well as fed to the middle office, where it is used for tracking of open positions and risk management. ***Client data*** (e.g., contracts, account statements, communication) is received from the custodian bank, broker or clearing house. It is the back-office staff that manages this type of data together with any other client related documents and is responsible for the preservation of this type of data. ***Trading Models*** are developed by the R&D department and installed at the trader's desks. Thus, the financial engineers perform the retention of all models and market data.

Main challenges for LTDP for this sector refer mainly to the heterogeneity of the data that needs to be stored and the retention of the preserved information (e.g., the retention of: client information, proprietary applications due to business purposes, very large amounts of market data stored over time), while meeting regulatory directives and business goals. Thus, a preservation system for this sector needs not only to preserve large amounts of heterogeneous data, but it should also allow conformance to regulatory, contractual and legal requirements, and management of long term authenticity and integrity of intellectual propriety and personal data.

Another characteristic of this scenario is the distribution of stakeholders over two distinct departments. Two different types of users with very different levels of computer literacy will be interacting with the preservation system: basic skilled back-office staff on the one hand, and technically skilled financial engineers on the other. This has consequences on the selection of an appropriate preservation system that can provide for role based access mechanisms, preventing unauthorized data access for the respective group of users, but has also organizational implications that have to be valuated economically. Distributed (and eventually unclear) responsibilities among stakeholders are mentioned by BRTF [21] as one of the main obstacles to the adoption and efficient usage of preservation systems. Hence, additional effort has to be spent on the definition of clear procedures for the preservation in every stage.

5.2 EPA Analysis

The EPA analysis is relevant for managers of financial institutions because it supports decision making (e.g., to adopt a preservation system, to adopt or not a new preservation solution/ configuration). It provides means to perform an economic analysis, e.g., cost-benefit analysis, determine the payback period for a preservation system, and determine the expected return on investment.

A simple example for EPA analysis is illustrated in Table 3. In this example, the results of the analysis reflect negative values of Return on Investment[9] (ROI) (in the case of client data) and positive ROI (in the case of market data). However, the results have to be interpreted with care, e.g., the analyzed preservation configuration might bring positive (high) ROI for a longer lifetime of the analyzed preservation configuration (e.g., more than 10 years).

When performing an economic performance analysis (e.g., to support decision making concerning the adoption of a certain preservation solution), several factors need to be considered, such as: preservation solution lifetime, amount of data to be

[9] **Return on Investment (ROI)** is a performance measure commonly used to evaluate the efficiency of an investment or to compare the efficiency of a number of different investments. The benefit (return) of an investment is divided by the cost of the investment. The result is expressed as a percentage or ratio.

preserved, estimated value of the preserved data, estimation of expected payoffs, estimation of operations to be performed (e.g., ingest, access), preservation type (e.g., gold, silver, bronze[10]), costs.

Table 2. A Simple Example

	Market data	Client data
TIME		
Lifetime preservation solution/configuration	2 years	2 years
Preservation period	50 years	50 years
AMOUNT OF DATA		
Annual amount of data to be preserved	10TB	7,5 GB
VALUE OF PRESERVED DATA		
Year 1	50K	invaluable
Year 2	55K	invaluable
POTENTIAL LOSSES (for the preservation period)		
Estimated value	2,5K€	50K€
PAYOFFS		
Potential gains	50K€	
Probability	0,9	
NUMBER OF OPERATIONS (annual)		
Number of *access* operations	30	240
PRESERVATION		
Gold		X
Silver		
Bronze	X	
COSTS		
Initial Investment	5K€	5K€
Cost of cloud (annual)	120€/ year	
Costs related to preservation operations (e.g., ingest, access, retrieval)	1200€/year	
Preservation system administration	1000€/year	
Other costs	180€/year	
RESULTS Economic Performance Assessment (EPA) ENGINE		
RETURN ON INVESTMENT (ROI)		
ROI_{year1}	35%	-0,2%
ROI_{year2}	42%	-0,04%

The metrics need to be correlated with additional information (e.g., uncertainties and associated probabilities) to support decision making (e.g., to adopt a certain preservation solution or not). Figure 2 illustrates a simple example, considering the probability that long-run cost of preservation increases, and policy gets stricter.

6 Conclusions and Future Research Work

Public and private institutions face numerous challenges on identifying and quantifying payoffs to be attained by preserving digital data for future use. Metrics,

[10] This is an analogy of ‘gold silver bronze service level’ used to reduce the number of parameters to be submitted by the user through the GUI, e.g., storage type, validation algorithm, frequency (of ingest).

methodologies and tools to support economic performance assessment in the context of long term digital preservation (LTDP) are not yet available.

Preliminary results of the research work currently being pursued (within the scope of the on-going ENSURE FP7 project) towards the design and development of an economic performance assessment (EPA) engine and metrics to support an economic performance analysis in the context of digital preservation are presented in this article. Part of the functionality of the EPA engine is already integrated into the ENSURE preservation stack. A simple example from the financial sector is also discussed.

Economic performance evaluation results can support decision making about preservation systems in several ways. Depending on the particular goals of preservation, economic considerations can help to choose between alternative preservation solutions or configurations, or to abandon the adoption of preservation technologies at all. Where data is stored for reasons of protection of business values, preservation costs are usually expected to be lower than the values to be protected. In this case, only if the ROI is positive, a decision maker would give green light for the acquisition of a preservation system. On the other hand, where legal obligations dominate the motivation for implementing a preservation system, as in the case of financial client data, considerations about data value are typically helpful for a decision only in the second place. Data value can sometimes be extremely difficult to quantify. Even if we attempt to economically quantify the consequences of data loss, e.g. expressed in fines for breach of record retention obligations, these will typically not consist of a fixed catalogue, but be extremely variable amounts due at the discretion of the regulating authorities. Anyway, if we take into account that the value of preserved data should not be confused with its monetary or financial value *per se*, as emphasized by [21], but consider instead value to be determined by the ways, the data are used after years, the utility measure U from decision theory (Table 1) may point to a way out from this dilemma.

Future research work will focus on the development of new economic performance metrics, relevant in the context of LTDP, and their validation.

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