1. Goals and project framework
In our paper we will describe methods to automatically detect and annotate technical terms in written text corpora. These methods are developed within the framework of the project HyTex. In this project we create and evaluate strategies for automatically generating hypertext views and link structures that support both the selective reading and browsing of technical documents.

Two strategies that we implement in this context are:
(1) We link occurrences of technical terms in the documents with a ranked list of text segments, in which these technical terms are explicitly defined. The ranking of the definitions is based on a typology of definition types and on the position of the definition in the document (cf. Beisswenger et al. 2002).
(2) We create glossary views, in which the technical terms are displayed within the context of related terms (near-synonyms, hyperonyms, antonyms etc.). With these glossary views, definitions for all related terms can be retrieved and displayed in a new window. The glossary views are generated on the basis of a WordNet-style semantic net, in which technical terms are represented by using XML Topic Maps (cf. Lenz/Storrer 2002).

In the first phase of our project, the hypertextualization strategies were implemented and tested using a corpus with German technical texts. However, the linguistic basis of these automatic processes – the annotated definitions and the semantic net – was developed by hand-coding. In the second phase of our project we want to automate these linguistic preprocessing steps by developing and evaluating two approaches:

(1) The DefTagtiv approach detects definitions of technical terms in documents and annotates its components according to the annotation scheme we developed in the first phase of our project. In the following section we will describe our annotation scheme for definitions, specify our detection strategies and compare our approach to related work. In section 3 we discuss the results of a pilot study in which we evaluate this detection method on a German text corpus with manually annotated definitions.
(2) The NetExpander approach uses these annotated definitions to extract WordNet style semantic relations that will be used to enrich and expand the semantic net developed in the first phase of our project. In section 4 we will explain the results of a feasibility study on the possibility to extract semantic relations from definitions annotated according to our scheme.

In the framework of the HyTex project, both approaches are important if we want to apply our hypertext linking strategies to arbitrary technical domains. Furthermore, the detection and annotation of definitions may be useful in the context of terminology work and in computational lexicography: the DefTagTiv approach could support the lexicographers in writing adequate sense definitions in terminology databases and digital dictionaries. In addition, one could establish links between entries in digital lexicons and their definitions occurring in corpus documents. This may support the dictionary users in getting a better understanding of how terms are used in different schools or approaches of a scientific domain.

2. Annotation scheme for definitions and guidelines of the extraction approach
The main purpose of a definition is to explicitly ascertain the meaning in which a word is used in a technical or scientific document. Definitions typically consist of three functional components: the Definiendum (the term to be defined), the Definiens (meaning postulates for the term...
and the Definitor (the verb which relates the definiens component to the definiendum component). In the first phase of our project, we developed an annotation scheme with specific mark-up for these three main components. This annotation scheme may be illustrated by the following example:

Example (1):
Software, die dem Nutzer Orientierungs- und Navigationswerkzeuge für die interaktiven hypertextspezifischen Rezeptionsformen bereitstellt, bezeichnet man als Browser.
(Engl.: Software that provides the user with orientation and navigation tools for the interactive hypertext-specific forms of reception is called a browser).

The three main components of this definition will be annotated according to this schema in the following way:

<defSegment>
  <def>
    <definiens>
      Software, die dem Nutzer Orientierungs- und Navigationswerkzeuge für die interaktiven hypertextspezifischen Rezeptionsformen bereitstellt
    </definiens>
    bezeichnet
    <defnSegment>
      man
    </defnSegment>
    als
    <defniendum>
      Browser
    </defniendum>
  </def>
</defSegment>

In the first project phase we manually annotated definitions of a test corpus according to this scheme. This corpus comprises 20 technical documents (103,805 words) from the domains of text technology and hypertext research. We developed an annotation guideline in which we specified the characteristic properties and patterns of definition segments. This guideline concentrates on definition patterns that correspond to the Aristotelian definition schema of genus proximum and differentiae specificae in their definiens. These definitions correspond fairly well to formal definitions in the typology of Trimble (1985,74f) und Flowerdew (1992, 209f). On the basis of this guideline we manually annotated 174 definitions in the corpus according to our scheme. These manually annotated definitions are used (1) as the gold standard in the pilot study on definition detection (cf. section 4), and (2) as the empirical basis in our feasibility study on extracting semantic relations from definitions (cf. section 5).

We tested our guideline on interoperability with two students. This study revealed that, in some cases, one needs to be familiar with the domains of text technology and hypertext research in order to decide whether a term occurs as a definiendum or is just used in a more general way. Since the annotated definitions are used as the gold standard in our evaluation study, we needed to obtain a reliable basis. Thus, the final decision whether a text segment was annotated as a definition or not was made by a researcher familiar to the domains of text technology and hypertext research.

3. Related Work

In comparison to other approaches on finding definitions (e.g. Saggion 2004, Klavans/Muresan 2001, Muresan/Klavans 2002), our understanding of "definition" and "term" is more narrow: technical terms in our approach are linguistic expressions, the technical meaning of which is explicitly defined in our corpus. The term "definition" is used to refer to text segments that contain the three main structural components of the definition schema: definiendum, definiens, and definitor. Different definition patterns with these components are specified in our annotation guideline.

Definition detection approaches developed in the context of question-answering-tasks (e.g. Saggion 2004) are definiendum-centered, i.e. they search for definitions with a given term. Our approach, in contrast, is definitor-centered, i.e. we search for verbs that typically appear in definitions with the aim of finding the complete list of all definitions in a corpus independently of the defined terms. In our search patterns we define valency frames for such characteristic verbs like "bezeichnen als" (= to refer to as), "definieren" (= to define), "verstehen unter" (= to mean by). These frames specify the syntactic slots for the definiens and the definiendum components. In our project framework this approach has several benefits: (1) It facilitates the elimination of polysemous occurrences of these verbs (such as "jmd verstehen" in the sense of "to understand s.o."). (2) It is a good basis for annotating the internal structure of the definition in order to automatically extract semantic relations. (3) It helps to cope with variable word order in German sentences (a definiendum slot may occur on different positions).

In our approach definitions without a definitor-verb, as in example (2), have to be treated as special cases:

Example (2):
Homepage dtisch. Leitseite . Eingangs- oder Startseite eines Hypertext-Clusters.
(Engl: Homepage Germ. Homepage . Introductory or starting page of a hypertext cluster)

Such examples are typical for glossary or dictionary entries, but we also found them in ordered and unordered lists of our corpus documents. In these types of definition (henceforth called "glossary definitions") the components always appear in the same order: the definiendum component in the first position, followed by different types of separators, followed by the definiens component. Glossary definitions are hard to detect with our definitor-based method, since a multitude of different separators exists. In some cases there is no separator at all; instead, the definiendum is separated from the definiens by a different font or a different type face.

Definitions occurring in glossaries and online dictionaries are the primary source of the Google Glossary search function which offers possibilities to display definitions to search terms. By contrast, the focus of our approach is on definitions that occur in the text body of technical and scientific documents.

2 Cf. http://www.googleguide.com/glossary.html.
4. Pilot study on detecting definitions

In a pilot study, we evaluated our definitor-centered approach using the Insight Discoverer™ Extractor from the TEMIS Group.¹ This information extraction technology allows one to specify search and extraction patterns on different levels of analysis in so-called Skill-Cartridges™. With this technology we defined general concepts for the main components of our definition analysis – definiendum, definitor, definiens – and then specified for each definitor the valency slot for the definiens as well as for the definiendum. Additional constructs are introduced to cope with German word order alternatives.

We specified frames for 19 definitors (see table 1) in a Skill-Cartridge™. We applied these extraction patterns to our corpus and evaluated precision and recall using the definitions that we had manually coded according to the guidelines developed in the first project phase (see above). Table 1 shows the results of this evaluation. The figures in parenthesis (behind the definitor verbs) correspond to the number of definitions that we found in our corpus.

| definitor            | precision | recall |
|----------------------|-----------|--------|
| sein (80)            | 31%       | 83%    |
| bezeichnen als (16)  | 43%       | 75%    |
| verstehen unter (13) | 100%      | 85%    |
| nennen (10)          | 100%      | 20%    |
| bestehen aus (7)     | 41%       | 100%   |
| spezifizieren als (4)| 100%      | 100%   |
| heißen (3)           | 50%       | 100%   |
| verwenden als (3)    | 9%        | 100%   |
| bedeuten (2)         | 11%       | 100%   |
| beschreiben (2)      | 33%       | 100%   |
| begreifen als (1)    | 100%      | 100%   |
| benennen (1)         | 100%      | 100%   |
| charakterisieren als (1)| 100% | 100% |
| definieren als (1)   | 100%      | 100%   |
| gebrauchen (1)       | 50%       | 100%   |
| sprechen von (1)      | 50%       | 100%   |
| Terminus einführen (1)| 100% | 100% |
| vorstellen als (1)   | 100%      | 100%   |
| bekannt als (1)      | 50%       | 100%   |
| total                | 34%       | 70%    |

Table 1: Results of the evaluation study

The results show, that precision and recall are both highly dependent on the definitor. Recall values are considerably high when the definitor occurs with a characteristic preposition that is specified in the valency frame of the definitor (as in "verstehen unter" or "spezifizieren als"). For the definitors that occur only once, the values are not significant and have to be evaluated with larger corpora. The precision value for the definitor "sein" (= to be) is especially problematic. Although the part of speech tag set used in the Insight Discoverer™ Extractor allows one to differentiate between the possessive pronoun "sein", the main verb "sein", and the auxiliary "sein", there are still many examples that satisfy all characteristic properties but that, nevertheless, are not definitions. Such an example is:

(3) Visualisierung ist eine gute Möglichkeit, Anwenderprobleme bei der Suche abzumildern.
(Engl.: Visualization is a good possibility for downplaying user problems in a search.)

Since "sein" is the most common definitor, the problems associated with this definitor have an impact on all of the recall and precision values. In addition, we do not yet account for glossary definitions in our search patterns for the reasons explained in the previous section. Since 25 definitions in our corpus are glossary definitions, this has, of course, negative effects on the evaluation of recall.

5. Feasibility study on extracting semantic relations from annotated definitions

In the NetExpander approach we want to exploit our annotated definitions for an automatic extension of our semantic net. This net uses an extended inventory of the semantic relations that are specified in the Princeton WordNet (Fellbaum 1996). The idea of the NetExpander approach is that we use the annotated definitions and additional pattern matching rules to extract semantic relations that occur between the head noun of the definiendum and the head noun of the definiers. If the definiers follows the classical scheme "genus proximum + differencia specifica", the following extraction rule should apply: the definiendum head noun is a hyponym (a subclass) of the definiers head noun. An example that confirms this rule is our definition example (1) (cf. section 2). In this definition the head noun of the definiendum “Browser” is a hyponym of the head noun of the definiers “Software” which is the hypernym (the superclass). In our feasibility study we checked for all definitions, whether this rule can be applied and whether there are other types of relations that may be systematically extracted.

The results of this study are shown in Table 2. It is obvious that in a considerable number of cases, the rule that the head noun of the definiendum is a hyperonym of the head noun of the definiers proved to be valid. This encouraging result shows that it is worthwhile not only to detect definitions but also to annotate their internal structure. However, the study also revealed that there are exceptions to this rule. In one of these exceptions, the relation between the definiendum and the definiers seems to be conversely specified. An example is definition (4):

(4) XML ist der Oberbegriff für die Regeln, die beim Definieren von Datenformaten angewendet werden.
(Engl.: XML is the generic term for the rules that are used when defining data formats.)

In this example, the definiendum XML is explicitly stated as being a hypernym (a superclass) of the subclasses denoted in the definiers: the German word "Oberbegriff" (= generic term) is synonymous to "hypernym". In most of the definitions in which the relation between the definiendum and the definiers is conversely defined, we find such characteristic head nouns ("Oberbegriff" or "Klasse" (= class) in the definiers. In fact, if our main rule

¹ For our study we used the Insight Discoverer™ Extractor Version 2.1. (cf. http://www.temis-group.com/). We thank the TEMIS group for kindly permitting us to use this technology in the framework of our project.
is correctly applied to these cases, the definition states that the definiendum "XML" is a hyponym (a subclass) of the superclass "Oberbegriff". Since such relations on a metalinguistic level are not relevant for our semantic net, we extract the converse relation between the superclass in the definiendum (in our example "XML") and the subclass in the head noun of the prepositional modifier (in our example "Regeln").

Table 2: Results of the feasibility study
Some definitors indicate part-whole relations rather than superclass-subclass relations. The head noun of the definiendum that occurs in definitions with the definitor "bestehen aus" (consist of) is typically a holonym (whole) of the definiendum. An example is definition (5):

(5) Links bestehen aus einem oder mehreren Anker, die in Ressourcen verankert sind.
(Engl.: Links are made up of one or more anchors, which are fixed to resources)

But we also found cases with other definitors that indicate part-whole relations. An example is definition (6):

(6) Unter einem Datenformat versteht man die Gesamtheit der Richtlinien, die für jedes Dokument dieses Typs gelten.
(Engl.: Under 'data format' one understands the totality of principles that hold for every document of this type.)

These cases are regularly indicated by characteristic head nouns in the definiens like "Gesamtheit" (= totality). Typical for the converse relation of meronymy are nouns like "Teil" (= part) or "Bestandteil" (= component). It should, thus, be feasible to sort out these exceptions from the general hyponymy rule and determine holonymy or meronymy correctly.

6. Further work and outlook
Future work aims to improve precision and recall of the extraction patterns in the following way: we want to evaluate and optimize the search patterns specified for our definitors on the basis of a large German text corpus, namely the DWDS core corpus. In this step we will pay special attention to "booster words" and typical constructions indicating that polysemous verbs (like "sein" or "bedeuten") are used as definitors. Furthermore, we want to enhance our list of definitors by examining more documents from various technical and scientific domains. This will be done semi-automatically using TEMIS extraction technology. In order to improve our recall values, we want to include search patterns for glossary definitions occurring in the text body of technical and scientific documents. Since the results of our feasibility study on the extraction of WordNet-style relations are quite encouraging, we want to implement these extraction methods and evaluate them using definitions in corpora of different scientific domains.

7. References
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