Preprocessing and Tokenisation Standards in DELPH-IN Tools

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Abstract
We discuss preprocessing and tokenisation standards within DELPH-IN, a large scale open-source collaboration providing multiple independent multilingual shallow and deep processors. We discuss (i) a component-specific XML interface format which has been used for some time to interface preprocessor results to the PET parser, and (ii) our implementation of a more generic XML interface format influenced heavily by the (ISO working draft) Morphosyntactic Annotation Framework (MAF). Our generic format encapsulates the information which may be passed from the preprocessing stage to a parser: it uses standoff-annotation, a lattice for the representation of structural ambiguity, intra-annotation dependencies and allows for highly structured annotation content. This work builds on the existing Heart of Gold middleware system, and previous work on Robust Minimal Recursion Semantics (RMRS) as part of an inter-component interface. We give examples of usage with a number of the DELPH-IN processing components and deep grammars.

1. Introduction
The standard assumption about natural language parsing is that input data must be initially divided into chunks suitable for analysis (generally sentences) with each chunk further split into tokens. The tokenization step is generally defined to return a sequence of strings. There are several complications to this simple story when we consider processing real documents. Data which we wish to parse comes in many formats, possibly textual (e.g., raw text, HTML, SGML or XML markup, PDF), but possibly audio or video. Markup on the original input which is irrelevant for sentence parsing may nevertheless be useful for further processing (e.g., paragraph boundaries) and thus should be preserved so that it is available alongside the information extracted from parsing. Furthermore, it may be impossible in general for tokenization to produce a unique correct output without access to information usually associated with deeper processing. Finally, the assumption that tokens are strings does not allow for preprocessing which returns further information (e.g., named entity recognition, POS tagging or morphological analysis). Thus a general text interface should:

1. take into account document markup (e.g., via markup-aware tokenizer rules which provide the possibility to strip and recover markup as needed)
2. provide grounding in the text document under consideration (e.g., via standoff pointers)
3. provide an adequate representation for token ambiguity (e.g., a lattice)
4. provide a representation of adequate power for description of token content (e.g., feature structures).

Obviously it is also desirable to adopt commonly accepted standards such as Unicode and XML. Ideally, it should be possible to use the tokenization component in generation as well as for analysis, although we will not discuss that further here.

In this paper, we present a preprocessing and tokenization standoff-annotation standard which has been designed for use in DELPH-IN1, a loose international collaboration of researchers developing open-source software components for language processing. DELPH-IN components include deep parsers (currently the LKB (Copestake, 2002) and PET (Callmeier, 2000)) which run deep grammars for various natural languages (e.g., the English Resource Grammar (Flickinger, 2002), JACY2, NorSource3) and a range of tools for shallower processing. In previous work associated with DELPH-IN, in the Deep Thought project, the Heart of Gold system (Callmeier et al., 2004) for the integration of shallow and deep linguistic processors was developed along with the Pet Input Chart (PIC) XML interface format. Our current work extends this to provide a more general approach.

2. Standoff Annotation
Linguistic annotation may be generated automatically (the situation we are interested in here) or manually. Annotations may be inline or standoff (Thompson and McKelvie, 1997). Inline annotation is simpler and provides a convenient and straightforward way to annotate many documents. It is particularly suitable to unambiguous manual annotation. However, in the case of XML documents, it

1http://www.delph-in.net/
2http://wiki.delph-in.net/moin/JacyTop
3http://www.ling.hf.ntnu.no/forskning/norsource/
presupposes that the annotated output can be treated as tree-structured, which may be inconvenient or impossible. In contrast, in standoff annotation, each layer of annotations is kept in a separate space: the original data is left unaltered and the standoff document contains structures which are grounded via pointers into the original document. In such a framework, complex annotations with non-tree structure are possible, and a clear distinction exists between markup found in the original document and annotations in the separate standoff document. If parsing is treated as providing standoff annotation, document markup remains available to discourse-level processing.

Standoff annotations have been used successfully in other work: e.g., NITE (Carletta et al., 2003); GATE (Cunningham et al., 2002); WHITEBOARD (Frank et al., 2003); TEI (Sperberg-McQueen and Burnard, 2004). The Deep Thought project, which used and developed various DELPH-IN technology, experimented with a limited form of standoff annotation in the form of character position information encoded as part of RMRS (Copestake, 2003). The appropriate pointer scheme for standoff annotation depends on the data format of the original input. For example, annotations over an audio file may use frame (or time) offsets; annotations over text might use character pointers into the source. In this paper, our primary focus is standoff annotation over XML documents — we assume that other text formats will mapped to XML in a prior stage. In the next section, we discuss XML standoff pointers in more detail.

2.1. Choice Of Standoff Pointer Implementation

A variety of approaches to standoff pointers in XML have been investigated and have different strengths and weaknesses: XML ID tags are coarse-grained, requiring that the source document contain markup elements around everything of interest (and crucially they cannot overlap); byte offsets are fine-grained but not robust to changes in the character encoding; character offsets are simple to use, although not robust to changes elsewhere in the document; XPointer\(^4\) is very powerful, but its full machinery unnecessary for our purposes.

We take a hybrid approach to choice of standoff pointer: existing non-XML-aware processing components can often easily be converted to produce character pointers, but for XML-aware components, it is easier to work with a pointer scheme aware of the XML tree structure. A mapping between the two pointer schemes provides the necessary interconversion.

An XML text document may be considered at a number of levels: (i) at one level, the document consists of a sequence of bytes, to be interpreted with respect to some coding scheme (specified in the XML header; e.g., \texttt{encoding=’ISO-8859-1’}); (ii) at a higher level, an XML document is considered a sequence of Unicode characters; (iii) at an even higher level, the document is a collection of abstract nodes forming a tree structure (in which certain distinctions in the input, such as sequences of whitespace, have been collapsed). Non-XML-aware processing components consider an input document as a sequence of bytes or characters. XML-aware processing components work with the XML tree.

We use ‘character’ pointers refer to points between the sequence of Unicode characters (see fig. 1); ‘xpoint-based’ pointers refer to points in the abstract XML tree (see fig. 2). Our xpoint-based pointers are derived from the xpoint scheme detailed in the XPointer specification. Any point may be uniquely referenced by specifying an XML node (via XPath) paired with an offset (Unicode character offset inside a text node; XML node offset otherwise). Points within XML attribute values can also be specified in this way. XPath allows multiple expressions to refer to the same node in a particular document; by appropriate choice of XPath expression, it is possible to trade simplicity of pointer scheme against robustness. For example, suppose the \texttt{<p>} element in fig. 2 contained attribute \texttt{id=’p23’}. Point \texttt{x} could be specified by one of: ‘/1/1.4’ or ‘/p/text()[1].4’ or ‘/[@id=’p23’]/1.4’ (in order of robustness to changes to the raw document).

3. Interface formats within DELPH-IN

Firstly we outline the PIC XML interface format which has been in use for some time within DELPH-IN. PIC provides an XML input format tailored to the needs of the PET deep parser. It utilises: (i) standoff pointers (character counts in the source document); (ii) two types of annotation (word, named entity); (iii) an implicit lattice; (iv) for the annotation content, a variety of XML elements/attributes chosen to mesh with the data structures of the deep processor. The PIC format is generated using XSLT mappings from other formats. PIC documents reference grammar-specific types. Secondy we describe a more generic XML interface format (SMAF) which was derived from MAF (Clement and de la Clergerie, 2005). This is intended to be independent of the parser and grammar. SMAF utilises: (i) choice of standoff annotation scheme; (ii) a number of annotation types

\(^4\)http://www.w3.org/TR/WD-xptr

**Raw Text:** 
"\(<p>\text{Come <i>here</i>!}</p>""

**Unicode character points:**
\[
\text{\textless}<p>,\text{C.o.m.e.\Delta,\textless,i,\textgreater,\text{h.e.r.e.\Delta,\textless,j,\textgreater,\textgreater,\textless,i,\textgreater,\textless,j,\textgreater,\textlt;/p,\textgreater}.
\]

Figure 1: character pointers (points shown as ‘.’ and numbered from the left, starting from 0)

\[
\text{ROOT}() \quad \cdot \text{P}(1) \cdot
\]

\[
\text{TEXT}(1/1) \quad \cdot \text{i}(1/2) \quad \text{TEXT}(1/3) \quad \cdot
\]

\[
\text{.C.o.m.e.\Delta} \quad \text{.TEXT}(1/2/1) \quad \cdot \text{.\Delta} \quad \text{.h.e.r.e.}
\]

**xpoint at \texttt{x} is:** ‘/1/1.4’

Figure 2: xpoint-based pointers (points shown as ‘.’)
for specific purposes; (iii) a lattice; (iv) intra-annotation dependencies; (v) a range of representations for the content of individual annotations. The mapping from annotation contents into grammar data structures is specified in grammar-specific configuration files. SMAF is designed for the situation where multiple processors are to be flexibly integrated, as, for instance, in the SciBorg project. It allows for levels of interface other than tokenization and morphology, although these will not be discussed further here.

3.1. PIC implementation

The PIC (PET XML Input Chart) format has been used with the deep HPSG parser PET within the Heart of Gold system (Callmeier et al., 2004; Schäfer, 2005). Heart of Gold is a middleware for the integration of deep and shallow natural language processors on the basis of XML standoff annotation that can be flexibly configured and easily accessed by applications.

Heart of Gold uses XSLT (Clark, 1999) for combining and integrating XML markup. The general idea has been presented and motivated in (Schäfer, 2003). XSLT can be used to convert between the various XML formats, and to combine and query standoff annotations. In particular, XSLT stylesheets may also be used to resolve conflicts resulting from multi-dimensional markup, choose among alternative readings, follow standoff links, or decide which markup source to give higher preference.

The PIC format contains the original input text to be parsed, the character span information of the words, optional part-of-speech information (e.g., to allow guessing of the type of unknown words) with weights in case of multiple readings, and a construct for combining simple items to complex ones, e.g., multi-words named entities or chunks. Furthermore, types and, more generally, typed feature structures can be ‘injected’ via PIC directly into the deep parsers’ chart by specifying feature paths with associated values.

In the following, we give an example (for sentence ‘When will LREC 2006 take place?’) of two preprocessing components, a PoS tagger and a named entity recognition (NER) component. Their output triggers generic entries of words unknown to the HPSG lexicon to increase robustness. Both preprocessing components independently produce standoff markup from the input text. The markup is transformed and combined into a single PIC markup document which is then passed to the deep HPSG parser running the English Resource Grammar.

Similar setups as for English have also been implemented for German, modern Greek and Japanese preprocessing components and HPSG grammars in the Heart of Gold.

SProUT (Drożdżyński et al., 2004), the NER component used for these languages, produces typed feature structure markup (Lee et al., 2004) (Figure 3), and transforms it to the PET input chart format using XSLT stylesheets that are automatically generated offline from the SProUT output feature structure specifications (Schäfer, 2005).

The various PoS taggers either directly produce the PIC format or use small, manually developed transformation stylesheets. Figure 6 shows the PET input chart generated by combining PoS tagger output (<w> elements) and NER (in element <ne>).

Finer-grained information (e.g., gained from integrating ontology information in the NER resources as described in (Schäfer, 2006)) that is not relevant for robust HPSG parsing, can be by-passed as an RMRS structure. The RMRS (Figure 4) is generated from the SProUT output using another automatically generated stylesheet, and can be combined with the deep RMRS (Figure 5) in a post-parsing transformation.

3.2. SMAF implementation

A SMAF document describes a segment (generally, sentence) of the raw input document packaged in a manner suitable for input to a parser. Relevant annotation levels for such a description include simple token strings, part-of-speech tags over simple tokens, complex named-entity tokens and morphological descriptions of tokens (when these are provided by a component external to the parser). The format borrows from MAF and PIC. It incorporates RMRS-XML as a possible annotation content.

The following properties are global to a SMAF document:

- **document** points to the original document (optionally, the raw data may be embedded in the **text** property);
- optionally, the standoff pointer addressing scheme may be specified (defaults to **character** pointers);
- a collection of OLAC-compatible metadata (including an **identifier**);
- a global span (standoff pointers **cfrom** and **cto**);
- a **lattice** containing the annotations themselves as **edges** (with special **initial** and **final** nodes).

The following properties are applicable to an **edge** annotation:

- an **identifier**;
- a **type** (one of **token**, **pos**, **namedEntity**, **morphology**);
- a span (standoff pointers **cfrom** and **cto**);

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5http://www.sciborg.org.uk/
specific mappings (in general determined by the edge
tent (component- (and grammar-)specific data structures. The
PET) must map an input SMAF document into internal
annotations from a larger standoff annotation document.

Fig. 4: RMRS generated by SProUT with fine-grained named entity information.

Fig. 5: Deep RMRS generated by PET with named entity from external NER component.

- **deps**, a set of edge ids on which the annotation has a
dependency;

- plus the annotation ‘content’ (below).

Annotation content consists of a combination of the follow-
ing elements:

- simple slot elements, each consisting of a name part
  (such as surface, weight, tagset, tag) paired with a
  value string;

- complex feature structure (fs) elements: these may be
typed, and are compatible with the TEI/ISO FSR stan-
dard used by MAF;

- complex RMRS description.

Fig. 7 provides a sample SMAF XML document.
A SMAF document may be generated natively by a pro-
cessing component (such as the DELPH-IN tokenizer), via
a wrapper around an external component (e.g., around the
ChaSen morphological analyser (Asahara and Matsumoto,
2000) for Japanese), via an XSLT stylesheet from an alter-
native XML format such as PIC, or by picking relevant
annotations from a larger standoff annotation document.
A deep processing component (such as the LKB or
PET) must map an input SMAF document into internal
component- (and grammar-)specific data structures. The
input format is designed with this in mind. The con-
tent (slots, fs’s, rmrs’s) requires component- and grammar-
specific mappings (in general determined by the edge type);
these are specified in simple configuration files. For exam-
ple, the tag slot on an edge of type pos (part-of-speech)
will be mapped to a grammar-specific type dependent on the
tagset used. A sample SMAF configuration file entry is
shown below:

```
  • pos.[tag="NN1", tagset="CLAWS7"] => $genericname
```

SMAF represents structural ambiguity in tokenization by
means of a lattice. The lattice is required to allow for com-
plex forms of ambiguity. For instance, a comma might be
normal punctuation or part of the name of a chemical com-
 pound. While some disambiguation can be handled by the
tokenizer, other cases could require a lexicon and process-
ing of the surrounding context. Rather than complicate the
tokenizer, we prefer to delay the decision so that the re-
sources of deeper processing can be brought to bear. This
approach is also useful in handling clitics such as the poss-
sessive ‘s’ in Norwegian.

SMAF allows three types of annotation content. Simple
slots hold simple unstructured values, such as a part-of-
speech tag with respect to some tagset. Complex structured
content may be represented as a (typed) feature structure
or as an RMRS.

Users of the DELPH-IN machinery have a number of
choices when choosing components for the preprocessing
and deep processing modules. The first step in processing a
document is segmenting the document into segment spans
(generally, sentence units) fit for parsing, and tokenization
of text within such spans. This provides us with the nec-
essary data to create a simple SMAF document containing only
edges of type token. In addition, further components
such as a POS tagger or named-entity recogniser (or mor-
phosyntactic analysis external to the deep parser) may pro-
vide additional edges. The DELPH-IN tokenizer (regex-
based, character-point standoff-aware, markup-aware, and
incorporating a light-weight named entity component) provides a simple preprocessor sufficient for many contexts. It produces SMAF documents natively. Other components have been written from scratch, or adapted (the RASP (Briscoe and Carroll, 2002) sentence splitter, the ChaSen preprocessor for Japanese) to produce this XML interface format. Components previously adapted to produce PIC within the Heart of Gold system are converted via a PIC2SMAF XSLT stylesheet as an interim solution.

Crucially, grounding in the source document (via standoff pointers) is preserved throughout processing and hence the link between system output and the processed text is never broken. These standoff pointers are preserved in the RMRS semantic analyses output by the deep parsers.

4. Summary

This paper has described the use in DELPH-IN of a standoff-annotation interface format between the level of preprocessing (consisting of an obligatory tokenizer module plus optional additional modules) and the deep parser module (consisting of a deep grammar for a particular natural language running on a DELPH-IN deep processor) of the DELPH-IN tools. The role of interface format is played by SMAF, a fairly general XML serialization loosely based on the MAF ISO working draft. Configuration files define the mapping from this format to the specific data structures required by particular deep processor implementations and the type systems of particular grammars.

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<pet-input-chart>
  <w id="TNT0" cstart="0" cend="3">
    <surface>When</surface>
    <pos tag="WRB" prio="1.000000e+00"/>
  </w>
  <w id="TNT1" cstart="5" cend="8">
    <surface>will</surface>
    <pos tag="MD" prio="1.000000e+00"/>
  </w>
  <w id="TNT2" cstart="10" cend="13">
    <surface>LREC</surface>
    <pos tag="NNP" prio="1.0.000000e+00"/>
  </w>
  <w id="TNT3" cstart="15" cend="18">
    <surface>2006</surface>
    <pos tag="CD" prio="1.0.000000e+00"/>
  </w>
  <w id="TNT4" cstart="20" cend="23">
    <surface>take</surface>
    <pos tag="VB" prio="8.349828e-01"/>
    <pos tag="NN" prio="8.672786e-02"/>
    <pos tag="VBP" prio="7.828936e-02"/>
  </w>
  <w id="TNT5" cstart="25" cend="29">
    <surface>place</surface>
    <pos tag="NNM" prio="1.0.000000e+00"/>
  </w>
  <w id="TNT6" cstart="30" cend="30" constant="yes">
    <surface>?</surface>
    <pos tag="?" prio="1.0"/>
  </w>
  <ne id="SPR1" prio="1.0">
    <ref dtr="TNT2"/>
    <ref dtr="TNT3"/>
    <surface>LREC 2006</surface>
    <pos tag="PN" prio="1.0.000000e+00"/>
    <typeinfo id="TIN2" baseform="no">
      <stem>$generic_name</stem>
    </typeinfo>
  </ne>
</pet-input-chart>

Figure 6: PET input chart generated from PoS tagger and named entity recognition component output.

<smaf document="/data/doc01.txt">
  <olac:olac xmlns:olac='http://www.language-archives.org/OLAC/1.0/' xmlns:dc='http://purl.org/dc/elements/1.1/'>
    <dc:creator>SMAF 0.0</dc:creator>
    <created>16:14:31 3/05/2006 (UTC)</created>
    <dc:identifier>s4</dc:identifier>
    <posTagset>CLAWS7</posTagset>
  </olac:olac>
  <lattice init='vo' final='v7' cfrom='0' cto='31'>
    ...<edge type='token' id='t43' cfrom='10' cto='14' source='v2' target='v3'>
      <slot name='surface'>LREC</slot>
    </edge>
    ...<edge type='token' id='t44' cfrom='15' cto='19' source='v3' target='v4'>
      <slot name='surface'>2006</slot>
    </edge>
    ...<edge type='token' id='t45' cfrom='20' cto='24' source='v4' target='v5'>
      <slot name='surface'>take</slot>
    </edge>
    ...<edge type='namedEntity' id='n10' deps='t43 t44' cfrom='10' cto='19'>
      <fs type='ne-event'>LREC 2006</fs>
      <f name='eventname'>LREC 2006</f>
      <f name='ne-concept'>Active_Conference</f>
      <f name='ne-objid'>obj_89404</f>
      <f name='ne-abbid'>LREC 2006</f>
    </edge>
    ...<edge type='pos' id='p63' deps='t43'>
      <slot name='tag'>NNP</slot>
    </edge>
    ...<edge type='pos' id='p64' deps='t43'>
      <slot name='tag'>CD</slot>
    </edge>
    ...<edge type='pos' id='p65' deps='t43'>
      <slot name='tag'>NNP</slot>
    </edge>
    ...<edge type='pos' id='p66' deps='t43'>
      <slot name='tag'>NNP</slot>
    </edge>
    ...<edge type='pos' id='p67' deps='t43'>
      <slot name='tag'>NNP</slot>
    </edge>
  </lattice>
</smaf>

Figure 7: SMAF document