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Towards a Framework for Corporate Data Quality Management

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Abstract

Today's market environment requires companies to adapt to new business models and to improve their operational excellence in terms of process efficiency and organisational effectiveness. Agility and flexibility build on high-quality corporate data and powerful corporate data management. This paper proposes a framework for corporate data quality management. The structure of the framework consists of the three layers of Business Engineering (strategy, organisation and information systems) as well as the two perspectives of data management (governance and execution). The scope of the framework is deduced from the state of the art in the domains of IT and data management such as COBIT and ITIL. The framework helps to determine which tasks need to be performed for improving corporate data quality and how they are interrelated. It helps to combine corporate data management to the business objectives of an organisation and to anchor it efficiently within the existing organisational structure.

Keywords

Data Quality, Data Quality Framework, Corporate Data Management, Corporate Data Quality, Business-IT Alignment

Introduction

Today, companies are forced to continuously adapt their business models. Global presence requires harmonised business processes across different continents, customers ask for individualised products, and service offerings must be industrialised. This certainly has an impact on the business process architecture and the IT strategy of organisations. But in the end, a major prerequisite to fulfil those changing business requirements is the efficient and effective management of corporate data.

In addition to such strategic factors, however, there are also several operational aspects which directly rely on high-quality corporate data. The following list outlines some of the most relevant areas for which corporate data management plays a crucial role:

- *Business networking.* Many industries are characterised by decreasing ranges of manufacture. Cooperating with business partners along the value chain requires consistent and aligned data models. In the retail industry, for example, harmonised material master data between retailer and supplier would save up to three percent of the overall supply chain costs (Capgemini 2004).
- *Customer management.* Companies make widespread use of call centres and self-service channels to interact with customers. However, they still encounter severe data quality problems such as mismatches in addresses, missing information on order statuses, misleading marketing campaigns, etc. (Reid & Catterall 2005).
- *Decision-making and business intelligence.* Increased awareness of public reporting and shorter product life cycles demand secure decisions. For this purpose, companies need to consider the quality of data sources which provide input for business intelligence applications and decision-making processes. For the latter, organisations need a clear understanding of data quality management, and how quality is measured and improved (Price & Graeme 2005) – particularly during the “production” of data.
- *Regulatory compliance.* Companies need to comply with an increasing number of regulations. There are prominent ones with cross-industry applicability, such as the Sarbanes-Oxley Act, as well as industry-specific directives. They add new requirements to data storage, availability, security and management which can only be fulfilled with efficient data governance in place (Wenk & Bertrand 2005).

Despite the fact that data quality has an enormous impact on business aspects, the responsibility for improving and managing corporate data is often assigned to the IT organisation (Friedman 2006). This corresponds to the perception that many companies try to cope with data quality issues by simply implementing a data management system. One of the major reasons for the insufficient treatment of the topic is the lack of transparency on its interdependencies with business issues. A solid business case is very often missing (Lee et al. 2006). What is needed is an integrated approach that combines business-driven and technical perspectives on data quality management (DQM).

A number of concepts and approaches are available in the domain of DQM, such as Total Data Quality Management (TDQM) (Huang, Lee & Wang 1999; Wang 1998; Wang et al. 1998), Total Quality data Management (TQdM) (English 1999), Total Information Quality Management (TIQM) (Nohr 2001) and the framework for information quality management (Eppler 2006). Focussing on the particular guidance, practitioners need for implementing and sustaining successful DQM, the approaches have certain shortcomings. First, neither relevant design objects are identified nor organisational responsibilities defined which is of particular importance when addressing DQM in a cross-divisional and corporate context. Second, the existing concepts lack a strategic orientation including the business view of DQM, and third, methods and tools for DQM realisation as well as operative measures for data quality are not sufficiently specified.

This paper takes up on the first two aspects and proposes a framework for Corporate Data Quality (CDQ) management that provides an integrated reference for the implementation and management of data quality in corporate structures. The framework addresses both business-related and technical questions, such as organisational alignment and implementation of data architectures. The framework helps to determine the tasks for instituting DQM in order to improve corporate data quality on a sustained base and outlines how these tasks are interrelated.

The paper is organised as follows. The background section outlines related work to corporate data quality. It starts with necessary definitions and outlines existing approaches to data quality management. It then analyses the possible contribution of IT and quality management to DQM. The following sections propose our framework for CDQ Management – the CDQ framework. The framework design section is dedicated to the deduction of the framework structure and its scope. Thereafter, the six CDQ practices which constitute the overall framework are described. The paper closes with a discussion of the results and gives an outlook on future research.

Background

Corporate Data and Data Quality

A large body of literature has investigated the demarcation between data and information. In the data quality context, data are generally considered as simple or “raw” facts. Information is data put into a context or data that has been processed (Huang, Lee & Wang 1999; Price & Shanks 2005). Conforming to this differentiation, we explicitly refer to the term “data” without neglecting the strategic dimension that is inherent due to the interdependencies outlined above. Data represents the foundation for generating business-related information and serves as a key enabler for efficient processes.

Data quality is defined with two consentient aspects: first, the dependence of perceived quality on the user’s needs; second, the so-called “fitness for use”, which is the ability to satisfy the requirements of intended use in a specific situation (Olson 2003; Redman 2000). One common denominator of these definitions is that data quality is considered a multi-faceted construct, consisting of a set of quality attributes (so-called data quality dimensions) requiring consumer assessment (Wang & Strong 1996). Examples for these dimensions are accuracy, completeness, consistency, relevancy and timeliness.

In the context of this paper, we emphasise the corporate scope of data quality. The challenge of guaranteeing good data quality is particularly salient in global and decentralised companies. They produce diverse products or services in more or less independent business units and operate in several countries. These companies possess a diversified portfolio of data storing and processing systems due to a history of mergers and acquisitions, deviant requirements of business units and different regulations among countries. Data quality problems often occur when gathering information across business functions or organizational boundaries from several distributed systems (Lee et al. 2006). Therefore, our focus in this paper is on multi-business and multi-national firms looking for a corporate-wide approach to managing data quality.

Data Quality Management

Data management refers to defining the data architecture including enterprise-wide data models and data modelling standards; data administration including data dictionaries and data management processes; and data management systems including their design and operations (Krcmar 2005; Stahlknecht & Hasenkamp 1999).

We refer to data quality management as quality-oriented data management, i.e., data management focussing on collection, organisation, storage, processing, and presentation of high-quality data.

TDQM is the best known approach to Data Quality Management (Huang, Lee & Wang 1999; Wang 1998; Wang et al. 1998). The TDQM program was initiated at the MIT in 1991 with the long-term vision to build a new paradigm for data quality management and to develop a rigorous theoretical foundation for data quality (MIT 2007). The key message of TDQM is to manage information as a product by following four simple principles. The four principles of the information product approach in TDQM are understanding consumers' information needs, managing information as the product of a well-defined production process, managing information as a product with a life-cycle, and appointing an information product manager (Wang et al. 1998). The "information product approach" argues that information needs to be treated as a product, i.e., as an end deliverable that satisfies consumer needs (Wang et al. 1998). (Lee et al. 2006, 171ff.) used this approach for elaborating ten guidelines for a data quality policy – the so-called Data Quality Principles (see section "Framework Scope" for further explanation). The TDQM methodology is based on the TDQM cycle, which outlines the definition, measurement, analysis and improvement of information quality. These tasks are performed in an iterative manner. (Nohr 2001) advances the MIT work with his Total Information Quality Management (TIQM) approach. The approach is based on the TDQM cycle and is complemented with six concepts, which has not been explicitly stated in TDQM. The concepts are customer orientation, leadership, teamwork, continuous process improvement, success measurement, and benchmarking.

The Total Quality data Management (TQdM) methodology proposed by (English 1999) consists of five processes for measuring and improving information quality and an overarching process to establish the information quality environment. The goal of TQdM is improving business performance and customer satisfaction through information quality improvement. Most recently, (Eppler 2006) defined a framework for information quality management focusing on knowledge-intensive business processes. The framework consists of four components: levels or categories of information quality criteria, phases of an information life cycle, information quality criteria, and management principles.

The presented models and methodologies address particular aspects in the domain of DQM. With regard to the motivation for the topic, however, a number of shortcomings of the existing work can be identified. First and foremost, it is the lack of an integrated view incorporating a more long-term, strategic orientation of DQM in which relevant design objects are identified and organisational responsibilities are defined. The term "design objects" refers to objects in the company's environment that need to be considered and actively managed for a successful DQM. Furthermore, the precise methods and tools that need to be applied for the realisation of corresponding operative measures are not sufficiently specified (e.g. Wijnhoven 2007; English 1999; Huang, Lee & Wang 1999). From a practitioner's perspective, however, this guidance is from particular importance.

IT and Quality Management

Because of the outlined deficiencies of existing DQM approaches, we extended our focus and investigated adjacent research fields that may provide input for closing – or at least minimising – the identified gap. Because DQM comprises aspects of both quality management and data management, which in turn is mostly seen as part of IT management, we identified quality and IT management as being potentially capable for solving this task.

The goal of *IT management* is to ensure that IT is a valued and embedded element for business and is enabling, not constraining, the company's overall strategy (Sambamurthy 2000). This generic objective is operationalised through reference frameworks which help IT managers to analyse IT issues from a business perspective and transform IT departments into service providers (cf. Mayerl, Tröscher & Abeck 2006). Among the best-known and most-used frameworks are the IT Infrastructure Library (ITIL) and the Control Objectives for Information and Related Technology (COBIT) (Curtis et al. 2005).

- ITIL (Office of Government Commerce 2006) is a best-practice reference model for IT service management which has developed into a de facto standard. The British Office of Government Commerce released the last of eight books that build ITIL in 2005. ITIL gives guidance for IT service management, mainly dealing with the delivery and support of IT services.
- COBIT (IT Governance Institute 2005) is an IT Control and Governance reference framework which defines a set of control objectives for IT processes. ISACA and the IT Governance Institute have been developing the framework since 1993. In its current version 4.0, the framework distinguishes 34 high-level control objectives.

Both frameworks cover a wide range of IT management processes which we use to deduce practices for CDQ management.

The number of methods and tools in *quality management* are manifold and their scope is extremely broad. Widely applied concepts include Total Quality Management (comprising the EFQM Excellence Model (EFQM

2003), the Malcolm Baldrige National Quality Award (NIST 2007) or the ISO 9000 series standards (ISO 2007)) and Six Sigma (e.g. Pande & Holpp 2002). These management methods are process-oriented, focusing on process efficiency and zero-defect quality. The data underlying these processes and their quality are not incorporated. Hence, we cannot deduce new insights addressing the specific characteristics of DQM from research on quality management. However, quality management approaches can provide helpful input concerning e.g. the general procedure of anchoring DQM within an organisation.

CDQ Framework Design

Framework Purpose

Existing concepts for DQM fall short of incorporating a long-term, strategic orientation, identifying relevant design objects, and defining organisational responsibilities. We propose a framework for CDQ that explicitly addresses these open points. We refer to a framework as a model to structure relevant elements and interdependencies of a certain domain at a high level of abstraction with no particularly formalised language. A framework aims at providing an overview of the domain as well as yielding insight into the design objects of the domain and their interrelationships (Meise 2001). It is a frame of reference where thoughts can be placed and organised systematically which fosters a more rapid problem solving process (Ulrich 1984). Accordingly, in the first step of the framework design we identify the structural dimensions and the scope of the framework.

Design Approach

Structural Dimensions

One of the major requirements of an integrated CDQ framework is its capability to not only cover technical or system-related aspects but also business-related and organizational issues. Since related work does not fulfil this need in the domain of CDQ, we refer to a broader domain, namely the interrelationship between IT and business goals of a company. This interdependency has already been emphasised by (Davenport 1993), addressing the overall linkage between strategy and IT via processes, and (Hammer & Champy 1993), who explicitly deal with the supportive role of information technology for business processes. Meanwhile, the strategic dimension is also expressed by the keyword “fundamental” within their definition on Business Reengineering. Inter-linkage between business strategy, processes and IT has further been concretized and operationalised in the field of Business Engineering (Österle & Winter 2003). This approach does not only support the “top-down” development of information technology, but is rather based on bi-directional links between the three layers in order to allow for business innovation which is initiated by technology (cp. Winter & Landert 2006). With reference to Business Engineering, the first structural dimension of the CDQ framework is the distinction between three *horizontal* layers: strategy, organisation and information systems.

Following the idea of different phases of more or less radical changes in business development and transformation (Dubs et al. 2004), the CDQ framework must also fulfil the need to distinguish between governance and execution. We refer to related work in the area of IT and data management which indicates that two perspectives exist, namely “governance” and “execution”. The governance perspective sets the stage by defining what needs to be done, who is involved and how responsibilities are distributed. During execution the specified functions and tasks are fulfilled. Consequently, we introduce a second structural dimension into the CDQ framework, namely two *vertical* columns for governance and execution. Governance comprises framework elements on the strategic, organisational and information system-related layers and forms the decision-making foundation for CDQ. In contrast, the second column deals with the actual execution of data quality policies, the monitoring of data quality and operational problem-solving on the three layers. However, execution and governance are not independent of each other but instead closely interlinked. Governance and execution form a control loop in order to continuously review and adjust the single elements if necessary.

Framework Scope

In accordance with its two structural dimensions the CDQ framework spans a matrix including six elements which we call “practices”. The totality of practices forms the scope of the CDQ framework. We deduce the content of these practices from existing DQM and IT management approaches. The concepts which deliver the most substantial input to the CDQ practices are COBIT, ITIL and Data Quality Policies (see also Table 1):

- The COBIT reference framework defines 34 high-level control objectives for IT processes. Every control objective supports business goals and defines a number of sub-control objectives to monitor compliance with these goals. The IT processes are grouped into four domains: Plan and Organize (PO1 to PO10), Acquire and Implement (AI1 to AI7), Deliver and Support (DS1 to DS13), and Monitor and Evaluate (ME1 to ME4) (IT Governance Institute 2005).

- ITIL defines two core areas of IT service management: Service Support and Service Delivery. Service Support concentrates on the effective operation and maintenance of IT services. It encompasses incident management, problem management, configuration management, change management and release management. Service Delivery focuses on how services are provisioned and enhanced. The key processes of service delivery are service level management, IT financial management for IT services, capacity management, IT service continuity management and availability management (Zarnekow, Hochstein & Brenner 2005). The essential input for our framework consists in the topic of service level agreement and management (not explicitly mentioned in Table 1) supporting a proper definition of organisational structures to enhance organisational anchorage of DQM.
- (Lee et al. 2006, 171ff.) have elaborated ten guidelines for a data quality policy forming the basis for successful data quality efforts. They explicitly accentuate the significance of anchoring data quality in the organisation as well as a clear definition of roles and responsibilities. The overarching guideline is to treat information as a product.

Table 1: Contribution of related work to CDQ practices

	COBIT	DQ Policy
<i>CDQ Governance</i>		
Strategy	PO1: Define a strategic IT plan ME3: Ensure regulatory compliance	Guidelines 2, 3
Organisation	PO4: Define IT processes, organisation and relationships ME4: Provide IT governance PO8: Manage quality	Guidelines 2, 4, 7
IS	PO2: Define the information architecture AI2: Acquire and maintain application software	Guideline 5
<i>CDQ Execution</i>		
Strategy	PO6: Communicate management aims and direction	Guidelines 6, 7, 8, 9
Organisation	DS1: Define and manage service levels DS7: Educate and train users DS8: Manage service desk and incidents ME1: Monitor and evaluate IT performance	Guidelines 2, 7, 9, 10
IS	DS13: Manage operations	

Mapping the contributions of related work onto the structure defined above, we propose the CDQ framework depicted in Figure 1. The six CDQ practices are detailed in the following chapter.



Figure 1: The CDQ Framework

In accordance with IT management research, the key principle of CDQ management is the alignment with the company's strategy and its environment (cf. Sambamurthy 2000). All data quality policies, practices, principles, standards and the data quality architecture reflect and support the business view.

CDQ Practices

CDQ Governance

Develop a CDQ Strategy

A *data quality strategy* is required to manage and direct all data quality activities in line with the overall business strategy. The data quality strategy includes the strategic objectives which are pursued by data quality management, how it is aligned with the company's strategic business goals and its overall functional scope. Moreover, it makes statements about the involvement of its stakeholders which means analysing and comprehending the role of data within the organisation.

Based on the CDQ strategy, a portfolio of strategic *data quality initiatives* is planned. These initiatives start with a status quo *assessment of data quality*. The assessment helps organisations to identify the most critical areas for improvement. Subsequent assessments track progress in CDQ. The establishment of such a *review process* including audit charter, ethics, standards and plan of audit work, ensures compliance with laws and regulations.

This practice also includes the development of a *business case* for data quality management. Its realisation materialises in the portfolio of strategic initiatives.

Design the CDQ Organisation

The first activity on the organisational layer is determining the information needs of internal and external data consumers (Lee et al. 2006, 128). For example, sales representatives may need real-time data about changes in customer accounts. Business processes that produce this data, called "*data manufacturing*" processes, must be well defined and must contain adequate controls for quality assurance, inspection, production and delivery time management (Ballou et al. 1998).

A CDQ organisation must define clear *roles and responsibilities* across divisional boundaries. The role assignment has to ensure accountability, authority and supervision as well as the involvement of senior executives and business management and encourage desirable behaviour in the use of data. Examples of organisational structures can be found in (Dyché & Levy 2006; Russom 2006).

To measure and assure data quality throughout the whole data life cycle, companies specify *metrics and performance indicators* based on the data quality dimensions that fit consumers' information needs. These metrics ought to be linked to the company's general goals and objectives (Kovac, Lee & Pipino 1997) and can be gathered in a (Balanced) Data Quality Scorecard (Loshin 2001). The creation of such a scorecard provides an efficient means to continuously monitor and manage data based on key performance indicators. Furthermore, companies establish data quality *standards* and decide whether to use external (international, national, or industry) or internal standards, and the organizational range (global/local) of standards.

Metrics, standards, roles and responsibilities need to follow defined data quality requirements, policies and procedures that assure control, quality assurance, risk management and security. A policy example is the involvement of data quality representatives in relevant decision processes.

Design the CDQ IS Architecture

This practice comprises the development of a common *information object model* for all involved organisational units. It ensures a consistent understanding of data across the enterprise and contains a set of metadata that defines data elements, classification schemes and security levels. Furthermore, it describes rules and constraints for populating data items.

Based on the common information object model, metadata are collected in a *Business Data Dictionary (BDD)* describing important characteristics of data entities, such as their relationship to other entities, responsibilities and possible values facilitating database and application engineering (English 1999, 482) as well as a semantically unambiguous understanding of enterprise-wide used information objects.

Information system support includes the definition of the system architecture which supports the data quality management, i.e. systems that store and distribute the data, systems which allow for data management processes, and systems which are used for data quality improvement measures.

Table 2 summarises the activities within the perspective of CDQ governance.

Table 2: Tasks within the CDQ governance practices

Develop a CDQ Strategy
<ul style="list-style-type: none"> • Develop a data quality strategy including strategic objectives • Define a portfolio of strategic data quality initiatives • Formulate the business case • Carry out a status quo assessment and establish a review process
Design the CDQ Organisation
<ul style="list-style-type: none"> • Determine consumers' information needs • Define "data manufacturing" processes • Define roles and responsibilities across divisional boundaries • Specify data quality metrics and standards • Establish policies and procedures
Design the CDQ Architecture
<ul style="list-style-type: none"> • Develop a common information object model • Create a business data dictionary • Define information systems support

CDQ Execution

Communicate and Control the CDQ Strategy

Once the CDQ strategy has been defined, one of the main tasks on the strategic layer is the development and execution of a communication plan. (Lee et al. 2006, 9) recommend using rationales such as "data of high quality increases customer satisfaction" to motivate active participation in data quality initiatives and ensure that the organisation remains engaged. The above-mentioned (Balanced) Data Quality Scorecard should be used as instrument to facilitate the communication process as it helps to operationalise relatively abstract long-term objectives by means of concrete measurable target values.

Since strategic realignment of CDQ management requires a change in the behaviour of employees, this practice should make intensive use of measure to accompany *organisational change management*.

Within this change process the establishment of a *learning culture* by following a policy of rewards and sanctions, motivating open reporting on data quality problems, and making sure that data quality policies and standards are easily accessible plays a vital role.

Continuous *scanning of changes* in consumers' needs, the market and relevant regulations is part of the review process. Rationales for changes in the CDQ strategy have to be communicated.

Execute and Monitor CDQ Processes

Effective CDQ management requires compliance with standards, policies and procedures defined in the governance phase. *Compliance is monitored* according to previously defined metrics and performance indicators, and reported to stakeholders. The usability of data quality practices has to be questioned regularly and may result in their adaptation. The monitoring activities refer to data quality metrics, their impact on business key performance indicators, as well as to the efficiency and quality of data management processes themselves.

An effective *training program* reduces user errors, increases productivity and increases compliance with key controls. Education addresses core data principles and data quality practices complemented by role-specific training. In particular, data collectors have to understand why and how consumers use data.

Operate and Maintain the CDQ IS Architecture

As a cornerstone of the CDQ framework, this practice deals with the operation and maintenance of the IS architecture for data quality management as designed and specified in the related governance practice. It includes the systems for storage and distribution of relevant data (such as Enterprise Resource Planning systems)

as well as systems for the management and improvement of data quality. The latter include systems for data quality analysis, for data cleansing and transformation, for meta data management, and for the support of data management processes and reporting of data quality.

The complete and accurate processing of data requires effective management of data processing and maintenance of hardware. An effective operation helps maintain data integrity, and reduces business delays and IT operating costs. It includes capacity management, availability management, continuity management and change management. Capacity management encompasses IT performance and workload balancing of IT resources to ensure optimal use of hard- and software. With availability management the organization plans, assures and improves the availability of IT infrastructure, hard- and software as well as internal and external suppliers. Through continuity management, negative effects on core business processes caused by disastrous and unpredictable events are minimised. Change management coordinates and controls changes to the IT infrastructure, such as new business requirements, new regulations or incidents. Table 3 provides a recapitulating overview of the activities within the perspective of CDQ execution.

Table 3: Tasks within the CDQ execution practices

Communicate and Control the CDQ Strategy	
•	Develop and execute a communication plan
•	Carry out appropriate organisational change management measures
•	Cultivate a learning culture
•	Scan the environment for changes
Execute and Monitor CDQ Processes	
•	Monitor data quality levels
•	Monitor efficiency and quality of data management processes
•	Introduce an effective training program
Operate and Maintain the CDQ Architecture	
•	Operate and maintain systems for the storage and distribution of data
•	Operate and maintain systems for data quality analysis, for data cleansing and transformation, for meta data management, and for data management processes

Conclusion and Outlook to Further Work

Today, companies are confronted with the need to establish effective and efficient management of corporate data in order to be able to leverage new business models and to improve operational excellence. Existing research falls short in defining an integrated CDQ approach that is needed to address these challenges. We proposed a framework that, on the one hand, allows for the alignment of technical aspects of corporate data management with business-related issues, and, on the other hand, clearly distinguishes between governance and execution practices. The latter enables companies to establish the framework as a cross-function within a decentralised organisational structure.

The framework presented in this paper has so far encountered positive feedback in a first evaluation cycle with data quality managers in selected European multi-national companies where we intend to apply and implement the CDQ Framework. The identified design objects and practices were considered an important starting point for CDQ management. However, a formal validation and evaluation of the framework is still missing. Future research should therefore investigate these limitations of our research so far and extend this validation of applicability and impact, but in the meantime focus on the elaboration of techniques and practical guidance for all six CDQ practices we identified. Among those are e.g. semantic technologies and semiotic approaches for effective meta data management.

In order to provide practitioners with an easy-to-use tool guiding them in endeavour for CDQ, we need to further detail the outlined practices and enrich them with a set of methods and procedure models for the different design objects within the framework. This set of methods can then serve as a pool from which companies can extract the relevant methods necessary for their specific CDQ program.

Finally, the proposed framework provides the basis for data quality maturity assessments. Once an organisation assesses its status quo, it needs concrete guidance on how it may improve. To this end, maturity models specify

practices to step from one maturity level to the next. The Data Governance Maturity Model proposed by the IBM Data Governance Council (IBM 2006) provides a source which can be advanced to a data quality maturity model, with the practices defined in the CDQ framework building the maturity disciplines.

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