Link management in technical customer documentation

An exploratory study

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Abstract

The technical customer documentation of a technical product plays an important role in international competition in industry. Customer documentation is more and more delivered, used and managed in electronic form. The main problems of technical customer document management in inter-organizational projects are related to unsystematic working procedures and heterogeneous information systems between different organizations. These often cause unnecessary overlapping and manual work, and make technical communication between different actors in the project inefficient. Internet technology and SGML-based XML language family provide means to develop technical customer document management in inter-organizational industrial projects. The purpose of this exploratory study is to describe characteristics of an inter-organizational industrial project, characteristics and development potentials related to the technical customer documentation, and to identify problems related to link management for more precise investigation. A scenario for managing the technical customer documentation in extranet is introduced. The scenario indicates that link management in inter- and intra-organizational networks, such as extranets and intranets, will have crucial role in document management and that future research should focus on developing systematic methods for link creation, maintenance and delivery.

Keywords: Link management, document management systems, technical customer documentation, extranet, XML, exploratory study

BRT Keywords: AI0106, CB0902.01, HA07, HA10

1. Introduction

Document management is a challenge for today's business affecting the position of enterprises in international competition. Documents are becoming dynamic and reusable within different business applications and processes. Systematic approach to creating, composing, delivering, maintaining and using technical customer documentation is an issue of vital importance in industry. The challenge is keeping track of documents, getting right resources and sub-resources for users as well as ensuring that information is presented in the right context. Providing just the right amount and type of information is critical, for example, in trouble-shooting situations of technical objects, such as a paper machine, a digital telephone exchange, or a mill.

Large industrial projects are inter-organizational with several organizational actors. The actors of a project have different roles in producing, updating, composing, managing, delivering and using the technical customer documentation of the technical object concerned. Although all the actors in the project will not adopt totally compatible systems for document management, particularly in the case where some of the actors change project by project, some common rules may be sought and agreed upon. The need for flexible information systems solutions is obvious in a heterogeneous project environment of this kind.

Technical customer documentation is an important part of the technical product itself, and plays a crucial role in the international competition. New information technology provides interesting means, such as extranets, intranets and XML (eXtensible Markup Language) language family which may solve some of the problems, related to the management of technical customer documentation in inter-organizational industrial projects. The XML and XLink languages give possibilities to develop new management procedures for documents in network environments, such as external hypertext link management architectures.

The purpose of this exploratory study is to

- describe characteristics of an inter-organizational industrial project
- describe characteristics of technical customer documentation
- describe development potentials related to technical customer document management in an inter-organizational industrial project
- introduce a scenario for composing, delivering, managing and using technical customer documentation in inter- and intra-organizational networks, such as in extranets and intranets
- identify problems related to link management for more precise investigation.

The remainder of this paper is structured as follows. Related work is described in section 2. Section 3 describes characteristics of an inter-organizational industrial project with its actors, features of technical customer documentation, and development potentials related to. Some features of the XML and XLink languages are also presented in section 3. Section 4 introduces a scenario for managing technical customer documentation in extranets. Identified problems for further research are presented in Section 5.

2. Related work

Hypertext research indicates that the solution to many link management issues is to separate the links from the content. Nürnberg, Leggett and Wiil (1998) have described the development of conceptual architectures of hypermedia systems, demonstrating various stages from monolithic systems to open hypermedia systems. The idea of a link service has existed since the days of Intermedia (Bieber et al., 1997; Nielsen, 1995; Yankelovich et al., 1988). From a user's point of view the need for distributed link services has grown with the development of the World Wide Web. Hyper-G and Microcosm's Distributed Link Service are two projects where support for non-embedded links to WWW pages has been developed (Andrews, Kappe and Maurer, 1995; Carr, Hall and Hitchcock, 1998). In Microcosm SGML markup is used in the link databases and now some parts of the system have been modified to support some of the XLink based linking facilities, such as controlling link behavior and its presentation (Carr, Hall and Hitchcock, 1998). Grønbæk, Bouvin and Sloth (1997) have described the Dexter model (Halasz and Schwartz, 1994)

based distributed link service mechanism in which the links are maintained by a separate server, but combined with the text document by a Java applet embedded in the users browser. Another distributed link service has been produced for the Aquarelle project (Rizk and Sutcliffe, 1997).

Gruber, Vemuri and Rice (1997) have reported on model-based virtual document generation. They have described a system called Device Modeling Environment (DME). DME virtual documents answer questions about the structure and dynamic behavior of electro-mechanical systems. Queries take the form of questions about some aspect of a system such as what causes a valve to open. Answers are explanations in natural language that are filtered and organized for human readability. Vercoustre and Paradis (1998) have develop a language for virtual documents as a means to reuse and integrate information from various sources such as databases, SGML, XML and HTML documents. HTML tags contain no semantics of the links themselves, do not provide a significant level of structure for identifying and extracting information, since they are mostly used for presentation issues. HTML link mechanism does not support the controlled traversal of links to related pages. Vercoustre's and Paradis's study focuses on the selection and the traversal of XML links to extract information from linked pages. Wang and Rada (1998) have presented a semantic-net-based structured-hypertext model that is formalized. The application domain in their work is technical document authoring with reuse of existing documents.

Malcolm, Poltrock and Schuler (1991) have described needs for link authoring related to writing technical documents, such as link attributes, types, and functionality, as well as multi-ended, public and private links. Erkes et al. (1996) have described shared manufacturing services on the World-Wide Web that support interactions between corporate partners in virtual enterprises. Balasubramanian and Bashian (1998) have reported architecture for a component-based authoring and publishing in the area of financial management and advisory services. In their architecture information about products were separated into components. The IETF Working Group is defining standards for a distributed authoring and versioning protocol for the WWW (Whitehead and Wiggins, 1998).

The study presented here is a part of the document management project currently in progress at the University of Jyväskylä. The project aims to develop, test and customize methods for the SGML standardization process, especially for industrial purposes (Salminen, 1999b). The main goal of the whole project is to find means for optimizing the multipurpose use of structured documents and for minimizing manual and overlapping tasks in document management.

3. Application domain

3.1 An inter-organizational industrial project

The typical life cycle of an industrial project consists of a number of phases from start-up to commercial operations of the technical object. When the project starts, a vast number of actors enter the project. In this paper, an actor refers to an organization (Salminen, 1999a). The main actors of an industrial project are a customer, a constructor, a consult, large number of suppliers and subcontractors, and an information broker. Various official bodies are also involved in the project. The actors and their tasks in technical customer

document management are summarized in Table 1.

A constructor with subcontractors builds the technical object. Suppliers are responsible for the different components needed during the construction. A consulting or engineering company may act as a project co-ordinator. Official bodies produce rules and regulations related, for example, to environmental, legal or security aspects.

From the viewpoint of technical customer document management, the different actors form a complex inter-organizational network. They produce, compose, manage, deliver, update and use the customer documentation or parts of it according to their tasks in the project. Because an industrial project has a complex project organization with several actors in different roles, it might be one solution to separate the content production of the technical customer documentation from the composition, management and delivery. The information broker could act as the composer of the customer documentation. The information broker may be the constructor, the engineering company or a new media enterprise which is specialized in technical communication and producing technical documentation.

Table 1: The main actors of an industrial project and their tasks in technical customer document management.

Actors/Tasks	Production	Update	Composition	Maintenance	Delivery	Use
Customer						X
Constructor	X	X				X
Consult	X	X				X
Subcontractors	X	X				
Suppliers	X	X				
Official bodies	X	X				
Information broker			X	X	X	X

3.2 Technical customer documentation

Technical customer documentation describes the structure and function of a specific technical object such as a paper machine, a digital telephone exchange or a base station for mobile phones. Documentation is used in various environments, such as inside, outside, and in warm and cold weather conditions. There are many different user groups including technicians, maintenance personnel, vendors and trainers. All user groups have their own particular needs in searching for information. Moreover, the level of experience concerning a technical object will vary widely among the people in any user group. User group specialism, level of expertise, as well as task and situation specific matters will affect the way people use the information and how the pieces of information in technical customer documentation should be organized.

Technical customer documentation contains text, tables, and graphics, such as CAD drawings and figures, and possibly animation, sound and video sequences. Generally, customer documentation is organized in chapters and subchapters. Pieces of information in that documentation can have many internal relationships, for example a specific subchapter or a drawing in the Installation chapter may also have an important role in the Maintenance chapter. Documentation can include references to external information resources, such as standards and legal documents. Documentation will need to be updated either often or now and then depending on the technical object it is related

to. Possible components of technical customer documentation are presented in Table 2 (Heimbürger and Lanas, 1994).

Table 2: Components of technical customer documentation.

Component	**Examples of the contents**
User guide	Guidelines for using electronic customer documentation.
Project independent general information	Links to home pages of an information broker.
Project dependent general information	Project description and identifier, actors in the project.
Notes, cautions, warnings	Remarks related to security, such as cautions and warnings related to the technical object and individuals.
Structure of the technical object	A figure of the technical object.
Functions of the technical object	Descriptions of the main functions of the technical object; may include links to trouble-shooting situations.
Task and/or user group specific components • Installation • Operation • Commissioning • Maintenance • Training	Step by step procedures for installation, operation, commissioning and maintenance of the technical object, list of links between these procedures, user group specific training materials etc.
Processes	Descriptions of the main processes of the technical object; may include links to trouble-shooting situations.
Trouble-shooting situations	List of links to different trouble-shooting situations and step by step instructions on how to solve them.
Component catalogue	Access to external relational database which consists information about the components of the technical object.
Transportation	Matters or rules concerning transportation of the technical object or parts of it.
Storage	Matters or rules concerning storage of the technical object or parts of it.
Environmental aspects	Matters or rules concerning environmental aspects of the technical object or parts of it.
Indexes and lists • Technical terms • Abbreviations • Tables • Figures and drawings • Animation, video and sound sequences • Standards related to the technical object • Other manuals related to the technical object	Lists of links to technical terms, abbreviations, tables, figures and drawings, animation, video and sound sequences, standards related to the technical object, other manuals related to the technical object etc.
Users' notes	The user can make hers of his comments of a new trouble-shooting situation or a part of the technical object to be maintained.

3.3 Development potentials

Systematic working procedures

Nowadays, technical customer documentation is seen as a part of the technical product itself, and it plays an important role in international competition in various commercial fields. Customer documentation is more and more delivered, used and managed in electronic form.

It is typical for an inter-organizational industrial project that the actors change partly or in whole project by project. The main problem of technical customer document management in an inter-organizational project is related to unsystematic working procedures and heterogeneous information systems between different organizations. These often cause unnecessary overlapping and manual work, and makes technical communication between different actors in the project inefficient. From a customer's point of view, this is time consuming and expensive.

The information broker, who is responsible for composing the technical customer documentation, needs systematized, consistent and flexible working procedures. The information broker is also interested in developing new customized information services and products related to customer documentation, for example customized link sets which support users' information needs in specific tasks and situations. Production of training materials for different purposes is also an important issue.

Document reuse

Document reuse occurs when information created for one purpose in one document is used for another purpose in a new document (Wang and Rada, 1998). Reusable components typically require at least some modification during reuse. Integration processes ensure that reusable components that have been selected and tailored are properly integrated with other components of the document.

According to Wang and Rada (1998) the document reuse process may involve:

- copying without modification: an existing document or part of it is used in a new document without modification
- copying with modification: an existing document or part of it is used in a new document with changes
- referring: an existing document or part of it is referenced in a new document, but not included as a logical part of the new document
- sharing: an existing document or part of it is included as a shared logical part of both the existing document and a new document.

The modularity of information units and the flexibility in organizing these units by means of links make hypertext appropriate for document reuse. Document reuse in hypertext can be seen as a practice in which contents and structures created for one document, one view of a document or group of documents are used for a new document, another view of a document or another group of documents.

Link management

Links are becoming a common tool in the management of information. They play an important role in tracking the relationships within and among sets of data. In fact, links are important pieces of data themselves that need to be authored and maintained just like

other data (Angerstein, 1998). Methods and tools to manage the full life cycle of links are important for systematic maintaining and reusing hypertext applications.

When links are embedded in documents several disadvantages occur which affect the scalability and maintenance effort required to manage a large document collection (Ritchie, 1997):

- Resource requirements for link generation. As the number of document collections increases the effort required to author the links manually grows exponentially.
- Link decay. As documents change it becomes very difficult to keep track of all the links and their effects so that they can be updated reliably. The links will often fail after documents are moved, edited or deleted.
- Explicit authoring. Because embedded links have to be authored explicitly they cannot be generated automatically. That is, users can only follow links to documents which the author of the document is aware of, and considers being relevant. Relevant links cannot be processed automatically.

Hypertext research indicates that the solution to many issues concerning link management is to separate the links from the content. The solution is external hypertext link database architecture. By keeping the links separate from the data, greater flexibility and control are achieved (Ritchie, 1997):

- documents can be cross-referenced automatically according to their content without changing them in any way
- alternative sets of links can be associated with the same content to support task, situation and user group specific needs
- links can be included dynamically in content such as real-time data streams
- the task of large-scale link management becomes feasible
- verification of link integrity is automatic
- tracking of information use is automatic
- access to legacy data is greatly eased and can be automated
- links can be established in read-only data, such as CD-ROM files or documents with limited access.

Link management has become a matter of serious concern in the World-Wide Web. The World-Wide Web Consortium (W3C) has developed the Extensible Markup Language (XML) family which includes also a linking language (XLink). As soon as XLink conforming software is available, XML Linking Language may provide interesting means for link management in inter- and intra-organizational networks, such as extranets and intranets.

XML Linking Language

Standard Generalized Markup Language (SGML) is an international standard for defining markup languages, and it is designed to promote text interchange (ISO 8879; Goldfarb, 1993; Coleman and Willis, 1997). Markup rules of an SGML document are defined in the Document Type Definition (DTD) of the document. The DTD defines how valid documents of the type are written. The DTD specifies what elements are allowed, what elements are required, and how the markup itself is to be distinguished from text. For example, a technical document might contain a title element

<title>Customer documentation of the Project 2002</title>

where the title intended for human readers is indicated by a start-tag/end-tag pair which is intended for SGML software. Elements can have attributes written in their start-tags. For example, the element

<title language="English"> . . . </title>

has an attribute called *language* with value *English.*

SGML based document management solutions are application independent, consistent, flexible, and support reuse of information. The data can be used and re-used across different platforms and in different applications.

The Extensible Markup Language (XML) is a subset of SGML developed especially for the Web publishing (Extensible Markup Language, 1998). XML allows document markup also without associated DTD.

The XML Linking Language (XLink) is part of the XML language family (Boumphrey et al., 1998; XML Linking Language, 1998; XML Pointer Language, 1998). XLink specifies how documents or elements of a document should be linked into one another, and how fragments within XML documents should be addressed.

A link identifies a relationship between two documents or pieces of information. A linking element is an element that tells the existence and describes the characteristics of a link. A linking element can have any name, but a way to inform an XLink conforming application that this element should be treated as a link is done by using the XML reserved and designated attribute *xml:link.* A linking element can have other attributes too. The attribute *xml:link* can have the following values:

simple *extended* *locator* *group* *document*

An extended link differs from a simple link in that it can connect any number of resources, not just for example one local resource and one remote resource. It is a link whose traversal can be initiated from more than one of its participating resources. A linking element for an extended link contains a series of child elements that serve as locators. A locator is a string provided as part of a link which identifies a resource.

As simple links, extended links can be inline or out-of-line. An inline link is a link where the content of the linking element serves as a participating resource. In an inline link there is always something that can be displayed to the user for clicking, for example, a text string or a hot spot. HTML links are examples of inline links.

Extended links can contain extended links as well which makes nested tables of contents possible. With inline extended links it is possible to hide list of links behind a text string, and when the user clicks the string a drop-down box may appear on a screen. This is one way to save space on the screen. The appearance on the screen depends totally on how the XLink conforming browser treats the inline extended links.

It is possible for the links to reside in a completely different document. An out-of-line link is a link whose content does not serve as one of the link’s participating resources. A key issue with an out-of-line extended link is how a linking application software can manage and find it, when it is stored separately from its participating resources. By itself an out-of-line extended link seems to be useless. However, when it is combined with an XLink conforming linking application software it provides interesting possibilities to implement link databases with functions for maintaining, filtering, sorting, analyzing and processing of link collections.

An extended link *group* element is a specialized form of the extended link which

can be used, for example, to group lists of links together according to some criteria. To prevent lost in hyperspace phenomena *group* element can have the attribute *steps* which tells the XLink conforming browser how many levels to go in its exploration of links. A link author can also use attributes *show*, *actuate* and *behavior* to describe the traversal behavior of the link.

XLink provide many attributes that can be attached to linking elements to describe various aspects of links. Each attribute has a default name. It may be desired to use existing elements in XML documents as linking elements, but such elements might already have attributes whose names conflict with those described in this section. In XLink, user-chosen attribute names can be mapped to the default names using the *xml:attributes* attribute. The process is called attribute remapping (XML Linking Language, 1998).

As it is stated in the XLink specification the main design principles concerning XLink are:

- It shall be usable over the Internet.
- Its expression language shall be XML.
- It shall be formal and concise.
- XLinks shall be human-readable.
- XLinks may reside outside the documents in which the participating resources reside.

It is quite obvious that some kind of linking language is needed in the Web, but will it be exactly like the XLink can not be said for sure at the moment.

4. A scenario for managing technical customer documentation in an extranet

Intranets are a powerful platform for publishing corporate information and they are a way to provide broader access to corporate repositories. Extranets take this information and expose it to business partners and customers. An extranet can be viewed as part of a company's intranet that is extended to users outside the company or as a common information space for business partners and customers. The life cycle of an extranet can be either project specific or a more permanent solution. Some design methodologies that can be applied on intranet and extranet design have been reported in the literature (Bouguettaya, Benatallah and Elmagarmid, 1998; Garzotto, Paolini and Schwabe, 1993; Isakowitz, Stohr and Balasubramanian, 1995; Lee, 1998).

Extranets provide inter-organizational information spaces where business partners and customers can work together, develop common and systematic working procedures, and share information as well as applications. Let us assume that all the actors in the industrial project work in an extranet (Figure 1). The different actors in the project produce technical documents that they are responsible for according to a common set of rules and in agreed file formats. The documents are processed and stored in a common information area in the extranet. From these documents, the information broker composes the technical customer documentation. The documentation will be tested in the extranet. After the testing phase, the documentation can be transferred to the customer’s intranet. The end users will search information from the technical customer documentation through the intranet.

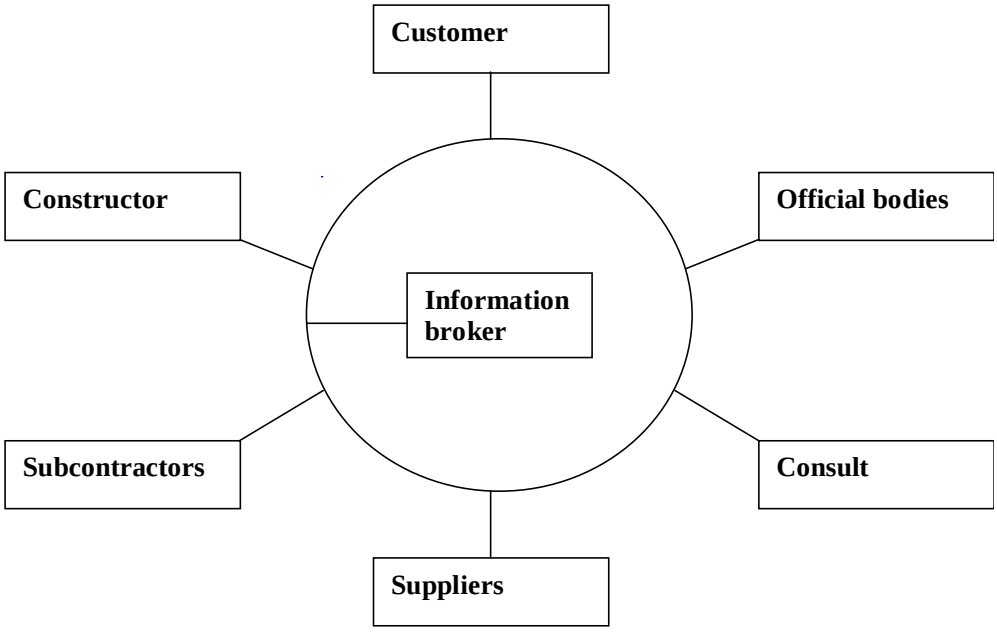

Figure 1: Main actors of an industrial project can work in the extranet as a virtual organization.

Content production and link authoring

Engineers and technical writers are responsible for generating the information content of documents and organizing the information which includes link authoring. They need rules and templates for automating routine links. Templates will enable engineers and technical writers to enter information into some predefined structure and the necessary links will be generated automatically according to the linking rules.

Engineers and technical writers also need to attach attributes to links. In external hypertext link management architectures, especially in network environments, it will be necessary to know

- which links are associated with a particular resource or a sub-resource
- in which servers the link destinations are
- who made the links
- when the links were made
- what kind of limits or rights there are for link management, by whom the links may viewed or changed
- what kind of versions there exists.

By means of the attributes, it will be possible to filter out needed information. For example, a link's title may suggest whether it would be useful to follow. Link types and roles are another form of link attributes. These attributes might be useful, for example in mobile communication applications, such as in trouble-shooting situations. Certain links or link groups could have an attribute *role="Mobile"* indicating that the resources of the links are specially design for users of mobile phones, for example according to the Wireless Markup Language (WML) which is one application of the XML. In addition to providing navigational paths, links must be able to initiate and control processes. Attributes related to link functionality would enable users to automatically invoke application programs, update data or start subroutines.

There are complex interrelationships within engineering data. Links should support representation of these relationships. For example, a link from a parts list should point to several locations in CAD drawings, such as all the places where a certain part is used. This example shows that the need for multi-ended links is obvious.

In network environments, support for both public and private links are needed. On the one hand, there are links which will be permanent and shared with other project actors; on the other hand, there are links which will be private and used by individuals to satisfy particular information needs. Public links will enable actors to share information that is required to accomplish their work collectively. These links will generally be available to all team members. There may be some restrictions concerning who may create and change links. Private links will enable engineers and technical writers to link information in ways that satisfy their personal needs without affecting information that pertains to the team.

Composing

When the engineers and technical writers have produced the information contents of technical customer documentation and organized the information. The information broker will compose the customer documentation by means of a link document that is designed, implemented and customized for the project. In this paper, a link document refers to an XML document which can consist of the following components or some of them (Figure 2):

- document type definition (optional for XML documents)
- project independent general information
- project dependent general information
- XLink or alike linking elements pointing to resources and sub-resources; it is entirely up to the XLink conforming linking application software and browser how the links are managed and shown to the user
- project specific instructions to convert one address space of links into another
- project specific instructions to convert resources and sub-resources into appropriate file formats
- project specific instructions to convert reused resources and sub-resources into new ones; reusable resources can be for example general warnings or figures produced in earlier projects

In the case of technical customer documentation a link document can be used as a template for composing customer documentation from documents and/or parts of them produced by different actors in an inter-organizational industrial project as well as for managing, delivering and using the customer documentation. The link document can have two roles in the customer documentation. Firstly, it defines the components and structure for specific customer documentation. Secondly, a link document can be used as a basis of designing a user interface for the documentation.

Generally speaking, a link document can be used by authors to design and compose publications for network publishing as well as by end users to read the publications and search related information, especially when there are several organizations responsible for content production and one organization composing the whole.

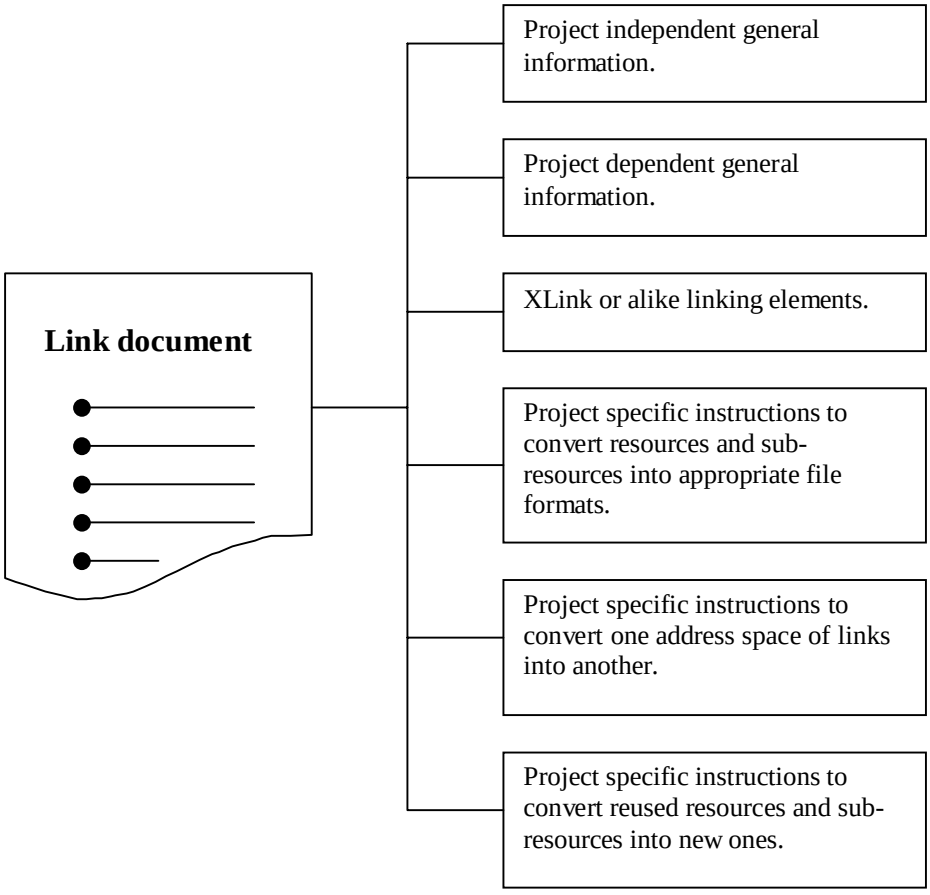

Figure 2: Possible components of a link document.

Testing

After composing procedure the customer documentation can be tested in the extranet by the actors who will use it. This is a great opportunity for a customer to take part in the testing phase. The information broker can also demonstrate additional features that can be added to the documentation.

Various sets of links can be associated with the same content to create for example very specific, step by step described task and situation views to information. This feature is interesting especially from mobile phone users' point of view.

XLink's ability to define structures for links makes them easier to control. This leads to more effective maintenance and to greater possibilities for automated processing. The XLink specification supports the idea of a central link repository in XLink conforming applications. It is possible to treat collections of links as an independent database. The possibility to use external link databases support the development of new information products and services related to technical custom documentation. For example, collections of customized link sets related to a specific project or a specific technical object could be marketed as separate products. The development of link database management systems, with filtering, sorting, analyzing, and processing capabilities is a challenge for software designers.

In the future, an information broker will be able to play an entirely new role in the business domain. It can act as a link broker, who develops new general and customized

information services and products which are based on the management of link collections.

Electronic archiving

After testing procedures the information broker or some other actor in the project shall archive a copy of the technical customer documentation. The process includes archiving the content and the structure (if there is a DTD) of the documentation, as well as archiving related styles and links. XLink's *group* element may be useful for archiving links. The element can group lists of links together according to some criteria, for example according to the name of the project or customer. By means of a *group* like element, it might be possible to identify and separate links belonging to one customer documentation from another.

Transformation from extranet to intranet

Once the composing, testing and archiving procedures of the technical customer documentation are completed the information broker can transfer the documentation to the customer's intranet, where it will be published for the end users. The transformation process from extranet to intranet requires that the values of the attribute *href* will be converted from the project's extranet address space to the customer's intranet address space. The end users will search information from the technical customer documentation through the intranet by means of portable computers or mobile phones.

5. Discussion

In this study the characteristics of an inter-organizational industrial project and managing technical customer documentation have been described. The development potentials, especially from link management point of view together with the scenario for producing, composing, testing, archiving and delivering technical customer documentation in an extranet have been introduced.

The exploratory study has concentrated on the issues related to link management. In this study following problems for further research were identified:

- a more precise understanding of the link document as a concept; its meaning for software developers, information brokers, and end users
- hypertext linking, resource and sub-resource identification principles so that links can be transferred automatically from the inter-organizational network to the intra-organizational network or the reverse
- precise analysis and definition of link life cycle and link record information to support link management processes, such as maintaining, verification, processing, sorting, filtering, analyzing, and reusing link collections
- a more precise understanding of the features in the XML and XLink languages that support (a) external hypertext link management architecture, (b) creation of new attributes for links, and (c) location-independent naming
- a more precise understanding of the *role* attribute of links and its possibilities in link management
- a more precise understanding of features in extranet and intranet network architectures that support link management

- domain analysis approach for finding principals for classifying links and domain specific linking rules
- templates for automating routine links; templates should enable link authors to enter information into some predefined structure and the system will automatically generate the necessary links between data objects
- templates for updating information after the delivery and for composing new link collections
- requirements for link management from the viewpoint of mobile communication applications related to using technical customer documentation in specific situations, such as in trouble-shooting situations
- electronic archiving principles for (XLink) links.

These issues motivate future research to concentrate on developing systematic methods for link creation, maintenance and delivery, especially for technical customer documentation in inter-and intra-organizational environments.

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