Semantic-based access to environmental reports using topic maps

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Abstract: Environmental reporting is an essential component of an organisation's communication with its stakeholders. In order to automate environmental reporting of organisations, the discussion focuses today on structuring and standardising environmental reports using the eXtensible Markup Language (XML). The development of XML-based environmental reporting is embedded in the process towards shaping an XML-based Environmental Markup Language (EML). Extending the XML-based approach we use the new international topic maps standard to describe the complex structure and the context (metadata) of environmental reporting.

Keywords: environmental management information systems; environmental reporting; metadata; XML, EML; topic maps; ISO/IEC 13250.

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1 Introduction

Environmental reporting is part of the internal and external communication and part of the environmental management system of organisations. In this article we emphasise that the environmental reporting of organisations is characteristic of:

1.1 Report as a service

Public and private organisations provide in their report information about adverse environmental impacts which are not (directly) caused by the reporting organisation information about prevention of pollution and information about the condition of the environment.

1.2 Public

Environmental reporting should answer questions the public may have with regard to the environmental impact of the organisation's actions.

1.3 Reports to gather information about the organisational environmental aspects

Organisations provide in their reports information about adverse environmental impacts that are (principally) caused by the reporting organisation, and information about their activities and success in avoiding, reducing and controlling pollution.

From this point of view there is neither a distinction between reporting actors (e.g. enterprise, federal state, national governmental institution, international organisation) nor reporting objects (e.g. company, site, concern, region, federal state, country, continent or globe).

In this article we will focus on reports to gather information about the organisational environmental aspects. This kind of environmental reporting is an essential contribution to an organisation's communication with its stakeholders.

2 Environmental reporting of organisations

According to ISO 14001, an organisation shall establish and maintain with '.. regard to its environmental aspects and environmental management system (…) procedures for

a internal communication between the various levels and functions of the organisation

b receiving, documenting and responding to relevant communications from external interests parties.

The organisation shall consider processes for external communication on its significant environmental aspects and record its decision.'

Lacking an international standard for environmental reporting of organisations, the German standard *DIN 33922 Environmental Reports for the Public*, issued in 1997, defines an *environmental report* as the report an organisation provides to the public that documents and evaluates significant environmental aspects.

According to DIN 33922, an environmental report for the public shall include at least the following semantic components [1]:

- basic information block: the basic information block consists of:
  - a description of the organisation's activities
  - a presentation of the organisation's environmental policy and programme
  - a description of the organisation's environmental management system
- presentation of significant environmental figures
- assessment of all significant environmental issues
- declaration of formal requirements.

Today, the use of ICT (information and communication technologies) in the environmental reporting of organisations is mostly restricted to the use of word processors and related desktop publishing software. Therefore paper-based documents remain at the centre of interest [2].

Word processing and desktop publishing systems are less in accordance with the requirements to ICT-based environmental reporting systems postulated in [3]:

2.1 Division of labour

Word processing and desktop publishing systems are not primarily orientated towards processing context information (metadata) of parts of an environmental report, which is, among other things, important for the division of labour in the environmental reporting.

2.2 Standardisation

Word processing and desktop publishing systems are not primarily orientated towards processing standardised structures of environmental reports in a non-proprietary data format.

2.3 Presentation

Word processing and desktop publishing systems are not primarily orientated towards processing content and structure of environmental reports independently of a formatted representation, which is particularly important for managing multimedia components (paper, CD-ROM, internet) of environmental reports without introducing redundancy.

2.4 Target group distinction

Word processing and desktop publishing systems are not primarily orientated towards processing target group specific reports and communication structures using hypermedia and internet technologies.

In order to automate the environmental reporting of organisations, the discussion focuses today on structuring and standardising environmental reports using the eXtensible Markup Language (XML).

3 XML-based environmental reporting

The eXtensible Markup Language (XML), which is platform-independent and particularly well-suited for dealing with semi-structured data, seemed to be a good basis for creating data formats for environmental reporting [4]. XML is a language to create specific markup languages. Using an XML-based markup language for environmental reporting we have the opportunity to handle the structure, content and presentation of an environmental report separately.

3.1 Structure

Document type definitions (DTDs) store the structure of environmental reporting. A DTD is a declaration that determines which are the required elements, which are the potential elements of environmental reporting and in which sequence the elements have to appear.

3.2 Content

XML documents based on a defined DTD store the content of the environmental reporting. An XML document is an instance of a previously defined DTD.

3.3 Presentation

Stylesheet languages (e.g. eXtensible Stylesheet Language (XSL)), define and process different presentations of one and the same environmental reporting content, such as Portable Document Format (PDF) or Hypertext Markup Language (HTML).

In Germany, there have been at least proposals for XML-based environmental reporting, developed by research groups in Kaiserslautern, Magdeburg, and Berlin, respectively [5]. All three proposed DTDs have been prepared autonomously and published more or less simultaneously. In order to contribute to the discussion of standardising environmental reporting of organisations, these three research groups started an ongoing process of harmonisation. This harmonisation is part of the process towards shaping an XML-based Environmental Markup Language (EML).

The motivation for the development of an EML is to be seen on the one hand in a uniform basis for discussion in the area of environmental computer science and on the other hand in an XML-based standardised (exchange) format for information and meta-information for environmental applications [6].

The ongoing EML-standardising process started with the definition of a core environmental metadata set (see Figure 1). This core set of environmental metadata (ELEMENT eml_meta_record) consists of:

- *Order declarations* represented by the sections '<!--recordInformation-->', '<!--indexInformation-->' and '<!--temporal-->'
- *Purpose and scope declarations* represented by the section '<!--scope-->'
- *Responsibility declarations* represented by the section '<!--responsibilities-->'
- *Procedure declarations* represented by the section '<!--resourceInformation-->'

which is to be completed with specific metadata according to the particular environmental management system element

- *Reference declarations* represented partial by the section '<!--resourceInformation-->'.

Figure 1 The core environmental metadata set (cutout) [7]

```
<!--domainmodell-->
<!ELEMENT   responsibilities (authorOriginator?,
            distributor,contact?)>
<!ELEMENT   temporal (temporalCoverage?,
            (publicationDate |
            dateOfLastUpdateOfRecord))>
<!ELEMENT   scope (referencePoint?, boundingBox?)>
<!ELEMENT   indexInformation (controlledVocabulary,
            unControlledVocabulary?)>
<!ELEMENT   resourceInformation (languageOfResource,
            sizeOfResource?, typeOfResource,
            formatOfResource?, relatedResources?)>
<!ELEMENT   recordInformation (ID, source, title,
            levelOfMetadata?, abstract?,
            distributionMedium?, accessConstraints?,
            useConstraints?, languageOfRecord?, URL, method?,
            aggregationLevel?, status?, keywords?)>
<!ELEMENT   eml_meta_record (recordInformation,
            resourceInformation, indexInformation?, scope?,
            temporal, responsibilities)>
```

The first step in the ongoing EML-standardising process of environmental reporting is a harmonisation on the top level (see Figure 2). This harmonised top level (ELEMENT envStatement) consists of:

- *Foreword declarations* represented by the element 'foreword'
- *Organisational activities declarations* represented by the element 'organisation'
- *Environmental policy declarations* represented by the element 'envPolicy'
- *Environmental management system declarations* represented by the element 'envManSystem'
- Environmental aspect declarations and environmental impact declarations represented by the element 'envAspectsImpacts'
- *Environmental Objective declarations* represented by the element 'envObjectives'
- *Environmental performance evaluation declarations* represented by the element 'envPerformance'
- *Stakeholder dialogue declarations* represented by the element 'stakeholderDialogue'
- *Sustainable development declarations* represented by the element 'sustDevelopment'
- *Financial aspect declarations* represented by the element 'financialAspects'
- *Formal statement declarations* represented by the element 'formalities'
- *Declaration of other factors regarding environmental performance* represented by the element 'other'.

Figure 2 Proposal for a harmonised DTD for environmental reporting of organisations [5]

```
<!ELEMENT   envStatement (foreword, organisation,
            envPolicy, envManSystem,
            envAspectsImpacts, envObjectives,
            envPerformance, stakeholderDialog,
            sustDevelopment, financialAspects,
            formalities, other)>
```

The next step in the ongoing EML standardisation process of environmental reporting is a harmonisation on the second level. This harmonisation step has to take into account at least:

- the purpose and scope in specific range of use
- the information extents of specific target groups.

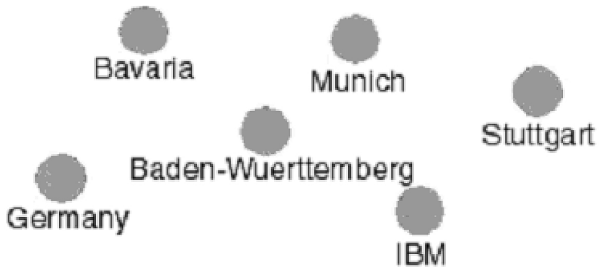
4 The topic map standard

Topic Maps are a new international standard for describing information structures and associating them with information resources. Basic concepts of the ISO/EC standard 13250 are:

4.1 Topics

A topic is defined as an "aggregate of topic characteristics, including zero or more names, occurrences, and roles played in associations with other topics, whose organisation principle is a single subject. In the most generic sense, a 'subject' is anything whatsoever, regardless of whether it exists or has any other specific characteristics, about which anything whatsoever may be asserted by any means whatsoever" [8]. Topics are objects within topic maps which represent subjects that their author had in mind when they were created. For example, topics could be an IBM site, the city of Munich or the federal state of Bavaria (see Figure 3).

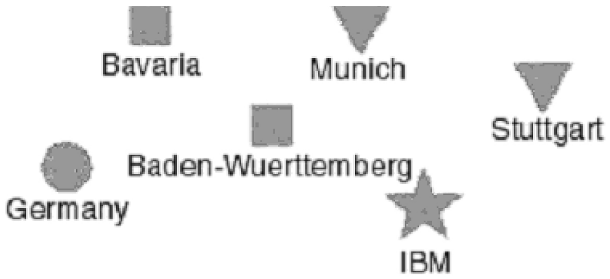
Figure 3 Topics (figure with reference to [9])



4.2 Topic types

Topics can be classified according to their type. Classes of topics are defined as topic types by the ISO/IEC standard 13250. Any given topic is an instance of zero or more topic types. Topic types themselves are topics. In our example e.g. IBM is topic of type 'cite', Munich a topic of type 'city' and Bavaria a topic of type 'federal state'. This relationship is depicted in Figure 4 by different symbols of topics.

Figure 4 Topic types (figure with reference to [9])



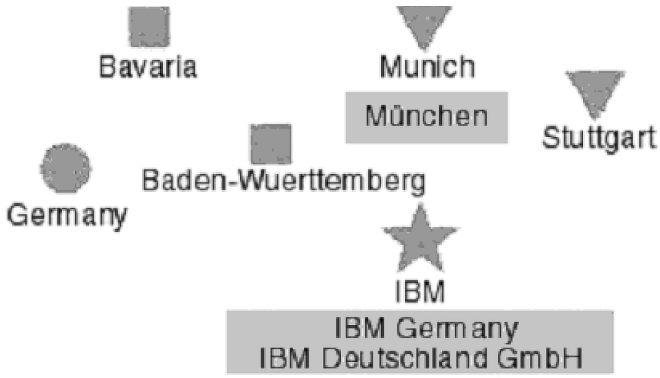
4.3 Topic names

Topics have an element form for topic names. Any given topic consists of:

- a base name (required)
- display name(s) (optional)
- sort name(s) (optional, used as sort key).

The topic name element form takes into account that there is a need to use one and the same topic with different names in different contexts. Figure 5 depicts the use of different names for single topics.

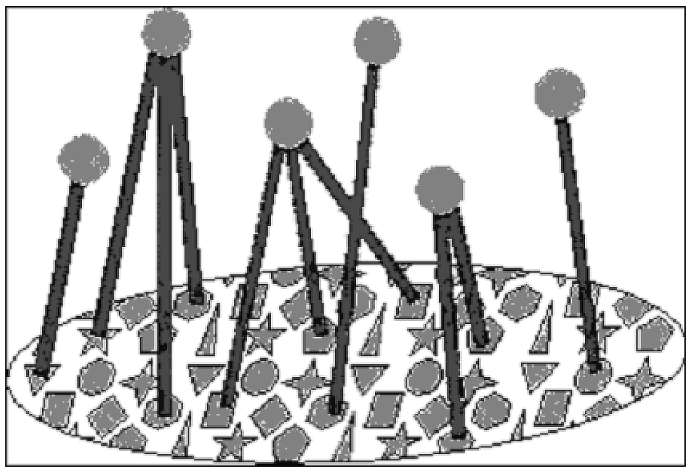
Figure 5 Topic names (figure with reference to [9])



4.4 Occurrences

Topic occurrences are defined as links to information indicated as relevant to a given topic, such as articles, monographs, pictures, videos, etc. about the given topic. Occurrences can be online as well as offline resources. According to the ISO/IEC standard 13250, such resources are generally outside a topic map. Figure 6 points out the relationship between topics and occurrences.

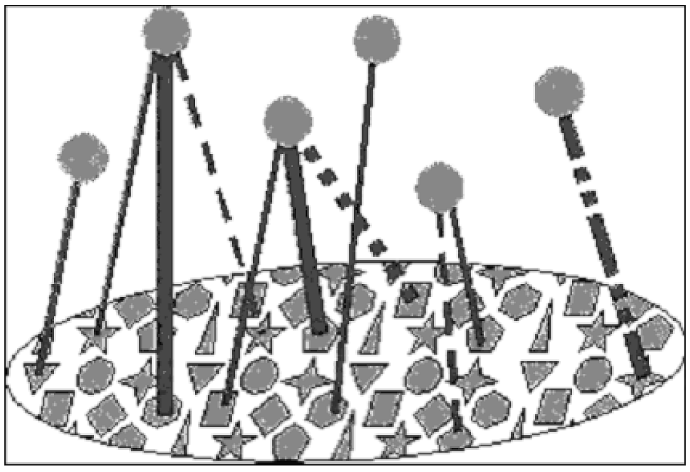
Figure 6 Occurrences [9]



4.5 Occurrence role

Occurrences can be classified according to their role. An occurrence role is defined by the ISO/IEC standard 13250 as the 'sense in which some set of occurrences is relevant to a topic.' The role indicates the way in which the occurrence supplies information to the subject in question (e.g. through being a definition, a figure, an example). In Figure 7, occurrence roles are illustrated by differently drawn arrows between topics and information resources.

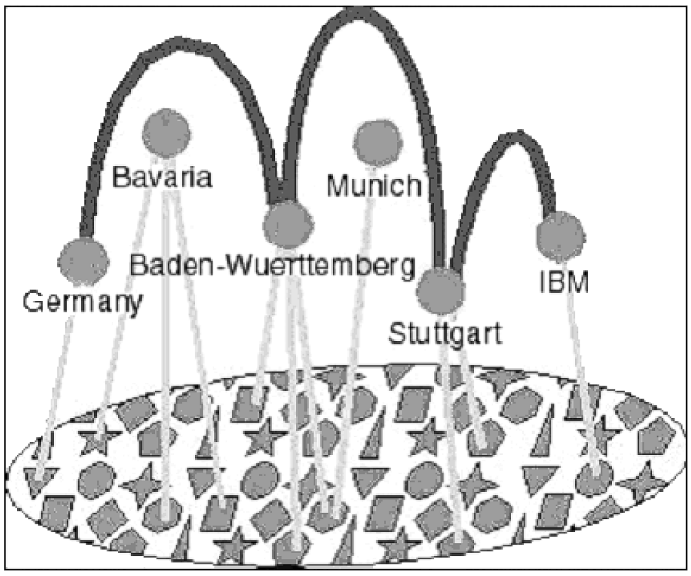
Figure 7 Occurrences roles [9]



4.6 Associations

Topic associations describe the relationships between topics. In the words of the ISO/IEC standard 13250, an association is a 'specific relationship among specific topics that is asserted by an association link element.' So it is possible, for example, to define an 'is-settled-in' association between the topics 'IBM' and 'Stuttgart'. As the use of associations is not limited by the ISO/IEC standard 13250, it is possible to define an 'is-settled-in' – association between the topics 'Stuttgart' and 'Munich' as well, which is not very meaningful. Figure 8 depicts the associations 'Baden-Wuerttemberg is-in Germany', 'Stuttgart is-in Baden-Wuerttemberg' and 'IBM is-settled-in Stuttgart'.

Figure 8 Associations (figure with reference to [9])

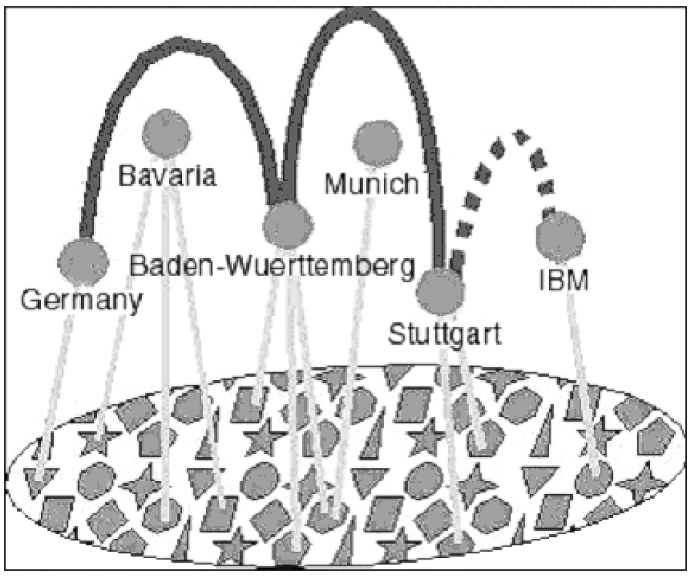


4.7 Association types

Associations can also be classified according to their type. The example of the last enumeration shows that, for semantic structuring, it is useful to provide associations of the same kind with a semantic meaning of the same kind. Therefore, the ISO/IEC standard 13250 introduces association types. An association type contains structure characteristics like the number of end nodes and the terms of the end nodes of an association.

But the association type is still no limitation to the semantic usability of associations. It is just a recommendation as to how associations with specific names should have to be employed. In our example the association type 'is-settled-in' could be provided with two end nodes, one end node named 'company' and the other end node named 'cite'. Figure 9 uses different line types for the visualisation of topic associations to point out the distinction between the used 'is-settled-in' – relationship and the used 'is-in' – relationship.

Figure 9 Association types (figure with reference to [9])



4.8 Scopes

Topics are characterised by their names, their associations and their occurrences. These three kinds of assignments are defined by the ISO/IEC standard 13250 as *topic characteristic assignments*. The assignment of a topic characteristic is always done within a specific context. The ISO/IEC standard 13250 does not require that this context be specified explicitly. But to do so, each topic characteristic can be provided with one or more context attributes. According to the standard, context attributes are the 'extent of the validity of a topic characteristic assignment' and are called *scopes*. Scopes themselves are topics. Scopes can aid the handling of ambiguity of topics and can be used e.g. for filtering topic maps.

4.9 Topic maps

According to the ISO/IEC standard 13250, topic maps are 'a standardised notation for interchangeably representing information about structure of information resources used to define topics, and the relationships between topics'. Topic maps themselves are navigable without occurrences and any reference to the real world, which is an essential advantage. Relationships between different topics can be illustrated without any altering of information resources in the real world.

Topic maps enable multiple, current views of a set of information resources. According to ISO/IEC 13250, topic maps can be used [8]:

- "To qualify the content and/or data contained in information objects as topics to enable navigation tools such as indexes, cross-references, citation systems, or glossaries.
- To link topics together in such a way as to permit navigation between them. This capability can be used for virtual documents assembly, and for creating thesaurus-like interfaces to corpora, knowledge bases, etc.
- To filter an information set to create views adapted to specific users or purpose. For example, such filtering can aid in the management of multilingual documents, management of access modes depending on security criteria, delivery of partial views depending on user profiles and/or knowledge domains, etc.
- To structure unstructured information objects, or to facilitate the creation of topic-orientated user interfaces that provide the effect of merging unstructured information bases with structured ones. The overlay mechanism of topic maps can be considered as a kind of *external markup mechanism*, in the sense that an arbitrary structure is imposed on the information without altering its original form." [8]

In the next section we discuss a new approach to environmental reporting of organisations, which is based on the topic map standard.

5 Topic maps as a standardised representation scheme for environmental reports

We believe that XML, which is platform-independent and particularly well suited to dealing with semi-structured data, is a good basis for creating data formats for environmental reporting of organisations. As shown in Section 2, XML DTDs have been created which define the structure of environmental reports. Two of these approaches and the harmonisation approach used single well-structured XML documents for encapsulating the data of environmental reports. These approaches, however, appeared to have three major drawbacks:

1 Putting all the data in one single file makes it difficult for many people to work on a document simultaneously.

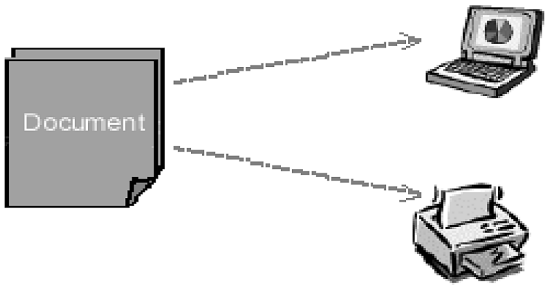
2 The integration of a core metadata set into environmental re-porting based on results of the EML working group (e.g. in the approach of the University of Magdeburg [5]) alters environmental report documents and does not allow a strict separation of report content and report context information. Therefore, our group has been following a different approach. Instead of using a single document for the whole environmental report, the report is split into components by using XML entities, which might be distributed over a network. By declaring each part of an environmental report to be an XML entity, we address the requirements for the support of a component-based approach to environmental reporting. Declaring them in another XML document aggregates those entities. The XML document in question is logically one level above the entities. However, its physical location can be anywhere in the network [4].

3 Different target groups need different information areas of the entire environmental report. A machine interpretable integration of all different target groups' information requirements in one standardised (hierarchical) XML-DTD is difficult to realise and does not permit a strict separation of report content and report context information.

Our entity-based approach is a step towards a semantic-based access to environmental reports using topic maps. On the way to a topic map-based approach we have to go through the following three steps:

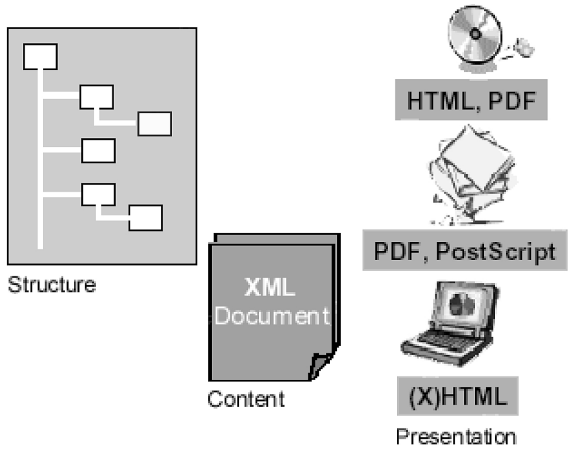
1 Using word *processing and desktop publishing systems* for environmental reporting: The analysis of published paper-based environmental report documents gives answers to what primary purposes the documents mainly serve and what kind of requirements have to be taken into account (Figure 10).

Figure 10 Using word processing and desktop publishing systems for environmental reporting



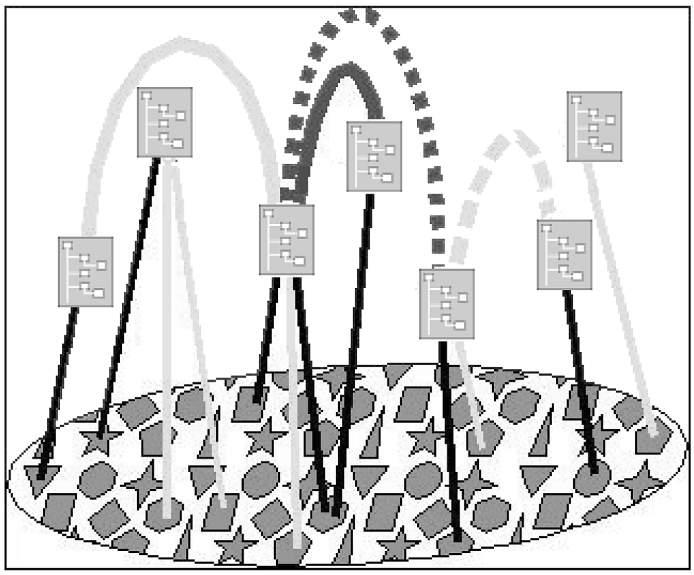
2 Using *XML* for environmental reporting: The strict separation of structure, content and presentation (see Figure 11) is one of the major advantages of XML. The development of a standardised DTD gives answers to what the (required/optional) elements of environmental reporting are and in which sequence do these elements have to appear in an environmental report.

Figure 11 Using XML for environmental reporting



3 Using *topic maps* for environmental reporting: the enabling of multiple, current views of set of information resources is one of the benefits of topic maps (Figure 12). The development of a topic map for environmental reporting can help get over the three major drawbacks of the existing XML-based approaches of environmental reporting. Topic maps can be used to describe the complex structure of an environmental report as well as to describe the context (metadata).

Figure 12 Using topic maps for environmental reporting (from [9])



We are, therefore following a topic map-based approach. Starting off with an entity-based approach to environmental reporting we have to identify parts (entities) of an environmental report in such a granularity that one needs no further decomposition (for the time being). All these identified entities have their own declared structure through an XML-DTD.

The level(s) above these identified entities of the entity-based approach will be replaced by a topic map. In our environmental reporting topic map all identified entities will be represented by topics. The (hierarchical) relationships between the entities will be expressed through topic associations. The use of topic sort names ensures the correct sequence of all identified parts (entities) in the environmental reporting.

Moreover, using topic maps instead of higher level entity-based DTD(s) provides the definition of target group specific associations between topics outside the relevant parts of the environmental report. Any kind of association can easily be considered, regardless of any specific DTD structure for environmental reporting.

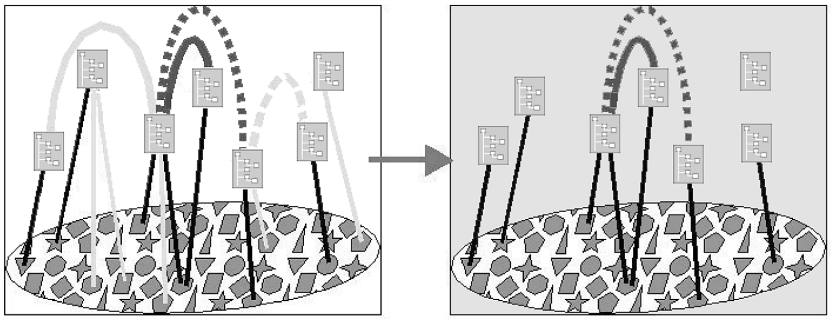
In our environmental reporting topic map, context (metadata) will also be represented by topics. Using external topics instead of an XML-based metadata integration we have a strict separation of report content and report context information. The topic map-based approach permits a flexible assignment of metadata and helps to avoid redundancy within the metadata of environmental reporting.

An environmental reporting topic map facilitates the representation of any kind of structure and context requirements. It is a semantic web of all declared structure and context requirements concerning environmental reporting.

So far, in our topic map-based approach we have the ability to represent an environmental report but not the ability to generate different (e.g. target group specific) environmental reports on the basis of the environmental reporting topic map. To do so, we have to obtain (see Figure 13):

- For the *specific structure* of the requested environmental report we mainly use the scope element of the ISO/IEC standard 13250. Specific environmental report structures will be generated dynamically by querying scopes representing structure information and – if necessary – querying other elements (e.g. topic names) of the environmental reporting topic map.
- The *specific content* of the requested environment report corresponding to the structure that was generated dynamically. Therefore, besides the generated structure itself we mainly use the scopes representing the context (metadata) of an environmental report. The occurrences of such filtered topics then contain the specific content of the environmental report requested.

Figure 13 Using scopes to generate different environmental reports (from [9])



The result of this query process should be designed in a way that each environmental report that is dynamically generated is an XML document with a corresponding DTD. XML documents can easily be transformed to other data formats, such as PDF or HTML using XSL. This transformation enables the multi-media representation (paper, CD-ROM, internet) that is expected from an environmental report.

Instead of handling one or more fixed DTDs for structuring an environmental report, our topic map-based approach handles the structural information by spreading it over scopes, topic associations, topic sort names, occurrences (with their optional DTD) and query statements. Therefore, the query statements represent important knowledge within environmental reporting and should be handled adequately.

The flexible external handling of structure and context information is one of the major advantages of the topic map approach. Another benefit of this procedure is the enabling of an approach for generating an environmental report more or less automatically.

Scoping topics, names and associations, and employing information resources linked by occurrences can be used for a machine-based document assembly of specific environmental reports.

6 Conclusion and outlook

We discussed a new approach to environmental reporting of an organisation that is based on the topic maps standard. The use of topic maps extends the flexibility and the field of possible applications of purely XML-based environmental reporting. The topic map notation itself can be defined as an XML architecture. While the ISO/IEC standard 13250 uses the Standard Generalised Markup Language (SGML) for the base notation, the members of the TopicMaps.Org Authoring Group provide XML Topic Maps (XTM), an abstract model and XML grammar for interchanging web-based topic maps [10].

The technical implementation of our approach, which we are currently working on, will use the XTM specification. Using XTM we try to exploit the following proposed benefits [10]:

- XTM is usable over the Internet in a straightforward manner
- XTM supports a wide variety of applications
- XTM is compatible with XML, XLink, and ISO 13250
- it is easy to write programmes that process XTM documents
- XTM documents are human-readable and reasonably easy to understand
- the design of XTM is formal and concise
- XTM documents are easy to create.

The goal of our approach is that XTM-based environmental reporting and dynamically generated XML-based environmental reports will complement one another in a harmonious way.

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