Towards Enterprise Management Systems
A Generic and Flexible Information Representation Approach

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Abstract: This paper describes an enterprise management system which provides an integrated approach to tackle management relevant topics like business process management, quality management, audit management, internal risk and control management, enterprise architecture management, compliance management and so on within a single information system. The new term "enterprise management system (EMS)" is introduced for such a kind of management system. The core idea is a generic, yet flexible object model for any kind of relevant information, e.g. audit, risk, measure, process, process step, control. The different kind of information is related to each other by links with semantic expressiveness. The approach was successfully implemented in the enterprise management system DHC VISION, which is used today worldwide by medium- and large-sized enterprises.

1 INTRODUCTION

Nowadays, management systems become a necessity for multi-site companies operating worldwide. There is a need to fulfill a vast number of legal requirements, national and international guidelines and norms. One the other hand, enterprises always need to improve their processes and structures to gain competitive advantages. Business process management (BPM, vom Brocke and Rosemann, 2010) and governance, risk and compliance (GRC, Tarantino, 2008) are the key approaches to master this challenge.

But today, most enterprises only have separate software solutions for purposes like business process management, quality management (QM), audit management (AM), internal risk and control management (ICS), enterprise architecture management (EAM), compliance management and so on. As we know from our consulting experience, information is often stored redundantly in several systems with disadvantages like redundancy, internal and external inconsistency, reduced changeability and ill-structuredness. None of the existing systems on an operational level like ERP software, business intelligence software, business process management software or office products (e.g. spreadsheets) fulfill the functional requirements of a holistic management system, especially with respect to integration aspects. Furthermore, most of them are not usable on a daily basis within the described management context.

There is a strong demand for the development of integrated solutions. In the midst of the 1990s, first steps have been made towards so-called integrated management systems (Laudon and Laudon, 2010), which comprise the three core topics of quality management, health and safety management and environmental management. The focus here is on an integrated management and documentation of quality handbooks, operating instructions, training material for norms like e.g. ISO 9001, ISO 14001 and OHSAS 18001 (Pardy and Andrews, 2009, ISO, 2008).

New approaches try to enhance these integrated management systems to a so-called enterprise management system (EMS). The main idea is the integration of all management-relevant information in one global database, starting with the description of strategic goals, business processes and attached key performance indicators (KPI), and the corresponding description of the organization with the roles and responsibilities of its employees (DHC Business Solutions GmbH, 2013). However, due to

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technical and business-oriented barriers, the development of such a system is far from being easy. Nevertheless, such a kind of process-driven enterprise management system provides among others the following main advantages:

- transparency for the management concerning the whole enterprise, i.e. structures, operational and management processes;
- consistent, non-redundant database content;
- avoidance of duplication of work and reduction of work complexity, especially with regard to data recording;
- avoidance of media breaks;
- consistent documentation of processes and support of approval workflows;
- uniform user interface.

By providing the aforementioned functionality, an EMS bridges the existing information gap between the management level and the operational level. This paper describes the approach and the system architecture of such an EMS. The approach was carefully conceived within the last five years and successfully implemented within the software product DHC VISION (DHC Business Solutions GmbH, 2013).

2 INFORMATION REPRESENTATION APPROACH

A database with the description of the enterprise organization, the business processes and associated information like forms, handbooks, IT systems, etc. is the basis of the system. Process orientation is the backbone of an EMS. Therefore, an EMS must provide functionalities for the graphical description and linkage of business processes to documents and organizational units. Different levels of process abstraction from a headquarters perspective up to location-specific variants and different types of process models (e.g. process maps, process hierarchies, BPMN diagrams, etc.) must be representable. Processes can also be seen as a kind of master data for an EMS. The semantics of business processes and their implementation can be described in a hierarchical way in form of a business process pyramid which provides the procedural basis for management solutions like e.g. risk management or audit management (Lux, Hess and Herterich, 2013).

In this paper, we concentrate on the approach to represent master data of an EMS in a generic and very flexible manner. In the following, we denote any kind of master data as information resp. information object.

Because of the heterogeneity of information and the goal of integrating several stand-alone management solutions in one EMS, the following functional requirements must be addressed:

- A generic representation concept for any kind of information must be provided - is it a process, an organizational item or any other kind of item (document, risk, measure, etc.).
- There must be a versioning mechanism to log information changes.
- Information must be available in different languages.
- Information must be modifiable according to different locations/sites of an enterprise.
- Information must be related to each other, e.g. it must be possible to link a document to a process step.
- A sophisticated and flexible search routine must exist to handle the different versions, language- and location-specific occurrences of certain information.
- Traceability of any kind of information object must be guaranteed.

Besides these, the following non-functional requirements should be addressed:

- Security: Only users with corresponding rights are allowed to read, create, modify or delete information objects.
- Scalability / performance: The 4-tier client/ server architecture (see section 4 in more detail) of the EMS is scalable and is able to handle hundreds of users with acceptable response time behavior.
- Maintainability and administration: The EMS should be easy to maintain. This is realized by mechanisms like Active Directory linkage and Single-Sign On (SSO).

Within a world-wide operating enterprise, information of an EMS can be created, modified, read or deleted depending on the location, language and role of a user. Location, language and role of an EMS user should be encapsulated in one or more login profiles.

To efficiently manage any arbitrary information, it has to be associated with meaningful object types like e.g. audit, risk, measure, process, process step, control, operating procedure etc. The main idea of our approach is that each kind of information is managed in a so-called information object, which

has a certain object type. The object type classifies the information. Each object type has a freely configurable set of attributes, which describes the type in more detail. Free configuration both means selection of pre-defined attributes as well as definition of new, enterprise-specific attributes (customizing).

Information objects can be related to each other by typed links. Typical examples are "is process-oriented superior", "is reference from", "is informed by", "has risk", etc. As object types, link types are also freely configurable and can be described by attributes. Link types are used to represent process-oriented relationships (e.g. is executed by), hierarchies (e.g. is superior), topic-oriented relationships (e.g. has risk) or general connections (e.g. is reference from).

Furthermore, information can be structured by so-called structural units, which are comparable to a folder structure in a file system. Structural units have an object type, too. All system functions regarding data management are realized on the basis of information objects and structural units.

An EMS object – either an information object or a structural unit – now consists of exactly one object wrapper (logical view) and one or more object contents (physical view) with respective attributes, see figure 1.

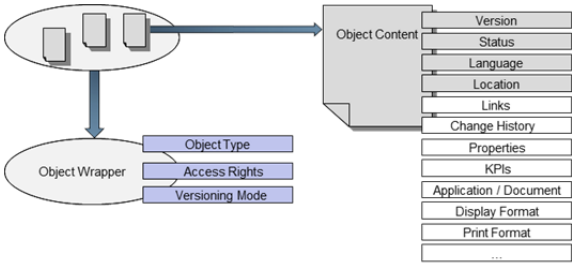

Figure 1: EMS Information Object Model (simple).

The object content contains the proper information and is identified by version, status (e.g. published, in progress/draft), language and location.

It has the following attributes:

- Version, status, language, and location are the identifiers of the object content within the object wrapper and are required for context resolution (details see below).
- Links: Typed links have their anchor on the object content itself, but refer to all derived information collected within an object wrapper (details see below).
- Change history: All changes to object content can be logged as well.
- Properties: Via the object type, attributes can be freely defined. These attributes are then manageable on the object content.
- KPIs: Information objects can manage, compute and aggregate KPIs.
- Application/Document: The file or application associated to the information object is managed here.
- Display format: If the attribute "application/document" contains a document, the document is automatically converted into a display format (HTML or PDF) for display.
- Print format: If the application/document attribute contains a document, the document is automatically converted into a print format (PDF or source application format) for printing.

The object wrapper contains the different object contents which can be seen as "variants" of the same information. The object wrapper of an EMS object has the following attributes:

- Object type: This attribute is used for typing objects. Most of the configuration settings are executed on the object type.
- Access Rights: Read permission is set for all object contents. Write, delete and translate rights can be defined according to users of different locations/enterprise sites.
- Versioning mode: The versioning mode defines the procedure how new versions of an information object are build.

Information objects are connected with other information objects. The relationships are also represented via typed links (see figure 2). Such a link always leads from the object content to the object wrapper of the target object. The most appropriate object content within the target object is determined via a so-called context resolution algorithm (see below) and is displayed to the user.

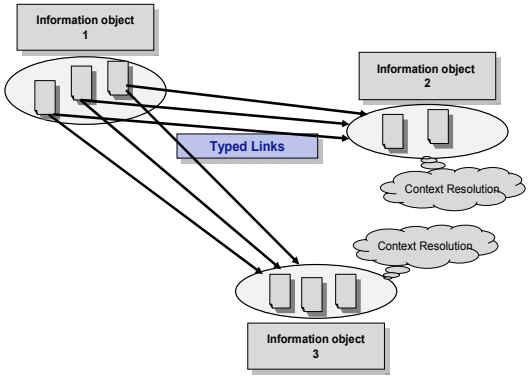

Figure 2: Links between Information Objects.

The object wrapper and its attached information contents allow for a decoupling of links between information objects and their respective individual "variants". Since all EMS functions are based on typed information objects and have not been implemented on specific object contents, this approach exhibits a very high flexibility for designing a generic database for an enterprise management system.

3 CONTEXT RESOLUTION ALGORITHM

In what follows we give a precise description of the context resolution procedure. If an EMS information object is accessed by a user, the algorithm determines the most appropriate object content within the object wrapper. For this purpose, it uses the following criteria:

- user role, e.g. reader or author;
- user rights, e.g. read or create or modify or delete or translate;
- language, e.g., English (EN), French (FR) or German (GER);
- location, e.g. corporate headquarters or location London, Paris, Munich etc. This concept is in the style of the SAP client concept.

Location, language and user role can be derived from the login profile. User rights are granted individually for each EMS information object. Each location has its associated original language, in which the information is maintained (see figure 3).

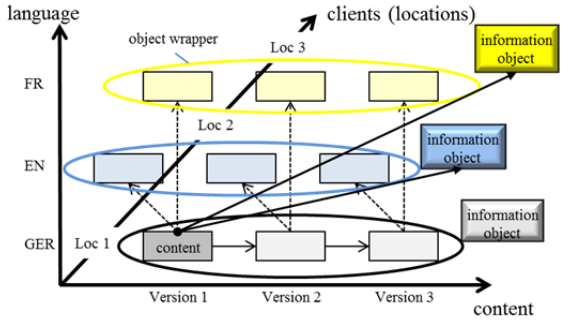

Figure 3: EMS Information Object Model (more complex).

The most appropriate content of an EMS information object is determined according to the following rules:

Rule 1: Only One Location and only One Language

- A user with the role "reader" and the corresponding access rights gets the latest version with status published.
- A user with the role "author", who only has read access rights on that object, gets the latest version with status published.
- A user with the role "author" and the corresponding rights for modification gets the latest version with status "in progress", if such a version exists. Otherwise, the latest version with status published is opened.

Rule 2: Several Languages

- If an actual version of the user's login language (e.g. French) exists, this version is displayed; otherwise, the latest version in English is displayed.
- If that version does not exist, the information is displayed in its original language (e.g. German).

Rule 3: Several Locations (SAP-like Client Concept)

- If an actual version in the "login-location" exists, this version is displayed.
- Otherwise, an actual version is searched for in the "predecessor location". The predecessor is determined by an algorithm following the information object link backward to the EMS object from which it was created. This backward step is repeated until the appropriate content is found in the initial EMS object at the latest.

Rule 4: Several Locations and Several Languages

- In general, the following rule applies: actual version dominates language version.

To clarify the context resolution algorithm, consider the following examples (see figure 4).

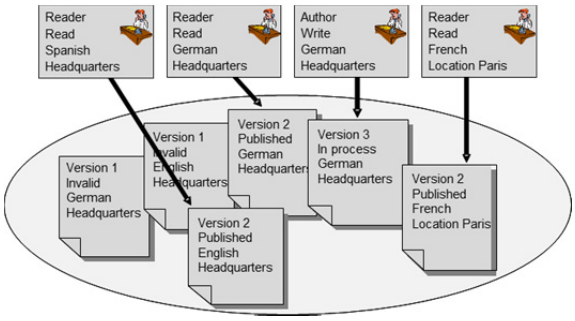

Figure 4: Context Resolution.

Example 1: A German-speaking employee located in the German Headquarters gets the actual version of the information object (Version 2 with status "published"), if she has read access; as an

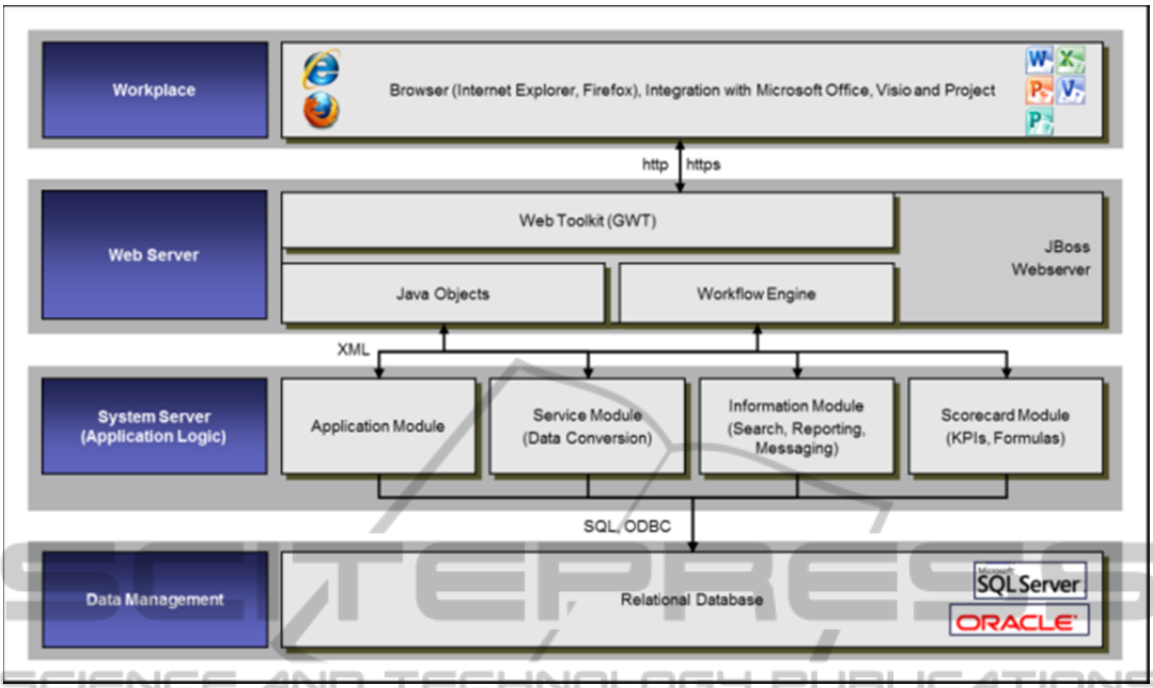

Figure 5: System Architecture.

author with write access rights she gets Version 3 with status "in progress (draft)". Given the history of an information object by a version list, an author can also open e.g. the latest published version.

Example 2: A Spanish-speaking employee located in the German Headquarters gets the actual version 2 with language English and status "published", because there is no Spanish version of the information object.

Example 3: A French-speaking employee located in Paris gets actual version 2 with language French and status "published". This information object was derived as a location-specific variant of the Headquarters information object.

4 SYSTEM ARCHITECTURE

On the basis of the described approach the EMS DHC VISION was designed and implemented. Technically, it is based on a scalable 4-tier architecture as presented in figure 5.

All data are stored in a central repository implemented on a relational database system from Oracle or Microsoft SQL Server. Communication with the system server is realized via SQL and ODBC.

The system server, which contains the application logic, consists of four separate servers, which communicate with each other via a self-implemented protocol based on XML. Customers can use that protocol to integrate legacy applications and exchange data with the DHC VISION system. The application module contains the business logic of the EMS. The service module transforms documents from their source format to their defined display, print or download format. The scorecard module is responsible for the management, calculation and aggregation of performance indicators. The information module handles modification of data and search queries and triggers actions according to data modification. For reasons of scalability, each module can be instantiated a number of times and can be run on the same or on different physical machines.

The web server is used to provide the information for presentation. Here, a data cache is realized for quicker data access.

The workplace layer contains the graphical user interface of the software (Tidwell, 2011). Figure 6 presents a rough overall impression of the interface. A sales process is presented both graphically as a process structure diagram and textually with its corresponding information stored in different tabs. The user interface is web-based and runs with established browsers like Internet Explorer, Firefox etc.

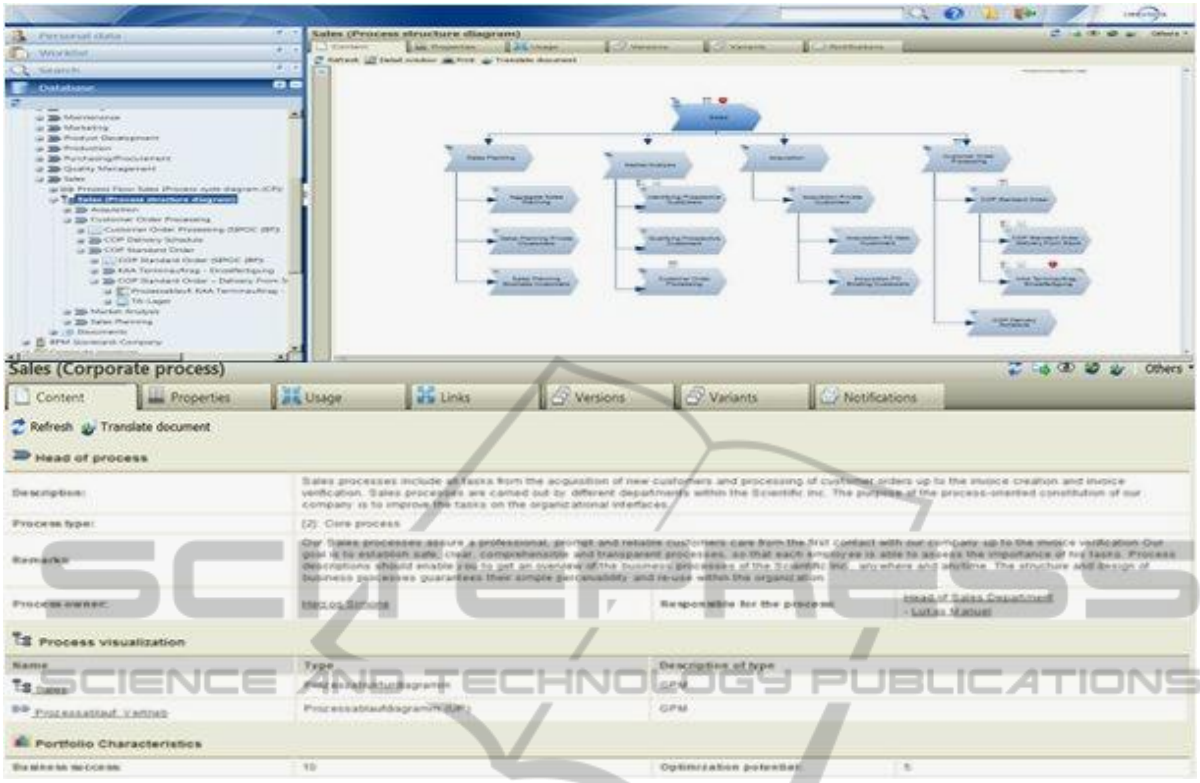

Figure 6: User Interface, here Process Visualization and Process Cockpit.

MS Office products, MS Visio and MS Project are integrated in DHC VISION, so that a user can create, read and model the information objects with his/her familiar working tools. The user interface also provides functionalities for handicapped persons (e.g. screen reader support, optical enlargement).

5 RELATED WORK

Most of the work described in this paper is influenced by graph theory (Chein and Mugnier, 2009), knowledge representation approaches, especially semantic networks (Sowa, 1991), and effective techniques for retrieving and processing semi-structured and XML-based data via the evaluation of path expressions (Abiteboul, Buneman and Suciu, 1999). Nevertheless, the implemented DHC VISION core functionality to manage a network of information objects is self-conceived and unique.

Within the last years, more and more software vendors, originating mainly from the area of business process management systems, pursue comparable approaches to develop integrated enterprise management systems.

Companies like e.g. BOC Group (BOC Group, 2013), BWise (BWise, 2013), EMC Corporation (EMC Corporation, 2013) or Software AG (Software AG, 2013) provide tools with similar approaches and features. Because all these systems are proprietary ones, we do not know their internal information representation structures and the underlying information processing algorithms.

Nevertheless, confirmed by feedback of interested parties and customers, our approach is rated as a sound and sophisticated one with regard to flexibility and extensibility. Several awards won by the software DHC VISION within the last two years emphasize this statement (DHC Business Solutions GmbH, 2013).

6 CONCLUSIONS

The technical approach of DHC VISION is a state-of-the-art 4-tier client/server architecture for an enterprise management system. All the underlying information can be addressed indirectly and dynamically on the basis of a complex information network with typed links and a sophisticated

versioning mechanism. This generic approach is used to describe and specify well-known management methods like BPM, QM, ICS, EAM by defining their semantic data as generic EMS information objects; therefore, also customer-specific management methods can be easily integrated as add-on module to the core system. New information objects for new management solutions can be specified by a customizing component and do not have to be implemented in a hard-coded form.

Within the last three years, the DHC VISION system was completely re-designed and implemented towards an integrated EMS with a huge set of standard management solutions. The concept of EMS information objects guarantees the re-usability of important enterprise information like processes, process steps, organizational charts (organizational units, roles), IT systems and general objects like resources, documents, training material, measures, risks, audits, controls, KPIs etc. All these objects can consistently be used for the definition of an integrated enterprise management solution with focus on business process management, quality management, audit management, internal risk and control management, enterprise architecture management, compliance management.

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