Reference Modeling As The Missing Link Between Academic Research and Industry Practice

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The influence of visual representation on the decision behavior of managers is frequently underestimated. With the IS-induced transformation of commercial transactions and market allocation mechanisms people have to deal with the problem of filtering and processing information in order to make the right decisions in rather short duration. As a consequence, the visualization of data remains a crucial factor in the analysis and design process of every (Web-based) mass information system. For this reason, a transaction-oriented derivative of the extended World Wide Web Design Technique (eW3DT) is presented. Focusing on consumer-to-business transactions, the document-oriented modeling framework is intended to remove existing communication barriers within the boundaries of individual organizations as well as to support cooperative efforts between such entities to develop and maintain Web-based mass IS. The divergent background, perspective, and policies of academic research, IS departments, and management are addressed, in particular.

1 Introduction

Information plays a central part in our lives, in a much deeper sense than many people would like to admit. There is no human action without information. We ourselves are a product of a formula, coded in the genetic alphabet composed of four "letters" and located in the core of every single cell. Information systems, in general, help us to interpret the enormous informational resources available on a worldwide scale in the context of their ecological, social, and economic impact.

Mass IS, in particular, allow the integration of all currently installed non-compatible systems (e.g., telephone, cable TV, computer networks, or VSAT-services), which further lead to economization of the communication sector. By streamlining these integration processes and presenting their results in a user-friendly way, information systems bear the potential to radically change the nature of business. As a consequence, the visual representation of data is becoming a crucial factor, not only as an analytical aid for the individual user of mass IS, but also as a communicative tool for supporting arguments, as well as informing and convincing decision-makers and the public. For this reason, a document-oriented modeling framework, the extended World Wide Web Design Technique (eW3DT), for the design of Web-based mass IS is presented. The proposed method primarily focuses on business-to-consumer transactions. Due to its high level of abstraction eW3DT supports different categories of market-based coordination: direct-search markets, brokered markets, dealer markets, and the auction markets.

Mass IS designers usually try to find ways to conceptualize the World Wide Web as a new medium with rather unique features. A sound theoretical framework for Web-based communication is provided by discourse analysis, describing the structures between conversations, in general, and between WIS developers and users, in particular. In this context, utterances are either examined as pairs (sequential accountability) or larger groups of utterances (distributional accountability). Single HTTP requests (hits) provide less information than the functional group with which those requests are associated. In the case of sequential accountability, this association is represented by a multimedia compound document. Consequently, discourse analysis represents an additional rationale for using document-oriented models in the analysis and design of Web-based mass IS.

2 Diffusion of Mass IS Technology

Although technology assessment is responsible for predicting costs, capacity, and overall time scales required to assimilate innovations, a general explanation
for the diffusion of technology is not available. There are many models which use logistic or s-shaped functions, but they are valid only within a narrow temporal and social segment and therefore have only limited expressiveness as far as the phenomenon of mass IS development is concerned. The diffusion process heavily depends on the technology itself and its fields of application. However, the key factors influencing this process may be categorized into technological, economic, political and social parameters. Never in history, international markets were confronted with such a dramatic reconfiguration of interaction patterns between individuals and organizations. This dynamic reconfiguration poses high demands on absorption and learning capacity of the people designing, propagating and using these systems. In order to support the required changes and to maximize the utility of new interactive technologies, appropriate representational aids for describing, analyzing and designing electronic markets are required (Figure 1).

3 Improving Intra- and Interorganizational Communication With eW3DT

The influence of visual information display on the information processing and decision behavior of managers is frequently underestimated. People have to deal with the problem of filtering and processing more and more information in order to make the right decisions in a rather short period of time. The increased dynamics of the environment as well as the cognitive demand of multidimensional problems puts a lot of internal and external pressure on them and may reduce the efficiency of decision processes. In order to cope with the complexities involved, managers need to reduce the multidimensional problem space to a manageable personal conceptual framework. The application parameters for visualization are technology, the manager himself, as well as the specific task and organizational structure he is confronted with.

According to empirical findings of Walden, managers do use information systems and have some very clear opinions of the impact of computer-based support systems on both decision-making and teamwork. Too much information together with poor representational models lead to sub-optimal solutions for businesses and consumers alike. If information is not presented in an intuitive way, people will not accept decisions based on facts and assumptions they do not fully understand. With special regard to the development and efficient design of information systems, there were many projects which aimed at formulating proposals and rules for the "adequate" representation of information for the upper and middle management. They are usually based on behavioral science or experimental psychology and compare changes in the representation regarding brightness, color, textures, outlines, or contrast. Independent of task demands and cognitive styles of managers ("contingency theory"), visual representations usually outperform other approaches (with the exception of very specific problem domains) and confront the problem of information overload since visual information can be absorbed and processed faster and more complete than text, numbers, or acoustic information.

None of these approaches, however, offers a consistent general theory or explicitly deals with specific features of mass IS or the World Wide Web which encompasses a global hypermedia publishing concept. One of the main problems regarding modeling and developing hypermedia applications is the strong interdependency between presentation (user interface) and representation (explicit structuring) of published information. Many meta models and design methodologies for mass IS lack the necessary object types for modeling this interdependency and are only suited for highly structured segments. This limitation was the actual reason behind the development of W3DT respectively eW3DT (section 4). In order to serve as an efficient interface to people with very heterogeneous knowledge and expectations, visual representations of hypermedia architectures intended for the general public have to include the essential information in an illustrative, clearly arranged, and comprehensible way. Using a hierarchical description format for mass IS, eW3DT aims at eliminating exist-
ing communication barriers between academic research, management (top-level management as well as functional units), and IS departments (Figure 1).

Such a description format is a prerequisite for an in-depth analysis and for the formulation of general, industry-specific as well as individual, company-specific design guidelines. These guidelines usually are presented as a reference (industry-specific) or implementation (company-specific) model.\textsuperscript{9,10} Reference modeling of mass IS with eW3DT facilitates the exchange and dissemination of information in two ways:

- The meta model serves as a common symbolic language, clearly understandable for the management and easy to handle for technical experts and authors of reference models.

- The replacement of intuitive by scientific criteria facilitates coordination between organizations. Reference solutions support the cooperation between academic institutions, business partners and departments within a company. The information transfer between these groups is improved by integrating group-specific patterns of communication.

Hierarchy is frequently interpreted as an organizational response to limits in communication. The removal of these limits and the conveyance of capabilities directly into the hands of every employee enables the replacement of traditional hierarchical structures by alternative, increasingly virtual models. The decline of hierarchy is not restricted to business organizations. The trend is equally relevant for political, military, religious, and even educational institutions.\textsuperscript{11} However, efforts to improve the information flow within and between organizations should not merely concentrate on operating levels, they have to consider top management as well, especially after the diminishing relative power of organizational hierarchy structured on control of information and after elimination of much of the middle management.

For every hypermedia design technique, it is important that the conceptual data and navigational constructs support a system-specific optimal level of abstraction and are applicable for structured as well as unstructured information. The transaction-oriented derivative of eW3DT deals with the document-oriented storage layer of the Dexter Hypertext Reference Model.\textsuperscript{11} It provides hypertext designers with a framework and graphical notation for the construction of user-centric models during the software development process of commercial mass IS. As precondition for pursuing a partial globalization strategy, eW3DT distinguishes between technical and content-specific responsibilities for designing, implementing, and maintaining mass IS.

4 Transaction-oriented Derivative of EW3DT

Due to limitations found in existing design concepts, Bichler and Nusser\textsuperscript{12,13} developed the World Wide Web Design Technique (W3DT) together with a working prototype called WebDesigner (http://wwwi.wu-wien.ac.at/w3dt/) which supports the graphical, interactive design of complex mass IS. Comparable academic or commercial modeling tools like the:

- WebArchitect (http://www.nttlabs.com/~kt/WebArchitect/),\textsuperscript{14}
- SchemaText (http://www.schema.de/), or
- FrontPage98 (http://www.microsoft.com/frontpage/),

to name just a few provide similar "authoring-in-the-large" functionalities. Other approaches like the widely accepted RMM\textsuperscript{15} or OOHDM\textsuperscript{16,17} are especially suited for highly structured information domains. In most cases they succeed traditional hypermedia design techniques like HDM/HDM2 which themselves are under constant development.\textsuperscript{18,19}

In contrast to these database-oriented methodologies, (e)W3DT was built from scratch to support the requirements of unstructured, hierarchical mass IS. Utilizing practical experiences in developing such systems, the graphical notation of the design tool was further refined and used to document a number of existing Web sites. With special regard to reference modeling of commercial mass IS, the extended World Wide Web Design Technique (eW3DT) was developed.\textsuperscript{20}

It is generally believed that if a mass IS cannot catch the visitor’s attention within 30 sec he will simply skip the rest of the document and will navigate to other areas more appealing to him. Comprehension of content and structure is essential.\textsuperscript{15} Therefore, the concept of hierarchy remains important for the architecture of any practical mass IS and requires adequate meta-level representations.\textsuperscript{14} Take e.g. the "Navigation View" of Figure 2, one of the new features of Microsoft’s Frontpage98: "Automatically generate your naviga-
tional links in this printable view by using it to build your Web site's key navigational structure - ensuring easy site-wide navigation and intuitive site organization” (http://www.microsoft.com/frontpage/productinfo/default.htm). While the hierarchical display structure seems similar to eW3DT at first sight, the Frontpage metamodel falls short in providing semantically rich (navigational and data) object types for a graphical description of content structure, structural document positioning, maintenance intensity, or organizational integration (compare Figure 6).

On the other hand – as far as database-centric hypermedia applications are concerned — there is no adequate substitute for entity-relationship respectively object-oriented approaches. Thus, both W3DT and eW3DT are not intended to replace modeling techniques like RMM but to act as hierarchically oriented, complementary communication tools between researchers, system analysts, and the management responsible for the decision to implement mass IS.

4.1 Reference Solutions for Electronic Commerce

The term electronic commerce is frequently used to describe the on-line processing of traditional functions such as payment and funds transfer, order entry, invoicing, inventory management, cargo tracking, electronic catalogs, data gathering for marketing, and customer support. With the convergence of previously disparate functions around electronic commerce the World Wide Web has become the basic infrastructure for almost all transaction-oriented applications. Every transaction process occurring in the electronic marketplace goes hand in hand with the access, absorption, arrangement and selling of information in very heterogeneous ways. User-friendly mass IS with adaptive system behavior as well as appropriate standards and protocols for dealing with user profiles are a precondition for hypertext applications to attract the required "critical mass” of potential buyers. Many system designers frequently do not give enough attention to the needs and preferences of private end-users. Mass IS are confronted with a lack of acceptance since developers concentrate on solutions to problems which are only of limited interest to the end user and forget to think about mass IS as a highly interdisciplinary field. As a consequence, the impact of social factors like data security, consumer and employee protection, or personal attitudes is often underestimated. Since strategic investments without a clear idea of the underlying architecture or the intended semantic structure have resulted in many economic failures, there is a growing need for reference solutions in the context of electronic markets. As one of the primary means of standardized communication regarding mass
IS architectures these models support cooperative efforts within and between organizations to design such systems. By integrating inductive and deductive methods the process of designing conceptual mass IS representations is both top-down and bottom-up. The metamodel of eW3DT provides a framework for the construction of both abstract reference and company-specific implementation models during the software development process of commercial mass IS. Note the difference regarding the level of abstraction between meta models (eW3DT), reference models, and implementation models.21,22

4.2 Object Types of eW3DT

Conceptual data and navigational models for mass IS should support structured as well as unstructured information. The composition of the documents themselves is not considered with the only exception of the so-called horizontal link for an adequate visualization of complex compound documents. They serve as interpretative guideline for people with very heterogeneous technical expertise and professional responsibilities. eW3DT is intended to eliminate existing communication barriers between functional units and IS departments due to this heterogeneity by propagating the use of document-oriented meta objects for conceptual mass IS modeling. Diagrams relying on eW3DT are a user-centric combination of structural and process diagrams which requires an explicit explanation of symbols. This explanation respectively notation will be presented in the following paragraphs (as the general notation has been published previously, special emphasis will be given to the transaction-oriented elements).

Every eW3DT data object type represents a special variation of a standard symbolic element, depicted in Figure 3, and is equivalent to an atomistic unit of the Dexter Hypertext Reference Model.11 In this paper the data object types will be referred to as information object types, the objects themselves as information objects or documents. In order to visualize this distinction, the names of information object types are marked with < >, those of information objects with [ ]. Independent of iconic similarity and real equivalence to a given object (hypertext compound document), every information object type defines a general profile for describing the characteristic attributes of this object. Each of these profiles corresponds to a set of abstractions commonly found in mass IS.

The attributes assign information on structural position, maintenance intensity, and organizational integration to the modeling constructs. In addition to the name of each object, the eW3DT standard symbolic element includes the following specifications:

- Together with an (optional) differentiation by color, the sub-symbol [S] on the right side of the object name signals the basic type of the information object.
- The hierarchical level where the document in question usually can be found within a hypertext application has to be specified in the bottom left field [x]. The second digit [y] describes optional sub-components. An interaction, implemented as part of the homepage, would receive the value 1.1.
- The eW3DT meta model distinguishes between technical and content-specific responsibilities for designing, implementing, and maintaining mass IS. Two abbreviations [OPT] next to the hierarchical level refer to functional units responsible for content and technical implementation.
- In the bottom right field, one to three 'Ι' -symbols represent the maintenance intensity of information objects (Table 1; initial efforts to implement documents are not considered). Interfaces to existing (marketing) databases, however, influence this value substantially.

Figure 4 Categorizes the object types of eW3DT into the three functional segments "Information", "Navigation", and "Structure". For each information object type with the exception of <DBase> there is a static class and a class for dynamically generated documents. In the case of <DBase>, internal and external data structures are distinguished since the content structure itself is in-

![Figure 3 - eW3DT standard symbolic element](https://example.com/figure3.png)
information

Very low maintenance intensity; the initial implementation has to be updated only at rare occasions; typical examples include error messages general navigational information, or standardized interactions.

Medium maintenance intensity; regular verification recommended in order to consider technical or economic changes. Company data or context-specific navigational aids may be part of this category.

The third category encompasses all information objects which have to be updated at least once a week (e.g., press releases, financial information, or dynamic pages with interactive content).

herently dynamic — a fact which doesn’t require explicit visualization. Structural variability is the relevant characteristic to separate static from dynamic information objects. If the structure is changing, the dynamic process becomes part of the architecture, independent of technical realization. Even if they are automatically generated out of database queries, the inherent characteristic of information objects might be independent of static nature.

With the help of the elements of Figure 4, it is possible to visualize mass IS of variable complexity, no matter if they are intended for a real organization (implementation model) or for an industry-specific analysis (reference model).

A <Page> object is used to model multimedia compound documents. They usually represent the logical end of a hierarchical tree. As already mentioned, the internal structure of a <Page> itself is not supported by the eW3DT meta model. Alternative navigational paths and access mechanisms belong to the object type <Menu>. The respective objects are usually found at higher hierarchical levels of mass IS. They are strongly influenced by considerations regarding the optimal width and depth of the contents offered — a tradeoff between usability criteria and efforts to reduce the maximum number of hierarchical levels.

In contrast to menus, an <Index> contains a complete enumeration of links, e.g., a company’s staff or a list of available products. Especially for statically implemented <Index> documents, maintenance is vital due to the well known fact that links pointing to missing, inactive, or irrelevant sources reduce the perceived quality of mass IS substantially. <Interaction> includes various interactive elements, characterized mainly by content and layout structure. Since eW3DT provides a conceptual metamodel, technical details are only of secondary importance. The electronic distribution of software or application-specific data blocks requires secure and efficient mechanisms to transport files of various formats and sizes in a platform-independent way from the content provider to individual users. These mechanisms may be visualized with the eW3DT object type <File>.

Due to an ever increasing demand for up-to-date and consistent information, it seems justified to expect many company-wide internal databases to be connected to more and more complex mass IS over a relatively short duration. Economically, it is not feasible and definitely
not in compliance with the basic assumptions behind a reference model to deal with these databases explicitly. Any attempt to do so would result in a redundant remolding of existing internal structures, not to mention the heterogeneous character of corporate database architectures. With eW3DT, only user inputs which lead to the creation of new database entries or the update of stored information are taken into consideration. The reserved symbol for these user inputs is the eW3DT object type <DBase>, depicted in Figure 5 and available in two different representations: internal and external.

While internal output objects refer to various corporate databases, the external ones include cooperative databases, databases held by other organizations, or other external information sources. If the object is marked with a lock, security mechanisms have to be implemented due to the sensitivity of the provided information. Since technical details are only of secondary relevance for conceptual modeling, eW3DT does not provide any object types to distinguish between different protocols like SSL, S-HTTP, SET, etc. or between the hierarchical network or application layer they are aimed at. The [R]ead- and [W]rite-flags indicate the user's right to access individual entries while the star symbols on the bottom right corner of the object describe the update intervals required, similar to the maintenance intensity of documents. "*" is used for static permanent data, "**" for occasionally updated entries (e.g., user profiles, marketing information, compiled Web statistics) and "***" for highly volatile transaction records (e.g., payment data, shopping lists, HTTP log-files for analyzing access patterns and user behavior, etc.).

4.3 Diagram Structuring and Navigational Design

With regard to the increasing complexity of contents and navigational elements, the complete structure of a mass IS cannot be covered in one single diagram. The required reduction in complexity is achieved by hierarchical diagram structuring with the eW3DT-elements <Primary Structuring Element>, <External Link>, and <Multiple Sources>. For a detailed description of structuring and navigational object types refer to Scharl. 21,24

The navigation within hypertext structures as well as the development of mass IS are non-linear, non-sequential activities which require an appropriate visual (symbolic) representation. Navigational design has to counteract the reduction of coherence in mass IS which frequently arises due to an inadequate consideration of the specific linguistic features of hypertext environments.

eW3DT distinguishes between <Static Links> (implemented permanently), <Dynamic Links> (leading to customized, automatically generated documents), <Horizontal Links> (for heterogeneous documents), and <Representative Links> as a sub-type of the <Dynamic Link> which points to different versions of static information.

5 Storefront of An Electronic Retailer

In order to demonstrate the semantic relationships between the eW3DT data object types described above, the simple reference solution of Figure 6 visualizes standard mass IS components of an electronic retailing solution at reduced complexity. Designing mass IS seen as an incremental and opportunistic human activity includes "backtracking and erratic switching among the following activities: thinking about ideas, production, reorganization, modification, and evaluation". During all these sub-processes and for the [Company Storefront] as the first hierarchical layer in particular, every designer should bear in mind recommendations with regard to a limited number of unrelated elements appearing in a single document. Being able to build and represent complex structures does not imply that the user absorbs them in the intended way. As a consequence, every hypermedia access structure has to find a balance between horizontal and vertical integration density.

After accessing the [Company Storefront] the mass IS user is provided with a [Company Profile] as well as a number of [Product Families] to identify his general requirements. Having selected a certain category, the user is able to choose between [Product Variations] more specifically. The product in question is represented by the description [Product X] as well as [Technical
Details) for further information. Note that in contrast to W3DT-models sub-diagrams relying on the syntax of eW3DT may have more than one single entry point. Should the [Bargaining Process] turn out to be satisfactory for both parties, the customer is able to immediately place an online-order by filling out the [Order form]. If all specifications have been entered correctly, a separate market transaction is triggered between the seller of the PC and a financial clearing institution. The secondary, value adding process has to settle the accounts between seller and buyer, no matter if the financial clearing institution is a bank, a credit card organization, an issuer of electronic money, or any combination of these virtual payment methods. As soon as a form of payment is agreed upon and verified by the seller, the database entries [Accounting], [Hardware Turnover] and [Customer Profiles] are updated and a [Confirmation of Order] including the estimated time of delivery can be sent immediately, either per e-mail or directly via a dynamic document.

The whole transaction is completed with the physical distribution of the product. In the case of immaterial goods (e.g. informational products like software, news, financial information services etc.) the actual delivery of the product is executed without delay, a customized
6 Conclusions

The paper presents a transaction-oriented derivative of the extended World Wide Web Design Technique (eW3DT) as a consistent visual representation model for the description and design of mass information systems. Complementary to approaches based on the entity-relationship model, eW3DT is intended to remove communication barriers within and between organizations with special regard to the specific requirements of academic research, management, and the designers of mass IS. Together with an overview of available data and navigational object types an electronic storefront has been presented as an example for the application of eW3DT to real-world scenarios. In addition to the seamless integration with database-oriented approaches, future research will have to address the classification and modeling of dynamic system behavior and to provide meta objects for adaptive components, standardized user profiles, and distributed models of trust.

References

Arno Scharl received his PhD from the Vienna University of Economics and Business Administration where he is currently employed as assistant professor and a member of the electronic commerce research group at the MIS Department. His research and teaching interests focus on the various aspects of information system modeling, commercial transactions via the World Wide Web, clickstream analysis, and the customization of electronic catalogs.