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Incorporating Information Quality Management into EAI Processes

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ABSTRACT

Nowadays Enterprise Application Integration (EAI) is rather a technical problem than an organizational issue in enterprise systems. Due to the increased complexity of EAI processes, it is difficult to guarantee the information quality (IQ) without scientific process control. Information Quality Management (IQM) highlights the control of the business processes by resolving IQ problems through IQ definition, measurement, analysis and improvement. When considering EAI's emphasis on the integration of business processes and the information flow within an enterprise, they are potentially mutually complementary for the IQ improvement. However, there are very few studies carefully examining IQ improvement in EAI processes, and complementary nature of IQM and EAI. By analyzing the challenges of EAI to IQ, and theoretical foundations of incorporating IQM into EAI processes, this study proposes a framework to effectively improve the IQ of EAI processes, and suggests six propositions for future research.

Keywords

Information Quality Management, Enterprise Application Integration, information quality, framework, enterprise systems.

INTRODUCTION

The increasing deployment of enterprise applications alongside legacy systems makes Enterprise Application Integration (EAI) as a priority. However according to InfoWorld's 2002 Application Integration Survey of IT leaders, EAI is still a tough and expensive nut to crack despite advances in technology: 38% of *InfoWorld* readers see room for improvement in their EAI efforts (Yager, 2002). Information Quality (IQ) is one of the most important issues that should be improved (Themistocleous, 2004). However there are very few researches carefully studying this issue in EAI processes. Enterprise Information Integration could be an effort in that direction, however it focuses on technology and can not feed the problem very well from the organizational perspective (Gilbane, 2004). This study introduces Information Quality Management (IQM) to EAI surroundings and tries to answer IQ problems in EAI processes comprehensively.

IQM is a management tool which aims to increase business effectiveness by eliminating the costs of non-quality information and increasing the value of high quality information assets (English, 2002). Extensive literature exists on IQM, which has been investigated over the years both from strictly the technical perspective of data cleaning, and organizational perspective of management problems (Wang, 1998). Methodologies for IQM focus on the notion that the IQ must be managed at the enterprise level during its entire lifecycle (Ballou and Pazer, 1985; Wang and Strong, 1996).

EAI, in general, is the unrestricted sharing of data and business processes among any connected application and data sources in an enterprise (Linthicum, 2000). Also it is the creation of business solutions by combining applications using common middleware (Ruh, Maginnis and Brown, 2001). In the last decades, about 18,000 billion dollars was invested in EAI (IDC, 2001). This huge investment created a myriad of application systems, such as supply chain management, business to business integration, and web application integration, so as to help manage intra- and inter-enterprise activities. These systems, alongside legacy systems, have drawn the attention of top management and led them to realize the value of, and necessity for, EAI (Hey, 2000).

One of the goals of the EAI is to provide technologies and procedures so as to smoothen the information flow within an enterprise. However, it also increases the complexity of information processing which, in return, lowers the quality of information within the enterprise. For example, EAI uses complex middleware to transform information from one system format to another, which increases the probability that IQ will suffer. This will require us to adopt appropriate control on EAI processes, making the best use of its advantages and bypassing its disadvantages.

To some extent, improvement of IQ is the common goal of EAI and IQM. However, their emphases are different. EAI emphasizes the integration of business processes and the information flow within an enterprise, while IQM highlights the control of the business processes by resolving IQ problems through IQ definition, measurement, analysis and improvement. In spite of their differences, they are potentially mutually complementary for the IQ improvement of enterprise systems. On one hand, the complexity of the EAI processes needs the vigorous methodology of IQM to direct, control, and improve the IQ; on the other, IQM also needs the advanced EAI technology to provide effective implementation. In this paper, we will focus on the first part: incorporating IQM methodology into EAI processes.

This study has two purposes: to introduce the concept of incorporating IQM into EAI processes so as to improve the IQ, and to put forward a relative comprehensive framework to carry out the IQM in EAI processes with the hope of laying down the foundation to integrate the EAI processes into the whole company's quality management systems. In the following sections, we will elaborate the challenges of EAI to IQ, describe the theoretical background and overview of the framework, explain some important issues in the three main processes of IQM in EAI processes, and suggest six propositions for future research. Finally, we will make our conclusions.

EAI AND ITS CHALLENGES TO IQ

The buzzword "EAI" has attracted more and more attentions in recent years. However, what EAI is still an under-developed question. In the early days of EAI, some experts thought it was only a platform or technology of transforming information systems. Later, more and more researchers gradually recognized that it was not only a platform and technology, but a methodology (Linthicum, 2000; Ruh et al., 2001).

Essentially, EAI is the unrestricted sharing of information by reengineering business processes. Large volume of information processing exists in the EAI processes. Thus, this study regards EAI as not only methodology and technology, but the concept of knowledge management that combines information, processes, software and hardware resulting into the seamless integration of two or more current or future enterprise systems, allowing them to operate as one.

EAI aims to increase the IQ. However IQ in EAI is mainly restricted to information sharing, and information security. In contrast, there is a more comprehensive concept to address IQ problems and dimensions in the IQM. Studies have confirmed that IQ is a multi-dimensional concept (Ballou and Pazer, 1985; Ballou, Wang, Pazer and Tayi, 1998; Lee, Strong, Kahn and Wang, 2002; Wand and Wang, 1996; Wang and Strong, 1996). In this study we would like to adopt Wang and Strong's IQ dimensions as follows.

IQ Category	IQ Dimensions
Intrinsic IQ	Accuracy, Objectivity, Believability, Reputation
Accessibility IQ	Access, Security
Contextual IQ	Relevancy, Value-Added, Timeliness, Completeness, Amount of data
Representational IQ	Interpretability, Ease of understanding, Concise representation, Consistent representation

Table 1. IQ Dimensions

According to Ruh et al. (2001), the four basic building blocks of EAI architecture are communications model, method of integration, middleware and services. Middleware is the core of EAI architecture. From the business process point of view, the EAI architecture, especially the adoption of middleware, will do harm to the IQ. EAI processes will integrate many systems together, for instance the DSS system and CRM system. After integration, the whole system will include more data sources, more data processing links. According to System Theory, the independent systems will generate new and emergent properties after integration. The new properties, as well as complex procedures, will affect the IQ dimensions. Secondly, successful EAI implementation requires strong communication, coordination, and cooperation between information technology and business personnel. The fact will also greatly increase the probability of impairing the IQ based on the Software Engineering theory (Lee, Siau and Hong, 2003). Finally, EAI architecture requires business-mapping processes (realized by middleware) that are critical processes to maintain IQ. However these processes do not use standardized business process like ERP, which could possibly cause great IQ problems if not carefully controlled (Lee et al., 2003).

From the data point of view, diversity of data structures, ambiguity of semantics, and complexity of data processes are all greatly influence IQ. Different systems employ different data structure, such as structured data, unstructured data, and semistructured data. When integrated them together, IQ problems would appeared (Ziegler and Dittrich, 2004). More demanding is to integrate data described by different data models with heterogeneous semantics, the chance of IQ suffering is even higher (Terziyan and Kononenko, 2003). Grosh (2001) identifies an enduring set of data processes in EAI. Whether the data processes in inter-application integration (i.e., data translation, data migration, data replication, data aggregation, data propagation), or in extended enterprise integration (i.e., data affiliation, data participation, data articulation, data congregation), they approximately influence IQ in the same way. For example, the data aggregation process is one of the most important operations in EAI for online analytical processing and makes possible some intricate operations, but it is extremely complex, time-consuming and mass-data generating and results in great impact on most of the dimensions of the IQ, such as accuracy, objectivity, timeliness, completeness.

In a word, EAI is a process that integrates and optimizes other processes, and may be too complex to be managed by non-systematic methods. In this study, we propose the methodology and technology of IQM to manage the EAI processes and subsequently enhance the IQ.

THEORETICAL FOUNDATIONS AND OVERVIEW OF IQM IN THE EAI PROCESSES

The concept of IQM originates from the product quality management in manufacturing systems (Ballou et al., 1998). By analyzing the analogy that exists between quality issues in product manufacturing and those in information manufacturing systems (information systems), information manufacturing systems can be viewed as a processing system acting on raw data to produce information products (Wang, 1998). Then we can call information an “information product”. This perspective makes it possible that the IQM could be conducted based on the ISO 9000:2000 Quality Management Systems which also provides solid theory foundations of IQM in EAI processes. Many elementary researches have been done for making the IQM systematic and mature (Ballou et al., 1998; Eppler, 2001; Kahn, Strong and Wang, 2002; Pipino, Lee and Wang, 2002; Wang, 1998).

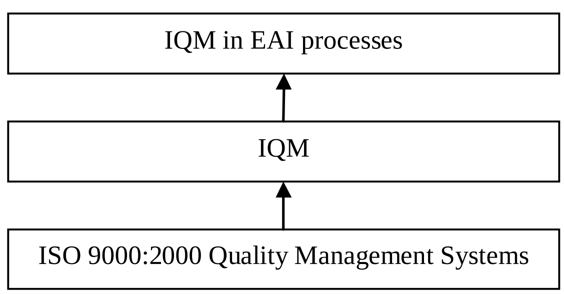

Figure 1. The relationship among the ISO 9000:2000 Quality Management Systems, IQM and IQM in EAI processes

ISO 9000:2000 Quality Management Systems, IQM and IQM in the EAI processes have the inherited hierarchy relationship that can be illustrated by Figure 1. ISO 9000:2000 Quality Management Systems, which has the solid theoretical foundations of quality management, is the ancestor or prototype of IQM. IQM revises some detailed implementation guidelines of ISO 9000:2000 Quality Management Systems. IQM in EAI processes further advances the detailed implementation of IQM, and makes it compatible with EAI surroundings.

Based on IQM, the concept of information product is introduced to emphasize the information output from an information system that has value transferable to the customer (including the internal employee and external consumer). It always relates to information product characteristics (IPC), information product quality (IQ), and information manufacturing systems (IMS) (Wang, 1998).

Information product characteristics generally include two levels: functional requirements of information product, and data structures and relationships. Information product quality refers to the IQ dimensions (see the above section). The same information product will have different IQ dimensions requirements for different customers. Information manufacturing systems controls the whole procedure of information manufacturing process, including the information source, information process, information storage, information check, information systems boundary, business boundary and information customer, and identifies the relationship between different processes. The information manufacturing systems is not identical to a practical system, but is a virtual system that describes the whole information production procedure.

The perspective of IQM asks us to consider three main processes in Quality Management Systems, i.e., “Management Responsibility”, “Resources Provision”, and “Technology Implementation” (They respectively correspond with the chapters 5, 6, and 7, 8 of ISO 9000:2000 Quality Management Systems). The three processes are also important to EAI processes.

The process of “Management Responsibility” is the strategic process whose main activity is taking the scientific management concept into consideration. For example, we could consider knowledge management complements and enhances the Management Responsibility Process (Gupta and Sharma, 2004). This is important to EAI on the fact of high cost of EAI processes. Without the support of top management and effective management, EAI is hard to succeed with high IQ (Kunene, 2003; Yager, 2002).

The process of “Resources Provision” includes the aspects of the human resources, infrastructure, and work environment. When considering the infrastructure, resources provision means the hardware, software platform, and especially the standards of every process in the methodology. Standards make systems interoperable and accomplish the objectives of EAI (King, 2000; Robinson, 2002). Despite a lot of standards present, there are still no suite of standards addresses the complete set of integration and interoperability problems that exist (Mackay, 2003). Further attention should be paid on the standards in EAI processes.

The process of “Technology Implementation” is the implementation of IQM, including detailed methods and tools, such as IP-Map methods (Shankaranarayan, Ziad and Wang, 2003) and XML applications (Carlson, 2001). More recently, EAI evolves from data-driven integration and event-driven integration to process-oriented integration in order to achieve a pragmatic, cost-effective integration (Davydov, 2005). The process technology implementation will help this trends become reality.

Thus we propose the framework for conducting IQM in the EAI processes.

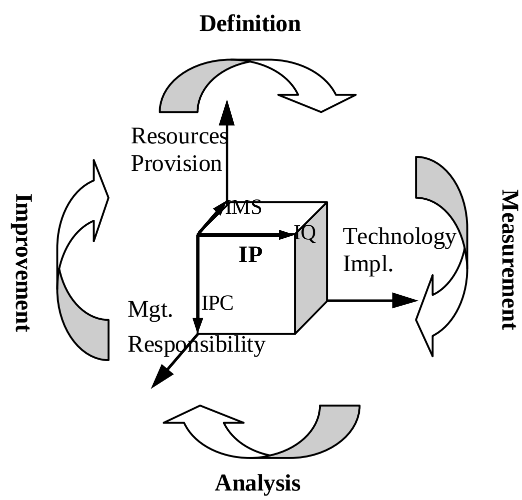

Figure 2. The framework of IQM in EAI processes

IQM in EAI processes should be a strategic decision of an organization and should promote the adoption of a process approach when developing, implementing and improving the effectiveness of an IQM system to enhance customer satisfaction by meeting customer requirements. The center of this framework is the three-dimensional structure of IP. Surrounding the IP are the three main quality management processes. In the overall process of IQM in EAI processes, we use the process approach (Cianfrani, Tsiakals and West, 2000) and adopt Deming cycle (the cycle of PDCA, “plan, do, check and act”) (Deming, 1986) or Six Sigma process (the cycle of definition, measurement, analysis and improvement) for quality enhancement (Smith, Blakeslee and Koonce, 2002).

The framework could be applied for every EAI processes as illustrated in Figure 2. The three main processes: Management Responsibility, Resources Provision and Technological Implementation (including realization and improvement) consist of a complete Deming cycle. And each process has experienced its own PDCA cycle to make continual improvement of processes based on objective measurements.

The main purpose of the process "Management Responsibility" is: 1) identifying the need to improve or assure IQ; 2) forming teams and assigning roles and responsibilities by the specific requirements of information product and knowledge management. And the main purpose of the process "Resources Provision" is providing corresponding resources, especially the "soft" infrastructure: software platforms, and standards. The process "Technological Implementation" is one of the most important processes in the IQM for its implementation essence. The main purpose of the process "Technology Implementation" includes: 1) carefully defining the three dimensions of information product: information product characteristics, information product quality, and information manufacturing systems; 2) measuring, analyzing, and improving information quality by large amounts of methods, tools, and technologies. There are some important issues related to the three main processes and we will cover those in the next section.

There are some advantages of the framework besides the systematic methods to improve the IQ in EAI processes. First, it has the solid theoretical and practical foundations which are provided by the ISO 9000: 2000 Quality Management Systems. Second, the framework is easily to incorporate into the company's overall quality management systems. Third, EAI technologies could enhance IQM methods and tools to make the framework more powerful.

IMPORTANT ISSUES IN THE THREE MAIN PROCESSES

In this section we will discuss some important issues in the three main processes of IQM in EAI processes.

Management Responsibility Process

Although the main actions of Management Responsibility process are consistent with the ISO 9000:2000 Quality Management Systems, the Management Responsibility Process should not use the ISO standard "as-is", but tailors it to its own special needs, assigning roles to department, adding information about tools to be used for some steps, and adding specific or leaving out irrelevant steps (Kneuper, 2002). What IQM in EAI processes differentiates other quality management are 1) focusing on information and 2) being applied in EAI processes. The revision of general quality management guidelines follows the two points.

1) We could consider the Information Resources Management theory to complement the Management Responsibility Process. IQM in EAI processes focuses on the production of information, while Information Resources Management deals with information as resources, identifies information flow and its relationships to other resources and people, incorporates information into strategic planning, and measures corresponding performance (Horton, 1991; Middleton, 2002). When we conduct the Management Responsibility Process, we could a) follow information flow to identify the roles and responsibilities, b) employ advanced information technology (IT) to establish objective of IQM, and c) adopt Information Resources Measurement tools for management review.

Proposition 1: Information Resources Management theory could be complementary to the Management Responsibility Process.

2) We could employ the Knowledge Management theory to improve the Management Responsibility Process. When executing IQM in EAI processes, we would generate much knowledge related to the quality management process. It is different from information just mentioned. If these knowledge is not properly managed, it could not be used to construct the organizational memory and further be used as the basis for continual improvement of quality management systems (Dingsoyr and Conradi, 2002; Kneuper, 2002). Thus, when we conduct the Management Responsibility Process, we could a) use the Knowledge Management theory to measure knowledge and form knowledge repository related to IQM in EAI processes, b) conduct management review and improvement according to the procedure of Knowledge Management.

Proposition 2: Knowledge Management theory could be complementary to the Management Responsibility Process.

Resources Provision Process

The Resources Provision Process offers resources including infrastructure, human resources, and working surroundings. The software infrastructure is our key point to state in IQM in EAI processes. It could be divided into two parts: the software platform, and standards.

The adoption of EAI technology strengthens the management platform of IQM in EAI processes. For example we can establish the IQM software platform via the Enterprise Information Portal (EIP) technology, or process-oriented knowledge management systems based on KM-services (Woitsch and Karagiannis, 2002).

Proposition 3: EAI technology strengthens the management platform for IQM in EAI processes.

The adoption of standards is crucial to IQM in EAI processes. For IQM we could adopt the open IQM standards, such as Dublin Core metadata, Library of Congress Subject Headings. For EAI processes, we could consider the standards that could be integrated for current and future applications, such as Simple Object Access Protocol, Electronic Business XML Initiative. However, besides great deals of international, national, and industrial standards, company could also formulate their own proprietary standards for security and privacy. Here occurs dilemma about adopting open standards or formulating proprietary standards. In this situation, researchers would prefer adopting the open standards, such as the international, national, or industrial standards, as many as possible for it would generally bring more benefit to company than proprietary standards (Spivak and Brenner, 2001).

Proposition 4: Open standards might bring more benefit to IQM in EAI processes than company's proprietary standards.

Technology Implementation Process

The Technology Implementation Process is the most important process in IQM. The starting point of the process is the definition, followed by measurement, analysis, and improvement. The methodology of the technology implementation has been discussed by many researchers (Ballou et al., 1998; Wang, 1998). For IQM in EAI processes, we can follow the methodology basically and make some revisions to suit the new surroundings.

In the definition phase, the traditional methods define respectively the information product characteristics, information quality, and information manufacturing systems using the Extensive Entity Relationship (Ballou and Pazer, 1985), and IP-Map methods (Shankaranarayan et al., 2003). Further improvement could be done about these methods. We can divide the phase into two separate steps. The first is the static modeling of information product, including the definition of information product characteristics and information quality; the second is the dynamic modeling of information product, including the definition of information manufacturing systems. Both of the two steps are important to process-oriented integration and could be integrated into the UML software, such as the Rational Rose®. For the static modeling, we can make use of the class diagram of UML. In the Figure 3, the study gives a sample static model of the financial news products. For the dynamic modeling, we can use the UML activity diagram (Scannapieco, 2002). We achieve the goal by re-defining the stereotype of the UML to represent the information source, information sink, information storage, information system boundary, quality check and process (Ballou et al., 1998; Shankaranarayan et al., 2003). We illustrate the financial news production process by Figure 4.

Proposition 5: To IQM in EAI processes, UML could be employed to conduct the modeling and facilitate process-oriented integration.

Then, we can follow the methodology given by Wang (1998) and Ballou et al. (1998) in the subsequent measurement phase, analysis phase, and improvement phase.

Another issue we want to discuss here is the EAI technology's contribution to Technology Implementation Process. We expect the technology implementation could be processed automatically with less human interaction and be one of the important ingredients of EAI architecture. For example, we could design and implementation the process using the component technology or Web Services technology and put it into Service-Oriented Architecture (SOA) (Roch, 2004) and/or .Net Framework (Spackman and Speaker, 2005).

Proposition 6: To IQM in EAI processes, it is possible to integrate the Technological Implementation process to EAI architecture.

CONCLUSIONS

In this study, we have proposed a framework for incorporating IQM into EAI processes to improve the information quality of EAI processes, and suggested six propositions for future research.

The power of the framework stems from the cumulative multidisciplinary research. Treating information as product is fundamental to the IQM in EAI processes. By introducing the framework, IQM could enhance the IQ of the EAI processes and EAI could provide more powerful technological implementation for IQM. In the end, they will achieve a status of reciprocation. The study is particularly timely on the IQ problems of the EAI processes in light of the industrial trend toward EAI.

Our future research will focus on refining and testing the propositions suggested in this paper.

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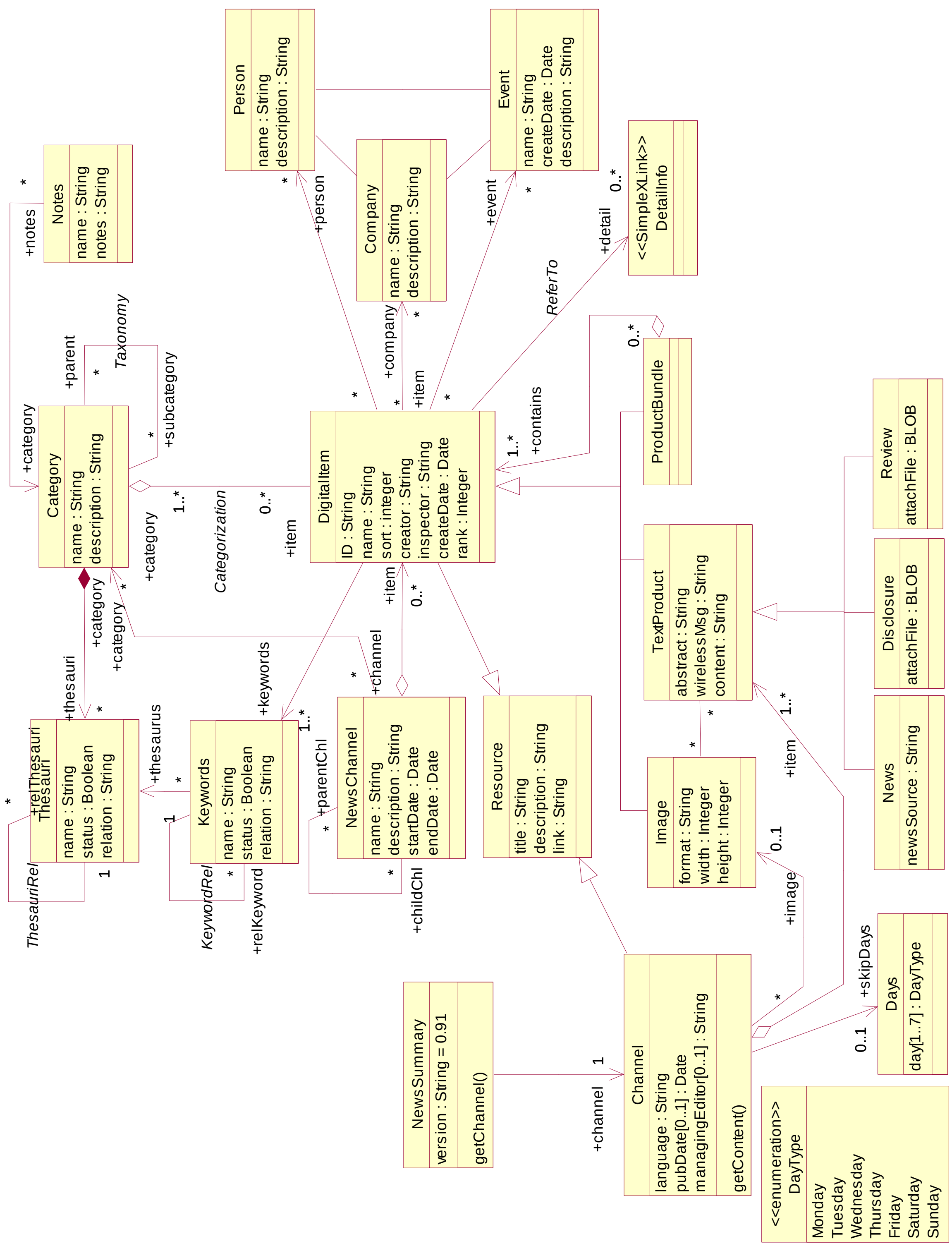

Figure 3. Static Model of the Financial News Products

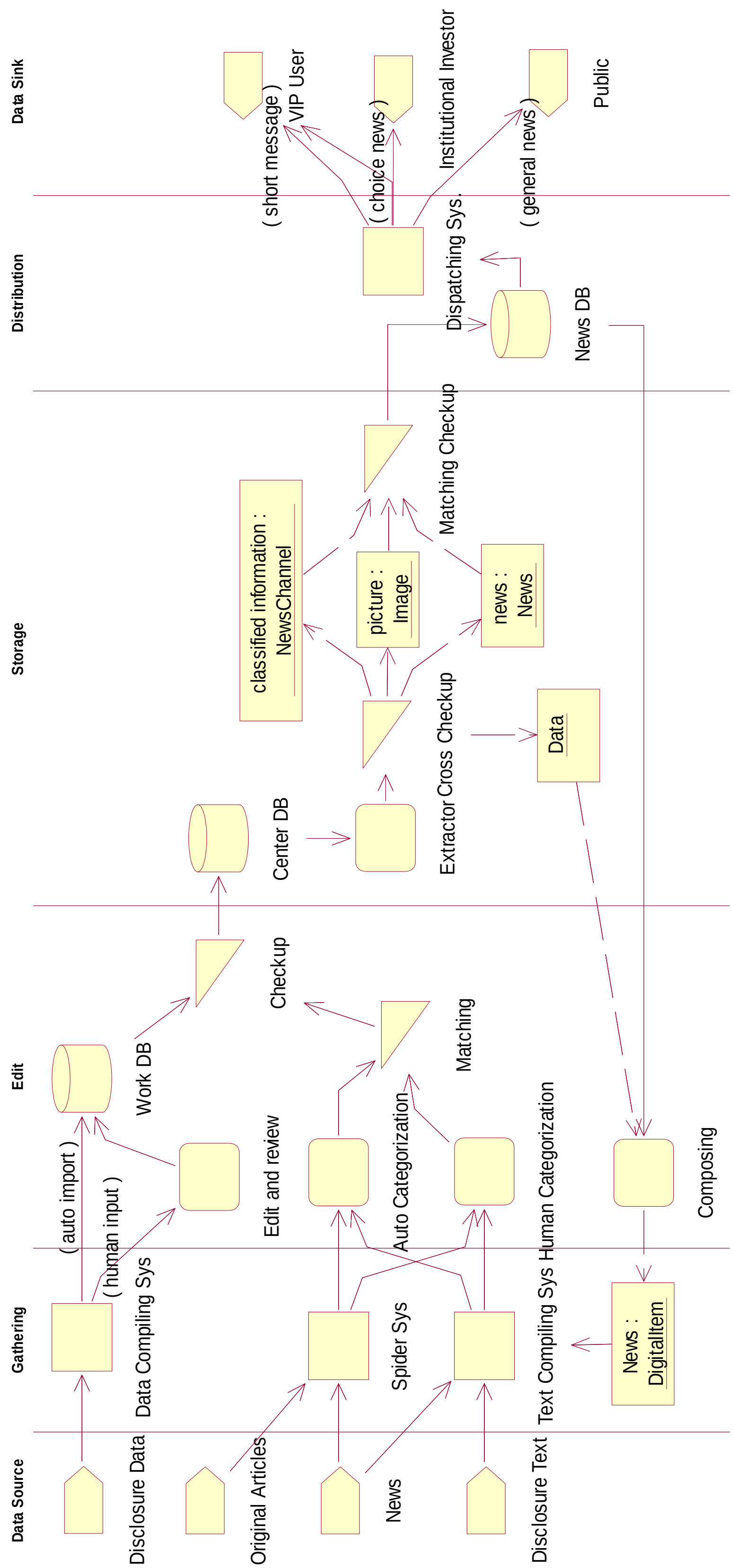

Figure 4. Dynamic model of the Financial News Production Process